Study to Monitor Connectivity

Connecting the EU to its partners though submarine cables

Final Study Report

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The results and conclusions presented in this report are the interpretation of the market research, online survey and interviews conducted by PwC, processed and interpreted in accordance with our addressees' guidance and inputs. In any reference to this report PwC shall not be named as author of this report.

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The results and conclusions presented in this report are the interpretation of the desk research and interviews conducted by PwC. PwC has not sought to establish the reliability of these sources or verified the information provided. Accordingly, we assume no responsibility and make no representations with respect to the accuracy or completeness of the information in this report. However, PwC examined the data sources with expertise to sort out the sources with the highest level of credibility. The traceable sources for all information are specified clearly in the Deliverable. In some cases, the data sources comprised estimations or projections, and hence the findings and calculations incorporated such data. It is always indicated in the materials of the sources if a data is an estimation. PwC consolidated the majority of publicly available data (e.g. Submarine Telecoms Forum, Telegeography) related to the Infrastructure and Business Model analysis and created a customized database. However, despite PwC's best efforts, the customized database may not contain all existing and planned submarine cables due to the fragmented nature of available data. The customized database was used for further calculations in all cases where no data source is indicated in the Report.

Abstract

Digital connectivity is the foundation of the next Digital Decade. There are two significant first mile technologies to consider in international connectivity: submarine and terrestrial fibre-optic cables, and satellite systems. In transcontinental connectivity submarine cable systems are key elements to consider for ensuring the goal of the EU: remain an integral part of the connectivity ecosystem, ensure the security of infrastructure and services, and establish digital sovereignty. The current document is dedicated to provide support to the listed goals of the EU and DG CONNECT. In order to give a comprehensive assessment, the current situation and outlook to 2030 of three key factors are analysed in this study: demand factors driving the connectivity needs and developments, digital connectivity infrastructure and the market mechanisms, including major business models and stakeholders. To identify risks and recommendations, the report assesses current EU regulatory frameworks and partnerships.

List of abbreviations

Abbreviations	Meaning
4K	Horizontal display resolution of approximately 4,000 pixels
AAG	Asia America Gateway
ADSL	Asymmetric Digital Subscriber Lines
APG	Asia-Pacific Gateway
ARIMA	Auto Regressive Integrated Moving Average
ASN	Alcatel Submarine Network
CAGR	Compound Annual Growth Rate
CIF	Contract In Force
CPA	Capacity Purchase Agreement
CSP	Cloud Service Provider
DC	Data Centre
DC-to-DC	Data Centre-to-Data Centre
DFFT	Data Free Flow with Trust
EaP	Eastern Partnership
EECC	European Electronic Communications Code
EMEA	Europe, the Middle East and Africa
EU-AITF	EU-Africa Infrastructure Trust Fund
EU-AU DETF	EU-African Union Digital Economy Task Force

Exabyte	1 million TB (terabyte)
FP	Fibre Pair
GB	Gigabyte
Gbps	Gigabit per second
GDPR	General Data Protection Regulation
HDR	High Dynamic Range imaging
ICP	Internet Content Provider
ICPC	International Cable Protection Committee
IoT	Internet of Things
IP	Internet Protocol
IRU	Indefeasible Rights of Use
IXP	Internet Exchange Point
LAC	Latin America and the Caribbean
LAN	Local Area Network
LEO	Low-Earth-Orbit
LTE/WiMAX	Long Term Evolution (4G LTE) / Worldwide Interoperability for Microwave Access
M2M	Machine-to-Machine
MDB	Multilateral Development Bank
MEA	Middle East and Africa
MENA	Middle East and North Africa
MEO	Medium-Earth-Orbit

MIU	Minimum Investment Unit
NIS Directive	Directive on Security of Network and Information Systems
OTT	Over-The-Top provider
PLTD	Philippine Long Distance Telephone Company
PPP	Purchasing Power Parity
Pbps	Petabit per second, or 1000 terabits per second
RFS	Ready For Service date
SDM	Spatial Division Multiplexing
Tbps	Terabit per second, or 1000 Gigabits per second
UHD	Ultra-High-Definition
UNCLOS	The United Nations Convention on the Law of the Sea

1. Executive summary

The competitiveness and sovereignty of the EU is highly dependent on its internal and external connections, as international digital connectivity is the foundation of the next Digital Decade. The EU is committed to remain a significant player of the connectivity ecosystem to establish international connectivity as a supporting factor. The EU is also highly committed to ensure a secure data economy for its citizens and establish digital sovereignty. For creating adequate measures that support these goals it is indispensable to have a comprehensive view of the market trends, including demand and supply aspects, relevant stakeholders and potential risks.

Drivers of digital connectivity developments

Based on the forecast of the current study, the global internet traffic is expected to grow more than sixfold in the next decade (equal to 22% CAGR). The persistent growth of global internet traffic is attributed to five emerging social, consumer, and technological trends, which are projected to continuously increase in the next decade: internet penetration rate, average daily time spent on the internet, number of connected devices, consumption of content that requires enhanced broadband connection and the use of data-heavy technologies, such as cloud data, big data technology etc. Besides the presented social, consumer and technological trends, unexpected phenomena, such as the COVID-19 pandemic in 2020, might significantly impact internet traffic.

These drivers will affect the developed and developing countries differently. In developed regions, the internet traffic growth will be driven mostly by new digital services, in developing regions, the increase of internet penetration will be the most important influencing factor. **However, significant differences between the regional internet penetrations widen the digital divide.** This can be attributed to two main factors: underdeveloped intraterrestrial infrastructure and low affordability of high quality services. In order to ensure an accelerated development of these regions and hinder the potential monopoly, **the EU has an important role in sharing best practices, supporting the policy initiatives for increasing the affordability of internet services and enhancing its own competitiveness.**

M2M connections will contribute to a significant internet traffic increase. The digital connectivity infrastructure, including submarine cable system, intraterrestrial and other infrastructure, has to be designed in such a way that can serve the needs of disruptive services.

In the future, the increase of internet traffic is unquestionable, entailing the need for more data centres and faster connection between them. **The hyperscale data centre market is forecast to grow continuously, which will be driven mainly by cloud service providers / OTTs.** The expansion of the data centre market also drives the requirements towards international connectivity infrastructure in necessary capacities and emerging new routes. In addition, in the future the data centre market players will focus on energy consumption, reducing carbon footprint, the usage of green energy and green cooling. Thus, geographically there is an increased interest for the Arctic region due to its optimal settings for operation of data centres. The driving force and pace of investments of foreign actors in the data centre market represents risk for the EU in maintaining sovereignty and independence. Thus, in order to remain a significant player of the data centre market, it will be indispensable to **strengthen the EU's own infrastructure and create legal frameworks** that ensure security of services and minimize the dependence on non-EU players.

Infrastructure

Today, about **99% of the world's international communications traffic is served by submarine fibre-optic cables**. Currently there are **over 400 submarine cable systems** in service and although new

cables will be installed while old ones retired, there total number is not expected to change significantly in the future either. The majority of these cables are located in the **EMEA, Austral-Asia and Americas** regions respectively. Based on announcements, in the upcoming five years 91 new submarine cables will be established which exceeds the number of new cables in the period of 2016-2020.

Overall design capacity[1] **is expected to more than double** and design capacity shares across the regions will be more balanced by 2025 thanks to new cables and technological improvements more than doubling average design capacity per cable. The **Arctic region,** which will experience the highest growth rate, will **continue to lag behind** even though **interest in the region is gradually increasing**. Despite new cables laid each year, **lit capacity**[2] **is growing faster than design capacity**, which implies that **demand is increasing more quickly than the potential traffic carrying capability** of submarine cable systems. Although there will be a significant number of cables likely retiring by 2025 too, total design capacity will not be nearly as affected as **by 2030** when **the Transpacific and the EU - Latin America route**, for example, **will lose around 20% of their capacity.**

Assessing resilience suggests that a **significant amount of new cables should be established on** some EU routes like **the EU - Latin America and EU - Far East** ones even if we consider new cables (most notably EllaLink) already announced.

Content providers have become unavoidable players in recent years. In the last 5 years, they accounted for 17-59% of newly deployed capacity. While this percentage will decline to 18.5% by 2021, they are expected to **continue to shape the submarine cable landscape** significantly - mostly as consortium members. However, since content providers are mainly focusing on connecting data centres and telecommunication companies struggle to build a sound business case, **it is up for debate who will develop submarine cables on secondary, less lucrative routes**.

As for the coming decade, a total of about **140 cables are needed to be installed** between 2021-2030[3], not only to cope with the increasing demand but also to make up for retiring cables. For this to happen, **technological advancements are highly needed** as without them, a financially feasible and future-proof submarine cable infrastructure cannot be achieved.

In order to overcome **infrastructural challenges and facilitate the development** of a future-proof submarine cable landscape, a series of measures is recommended. The EU should define **target coverage levels and monitor infrastructure gaps** continuously with high emphasis on regions and routes with high retiring capacity, low resilience and ones that are financially more challenging. The EU should monitor investment plans in the Transatlantic region, in particular, to keep up the EU presence. The EU should **drive and support technological advancements** to maintain its leading position and facilitate the use of encryption in submarine cable infrastructure to mitigate security risks.

Stakeholders and business models in submarine cable systems

The main actors in the first mile value chain are the surveyors, the system suppliers, the installers, the owners, the maintenance providers, the customers and other stakeholders - among whom **the two most crucial players are the system suppliers and the owners.**

There are four major companies dominating the supplier market: the EU-based **Alcatel Submarine Network** (ASN), the US-based **SubCom**, the Japanese **NEC** and the Chinese **Huawei Marine**. **As of 2020, the company with the most active EU connected cables is SubCom** (24% market share) **in the period of 2020 to 2025, European companies show the most significant activities** (73% market share), however US-based suppliers will be also dominant. Otherwise no remarkable change can be expected on a global scale until 2030. **The key players are expected to keep their market position**,

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1 Design capacity (or potential capacity) describes the maximum capability that submarine cables could carry theoretically if they were fully equipped to do so.

2 Lit capacity refers to the actual capacity that is available for use. It shows what the submarine cable systems are capable of at the moment, rather than what they could achieve if fully equipped.

3 Telegeography: Pacific Telecommunications Council - Telegeography Workshop 2020

while smaller players will operate at the regional level. However, it is also a conceivable scenario that either large suppliers will acquire regional companies or content providers enter the supplier market. Due to the **growing concern about the cybersecurity of networks,** several countries have already restricted or plan to limit activities of market players. However**, further evidence would be needed on this matter.**

Traditional owners of submarine cable infrastructure **are telecommunications service providers**. **In the past decade, content providers and Far Eastern-owned telecommunications companies emerged** (especially China Mobile, China Telecom and China Unicom) as new market leaders and started building their own cables. **In the period of 2016 to 2020 content providers were already the driving force behind 36% of the systems.** Consequently, **the business case of traditional telecommunications service providers has been disrupted thus the role of traditional service providers is being transformed.** The most relevant content providers are Google (owning 90,000 km of cables) and Facebook (with 50,000 km) but Microsoft and Amazon are also becoming more present. They have been mostly busy in the Australasia , the Transatlantic, the Transpacific and the Americas regions while Chinese telecommunications companies are active all over the world except the Americas region. **No remarkable change can be expected on a global scale until 2025. Globally content providers will stay the key market leaders** by building more than 200,000 km of cables and thus achieving a 53% market share, **in terms of EU connected cables, European owned companies are planning to build the most cables by far** (8 announced cables), however, the activity of Non-EU European companies and content providers is also significant with 5 cables each. After 2025, it is likely that the role of content providers will be further strengthened. It is also possible that traditional telco providers will focus their investments more in national infrastructure and niche areas.

Financing and investments

Investments in international connectivity are growing steadily, in 2021 the total investment value will be four times more than it was in 2020 (from $1 billion to $4.3 billion) and it is expected to remain high in the upcoming years as well. At the same time, **the total market size** will also **significantly grow, and it will most likely reach $28-30 billion by 2025**.

There are three major financing categories: multi investor, single investor and Public Private Partnerships. The multi investor model has been the most common financing model by far (as almost 90% of this total investment has been made by multi investors since 1990), however, in recent years, **single** investments and hybrid financing has also started gaining popularity (the previous category increasing by 10% point in the past 5 years compared to the period 2012 to 2016). Both multi and single owner **investments are the highest in the Australasia region**. **Most of the PPP investment (46%) has been made in EMEA** with a focus on Africa. **Total investment value shows a significant increase in the following years with 7.1% to 12.1% CAGR by 2025** and the proportion of investments from private investors and hybrid financing is expected to grow. MDBs will focus on less developed regions (such as the Pacific Island and Micronesia). Some experts also argue that working capital finance should also be introduced.

The two main risks are the lack of supplier capacity and the growing economic and financial power of content providers. The presence of Chinese service providers - mainly system suppliers and owners - in the submarine cable market **is not significant in the EU.**

A level playing field can be ensured by defining a common strategy at EU level and introducing the necessary incentives, subsidies and regulations, such as: driving the development and introduction of new technologies, supporting the commissioning of new cable ships, enable European owners to make longer-term investments and support the continuous development of EU-level cybersecurity.

Regulatory environment and international partnerships

There is a need for rapid policy actions to create a comprehensive, common EU approach towards the regulation of submarine cable landing and accessibility rights that ensure the integration into the global ecosystem, the security of services and infrastructure, and maintain the EU Digital Single Market and sovereignty.

Yet, there is a fragmented regulatory landscape and there is a growing need for a comprehensive, and consolidated regulatory framework for international connectivity, and balanced, fair and transparent contractual conditions and similar approaches for submarine cable landing rights or accessibility.

In addition, it is important to increase the security of services and infrastructure, thus it is **recommended to classify the submarine cables as critical infrastructure and define incident reporting requirements and cybersecurity guidelines.** The EU has already taken steps towards its objective, the enhancement of international connectivity, as well as the EU digital sovereignty and security, with partnerships and regulations.

Recommendations

Strategy, regulation and financing are the three main areas where actions need to be taken in order to strengthen the EU's position and ensure independence of the EU's connectivity.

In order to manage the potential risks and improve the competitiveness of the EU in the digital connectivity ecosystem, there is a need for well-defined, **comprehensive strategy** which includes the following elements:

- Create a **common approach to submarine cable system infrastructure** of the EU.
- Define the **desired coverage the EU aims to reach** and subsequently **monitor infrastructure gaps continuously.**
- **Examine whether a level playing field is equally accessible** to owners and all other stakeholders (suppliers, surveyors, installers, customers).
- **Enhance the competitiveness of the EU** in order to hinder the monopoly in developing countries.
- **Monitor the Transatlantic region** and **future submarine cable investment plans** to keep up the EU presence in the submarine infrastructure of this region.
- **Support market players in overcoming capacity issues** in order to solve supplier capacity problems.
- **Drive and support technological advancements**.
- **Increase the use of encryption** in the submarine cable infrastructure
- **Become a significant player of the data centre market,** by strengthening its infrastructure and creating legal frameworks to ensure digital sovereignty.

Development of the regulatory framework, including guidelines and other regulatory instruments is indispensable to ensure the harmonization of national regulation, fair market conditions and the security of services and infrastructure. Thus, the following actions are recommended:

- **Create a comprehensive and common EU approach** towards the regulation of submarine cable systems.
- **Classify submarine cable systems as critical infrastructure**, thus defining incident reporting and cybersecurity requirements for the actors
- **Creating regulation that ensures balanced market conditions.**
- **Examine the possibility of setting ownership requirements** for content providers,
- **Provide guidelines aiming to harmonize** in the long term national regulation related **landing rights and accessibility.**
- **Support the initiatives for increasing the affordability** of internet services and policy making by sharing best practices.

Available financial resources should be aligned to the strategic priorities, **by creating a comprehensive and common approach for supporting financing decisions,** that includes investment in infrastructure and other financial support for EU-based companies or technological innovations, such as:

- **Encourage the construction of new cables,** especially in areas where market mechanisms are not adequate and on routes that bring the most new resilience, touch countries that currently do not have many intercontinental cables, and that bring connectivity to regions of the world where the EU does not have direct connectivity with
- **Drive the development and introduction of new technologies**, especially Spatial Division Multiplexing (SDM);
- **Support the commissioning of new cable ships** and the **maintenance of existing ones for surveying, installing and maintaining purposes** in order to solve supplier capacity problems;
- **Help ease the pressure (both in terms of time and working fees) on system suppliers,** coming especially from content providers;
- **Enable European owners to make longer-term investments** (similarly to content providers' investments);
- **Drive the development of** European **data centre infrastructure;**
- **Support** the continuous **development of EU-level cybersecurity,**
- **Encourage private investments.**

2. Introduction

2.1. Purpose of this document

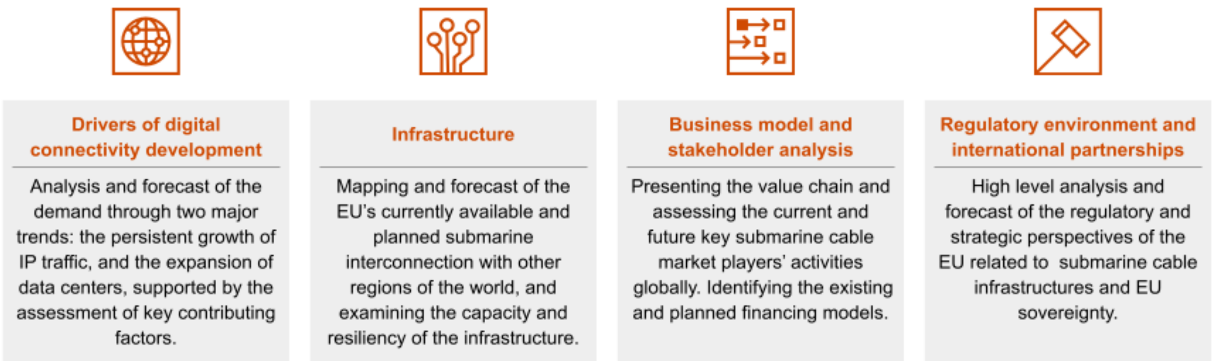
The Final Study Report is the Deliverable 3 of the project *"Study to Monitor Connectivity" - CNECT/2020/LVP/0087 (Nr. – LC-01592601)*, officially commenced on December 14, 2020, on the date of the contract signature.

The purpose of this document is to provide an overview of the project findings. In accordance with the project plan accepted in the Inception Report, the document incorporates the Current State analysis, the Future trends and forecasting and the Findings and Recommendations, as elaborated below.

The Final Study Report contains the following:

- **Mapping and assessment of the currently existing international and intercontinental connectivity infrastructure.** In line with the general principles, the mapping elaborates on the most significant infrastructure trends with dedicated attention to submarine cables[4] and focuses on "Focus regions" in terms of geographical specifications. The analysis is based on a demand and supply side analysis and incorporates a summary of the reliable data sources, such as the data derived from Telegeography, Submarine Telecoms Forum, Cisco, GSMA, ITU, The World Bank and Statista among others, consisting of descriptive and quantitative datasets as well. Based on these sources, PwC conducted its own calculations. Furthermore, 16 expert interviews have been conducted with telecommunications service providers, submarine cable system owners, suppliers, installers, coordinators, and cloud service providers. The list of interview participants can be found in the *Annex.*
- **Analysis of future trends regarding internet traffic demand, infrastructure growth and business models.** The timespan of the projection is the next ten years (2021-2030). The forecast explores the major consumer and market trends and their effect on international connectivity. It also focuses on submarine cable infrastructure and reflects on all predicted investment trends related to digital connectivity and its impacts. Furthermore, the analysis incorporates future business and financing models.
- **Gap analysis and reflection on risks and recommendations regarding EU digital autonomy.** The study determines potential gaps, risks and improvement areas by comparing the mentioned results, and reflects on the submarine cable regulations and the policy consequences of investments on digital connectivity, independent EU services and the free EU market.

The current state analysis, forecasting and Gap analysis are covered through the following



topics:

[4] The declared focus of this study are submarine cables, however, other infrastructural elements, that are out of scope for this study, like Internet Exchange Points (IXPs), play an important role in internet connectivity as well.

2.2. Project background

The competitiveness and sovereignty of the EU is highly dependent on its internal and external connections, as international digital connectivity is the foundation of the next Digital Decade. The main objective of the EU is to establish international connectivity as a supporting factor, rather than an impediment of economic growth. Hence, the EU is committed to be an integral part of the connectivity ecosystem to share best practices, form fruitful partnerships, and contribute to the development of the world economy, while at the same time, ensure a secure data economy for its citizens by sound regulatory frameworks, and establish digital sovereignty.

As the Project is dedicated to provide support to the listed goals of the EU and DG CONNECT. The objectives of the Project are the following:

1. **Mapping of the digital connectivity infrastructure** outside of the EU both connecting and not connecting to EU territory.
2. **Assessment of existing international and intercontinental connectivity infrastructure,** distinguishing different connectivity media.
3. **Projection of infrastructure growth** in the next ten years (2021-2030).
4. **Forecast** traffic demand and expected investments worldwide.
5. **Present the evolution of business models and services**, and map the main stakeholders shaping them.
6. **Gap analysis** of digital connectivity infrastructure needs, with special attention on digital connectivity infrastructure between EU and Africa, Latin America, the Far East, and the EU Neighbourhood respectively.[5]
7. **Reflection on risks and recommendations** regarding digital autonomy and the independence of EU services.

[5]The list of countries that belong to each region can be found in the Annex.

3. Current State analysis

3.1. Drivers of digital connectivity developments

Summary - Drivers of digital connectivity developments

Global digital connectivity is the foundation of the next Digital Decade and the driver of future social and economic growth. In the last decade two major demand trends affected the volume, locations, and owners of digital connectivity infrastructure developments:

- **Persistent growth of the global internet traffic,** increasing the average and peak traffic on international links and showing the need for more and more capacity.
- **Continuous expansion of data centres,** to provide adequate storage for the ever-increasing amount of data generated and to enable rapid traffic of this data.

Global IP traffic has more than doubled between 2016 and 2019 and reached about 200 exabytes/month in 2019. The persistent growth of global internet traffic is attributed to five emerging social, consumer, and technological trends, namely the following: internet penetration, average daily time spent on the internet, number of connected devices, consumption of content that requires enhanced broadband connection and the use of data-heavy technologies that require High-Performance Computing, such as cloud data, big data technology, machine learning and artificial intelligence. Besides, other unforeseen factors may have a significant impact on the IP traffic. For instance, in 2020, as a consequence of COVID-19, the international peak traffic increased by almost twice as much as the previous forecast.

The continuous expansion of data centres is attributed to the increasing internet traffic and data generation, which creates a growing need for more advanced facilities, storage and equipment. Data stored in data centres grew from 171 exabytes in 2015, to almost 1000 exabytes in 2020. Hyperscale data centres now account for 50% of all installed servers, from 21% in 2015. Amazon Web Services, Microsoft and Google own more than half of the world's hyperscale data centres, seeking to build their data centres with links to submarine cables and other data centres.

There are significant differences between the development levels of Focus regions. The Far East has the most developed infrastructure, highest penetration, best coverage, and cheap pricing resulting in high levels of internet usage, and many hyperscale data centre investments. Africa is the most underdeveloped in all factors analysed, followed by Latin America with remarkable regional disparities, and moderate data centre activities. The EU Neighbourhood is heterogeneous across regions, with high penetration rates and affordable price levels, but only with a few data centres.

All key trends suggest a further increase in IP traffic, which encourages numerous infrastructure investments. There is a question, however, whether capacity can keep pace with the accelerating growth of demand.

3.1.1. Persistent growth of the global internet traffic

Internet traffic has been growing persistently at a fast pace over the last decades, which triggers the need for continuous infrastructure and capacity improvements. Global IP traffic has more than doubled between 2016 and 2019, and reached about 200 exabytes/month in 2019.[6] Fixed IP traffic comprised almost 70% of total IP traffic, and, even though mobile data traffic only accounted for about 15% of total IP traffic in 2019[7], it grew by 50% between Q3 2019 and Q3 2020.[8] **Consumer IP traffic constitutes almost 4 times more of total IP traffic than businesses' IP traffic.** The IP traffic generated by consumers accounted for approximately 84% of total IP traffic in 2020. Both segments grow at a steady rate year-over-year, consumer traffic with a CAGR (Compound Annual Growth Rate) of 28%, and businesses traffic with a CAGR of 24%.

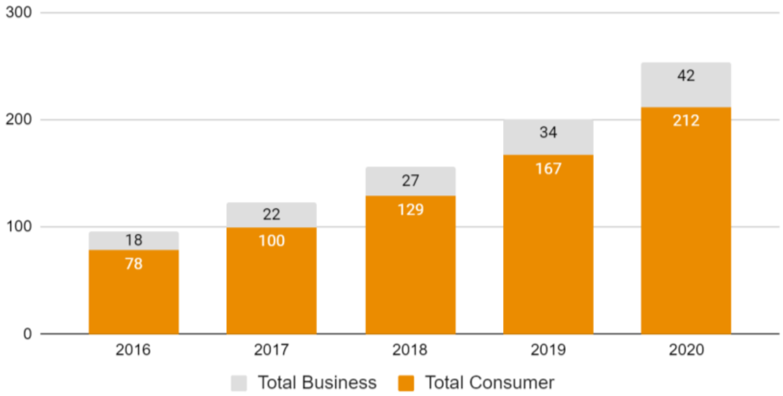


Figure 1: IP traffic by segment 2016-2020[9]

As a result of the persistent growth of the global internet traffic, the average and peak traffic on international links increased. Peak internet traffic is growing at a faster pace year-over-year than average traffic and this drives infrastructural developments to a higher extent. Average traffic also increased persistently, reaching well above 150 Tbps in 2020 compared to approximately over 60 Tbps in 2016. Peak internet traffic has more than doubled between 2016 and 2019 and grew almost at the same rate only in 2020 to about 100 Tbps from around 40 Tbps in 2016[10].

The COVID-19, stimulated working and studying from home, and has increased the use of streaming services and online meetings hugely. As a result, the international peak traffic increased by 47% in 2020[11] alone, which is almost twice as much as the previously forecast 28%.[12]

Five emerging social, consumer and technological trends are fueling this increase in internet traffic:

- **Increase of internet penetration.** The most apparent driver of traffic demand is the growing number of internet users worldwide, which more than doubled from 2 billion in 2010 to 4.8 billion in 2020.[13] However, the increase of worldwide internet users and penetration rates has been dynamic - approximately 10.5% CAGR between 2006 and 2013 -, **the pace of growth is declining with a CAGR of around 5.5% between 2013 and 2019.[14]**

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[6] Cisco: Visual Networking Index: Forecast and Trends, 2017–2022
[7] Cisco: Visual Networking Index: Forecast and Trends, 2017–2022
[8] Ericsson: Mobility Report 2020
[9] Cisco: Cisco Visual Networking Index: Forecast and Trends, 2017–2022
[10] Peak internet traffic: the level of traffic at the time when the majority of internet users are online.
[11] TeleGeography: The State of the Network
[12] TeleGeography: Global Internet Map 2021
[13] Statista: Number of internet users worldwide from 2009 to 2020
[14] ITU: Global and regional ICT Data: Individuals using the internet

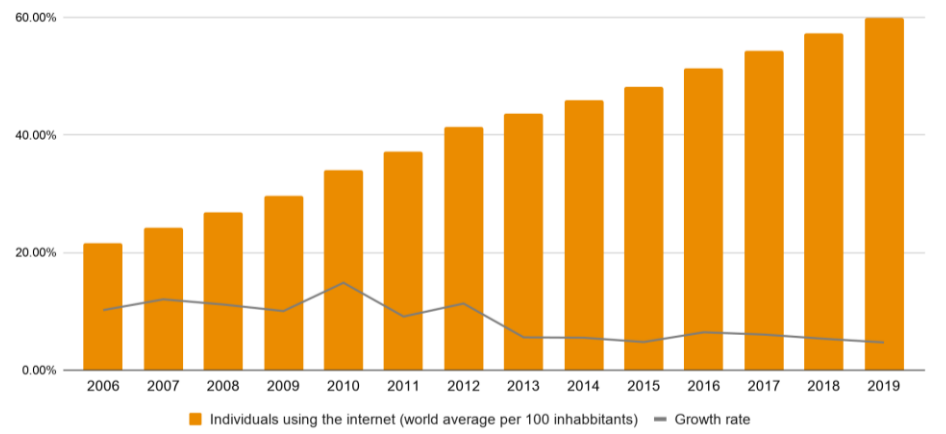

Figure 2: Individuals using the internet per 100 inhabitants 2006-2019[15]

- **Increase in time spent on the internet**. While an average internet user spent about 1.25 hours online in 2011, by 2017 this number had doubled, reaching 3 hours in 2020. Mobile data usage drives time spent online, while the daily desktop internet usage is slowly declining. In 2014, the daily mobile internet usage already exceeded that of the desktop and reached more than 1 hour per day, which has doubled by 2018.[16] Data consumption on smartphones and other portable devices contribute to overall internet traffic the most, with a CAGR of 37% and 33% respectively in the period of 2015-2019, compared to the lower growth rate of non-smartphone (19%) and fixed broadband (23%).[17]

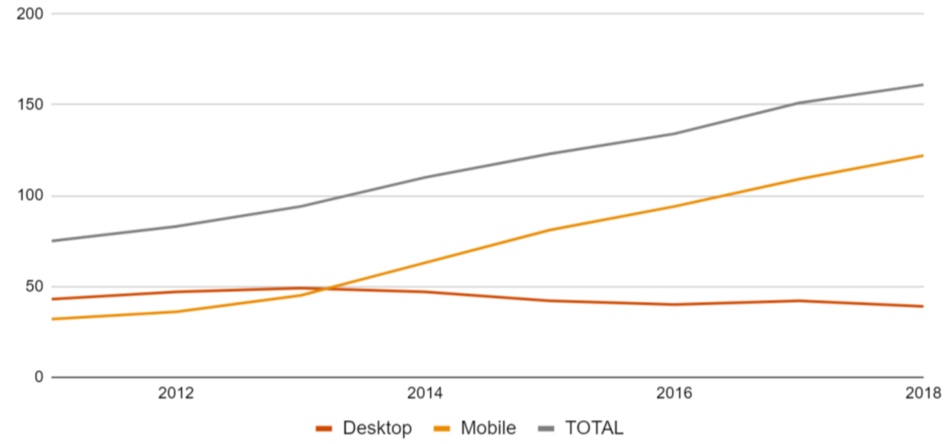

Figure 3: Daily internet usage per capita by device type[18]

- **Increasing number of connected devices**. While there were only about 2.2 networked devices per capita in 2015, this number had grown to 2.4 by 2018, meaning that the increasing population of internet users not only spends more time and generates more data online, but will also do it on several connected devices.
- **Increase in consumption of content that requires enhanced broadband connection.** The growing data traffic coming from video streaming can be attributed to the dominance of content providers' services, 4K, HDR, on-demand and live videos, which require better broadband connections. The internet traffic generated by video content has comprised 72% of all consumer traffic worldwide in 2016. This share has further increased to 79%, to 140 exabytes per month by 2020, which exceeds the total IP traffic observed in 2018.[19] Video streaming was more than 78% of data centre-to-end-user traffic in 2016 and was expected to grow continuously. Although online

[15] ITU: Global and regional ICT Data: Individuals using the internet
[16] Statista: Daily time spent with the internet per capita worldwide from 2011 to 2021
[17] PwC: Global Entertainment & Media Outlook 2020-2024
[18] Statista: Daily time spent with the internet per capita worldwide from 2011 to 2021
[19] Cisco: Cisco Visual Networking Index: Forecast and Methodology, 2016–2021

gaming accounted for only about 2% of total consumer internet traffic in 2016, it has grown at a CAGR of 66% between 2016 and 2020, doubling its share.[20] In terms of communications internet traffic[21], the amount of data consumed have tripled between 2015 and 2019 with a growth rate of 39% in the smartphone category.

- **Increased use of data-heavy technologies that requires High-Performance Computing,** such as the following:

    - **Cloud computing.** The global cloud data centre IP traffic has seen a fourfold growth between 2015 and 2020, reaching 16 thousand exabytes per year.[22] Enterprise IT spending on the private cloud market has increased at a CAGR of 53% to 100 billion U.S. dollars between 2017 and 2020[23], while public cloud services end-user spending grew at 21% to 258 billion U.S. dollars in the same period.[24] Most enterprises use the public cloud infrastructures of Amazon Web Services, Microsoft Azure, and Google Cloud, all concerned with investments in submarine cables.[25]

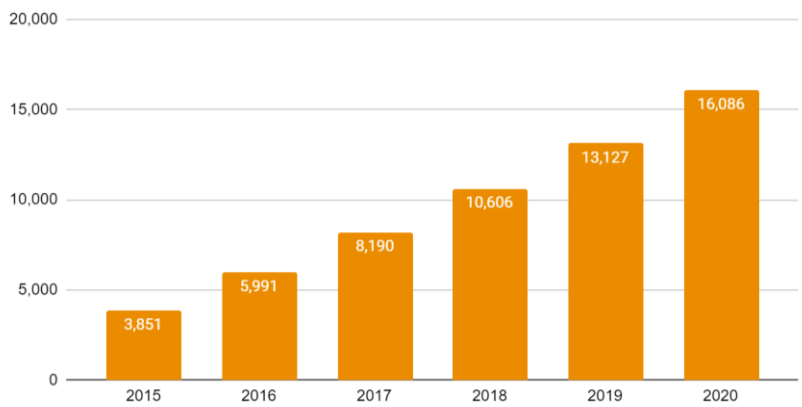

Figure 4: Global cloud data centre IP traffic 2015-2020[26]

    - **Big data.** The big data technology adoption rate has soared from 17% in 2015 to 52.5% in 2019, meaning that more than half of organizations surveyed worldwide use such technologies. While in 2015 36% of respondents showed no plans of using big data, in 2019 that number had dropped to 10%.[27] The volume of big data utilizing data centre storage has also increased from 15% in 2015 to 28% in 2020.[28]
    - **Internet of Things.** M2M connections accelerate bandwidth use, requiring future infrastructure investments and capacity upgrades, and will become the fastest-growing device and connections category, according to Cisco. The number of IoT connections grew from approximately 5 billion to 12 billion[29] between 2016 and 2020. The fast increase of IoT connections is driven by the business segment.[30]

Scientific data flows and major science collaborations were also mentioned by some interviewed experts, as one of the elements of the increase in data traffic[31]. Sharing and processing these huge amounts of data requires high-bandwidth, high-quality, and resilient (high-availability) networks. The

[20] Cisco: Cisco Visual Networking Index: Forecast and Trends, 2017–2022
[21] Communications internet traffic refers to applications, services and protocols that allow email, chat, voice and video communications. Examples include WhatsApp, Skype, Viber and iMessage.
[22] Statista: Global cloud data centre IP traffic from 2015 to 2021
[23] Statista: Enterprise IT spending on the true private cloud market worldwide from 2015 to 2027
[24] Statista: Public cloud services end-user spending worldwide
[25] Statista: Current enterprise usage of public cloud infrastructure and platform services running applications worldwide
[26] Statista: Global cloud data centre IP traffic from 2015 to 2021
[27] Statista: Big data technology adoption status in organizations worldwide
[28] Statista: Volume of big data in data centre storage worldwide
[29] The data includes cellular and non-cellular connections. Excludes PCs, laptops, desktops, tablets, smartphone, E-readers.
[30] GSMA Intelligence: The Mobile Economy
[31] Information received through expert interviews.

research-educational bandwidth provides a critical infrastructure for delivering research-education activity.[32] Its use is still a relatively small percentage when compared to internet backbone or content providers, it has been growing closer to the level of enterprise bandwidth use.[33] The scientific data movement of large data sets is a major challenge with most High-Performance Computing centres spending money on computation rather than Storage.

3.1.2. Continuous expansion of data centres

Increasing internet traffic and data generation create a growing need for a more advanced facility, storage and equipment that can transmit and process data efficiently. Also, as content providers utilize their own network for data synchronization, additional, new, and so far, latent demand is created.[34]

The data stored in data centres soared in the last few years, from 171 exabytes per year in 2015 to almost 400 exabytes per year in 2017, and continued to grow at a CAGR of 35% between 2017 and 2020, reaching almost 1000 exabytes per year.[35] However, there is still a considerable amount of data stored on end-user devices, such as PCs, smartphones, tablets.[36]

The big data utilization of data centre storage capacity has also grown significantly (from 15% of all data stored in 2015, 25 exabytes, to 28% in 2020, 272 exabytes) with a CAGR of 61% in exabytes, which shows the increasing importance of the technology.

Several Hub Metros provide locations for the growing data centre capacity need. Major hubs are Frankfurt, London, Amsterdam, Paris, Singapore, Hong Kong, Stockholm, Miami, Marseille, and Los Angeles.[37] Yet the focus on city-to-city connections has begun to shift to data centre-to-data centre (DC-to-DC) connectivity, which new trend is mainly driven by content providers.[38] Such new models could eliminate delays caused by backhauling workloads, resulting in faster, more secure, and direct access to data.[39]

Cloud computing and hyperscale data centres started exceeding the number and capacity of traditional data centres, providing better infrastructure for the growing demand for data processing. The total global installed data storage capacity in cloud centres was approximately 65% of total DC storage capacity, which has further increased to the expected 88% share in 2020.[40] The global cloud data centre IP traffic grew at a CAGR of 45% between 2015 and 2017 to approximately 8200 exabytes per year, and continued to grow at a slower CAGR of 25% from 2017 to 2020, and yet still doubled in 4 years to reach 16086 exabytes per year (quadrupled in six years).[41] The global data centre traffic exceeds that of the IP traffic (approximately 3000 exabytes per year in 2020) because the amount of data that flows only within data centres is also included in total data traffic, and comprise about three quarters of all data within, and transiting data centres. Furthermore, **the traffic between data centres equals** the total internet traffic, and it expects to grow at a similar rate as the internet traffic, reaching 2.8 zettabytes in 2021. The growth of traffic between the data centres contribute to an increase of investments in submarine cables, such as in case of the Curie cable between Google's San Francisco HQ and Valparaiso (data centre location), Chile.[42]

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[32] Information received through expert interviews.
[33] TeleGeography: A Complete List of Content Providers' Submarine cable Holdings
[34] Information received through expert interviews.
[35] Statista: Amount of data actually stored in data centres worldwide from 2015 to 2021
[36] Cisco Blogs: Five things that are bigger than the internet: Findings from this year's Global Cloud Index
[37] TeleGeography: Global Internet Map 2021
[38] Pacific Telecommunications Council: Convergence of data centres, subsea, and terrestrial fiber
[39] Equinix: New Subsea Cable Architectures Are Carrying the World's Traffic
[40] Cisco: Global Cloud Index: Forecast and Methodology, 2015–2020
[41] Statista: Global cloud data centre IP traffic from 2015 to 2021
[42] Cisco: Five things that are bigger than the internet: Findings from this year's Global Cloud Index

Hyperscale data centres accounted for 21% of all data centre servers installed (259 data centres) in 2015, and **their number exceeded the predicted 485 data centres**[43], and reached a **number of 541**[44] in 2020, about 50% of all installed servers.[45]

Amazon Web Services, Microsoft, and Google own more than half of the world's hyperscale data centres. In 2020, the investments in data centres reached a record high of $37 billion, which was led by Amazon Web Services, Microsoft, Google, and Facebook.[46] Apart from the leading companies, **IBM, Alibaba, Oracle, and Tencent** all announced several cloud data centre investments.[47] As content providers have already displaced internet backbone providers in terms of source of international bandwidth used, they have a significant effect on infrastructural developments.[48] **They seek to build their own infrastructure and connect their hyperscale data centres with submarine cables for the growing traffic on their own services, rather than resell capacities.** This might serve as a risk to the access to affordable, resilient intercontinental bandwidth for industry, and Research and Education.

3.1.3. Regional analysis

The amount of internet traffic is in close correlation with the economic and technological development of specific regions. The Asia-Pacific and North America regions have been driving the exponentially growing traffic. The Asia-Pacific region accounts for approximately 41% of global IP traffic with 105 exabytes per month in 2020, overtaking North America - 30% of global IP traffic with 77 exabytes per month - and Europe, - 19% with 48 exabytes per month. The Middle East and Africa (MEA) region grows the most dynamically (CAGR 39% 2016-2020) relative to all regions and emerged from 2.8% contribution in 2016 to comprise 4% of all IP traffic in 2020. The Latin America and the Caribbean (LAC) region, with a slower overall growth dynamic and 6.25% of all internet traffic in 2016, now constitutes only 5% to internet traffic.[49]

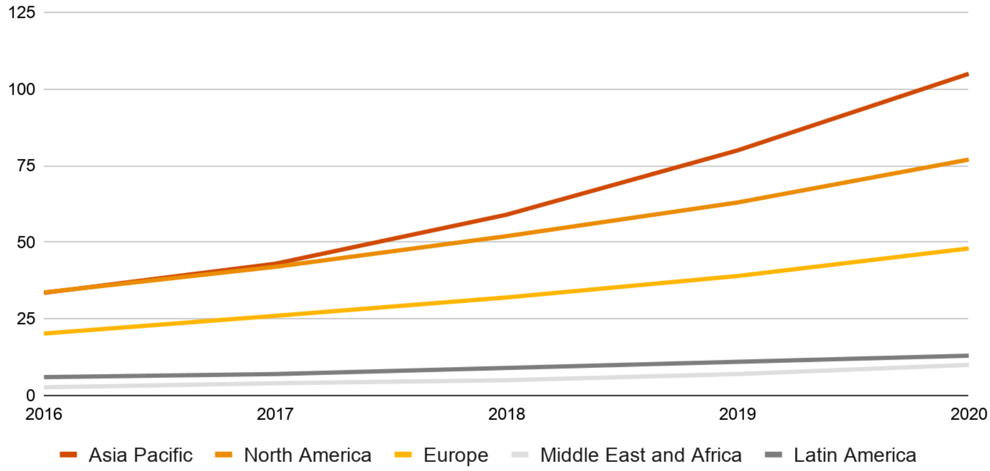

Figure 5: IP traffic levels by region 2016-2020[50]

The following section will focus on analysing the main elements that affect the internet traffic growth in the Focus regions of the study, namely Africa, Latin America, Far East and EU Neighbourhood.[51]

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[43] Cisco: Cisco Global Cloud Index: Forecast and Methodology, 2015–2020
[44] Statitsa: Number of hyperscale data centres worldwide from 2015 to 2020
[45] Cisco: Cisco Global Cloud Index: Forecast and Methodology, 2015–2020
[46] Synergy Research Group: AWS, Google, Microsoft Are Taking Over The Data centre Market
[47] TeleGeography: Global Internet Map 2021
[48] TeleGeography: Submarine cable Map 2019
[49] Cisco: Cisco Visual Networking Index: Forecast and Trends, 2017–2022
[50] Cisco: Cisco Visual Networking Index: Forecast and Trends, 2017–2022
[51] The examined regions' definitions, the countries they include and our methodology when analyzing them is explained in detail in Annex 6.2

Besides the two major trends presented previously, the analysis covers topics such as accessibility to the internet and its affordability in the Focus regions. Developed and developing countries face different challenges. North America, Europe, and many parts of Asia already achieved high internet penetration, and several technological developments, such as cloud services, IoT or UHD Video streaming become more and more widespread, showing immense demand for internet traffic. Thus, in these regions the main drivers of internet traffic are not the internet penetration, but the increasing number of digital services available on more digital devices resulting in more and more time spent on the internet. In developing regions, such as Latin America, some parts of Asia and Africa, the number of internet users are still medium or low, so a considerable amount of the population is digitally underserved. These regions are developing dynamically, but their main challenge is to ensure connectivity and affordable internet services. These challenges might highlight the need for further connectivity infrastructure developments, thus being indispensable indicators of the analysis.

3.1.3.1. Africa

The region is characterized by underdeveloped infrastructure and low affordability of internet services, resulting in currently the lowest internet penetration in the world. The low number of internet users indicates a considerable potential in serving the needs of the digitally underserved population.

Data centre activities are the lowest in the world, with only a very few hyperscale data centres and planned investments concentrated in South Africa.

The African continent has the lowest penetration rates among all regions, with 28.6 individuals using the internet per 100 inhabitants in 2019. Although the penetration rate grew dynamically in the last decade (CAGR 14% compared to average 7%), it is still half of the world's average penetration level.[52] (Figure 6) Certain regions - such as Mauritius, Seychelles, Cape Verde, or South Africa - have outstanding penetration rates with higher than 55% of their population using the internet, but their populations are relatively small, hence their contribution to the development of the whole region is relatively small. Other regions, mainly landlocked countries, such as Chad, South Sudan, or Niger, have lower than 10% penetration rates.[53]

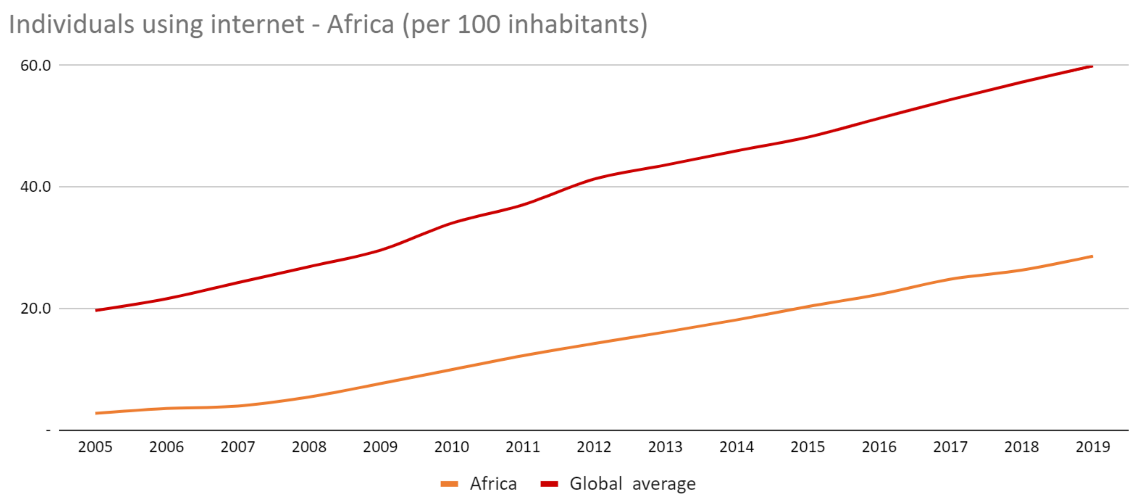

Figure 6: Individuals using the internet - Africa[54]

Africa lags behind all other regions in terms of both mobile and fixed broadband subscriptions. While mobile broadband subscriptions per 100 inhabitants was 32.1 in 2019 compared to the world average of

[52] ITU: Global and regional ICT Data
[53] World Bank: Individuals using the internet (% of population)
[54] ITU: Global and regional ICT Data, 2020

75.4, the fixed broadband subscriptions per 100 inhabitants experienced an even more significant difference with 2.74 in contrast to the 15.8 of world average.[55]

Despite the considerable infrastructural developments of the networks in the last five years, the region still lags behind the world average concerning network coverage and broadband speeds. Only 51% of the African population was covered by at least a 3G mobile network in 2015. The 3G coverage increased to 75.6% by 2019, while the global average was 90.6%. The same pattern can be seen in terms of the population covered by at least an LTE/WiMAX (4G) mobile network, as it remains the lowest on a global level with 36.7% in 2019 in contrast to the 76.4% world average.[56] The fixed broadband network is also underdeveloped in Africa[57], a problem which has been addressed by the *Connecting Africa Through Broadband* Strategy, aiming at doubling the connectivity of the region by 2021 from the 2016 penetration levels.[58] The underdevelopment is apparent likewise when contrasting mobile and fixed broadband speeds in the Focus regions. The download speed in Sub-Saharan Africa is as low as 7.5 Mbps[59], while in North Africa it is 20.4 Mbps on average.[60] These values are very low in contrast to the Focus region average, which is 31 Mbps. The fixed network speed shows an even more significant gap, as the average is 17.9 Mbps, less than the half of the Focus region average, 54 Mbps.[61]

The effect of the underdeveloped network and the lack of competition is also seen in the prices as affordability of internet services are the lowest in Africa. The average price of 1 GB mobile internet is $6.28 in Africa, $2.20 more than the average price in the Focus regions. When adjusted with PPP conversion rates, the prices in the region ($12.64) are twice of the average ($6.68).[62] Similarly, extremely high values are seen in the average price of 5GB fixed internet, as it is $32.35 ($24.33 Focus region average) and $80.97 with PPP rate adjustments ($48.75 Focus region average).[63]

Data centre activities remain low in the region with only a few hyperscale data centres and planned investments, all concentrated in South Africa. In terms of investors, Microsoft Azure owns two data centres in South Africa. Amazon Web Services has four data centre availability zones - and one currently on ramp -, and Oracle is planning to build one in the same region.[64] Although data centre colocation space has nearly doubled since 2014, according to the report of the UN Broadband Commission, and its strategy aims at improving the infrastructure, the number of hyperscale data centre investments is low compared to the hundreds of such data centres built all over the world.[65] This can partly be attributed to the fact that the African continent is still relatively expensive and unstable to operate data centres and all cutting-edge technologies - e.g. in terms of energy and water supply -, and cannot provide enough stability in technical capabilities to be competitive in the data and storage economy. However, data volume generated on the African continent remains significant, which many players strive to capture by building more submarine cables and compatible infrastructure in the region.[66]

3.1.3.2. Latin America

Despite the significant infrastructural developments, the affordability remains low and the penetration rates show a slow pace of growth. The major characteristic of the region is disparity with significant gaps across countries in terms of speeds, affordability, and consequently, also penetration.

[55] PwC Calculation based on ITU: Country ICT Data
[56] ITU: Global and regional ICT Data
[57] ITU: Interactive Transmission Map
[58] Broadband Commission: Connecting Africa Through Broadband
[59] GSMA: Mobile Internet Connectivity 2020 - Sub-Saharan Africa Factsheet
[60] PwC calculation based on Speedtest Global Index
[61] PwC calculation based on Speedtest Global Index
[62] PwC calculation based on Worldwide mobile data pricing 2020
[63] PwC calculation based onITU: ICT Price Baskets
[64] TeleGeography: Global internet map 2021
[65] Broadband Commission: Connecting Africa Through Broadband
[66] Information received through expert interviews.

Data centre activity is moderate, with hyperscale data centres concentrating in Brazil and only a few planned in Argentina, and Chile.

Latin America has a moderate penetration rate with 61.5% of the population using the internet, however, the growth rate has begun to decline in the last few years.

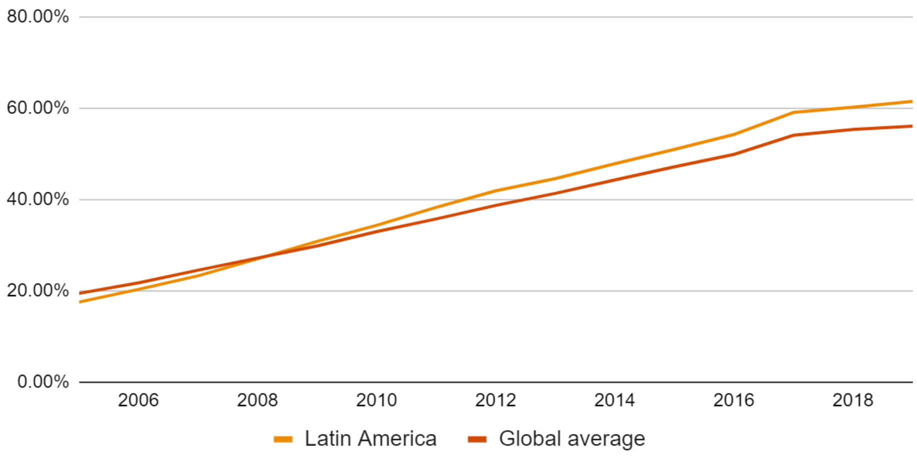

Figure 7: Internet penetration - Latin America[67]

The more developed regions, such as Chile, Costa Rica, or the Cayman Islands have more than 80% of their population using the internet, while in some regions, like Honduras, Nicaragua, or Haiti this percentage is below 35%.[68] The mobile broadband subscription per 100 inhabitants was 42.68 in 2015 and increased to 64.65 by 2019, which, compared to the 75.4 average, shows only a modest underdevelopment.[69] With regards to fixed subscriptions, the values indicate the same pattern. In 2019, the fixed subscriptions per 100 inhabitants in Latin America was 14.5, only slightly less than the global average which was 15.8.[70]

Among all Focus regions, Latin America is the second least developed region after Africa in terms of broadband coverage, albeit the accessibility is significantly better as operator investments increased 4G coverage in the region. In 2015, 86% of the population was covered by at least 3G mobile network, and it continued to grow to 94% by 2019, which exceeds the world average of 90.6%. As for LTE/WiMAX (4G) mobile network coverage, there was a remarkable increase between 2015 and 2019, from 49% to 85% surmounting the world average by more than 8%.[71] The fixed broadband coverage in Latin America has seen relatively moderate increase, with many Internet Exchange Points (IXPs) built along the coastline and major cities and with further developments in the pipeline.[72] There is only a lower average mobile download speed available in the region, with 16 Mbps.[73] Gaps between countries are significant, as there are some countries - e.g. Uruguay, Jamaica, Cuba -, which have mobile speeds available above 33 Mbps, while others, such as Colombia and Paraguay have speeds below 17 Mbps, or even below 8 Mbps as in the case of Venezuela. Fixed broadband speed is around 43.6 Mbps, meaning that both fixed and mobile speeds lag moderately behind the average speed of Focus regions.[74]

After Africa, Latin America has the least affordable internet service, which is also connected to the slow growth of the internet penetration. Also, the affordability varies across the region as there is significant income inequality across countries. The mobile data price remains high as the average price of 1GB mobile internet is $5.23, and the PPP adjusted is $6.96. Although the latter value is

[67] PwC Calculation based on The World Bank: Individuals using the internet (% of population)
[68] The World Bank: Individuals using the internet (% of population)
[69] GSMA: Mobile Internet Connectivity 2020 - Latin America Factsheet
[70] PwC Calculation based on ITU: Country ICT Data
[71] GSMA: Mobile Internet Connectivity 2020 - Latin America Factsheet
[72] TeleGeography: Submarine cable Map 2019
[73] GSMA: Mobile Internet Connectivity 2020 - Latin America Factsheet
[74] PwC calculation based on Speedtest Global Index

remarkably lower than in Africa ($13.50), there are countries, such as Panama, Bolivia, or Colombia, where the price level is around the African average. The average price for 5GB fixed internet is $34.33, and its PPP adjusted value is $48.58, which is almost half that of the African, and reaches the Focus region average.[75]

Data centre investments have been moderate, and most of them were concentrated in Brazil. There are a few planned investments, however, in Argentina, and Chile. Google has the largest number of data centre availability zones in the region, mostly in Brazil, on ramp also in Argentina, and planned in Chile. Amazon Web Services, Microsoft Azure, and Oracle all have data centres in Brazil, and Amazon also has one on ramp in the same country. IBM Cloud is also planning to invest in Brazil and build its first data centre in the region.[76]

75 ITU: ICT Price Baskets
76 TeleGeography: Global internet map 2021

3.1.3.3. Far East[77]

The developed connectivity infrastructure in the Far East results in relatively affordable pricing, which also contributes to the increased penetration in the region with only a few countries lagging behind.

Data centre activity is the highest among all Focus regions as all major players own several hyperscale data centres, mostly in the East Asian region, with further investments in the pipeline in both the East and Southeast Asian regions.

The internet penetration is the highest among all Focus regions with 66.3% of the population using internet services in the Far East. This rate has remained consistently above the world average, albeit with a declining growth rate in the past years.

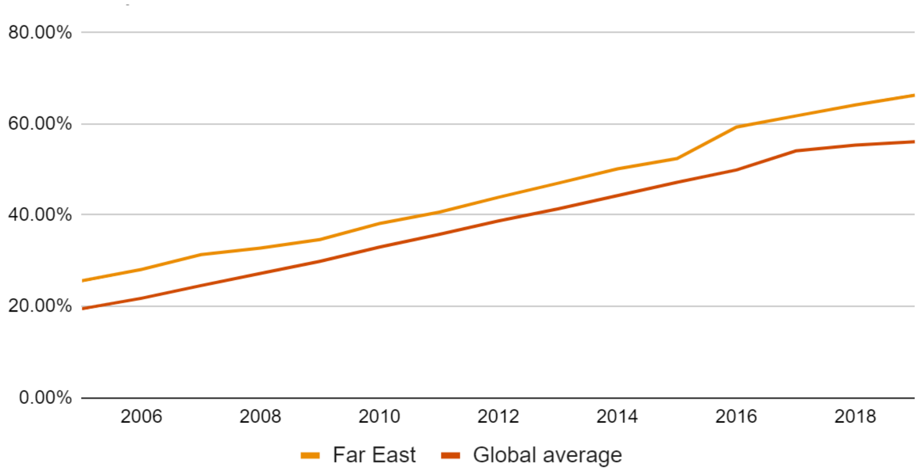

Figure 8: Internet penetration - Far East[78]

The more developed regions, namely South Korea, and Brunei had penetration rates above 95%, and Hong Kong, Singapore, Macau, or Japan also over 85% in 2019. Many countries lag behind, e.g. Laos, Myanmar, Cambodia, or the Philippines having below 40% of their population using the internet.[79] The mobile broadband subscription per 100 inhabitants was 86.14 in 2015, which grew dynamically to reach 112.28 in 2019, which is almost double the average in any focus country analysed. The fixed subscription per 100 inhabitants show a pattern more similar to that of other Focus regions with 16.56 in 2019 compared to the 15.8 average. Despite the smaller differences between regions, the Far East still has the highest, above global average values in terms of fixed subscriptions.[80]

The Far East has high levels of broadband coverage and developed infrastructure. The 3G mobile network coverage is 95% compared to the world average of 90.6%, and 89.95% of the population is covered by LTE/WiMAX (4G) mobile network, which is also considered as well-developed compared to the 85% world average. There are smaller gaps between countries as almost all have coverage above 90% in both types of mobile networks, except for Laos and Myanmar.[81] The fixed infrastructure is developed in the Far East, and hence most of the population in the region is covered by these networks.[82] The broadband speeds are also remarkable, as the average download speed is as high as 51.83 Mbps. Developed countries, such as South Korea and China have mobile speeds more than 150 Mbps, while there are some underdeveloped countries with only 20 Mbps mobile speed. The average fixed speed is more than double that of the other regions with 116.39 Mbps on average. In terms of fixed broadband speed, however, there are even more significant differences between countries. While in developed

[77] The examined regions' definitions, the countries they include and our methodology when analyzing them is explained in detail in Annex 6.2
[78] The World Bank: Individuals using the internet (% of population) - Taiwan is not included in the calculations.
[79] PwC Calculation based on The World Bank: Individuals using the internet (% of population)
[80] PwC Calculation based on ITU: Country ICT Data
[81] PwC Calculation based on GSMA: Mobile Connectivity Index
[82] PwC Calculation based on ITU: Interactive Transmission Map

countries (Thailand, Singapore, Hong Kong), there is speed mostly available well-above 200 Mbps, in underdeveloped countries it can be as low as 20-30 Mbps.[83]

The developed connectivity infrastructure in the Far East results in a relatively inexpensive pricing. The prices are low and the internet services are affordable, however, they are still more expensive than in the EU Neighbourhood. Mobile data prices are low with an average price of 1GB mobile internet being $2.38, and $3.41 when adjusted with PPP rates. Compared to the Focus region average, these values are approximately half that of the averages ($3.98, $6.59 in PPP adjusted terms). The average data price of 5G fixed internet is $17.35, and $34.71 when adjusted with PPP rates, which are all well-below the Focus region average, but above the average prices in the EU Neighbourhood.[84]

The Far East has many hyperscale data centres as all leading players are currently building or planning to invest in data centres in the region. Alibaba Cloud has approximately 50 data centre availability zones, mostly located in China, Amazon Web Services has around 20, and has plans to build more in Indonesia. Google Cloud Platform has approximately the same availability zones as Amazon, in the same regions, while Microsoft Azure has slightly less. Oracle and IBM Cloud are present in the region as well, with about 4-5 data centre availability zones mostly in Japan, South Korea and China.[85]

Being a digitally mature territory with developed infrastructure and high internet penetration, drivers such as the increasing number of connected devices, are important aspects of internet consumption. Some Far East countries, such as China, Japan and South Korea are leaders in 5G deployment[86], connected with above-average smart home device ownership. In countries such as the Philippines, Thailand, or Indonesia, people spend more than 7 or 8 hours using the internet, which is well over the global average of 6.5 hours. The same pattern can be seen when assessing video consumption and gaming, as major Far Eastern countries - e.g. Thailand, China, and Philippines - are the greatest consumers of such content.[87] More than three quarters of the Asian internet user population streams or downloads video content once per month, which value is as high as 92.5% in China.[88] Consumer internet video consumption has outpaced that of North America, becoming the highest among all regions, reaching 46.4 exabytes per month in 2020, which is 37% of total consumer internet video consumption.[89]

[83] PwC Calculation based on Speedtest Global Index
[84] ITU: ICT Price Baskets
[85] TeleGeography: Global internet map 2021
[86] GSMA: The Mobile Economy 2020
[87] Global Web Index: Global Digital Overview 2020
[88] Emarketer: Digital Video Consumption Is Spiking in Asia-Pacific
[89] Cisco: Cisco Visual Networking Index: Forecast and Methodology, 2016–2021

3.1.3.4. EU Neighbourhood[90]

The EU Neighbourhood is heterogeneous and has remarkable gaps between regions. However, the average penetration rates are above the global average as a result of affordable price levels in many developed countries, there are some countries with low coverage speeds, and also penetration.

The region lacks data centres, with only a few investments concentrating in Israel, one of the most developed countries of the EU Neighbourhood. (Figure 9)

The internet penetration is above the global average with 65.1% of the population using the internet in 2019 in the EU Neighbourhood countries, however, there are significant differences across territories.

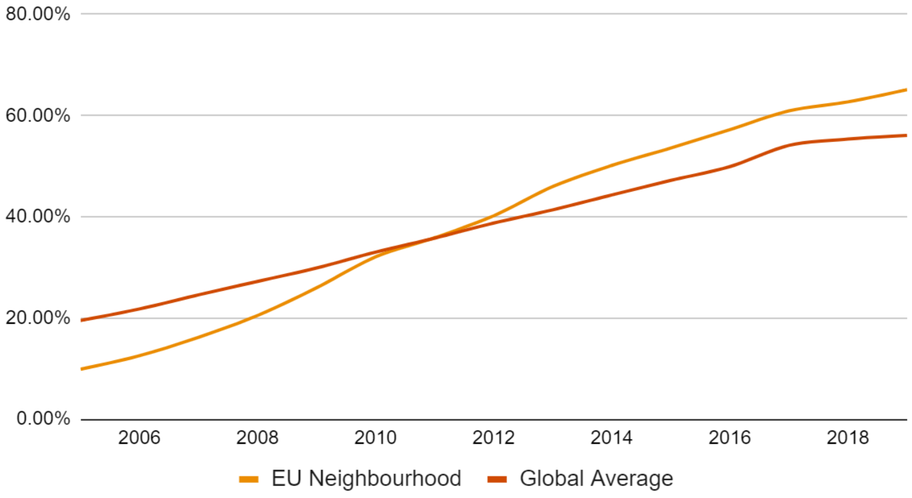

Figure 9: Internet penetration - EU Neighbourhood*[91]

The penetration rate outpaced that of the world average in 2011 and further increased continuously, however, with a declining year-over-year growth rate. This growth was mostly driven by Israel, Belarus or Azerbaijan, with 87%, 83%, and 80% penetration rates respectively. There are still many countries lagging behind with as low as 34% of the population using the internet in the Syrian Arab Republic and 22% in Libya.[92] The number of mobile and fixed broadband subscriptions has still not reached the global average in contrast to penetration rates. Mobile broadband subscriptions per 100 inhabitants was 45.7 in 2015, which increased to 71.16 by 2019, while the global average was 75.4. Fixed broadband subscription per 100 inhabitant was 11.20 in 2015, which grew slightly to 14.33 by 2019[93], similarly not reaching the 15.8 global average.[94]

The overall broadband coverage is rather developed, with remarkable gaps between countries. The 3G mobile network coverage was 94.65% in 2019, while the population covered by at least an LTE/WiMAX mobile network was 84.59%, just under the 85% global average The least developed countries are, similarly to other indicators, Syria and Libya with 85% and 78% 3G mobile coverage respectively, compared to the 99% coverage of nine countries in the same region.[95] In terms of fixed broadband coverage, the rather developed countries of the region have advanced infrastructure, however,

[90] The examined regions' definitions, the countries they include and our methodology when analyzing them is explained in detail in Annex 6.2
[91] The World Bank: Individuals using the internet (% of population)
*Palestine is not included in the calculations
[92] The World Bank: Individuals using the internet (% of population)
[93] ITU: Country ICT Data
[94] ITU: Global and regional ICT Data
[95] GSMA: Mobile Connectivity Index

the underdevelopment is shown in all countries with less advanced penetration and coverage.[96] The broadband speeds are fairly developed, but still considered as low compared to the broadband speed levels in the Far East. The average mobile speed is 25.98 Mbps in contrast to the 31 Mbps Focus region average. Fixed broadband speeds lag even behind Latin America and is approximately one third that of in the Far East, with an average of 38.26 Mbps. The gaps across countries are significant in speed as well, as in Israel the average fixed broadband speed is as high as 125.15 Mbps, while in Syria, Algeria and Tunisia it is below 10 Mbps.[97]

The EU Neighbourhood has the best price level and affordability indicators among the Focus regions, preceding even the Far East. Mobile data prices are low or moderate as the average price of 1GB Mobile internet is $1.87, while the PPP rate adjusted value is $3.34. Compared to the $6.96 and $13.50 adjusted PPP values of Latin America and Africa, internet services are significantly more affordable than in these regions, also slightly more than in the Far East. The average data price of 5GB fixed internet is $13.31, and the PPP rate adjusted value is $30.73, which is also the lowest price level in the compared regions.

Despite the rather developed level of the region, it lacks data centre activities even in the more advanced countries. There are only two data centres planned by Oracle and Microsoft, both in the most developed country of the region, Israel.[98]

[96] ITU: Interactive Transition Map
[97] PwC calculation based on Speedtest Global Index
[98] TeleGeography: Global internet map 2021

3.2. Infrastructure

Summary - Current state of international connectivity infrastructure

Overview

The two most significant first mile technologies in intercontinental and international connectivity are submarine cables and satellite systems. Submarine data cables are the most commonly used technology; they serve 99% of international communications traffic.

Connections

Today there are **over 400 submarine cables** in operation around the world, a **large percentage** of them located **in the EMEA, Austral-Asia and Americas regions** respectively. Regarding the EU's connections, the largest number of cables in service can be found on the **EU - Non-EU Europe** and the **EU - Africa routes**.

Capacity

The **EMEA region had the highest design capacity** in the **past five years** and is responsible for 32% of global design capacity. Although in 2018 design capacity was quite balanced among submarine cable regions, the high growth rates in the EMEA, Americas and Transatlantic regions solidified their leading position.

Despite the number of new cables laid each year, **lit capacity seems to be growing at a faster rate than design capacity**. Lit capacity (actual capacity available for use) has increased significantly from 2018 to 2019, with the Transatlantic region reaching 44% of design capacity that is lit. This is a notable jump considering the average lit capacity falls between 13-31%.

Regarding EU routes, **the EU - English North America one has the highest design capacity** (around 637 Tbps), which is many times higher than the 20 Tbps capacity of **the EU - Latin America link in last place** - although a new submarine cable system, EllaLink will be inaugurated in May 2021 on the latter route, adding an additional 72 Tbps of capacity.

Resiliency and diversity

To increase network resilience, industry players seek to enhance geographic diversity of undersea cable routes. When assessing resilience, another aspect to consider is the age of the cable systems. Considering the current proportion of age and average lifetime of submarine cables (25 years), **a significant amount of new cables should be established on some EU routes** in the next few years in order to serve the constantly rising traffic demand. The **proportion of 20+ year-old cables is quite high** on the **Intra-EU**, **EU - Non-EU Europe**, and **EU - Far East** routes. The **EU - Latin America route exclusively consists of 10+ year-old cables,** with 50-50% being in both 10-20 and 20+ year categories.

Many experts agree that **each country** should have **at least two terrestrial or submarine cable connections**. Currently **coastal EU Member States** have a **relatively large number of interregional cables**. **Member States** with the **highest numbers of submarine cables** play the **most important role** in **interregional submarine connections** as well, supplemented by the Netherlands and Ireland. At the same time, **Baltic countries play a more important role in Intra-EU connections**. In order to ensure good coverage in landlocked countries as well, these submarine cables along with terrestrial links play an important role, therefore an integrated network should be considered when planning future submarine investments.

Accessibility

Regarding cable ownership changes, **content providers have become unavoidable players as evidenced by the constantly growing amount of capacity they deploy** year by year. They were sole or partial owners of cables responsible for almost 59% of capacity introduced only in 2019, which is likely to increase in the coming years.

With regards to **Brexit**, **experts think that key market players will continue to favour the EU over the UK** as a landing point. Out of the interregional cables reaching Europe, as of now, there are a lot more cables landing in the EU than in the UK. Furthermore, in the past 5 years, all Transatlantic cables affecting Europe have skipped the UK but reached the EU. While the UK is a traditional landing point of submarine cables -

especially considering the Transatlantic routes - with sufficient coverage, the changes are not clearly linked to Brexit, experts say this trend is likely to continue.

3.2.1. Overview

3.2.1.1. The global internet access

The global internet access value chain may be divided into 3+1 main network elements or so-called metaphorical 'miles': First mile, Middle mile, Last mile and the Invisible mile. The first three miles are following each other from the internet entering the country (First mile), then passing through it in the Middle mile, to finally arrive at the end user in the Last mile. The Invisible mile is not preceded or followed by another mile, but its elements are ensuring the integrity of the whole value chain.

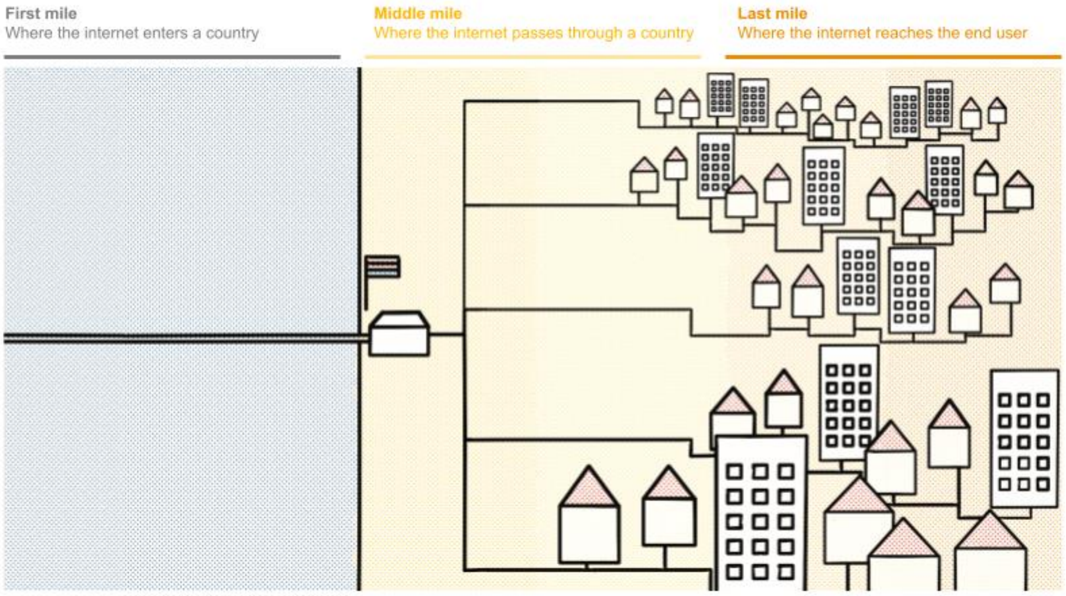

Figure 10: The global internet access value chain

First mile: where the internet enters a country
The international links providing this transition might be submarine or terrestrial fibre-optic cables, satellite links or sometimes cross-border microwave links.[99] The aim of this study is to examine the potential ways of connecting the EU with the rest of the world, hence the following links are the most important ones in terms of the study:

- *Submarine fibre-optic cables*: these cables, laid on the bottom of seas and oceans, enable intercontinental communication and serve 99% of international communications traffic.[100]
- *Terrestrial fibre-optic cables*: the technological background of these cables is almost the same as in the previous case, however, these are laid in the ground and used to extend connectivity provided by submarine cables to landlocked countries.
- *Satellite links*: artificial satellites used in telecommunications, orbiting the Earth, relaying analogue and digital signals to provide internet access between various locations worldwide.[101] This description refers to geostationary satellites. Low-Earth-Orbit (LEO) and Medium-Earth-Orbit (MEO) satellites - that orbit the Earth in minutes or hours - are to be examined in the Future trends analysis.

Middle mile: where the internet passes through a country

[99] UN ESCAP: Effect of Open International Gateways on the Broadband Connectivity Market
[100] ITIF: Submarine cables: Critical Infrastructure for Global Communications
[101] Britannica: Satellite communication

Middle mile usually means the national backbone, where the network operators' core network is connected to the local network, usually through fibre optic cables, sometimes through microwave links. However, there are new technologies, like the usage of balloons and drones, for example Facebook's Aquila project[102], using solar-powered drones as wireless internet relays, or Loon, Google's balloon-based cellular network, which has recently been shut down.[103]

Last mile: where the internet reaches the end user
In the last mile, the internet arrives to the end user through a local loop that connects the user's home and the telecommunications service provider's office. The local loop may be fixed or wireless. Fixed (or wired) technologies include fibre optic cables, coaxial cables and asymmetric digital subscriber lines (ADSL), while wireless technologies include mobile cellular, satellite, Wi-Fi, LAN and IoT technologies.

3.2.1.2. Submarine cables and satellite systems: the first mile of internet connectivity

The two most significant first mile technologies in intercontinental and international connectivity are submarine cables and satellite systems.[104]

Today submarine data cables are the most commonly used technology: submarine cables serve 99% of international communications traffic.[105] **There are several factors behind the widespread use of submarine fibre-optic cables**:

- *Capacity*: While the microwave spectrum available is limited, the spectrum available for optical communications could handle increasing IP traffic more flexibly. Since technological advancements are continuously increasing the capacity portable by single fibres, not only is there more available spectrum from optical communication, it also requires a lower and lower number of cables. Maximum performance of the submarine cable technology is thousand times higher than that of satellites: while top of the line submarine cables today are capable of 300 Tbps, high-performing satellites' traffic-carrying capability is only about 350 Gbps.[106],[107] For comparison, SpaceX, the largest low-Earth orbit (LEO) satellite project, is currently claiming around 24 Tbps of capacity, that is less than one fibre pair on a recently built Transatlantic submarine cable.[108]

- Latency: Data in submarine cables has to travel much shorter distances than in case of GEO satellites that are located 36,000 km above the Earth's surface. This means that while it takes about 0.2 seconds for microwave satellite signals to travel from the ground to a satellite, submarine cables are able to send data across the Atlantic in 1/20th of this time resulting in lower latency.

- *Security*: Sabotage and spying have not been a very frequent problem in the past. When such events occurred though, high attention was given to strengthening the security of cables by eliminating potential deficiencies. This way, today, fibre optic cables are supposed to be much harder to eavesdrop than satellites and there is also more knowledge on their repair practices.[109] Furthermore, technological advancements enabled the use of encryption in submarine cables, helping communication to be more secure.[110] Also, the use of coherent transmission technology

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[102] Grant Gross, 2018: Internet Drone and Balloon Projects Move Forward
[103] Rob Verger, 2021: RIP Loon, Google's balloon-based cellular network
[104] This chapter, if the contrary is not stated aforehead, is mainly discussing geostationary (GEO) satellites that have solely defined satellite internet services until very recently. Low-Earth Orbit (LEO) and Medium-Earth Orbit (MEO) satellites are very new satellite technologies thus they are discussed in further detail in the analysis of future prospects.
[105] For example, in the US, according to the Federal Communications Commission's calculations, the ratio of data traffic carried by submarine cables is so high that only 0.37% of the US international data traffic passes through by satellite. Source: Doug Dawson, 2019: The Hidden World of Undersea Fiber
[106] Erwin Hudson, 2017: Broadband High-Throughput Satellites
[107] Asia-Pacific Satellite Communications Council: VHTS (Very High-Throughput Satellite)
[108] Alan Mauldin, 2019: Will New Satellites End the Dominance of Submarine cables?
[109] M. Mandell, 2001: 120000 leagues under the sea [undersea optical cables]
[110] Ciena: What is optical encryption?

on submarine cables makes it very hard to eavesdrop "in the middle of the ocean", on top of challenges to reach and open the cable unseen.

- *Cost*: Thanks to the advancing technology, capacity of cables is increasing, without increasing their size, the costs of deploying them is also lowering, especially compared to the high costs of satellite deployment and maintenance. Furthermore, the higher speed of data transmission through submarine cables also contributes to them being cheaper than satellite transmitted data.[111]

- *Exposure to environmental conditions*: Both submarine cables and satellites are exposed to certain environmental conditions. In the case of submarine cables, most common cases are damage caused by human activities, such as fishing (38%), and anchorage (25%).[112] When talking about satellites, the exposure is most commonly caused by the weather. The difference is that a random damage caused by human activities usually affects one cable at a time, thus it can be substituted with other cables. However, if there is a storm or a cyclone, submarine cables are only affected to a low extent[113] (environmental conditions only cause 8% of submarine cable failures)[114], while none of the satellites could continue operating in the area. This makes quick replacement impossible, if the given area solely relies on this kind of internet access.[115]

Based on the above differences, today, **satellite and submarine cables are not comparable technologically** regarding first mile communications. **Satellite technology provides an excellent solution for** moving targets, such as vessels and planes, and for **serving remote areas,** where it would be expensive or impossible to install fibre optic cables, such as island nations and remote land-locked areas. Satellites might have an important role in emerging sectors like IoT or automation as well. **However**, in terms of international connectivity, **satellites could not substitute cables as the backbone of the infrastructure on a large scale**. For this reason, **the study will focus on submarine cable technology**.

3.2.2. Connections

Today there are **about 406 submarine cables** around the world, according to Telegeography[116], one of the most respected data sources in connectivity infrastructure assessment. As it is detailed in the Chapter *3.1 Drivers of digital connectivity developments*, the locations of cables are mostly driven by data traffic and data centres.

3.2.2.1. Connections by submarine cable region

There are seven main submarine cable regions in the world.[117]

- EMEA (submarine cables connecting or located in Europe, the Middle East and Africa),
- Australasia (submarine cables connecting or located in Australia, New Zealand and neighbouring islands),
- The Americas (submarine cables connecting or located in North and South America and associated islands),

[111] Nicole Starosielski, 2015: In our Wi-Fi world, the internet still depends on undersea cables
[112] TeleGeography Blog: Cable Breakage: When and How Cables Go Down
[113] One example is the Typhoon Morakot near Taiwan in 2009, which broke eight submarine cables caused by the earthquakes and landslides. - Submarine cable Networks: Submarine cables Cut by Taiwan Earthquake and Typhoon Morakot
[114] TeleGeography Blog: Cable Breakage: When and How Cables Go Down
[115] MAPFRE Global Risks, 2019: Submarine cables, the True Communication Highway
[116] TeleGeography: Submarine cable 101
[117] The examined regions' definitions, the countries they include and our methodology when analyzing them is explained in detail in Annex 6.2.

- Indian Ocean Pan-East Asian (submarine cables connecting or located in South and East Asia)[118],
- Transatlantic (submarine cables connecting or located in North America and Europe),
- Transpacific (submarine cables connecting or located in East Asia, Australia, New Zealand and the West coast of North and South America),
- The Arctic (submarine cables connecting or located in parts of Alaska (United States), Canada, Finland, Greenland (Denmark), Iceland, Norway, Russia, and Sweden).

Assessing the submarine cable regions, the number of active cables is not balanced among the regions.

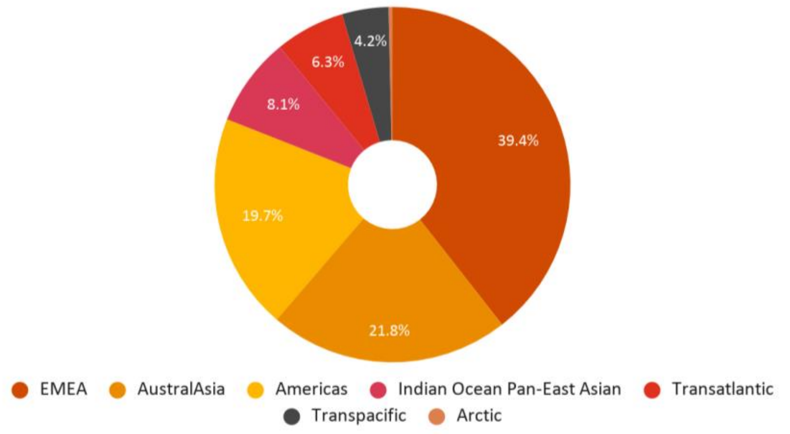


Figure 11: Active systems (submarine cable regions)

The **EMEA** region has the **most active systems** by far. The **second highest** number of active cables is in the **Australasia region**, however, the global share of this region is around 18% lower than that of the EMEA. The third highest number belongs to the **Americas, and its global share is only half of the EMEA region**. The four other regions' (ordered by the number of active cables: Indian Ocean Pan-East Asian, Transatlantic, Transpacific, Arctic) global share combined is equal to the share of active cables of the Americas region.

The number of **new submarine systems decreased** between the two periods **in the EMEA region**. **All the other regions experienced an increase** in new systems.

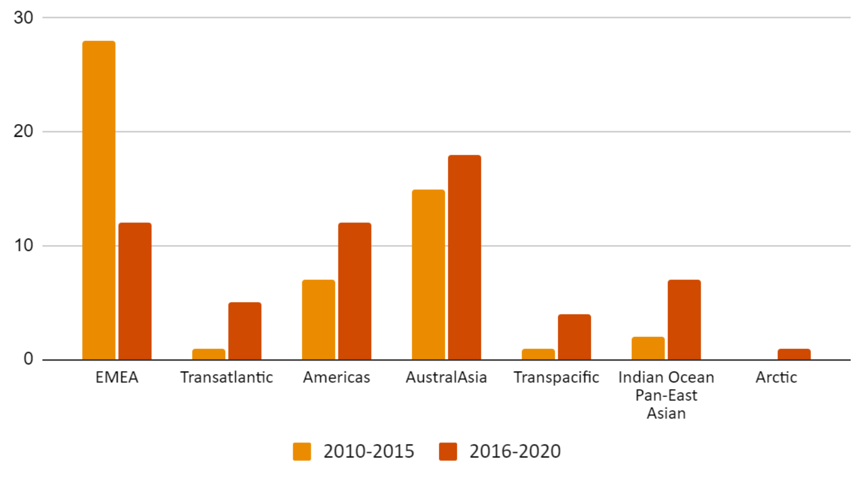


Figure 12: New submarine systems by submarine cable region

The Australasia, Transatlantic, and Transpacific regions had much lower numbers of submarine systems in the earlier period than the Americas and the Indian Ocean Pan-East Asian regions, thus the growth rates are higher here. The reason behind the increase in the Transpacific and Transatlantic regions is the

[118] Submarine Telecoms Forum: [Submarine Telecoms Industry Report – Section 8.6: Indian Ocean Pan-East Asian regional market]()

renewed interest for new routes and improving route diversity. The growth in the Americas region is partially due to emerging markets in South America.

3.2.2.2. Connections by EU route

The **highest number of active systems among the routes connecting the EU to other parts of the world is on the EU - Non-EU Europe route**, **followed by the EU - Africa route** (Figure 13). In the period of 2016-2020, the most cables (3) have been established on the EU - Africa and the EU - English North America routes.

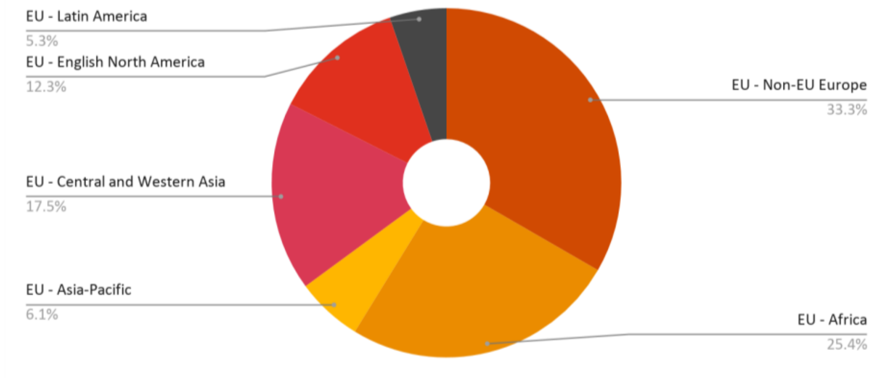


Figure 13: Active systems (EU routes)[119] [120]

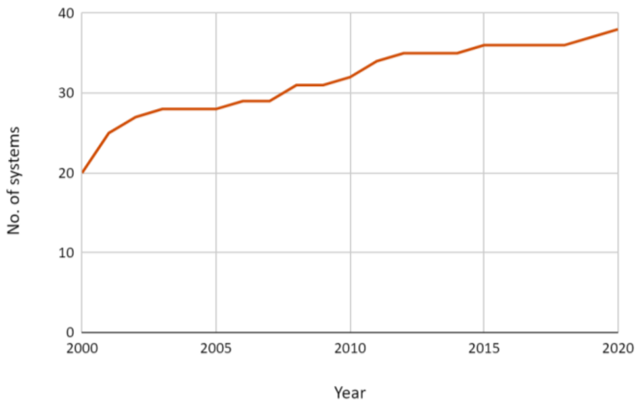


Figure 14: In service systems by year (EU - Non-EU Europe)

EU - Non-EU Europe

The EU - Non-EU Europe route is connected by the **most cable systems**. The number of these cables has been relatively high already in 2000 and after a small jump between 2000 and 2001 it **evenly increased** year by year from 20 to 38 in 2020. The lengths of these cables are relatively shorter - compared to intercontinental routes - since they are mainly connecting parts of the United Kingdom to each other and to the mainland of Europe. (Figure 14)

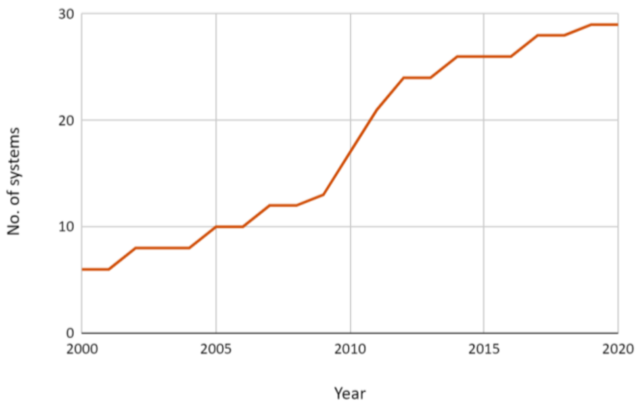


Figure 15: In service systems by year (EU-Africa)

EU - Africa

Today the number of **cables connecting the EU to Africa (29) is similar in magnitude to the EU - Non-EU Europe route (38)**. The difference is that in the case of Africa a **steeper curve** can be observed. While in 2000, there were only six cables between the two continents, a **big jump happened between 2009 and 2012**, when **11 new systems** were established. (Figure 15)

[119] The examined regions' definitions, the countries they include and our methodology when analyzing them is explained in detail in Annex 6.2.
[120] This regional breakdown is meant to aid the future analysis of the four distinct platforms of connectivity networks around the EU established by the Ministerial Declaration on European Data Gateways as a key element of the EU's Digital Decade, adopted by 25 Member States in March 2021. For more information, please see Annex 6.2.

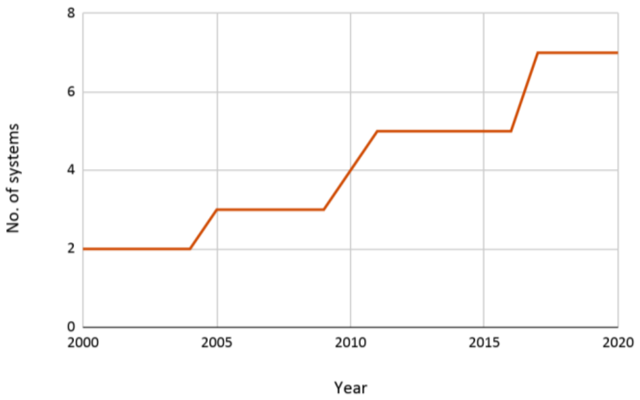


Figure 16: In service systems by year (EU-Asia-Pacific)

EU - Asia-Pacific

Although the EU - Asia-Pacific route has the **second lowest number of in-service systems**, a **250% increase** can be observed in the past 20 years. While there were only 2 systems in 2000, this increased to 7 by 2020. The most recent cables - AAE-1 and the SEA-ME-WE 5 cables - were deployed in 2017, connecting the EU to Central and Western Asia and Africa as well. (Figure 16)

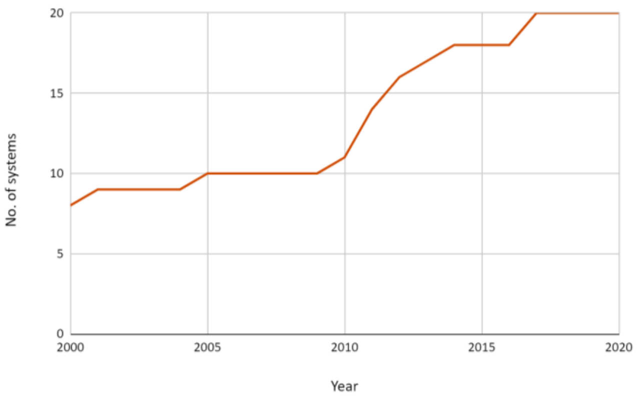


Figure 17: In service systems by year (EU-Central and Western Asia)

EU - Central and Western Asia

Similarly, to the EU - Asia-Pacific route, the EU and Central and Western Asia one experienced a **relatively high increase of 250%** in the past 20 years. The **most cables (6) came into service between 2010 and 2013**. The last cables came into service in 2017 and they are the same as the most recent cables on the EU - Asia-Pacific route: the AAE-1 and the SEA-ME-WE 5. The one before these two, MENA, was installed in 2014 and it connects the Middle East to North Africa. (Figure 17)

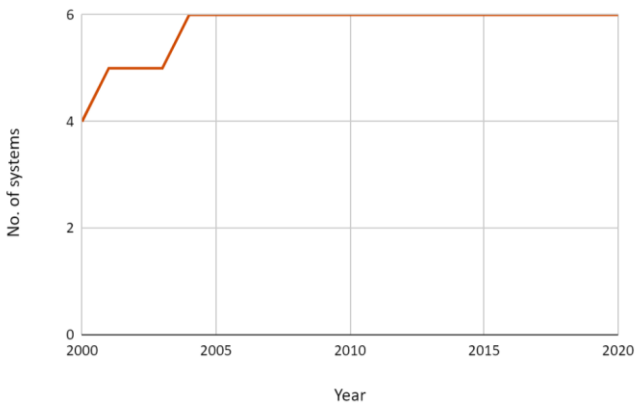


Figure 18: In service systems by year (EU-Latin America)

EU - Latin America

Out of all the other connections, **the number of in-service systems is the lowest** with Latin America. Furthermore, the **most recent cable was established 17 years ago,** which is the longest time that has passed since the last cable installation among the assessed routes. The reason behind this lies in the fact that when it comes to **international connectivity, Latin America mainly relies on the US**. However, the region is becoming more and more important, as evidenced by a new cable (EllaLink) planned to be deployed in 2021. (Figure 18)

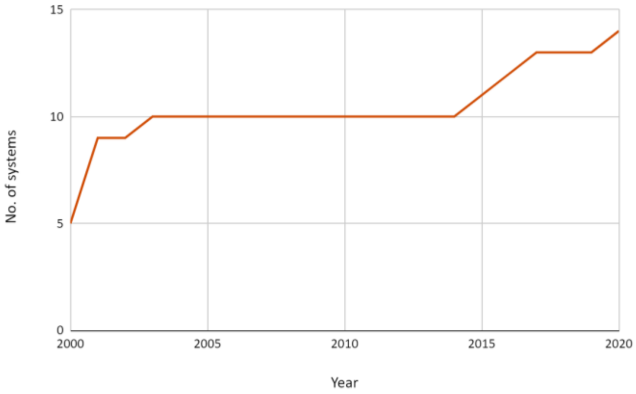


Figure 19: In service systems by year (EU-North America)

EU - English North America

The route quickly gained many new connections in the 1990s, and although the financial crash of the early 2000s caused by the overinvestment in the submarine cable industry slowed down the process, it could not stop the **steady growth** in the area since. The **most recent cable**, the Havfrue/AEC-2, was installed in 2020 and is owned by a consortium consisting of Google and Facebook. (Figure 19)

Besides the main submarine cable regions of the world previously discussed, there are other geographical routes that are important for the EU to be assessed as well - whether because of strategic purposes, or whether to get an overview on cables on EU territories. These include the EU's connections to the Far East, the EU Neighbourhood (both of which overlap the regions previously analysed), and connections in the continental EU and EU Outermost regions.

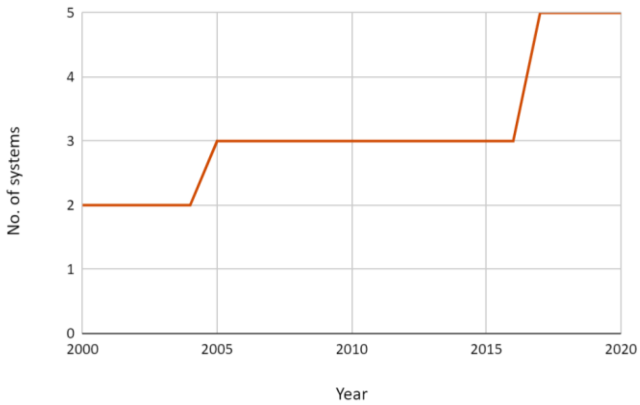


Figure 20: In service systems by year (EU-Far East)

EU - Far East

Currently, there are **only 5 submarine cables** linking the EU to the Far East. The first cables have been in service since 1997 (FLAG cable, later renamed to FEA) and 1999 (SEA-ME-WE-3). In the past 10 years, **new cables** were introduced on two occasions: **one in 2005 (SEA-ME-WE-4) and two more in 2017 (AAE-1 and SEA-ME-WE-5**, which had its last landing point in Sri Lanka inaugurated in 2017 Q3). All cables on this route **also connect the EU to Central and Western Asia and Africa**. One of the last cables installed, AAE-1, provides more capacity than all of the others combined. It was also upgraded from 80 to 160 Tbps recently, in 2018. There is a planned cable, PEACE cable that will connect China with France, Malta and Cyprus, and will add 96 Tbps to the current capacity of approximately 222 Tbps.

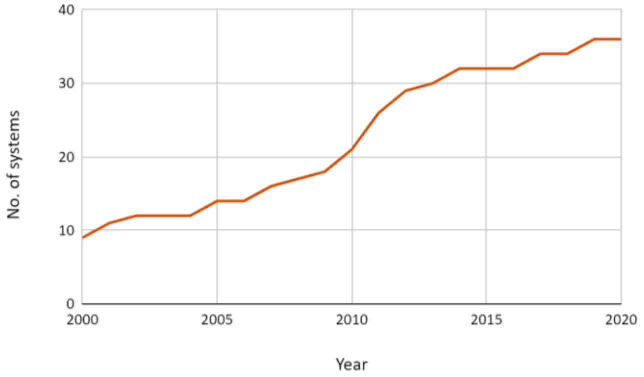


Figure 21: In service systems by year (EU-EU Neighbourhood)

EU Neighbourhood

As of 2020, **36 cables** link the EU to the EU Neighbourhood. The past 10 years showed **steady growth** (a CAGR of 13%) in terms of new cables added. The last cable, ORVAL, was introduced in 2019, linking Spain to Algeria with a design capacity of 40 Tbps.

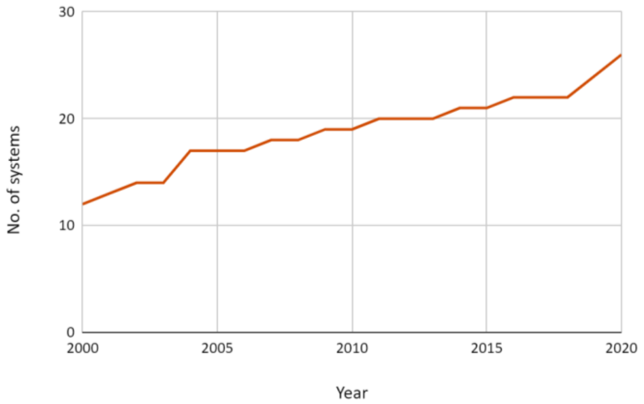


Figure 22: In service systems by year (Intra-EU)

Intra-EU

According to our database, currently there are **26 submarine cables that connect EU Member States exclusively**, most of which are located **in the Mediterranean Sea (13)**, connecting countries like Greece and Cyprus or Spain and Italy. Almost the other half **(12) is in the Baltic Sea**, connecting for example Denmark and Sweden or Germany and Finland. **The last cable is in the North Sea**, connecting Denmark with the Netherlands. Apart from these 26 cables, there are several others connecting EU Member States that are also connecting countries from other regions - these are included in the sections above.

EU Outermost Regions

EU Outermost regions form a special fragmented region in the assessment of EU connections. As some EU Member States have territories (islands) sometimes thousands of km away from continental Europe, it is not a coherent region geographically, but EU rules and principles apply to them as well. In the matter of submarine cables, the most important EU outermost regions are:

- La Réunion (French territory in the Indian Ocean near East Africa),
- Mayotte (group of islands of French territory in the Indian Ocean between Madagascar and the coast of Mozambique),
- Martinique (French territory in the Caribbean),
- Guadeloupe (group of islands of French territory in the Caribbean Sea),
- French Guiana (French territory on the northeast coast of South America and the only territory of the mainland Americas that is the territory of a European country),
- Canary Islands (island group of islands of Spain in the Atlantic Ocean, near the coast of northwestern Africa),
- The Azores (island group in the mid-Atlantic that is the territory of Portugal),
- Madeira (island of Portugal in the North Atlantic Ocean).

These islands are either connected to the international communication network through **satellite connection** or connect into **submarine cable networks**, through a larger submarine cable network (like in the East Caribbean Fibre System, which connects fourteen Caribbean islands), or interconnected with

a group of islands and to a mainland country (such as the Columbus-III which connects the Azores to Portugal).

There is a total of 22 cables available in the eight outermost regions assessed. (Figure 23) All areas are connected to the communication system through submarine cables. Currently all of them are owned by traditional telecommunication companies or consortiums, seven of the nine assessed regions have submarine cables that are reaching the end of their timespan in the coming years and only three of them have modern cables available by the end of 2020.

There are also planned cables affecting EU Outermost Regions connectivity (EllaLink is of the biggest significance out of those), that will interconnect the Canary Islands, the Azores and Madeira and should be ready for service in 2021.

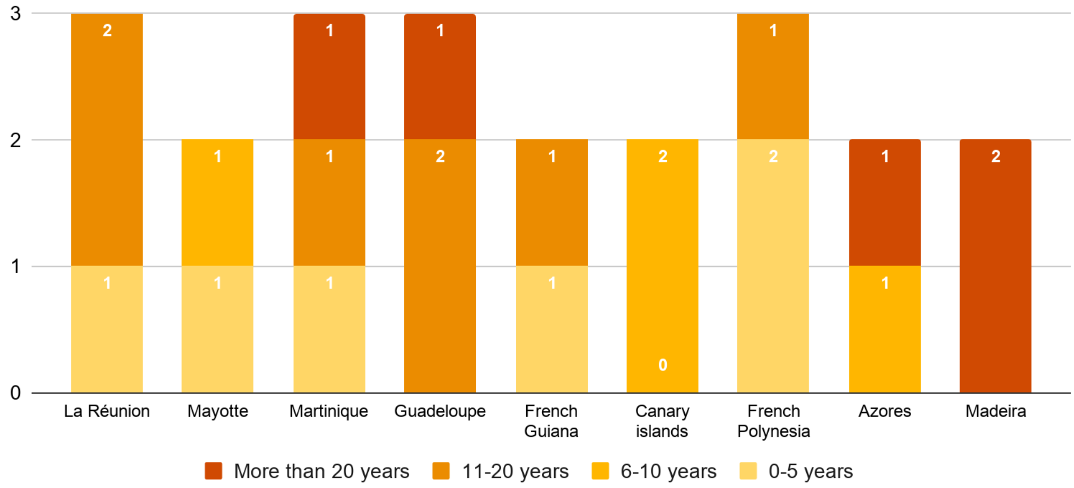
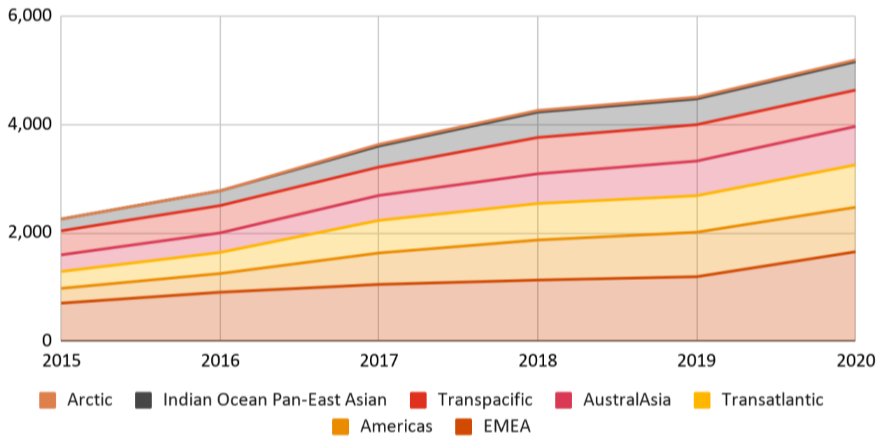


Figure 23: Proportion of outer region submarine cable systems by age

3.2.3. Capacity

3.2.3.1. Capacity by submarine cable region

Design capacity (or potential capacity) describes the maximum capability that submarine cables could carry theoretically if they were fully equipped to do so.[121] The following figure shows the potential maximum data traffic that could be carried by the systems in each submarine cable region.



[121] TeleGeography Blog: What's the difference between lit capacity and potential capacity

Figure 24: Design capacity by submarine cable region[122]

Currently the **EMEA region has the highest design capacity**: the cables in this region are responsible for **32% of global design capacity**. The **second highest** design capacity **is in the Americas region**, with a **16%** global share. These two regions' design capacities combined are responsible for almost 50% of the global capacity which leaves the other five regions with significantly less. Out of these five regions, the **Transatlantic** has the highest capacity with a 15% global share but still, that is **only half of that of the EMEA region**. **Australasia and the Transpacific are very similar,** with 710 Tbps and 671 Tbps of capacity (which account for 13.5% and 13% of the global capacity respectively). The **Indian Ocean Pan-East Asian** region has 10% of the global capacity, and the **Arctic region** has, unsurprisingly, the **lowest design capacity (30 Tbps)**.

Although the EMEA region always had the highest design capacity, between 2016 and 2019, its share of the global capacity was lower, which meant a more even distribution of design capacity among submarine cable regions. The **Americas had the highest growth rate** during the analysed period, which was 68% in 2016 to 2017. This, and the Transatlantic's 54.5% capacity increase in the same year were the main reasons behind the capacity distribution becoming more even. Australasia, the Transpacific and the Indian Ocean Pan-East Asian regions had growth rates of 19-28% in 2018 which seemed like a sign that **smaller-capacity regions are gaining on other regions**. However, in **2020, the EMEA grew by 39%** and the **Transatlantic with further 16%.** This way **the global shares among regions became very similar to the ones in 2016**.

Altogether, the past five years have shown that the Transpacific, the Transatlantic and the Americas regions rotate the place for the second highest design capacity region between each other, but **these are only short-term changes**. The **EMEA region has been leading the list by far**, while the **Indian Ocean Pan-east asian and the Arctic regions** still have **very low**, 527 Tbps and 30 Tbps total design capacities respectively. The latter can be attributed to the difficulty of laying cables around the North Pole.

Another aspect of capacity to consider is **lit capacity.** While design capacity describes the potential future traffic carrying capability of submarine cable systems, lit capacity refers to the actual capacity that is available for use. It shows what the submarine cable systems are capable of at the moment, rather than what they could achieve if fully equipped.[123]

The figure below shows the percent of capacity that is lit in certain regions.

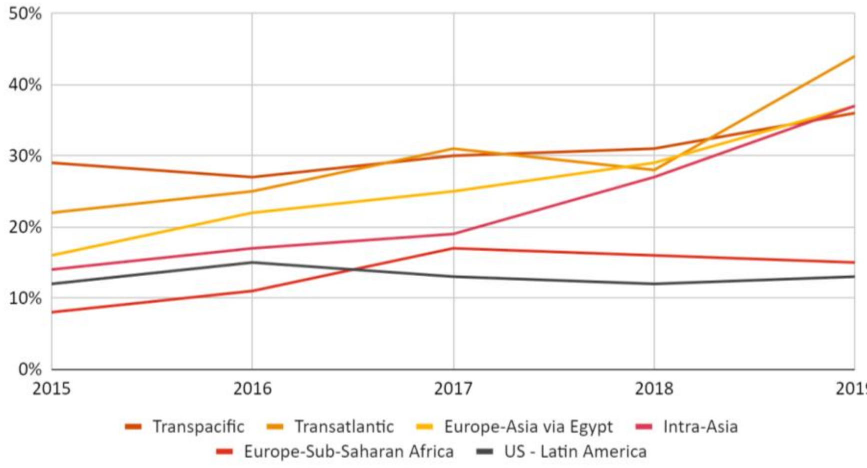


Figure 25: Share of Design Capacity that is Lit[124]

Between 2015 and 2019, on average, the **lit capacity was the highest in the Transpacific region**, followed by the Transatlantic and the Europe-Asia links. However, by 2019, a **significant (57%) growth**

[122] Sorted by size of design capacity. The sum of design capacity of submarine cable regions depicted here is not equal to the total global capacity because of submarine cables connecting multiple submarine cable regions, however, they do not differ significantly.
[123] TeleGeography Blog: [What's the Difference Between Lit Capacity and Potential Capacity?]
[124] TeleGeography Blog: [The Global Bandwidth Magic Eight Ball Says "Ask Again Later"]

rate in the Transatlantic region increased its share of lit capacity to 44%, which is the highest among all regions. Furthermore, Europe-Asia and Intra-Asia also had high growth rates between 2018 and 2019 which resulted in the Transpacific region having only the fourth highest lit capacity share by 2019 (despite its leading role in 2015, 2016 and 2018). **In terms of the CAGR** of these 5 years, the **Intra-Asia region had the most dynamic growth**, followed by the Europe-Asia region.

The investors in the **Americas** region (or US - Latin America) seem to have planned the submarine cable capacity for future demand, as the region has the **highest design capacity but the lowest percentage of lit capacity**. In contrast, the Transpacific, which has the third smallest design capacity, on average, has had the highest lit capacity in 2018 (31%).

As a conclusion, it can be stated that **between 2018 and 2019, lit capacity increased in five out of six regions**, and four out of the five increased lit capacities to over 35%. Design capacity has been also increasing, however, there are differences among regions in terms of the relations between design and lit capacity. **Lit capacity seems to be growing at a faster pace than design capacity**. This suggests that the **installation of new cables and the upgrade of old ones were not enough for design capacity to keep up with the increase of lit capacity**, hence the share of the latter has increased in some regions in the past years.

3.2.3.2. Capacity by EU route

The following figure shows the design capacity of the submarine cables connecting the EU to the rest of the world.

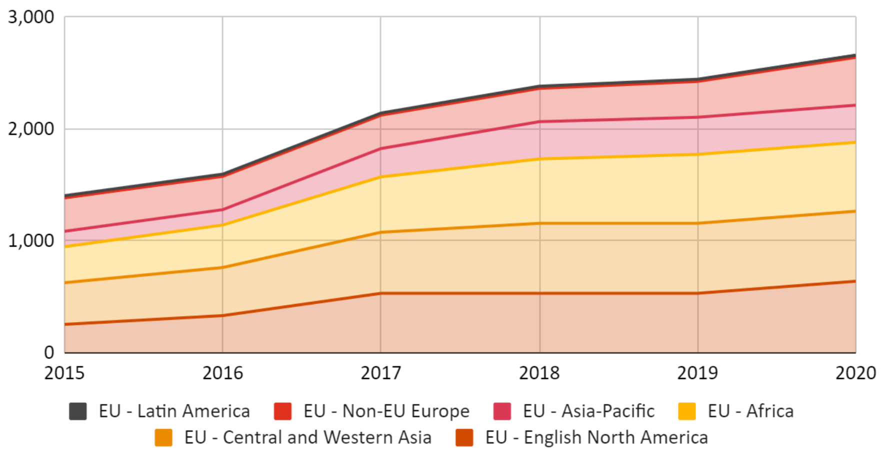


Figure 26: Design capacity by EU route[125]

The **highest design capacity is on the EU - English North America route**, which **also had the highest growth rates** out of all regions. The capacity of the EU's connections with **Central and Western Asia and with Africa are also significant** and quite similar (626 and 617 Tbps respectively). Both of these regions were ahead of the EU - English North America route in 2015, however, while they had 168-190% growth in the past five years, the design capacity of the connections with English North America increased by 254%, hence it gained upon the formerly leading regions. The fourth highest capacity is on the EU - Asia-Pacific route, however, it is only half of the EU - English North America route's capacity. The **EU - Latin America route has quite low capacity**, making up only 3% of the capacity of the EU - English North America route. Hence **the design capacity of the routes between the EU and other regions is not balanced**.

To conclude, the **highest growth happened between 2016-2017 and 2019-2020**. However, the vast **majority** of this growth took place **on the EU - English North America route**. The routes of the EU with Africa and the Asia-Pacific region have also experienced significant growth, especially between 2015 and 2018. There is a similarity between the connection of the EU with Central and Western Asia and the Asia-

[125] Sorted by size of design capacity. The sum of design capacity of EU routes depicted here is not equal to the total capacity on EU routes because of submarine cables connecting multiple regions.

Pacific region since both experienced growth until 2018 but none after that. **There was not any increase in capacity on the EU - Latin-America route in the past five years**. The EU - Non-EU Europe connections did not have a balanced growth either in the analysed period (it only started increasing in 2019).

These numbers supplement the previous chapter's information about active systems, where the **underdevelopment of the EU's connections with Latin America** already started to appear.

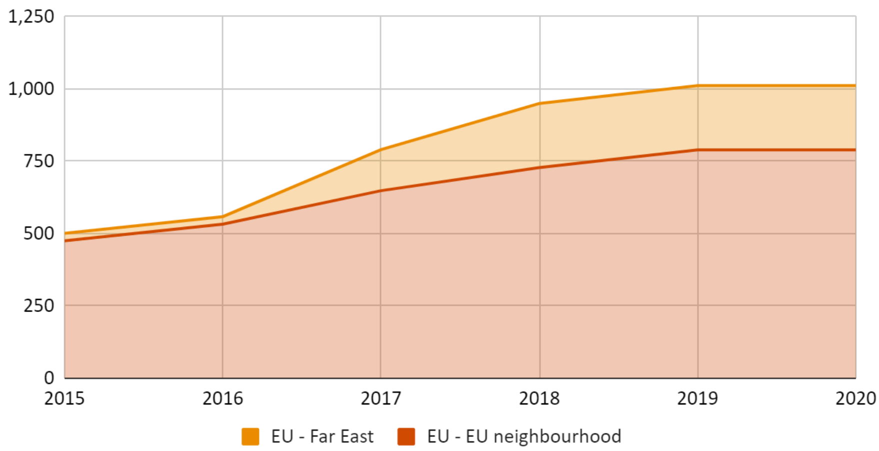


Figure 27: Design capacity by EU route (other Focus regions)[126]

There are two other regions that, although overlap with the previously discussed ones, are important to the EU's global connectivity strategy to look at separately as well.

The **capacity** on the **EU - EU Neighbourhood route** is quite **substantial** (789 Tbps) and is **even larger than the size of the EU - English North America route**. Over the past 5 years, it has been growing at a CAGR of 10.7% with the biggest increase (22%) happening between 2016 and 2017. This is the result of the introduction of the previously presented two cables, AAE-1 and SEA-ME-WE 5.

The **EU - Far East route** has a **much more modest design capacity** of 222 Tbps in 2020, which falls right between the capacity of the Non-EU Europe and Latin America routes. Similarly, to the previous route, the **biggest growth (444%)** in terms of capacity happened in the period of **2016-2017** and is the result of the same two cable systems that reach as far as Myanmar, Thailand, Cambodia and Vietnam.

3.2.3.3. Capacity growth enablers and examples of high-capacity systems

The **technological advancements** of the past few years in the optical communications industry **allow achieving much higher capacities than ever before**, **on new cables** and **on already existing ones** as well. While 20 years ago the design capacity of submarine cables was measured in **Gbps**, in 5 years it increased to the level of **Tbps**, reaching about **25 times higher capacities** on average in 2020 than in 2005. Now, it is possible to achieve 80 times higher capacity on already existing cables than their original design capacity, and lately, on an average, even 20-40 times higher capacities have been achieved on these cables.[127] If the upgrades and the new systems are included as well, **design capacity increased at a CAGR of 15.8%** between 2016 and 2020. Based on available information on planned cables for the next few years, this **growth seems to only intensify**, **especially the number of fibre pairs**: in 2021, the average number of pairs will reach 18. With the constantly increasing demand (that has been detailed in the earlier chapter of the study) it is necessary to continue increasing capacity as well. There are estimations that the global capacity will increase up to 100% by the end of 2023[128] and soon the design

[126] Sorted by size of design capacity. The sum of design capacity of EU routes to other Focus regions depicted here is not equal to the total capacity on these EU routes because of submarine cables connecting multiple regions.
[127] Colin Anderson, 2016: Extending Submarine cable's Lifespan
[128] Submarine Telecoms Forum: Submarine Telecoms Industry Report

capacity of submarine cables could be **measured in Pbps,** meaning an astonishing growth in international data carrying capacity.

The following figure depicts how the capacity of submarine cables increased in the past 20 years, in terms of fibre pairs per cables and capacity per fibre pairs (Gbps, Tbps).

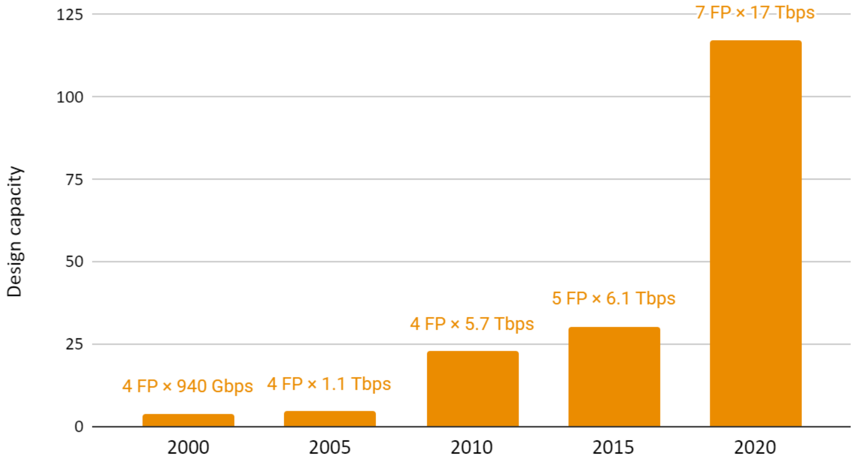


Figure 28: Average design capacity of submarine cable systems

The Dos Continentes I and II are examples of recently built, high-capacity, cables connecting the EU with other regions.

The **Dos Continentes I and II** cables **connect Europe and Africa** with landing points in Spain and its enclaves in Northern Africa. The systems were put in service - according to interviewed experts - in March of **2020 on a 95 km** length. It has **24 fibre pairs** and a **460 Tbps design capacity**.[129]

3.2.4. Resiliency and diversity

As the vast majority of data traffic is carried by submarine cables, resiliency is crucial in terms of these systems. **Network outages or unforeseen traffic peaks** beyond the capabilities of the network **could have dire consequences** not only for the average internet user but, considering our dependence on digital technologies, also for the economy as a whole. For this reason, **industry players seek to enhance geographic diversity** of submarine cable routes as much as possible in an effort **to increase the resiliency** of the network and mitigate the risks arising from network failures.

Many experts agree that **each country should have at least two terrestrial or submarine cable connections**. In fact, content providers, eager to establish redundant cable paths, ensure network resilience by installing not one but two or three cable systems in the same region (e.g. one cable connecting the US to Singapore and another one to China as well).

When talking about resilience in relation to the number of active cables, it should be considered that **newer cables have higher capacities** in general, thus **they can replace several older cables at the same time**. However, **maintaining a certain number of cables is still important**, since it **lowers the chances** of being **completely cut from the internet in case of a cable failure.**[130]

[129] Submarine Telecoms Forum: Subtel Cable Map
[130] TeleGeography Blog: Cable Breakage: When and How Cables Go Down

3.2.4.1. Resiliency of EU routes

Beside the number of cables available in a region, **another important aspect that influences resilience is the age of cables**. Based on these two factors, resiliency scores are defined in case of each EU route.[131]

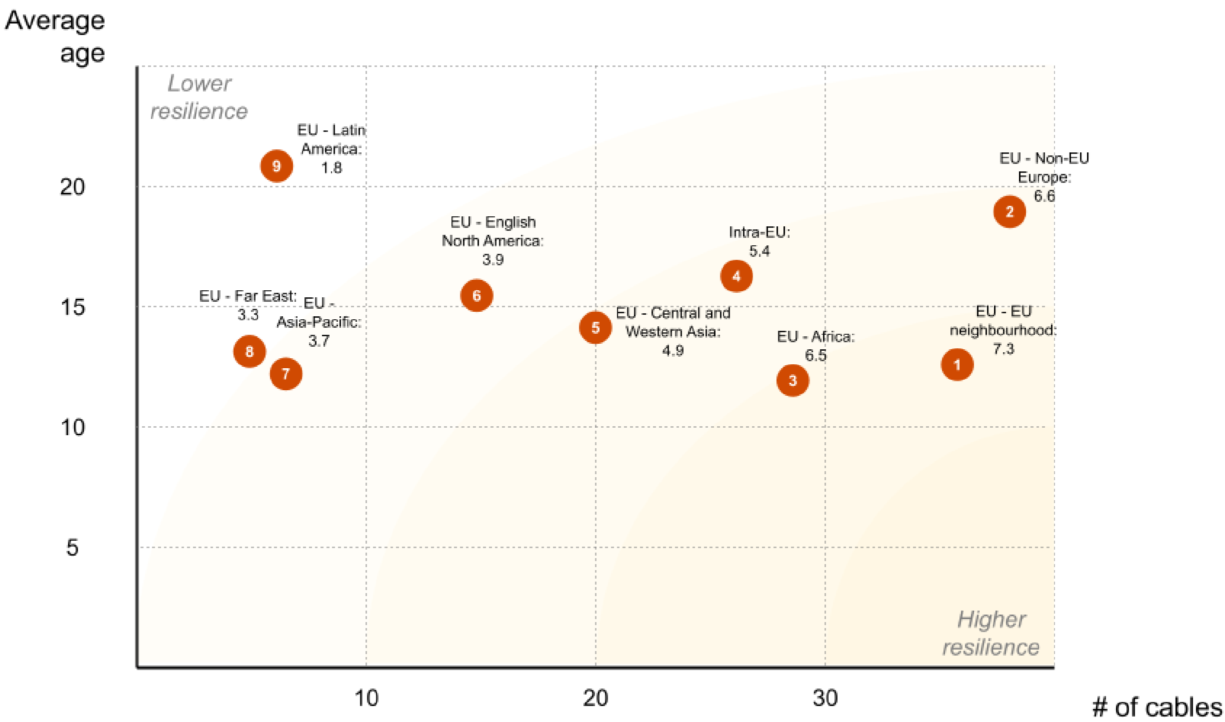


Figure 29: Overall resilience of EU routes as of 2020

The **EU - EU Neighbourhood**, **EU - Africa**, **EU - Non-EU Europ**e and **Intra-EU** routes have the **four highest resiliency scores**, which implies that **EU routes in the EMEA region have strong resilience**. The average number of connections is between **26 and 38** while the average age is between **12.3 and 18 years**. Although they received the highest scores among the EU routes, an average cable age of **18 years is actually very high** so the EU - Non-EU Europe and Intra-EU routes require attention.

The **EU - Far East** and **EU - Latin America routes** have the **lowest resiliency scores**, though the EU - Far East route is not so far ahead them either. They both have a **low number of cables** (5 and 6) and at the same time the **EU - Latin America route has an astonishingly high average age** of **21 years**.

The upside of examining average cable age is that it helps to get an overall picture of the current situation. However, to understand the future prospects of each route more thoroughly, it is also necessary to analyse the **age composition** of the routes as well.

[131] Resiliency score is determined on a scale of 1 to 10 where 10 means the highest resiliency. For a more detailed methodology, please see Annex 6.4.

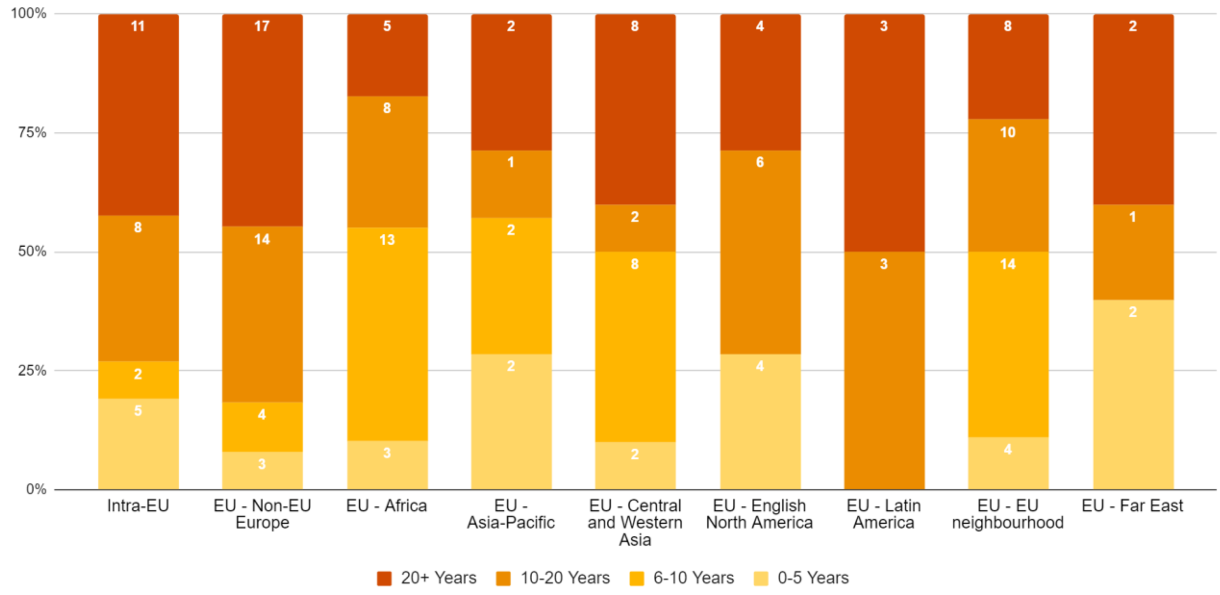


Figure 30: Cable age and Capacity by Route between the EU and other regions

Half of the cables on the **EU - Latin America route are older than 20 years old**. Four out of the six cables are connecting Latin American countries with outer regions of the EU, more precisely, islands under the territory of France and the Netherlands. This means that these cables are five to ten thousand km shorter than the other two cables (Atlantis-2 and Columbus II) which are connecting Latin America with the continental Europe. Both of the latter cables are more than 20 years old which **poses the risk of the continental Europe losing its connection to Latin America.**[132] However, **there is already one planned cable to reduce this risk** which will be elaborated on later in the upcoming Chapter 4. *"Future trends and forecasting"* of the study.

Intra-EU and EU - Non-EU connections also bear a high risk in terms of cable age. Both regions' systems consist of **more than 40% of 20+ year-old cables**, which means that in just a few years most of these cables will be out of service. At the same time, younger cables' (0-10 years old) percentage is relatively low. In both regions there are already confirmed, **planned cables**, but **not nearly as much as would be needed** based on the number of cables that are more than 20 years old.

The **EU - English North America** connection has around 29% of 20+ year-old cables and **0-5 year-old** each. In addition, the latter will be further increased by three more cables that are going to be built in the next few years. Hence the **risk posed by the high percentage of more than 20-year-old cables is partially mitigated** by new and planned cables.

50% of the EU - EU Neighbourhood route's cables are **more than 10 years old**. Although compared to the 25 years life span, a **ten-year-old cable is relatively young**, the relatively low ratio of 0-5 years old cables (11%) makes the route's age composition **quite unbalanced**. The **EU - Africa route is very similar**, where **45% of the cables belong to the two older age groups**, and only 10% of the cables fall into the 0-5 years category.

Unbalanced age composition increases the risk of a route, since it **endangers the chances of proper replacement of aging cables**. This is a relevant problem on the **EU - Latin America** and on the **EU - English North America routes.** On the former, there are no 0 to 10-year-old cables, while the latter route lacks 5 to 10-year-old cables and 71% of its cables are 10+ years old.

The **EU - Far East** route has only the fourth highest percentage of more than 20-year-old cables (40%), but it also has the **highest percentage (40%) of 0-5-year-old cables among the routes.** This way, it partly balances the age composition (60% of its routes are 10+ years old).

[132] Since the life expectancy of a submarine cable is 25 years. Source: Colin Anderson: Extending Submarine cable's Lifespan

The **EU - Asia-Pacific** and the **EU - Central and Western Asia** routes seem to have the most balanced age composition. On these routes, **none of the age groups includes more than 40% of the cables**. Since the **percentage of cables that are older than 20 years** is **very similar to the 0-10- and 10-20-years old groups**, these routes **do not bear a high risk**.

3.2.4.2. Resiliency of EU Member States

Most of the coastal EU Member States (73%) have interregional submarine cables.[133] Malta[134], Latvia, Lithuania, Poland, Estonia and Slovenia each lack interregional connections, and Slovenia does not have submarine cables at all.

Figure 31: Submarine cables by EU Member State[135]

Italy and France have the most interregional submarine cables (19 and 18 respectively), followed by Spain (14), Cyprus (13) and Portugal (11).

In **France, Ireland, Belgium, Bulgaria, Romania** and **Croatia, 100%** of **submarine cables landing there provide interregional connections**, although in the case of Bulgaria, Romania and Croatia this means only three cables or less. When talking about interregional cables, it is worth noting that **not all of them cross oceans** to connect the EU with other continents. For example, four out of five interregional **cables in Belgium go only as far as the United Kingdom**. The same thing only applies to two cables out of the six in **Ireland**. The other **four cables extend over the Transatlantic region**. The reason behind this is two-folded: one is the country's **location** (it is closer to North America than any other EU Member State), and the other is that there are **many data centres** in **Ireland**, which makes it an ideal landing point for submarine cables.

Besides these countries, there are **other Member States** also that are **significant in terms of connecting the EU with the outside world**. Over 90% of submarine cables landing in **Portugal** and **the Netherlands** are interregional cables while for **Spain** and **Cyprus** this percentage is more than 80%.

While the aforementioned Member States were clearly important in terms of interregional submarine connections, **Baltic countries are stronger in intra-EU links.**

[133] Meaning cables that connect the EU to outside regions
[134] Although as of 2020, Malta has no interregional submarine cable connections, this will change in Q4 2021 with the introduction of the PEACE cable that will connect Malta to the Middle East, Africa, the Indian Ocean and China.
[135] The figure only includes cables that connect the EU to outside regions. Solely intra-EU cables are disregarded on this figure.

Although there are quite big differences between EU Member States in terms of the number and the regional distribution of submarine cables, **if the terrestrial cable system is well developed and each coastal country makes proper use of their natural endowments, international connectivity might reach its potential in the EU**.

3.2.4.3. Handling traffic bottlenecks

In 2020, the **COVID-19 pandemic significantly raised data traffic** throughout the world. In Europe, internet bandwidth increased by 34% (compared to the 22% growth of 2018-2019), and peak traffic increased by 44% (compared to the 19% growth of 2018-2019).[136] International internet capacity has always been the highest **in Europe**, and by 2020 it also **had the highest increase compared to other regions**, reaching just below 500 Tbps.[137] The peak hours have also changed: before the pandemic, the peak hours were usually at night, after people arrived home from work. However, in 2020 peak times extended to daytime hours as well.

The crises posed a further challenge to the submarine cable industry, as it also led to **temporary supply chain, permitting, and marine installation delays**. Hence short-term technological improvements were required (e.g. managing traffic throughput, boosting cache deployments, accelerating capacity upgrades, and addressing network maintenance needs).

The **submarine infrastructure** was **able to handle** the **sudden increase of demand successfully**[138]**, however, EU measures were required to protect the infrastructure. The requisite short-term improvements** indicate the **necessity for long-term investments** into **better capacity** and **new submarine cable systems** as well.[139]

3.2.4.4. Geographical choke points

Besides the number of cables, geographical choke points in submarine cable infrastructure, meaning **locations where many cables pass through or land**, pose a **high risk** in terms of network resilience as well. These locations are generally **tight areas**, for example the **Strait of Malacca**, a narrow stretch of water between the Malay Peninsula and Sumatra, an Indonesian island. Here **more than ten cables pass through**, including the **SEA-ME-WE-3, 4 and 5** cables as well which are all **very long cables** connecting Europe with the Far East and with **landing points in many countries**.[140]

Another example is the **Gulf of Suez**, where there are also more than 10 cables landing currently, for example the **SEA-ME-WE-3,** the **Europe India Gateway (EIG),** or **SEACOM.**[141]

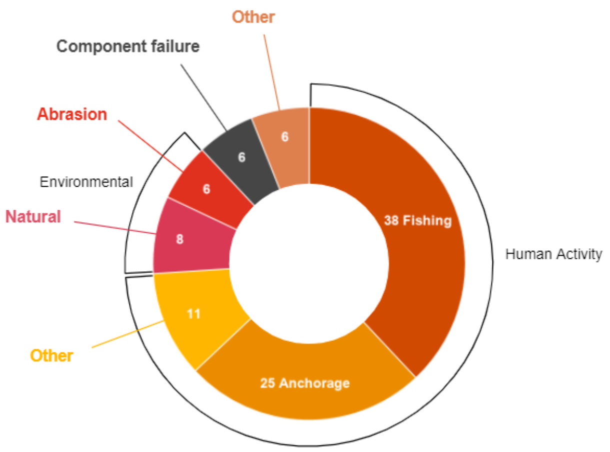
According to interviewed experts, there is a **similar issue on the EU - English North America route** as **most of the cables are landing at the same point**. When the **vast majority of cables** are **landing** in just a **few landing points**, the issue is that **in case a landing station on the coastline is eliminated**, it will **affect many cables** at the **same time**. This way, the **elimination of these few landing points** could **cut all connections** between the **EU** and **North America**.

An example from the past for this kind of exposure is the **2006 and 2009 earthquakes in Taiwan**. The **same eight cables were affected both times**, including the previously mentioned **SEA-ME-WE-3** which is the **longest submarine cable** in the world and has the most landing points. In 2006, the **largest operator in Taiwan** reported a **complete internet outage to Hong Kong and Southeast Asia** and almost **75% to Mainland China**. The **top 2 Chinese internet service providers reported more than 90% internet outage.**[142] Although the disaster in 2006 increased preparedness for a similar situation, **in**

[136] TeleGeography: Global Internet Geography: Executive Summary
[137] TeleGeography: Global Internet Map 2021
[138] SubTel Forum Magazine: Global Capacity
[139] Telegeography Blog: The Global Bandwidth Magic Eight Ball Says "Ask Again Later"
[140] Infrapedia: Infrastructure Map
[141] Infrapedia: Infrastructure Map
[142] Winston Qiu: Submarine cables Cut after Taiwan Earthquake in Dec 2006

2009, China's connection to the US decreased by 70% due to earthquakes and **connections were disturbed** in **Singapore, Malaysia, Hong Kong, and Taiwan** as well.[143]

3.2.4.5. Common causes of network failures



The usual life expectancy of a submarine cable is 25 years. However, it does not mean they always operate smoothly during this period, since there are often cable failures, caused by several reasons.
As mentioned before, since submarine cable industry players are familiar with the extents of the problem that could be caused by a cable failure, they **try to avoid this situation by spreading the traffic on several cables** and **by laying cables on secure sea floors**.[144] Largely due to this, **cable faults rarely cause massive network outages, even though they are actually quite common**: on average 100 cases of cable failures happen yearly. These are **mostly caused by unintentional human activity** - meaning **most of them could be prevented**. Fishing and anchorage are responsible for 63% of cable failures. (Figure 32)

Figure 32: The reasons behind submarine cable failures[145]

Comprehensive and targeted information for fishermen and sailors, like the International Cable Protection Committee's booklet from 2006, titled "*Fishing and Submarine cables - Working Together"*, might alleviate the problem. The release date of the example, however, shows that this kind of communication should definitely be more frequent, and it should also be more promoted. There is a common belief about cable failures that shark bites and intentional sabotage are the main reasons behind them, however, both issues are very rare. One example of the latter is the intentional cut of the SEA-ME-WE 4 cable close to Egypt in 2013. Three scuba divers were arrested for cutting the submarine cable. The case - together with previous unintentional submarine cable cuts - resulted in serious connectivity disruption between Europe and Asia.[146]
Some more recent examples show how serious issues might derive from cable failures. On 30 of March **2016** the **ACE cable** running along the west coast of Africa between France and South Africa was **cut by a ship**. It is the only internet source for six countries (Sierra Leone, Mauritania, Liberia, Guinea-Bissau, Guinea, and the Gambia). Two of these countries, Sierra Leone and Mauritania suffered **one to two days long complete internet outages**. **Ten countries were negatively affected by the cable cut**.[147]
In the early summer of **2020**, the **Asia-Pacific Gateway (APG)** and the **Asia America Gateway (AAG)** each suffered a breakdown with a one-week difference. Although there are six cables providing internet for Vietnam, these two cables are responsible for 60% of the traffic. **Weeks of slow and disrupted internet connection** followed these events, causing problems not only in Vietnam but in Cambodia and Laos as well.[148]

[143] Winston Qiu: Submarine cables Cut by Taiwan Earthquake and Typhoon Morakot
[144] EllaLink, for example, will follow a secure route across the Atlantic Ocean, void of any possible subsea earthquakes.
[145] TeleGeography Blog: Cable Breakage: When and How Cables Go Down
[146] Charles Arthur: Undersea internet cables off Egypt disrupted as navy arrests three
[147] David Belson: ACE Submarine cable Cut Impacts Ten Countries
[148] SubTel Forum: Cable Faults Impact Internet in Vietnam, Cambodia & Lao PDR

3.2.5. Accessibility

In addition to network resilience and diversity, it is also essential to examine the impact of changes in the ownership structure of cables and international economic trends (e.g. Brexit) on infrastructure availability.

3.2.5.1. The impact of content providers on capacity accessibility

In terms of cable ownership, **content providers have become very important players** in recent years, as shown in the figure below.

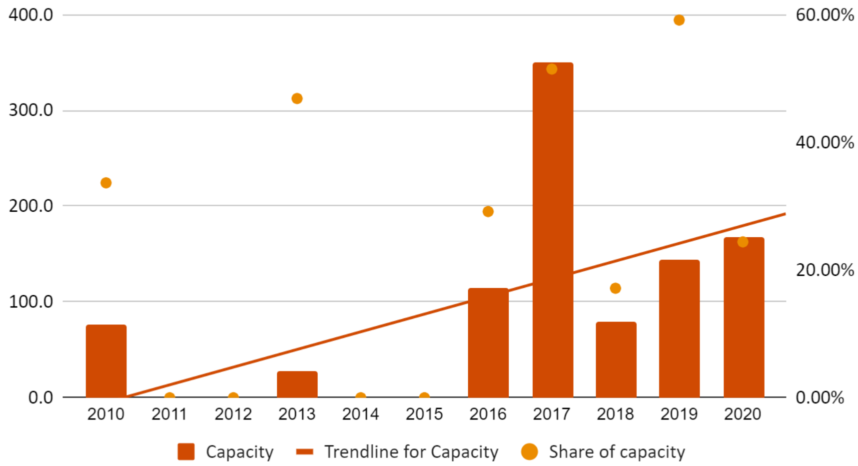


Figure 33: Content provider driven new submarine cable capacity

As the figure above indicates, from 2010 onwards, **there is a clear trend that more and more capacities are driven by content providers.**[149] 2017 was exceptionally outstanding, as these companies accounted for more than 50% of newly built capacities.

Furthermore**, content providers install cables with significantly higher capacity than traditional telecommunications service providers. On average, content provider driven cables have been built with 74% higher capacity,** however, there has been an example in 2010 of achieving more than 200% higher capacity than their competitors.

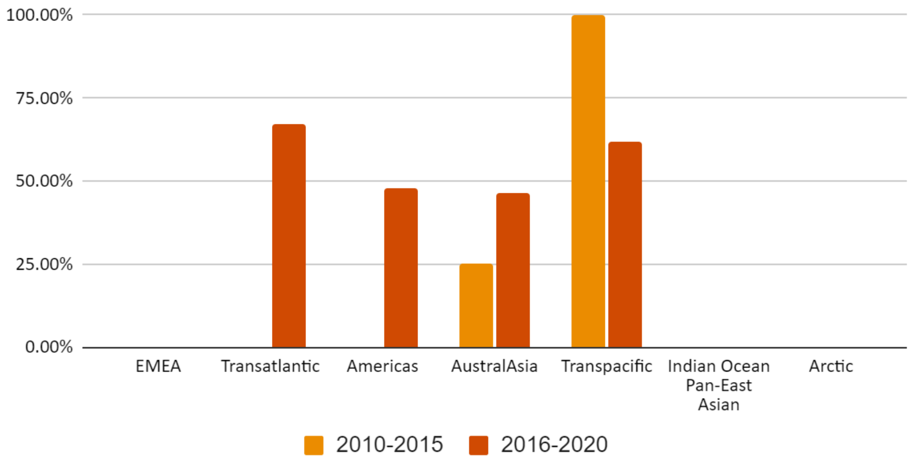


Figure 34: Content provider driven new submarine cable capacity

[149] Here, the phrase "content provider driven" is meant to indicate submarine cables that are owned solely or partially by content providers. In case of the latter, the exact share of content provider capacity is not assessed due to insufficient data. (Figure 29)

In terms of regional activity, it can be observed that in the period of 2010 to 2015 **content providers focused only on the Australasia and Transpacific regions. However, in the last 5 years they have established the majority of capacities in the Transatlantic and Americas regions as well -** in addition to the former regions. Although they are not yet active in the EMEA region, the situation will change based on new cables announced.

Some of the major recent investments include, for example, the Google owned cable called Junior built in 2017 in the Americas region or Curie, which was built in the same area in 2019, and started transmitting data in Q2 2020.[150] However, there are also many examples of content providers building cables with each other and / or telecommunications service providers, such as the 2019 Indigo West in the Transpacific region or the Malbec cable, which was introduced in 2020 in the Americas region.

Accordingly, even on EU connected routes, content providers appeared only on the EU - English North American route - being owners to 72% of new cables deployed in the period of 2016-2020.

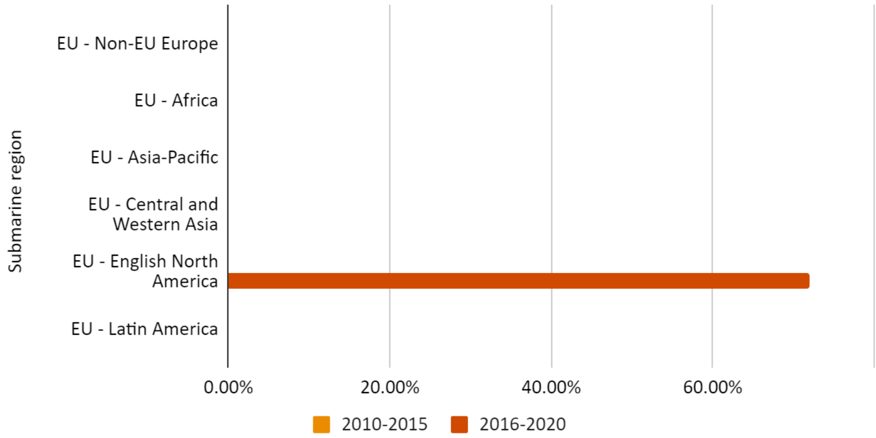


Figure 35: Content provider driven new submarine cable capacity on EU routes

3.2.5.2. The impact of Brexit on accessibility

One of the most significant international economic changes in recent years has been the exit of the United Kingdom from the EU (Brexit). Its impact on international connectivity is also an important risk to assess.

Figure 31 shows the proportion of Europe-reaching interregional cables that have a landing point in the UK or in the EU. It can be concluded that **each submarine cable region has more cables landing in the EU than in the UK.** The most cables with UK landing points and with the highest capacity are in the Transatlantic region, however, the number of EU cables is significantly higher in this region as well. Furthermore, no new intercontinental cable landing in the UK has been established in the last 5 years, which may also indicate the declining importance of this landing point.

[150] Submarine cable Networks: Findings on Google's Curie Cable System Ready for Service

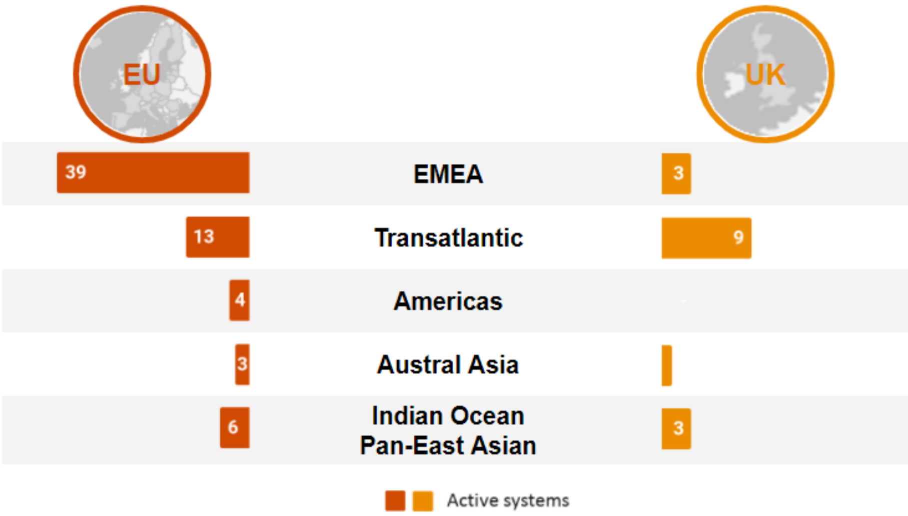


Figure 36: Active systems by landing point

Conducting a deeper analysis in the Transatlantic region, it appears that before 2015, approximately as many cables were laid in the UK as in the EU (9 and 10 respectively). However**, in the past 5 years, a drastic change has taken place, with all Transatlantic cables affecting Europe landing in the EU**. This coincides with the time of the Brexit vote (2016), however, it is unclear whether Brexit had a direct impact on new cable investments. On one hand, the market is not able to react so quickly, as cable construction and installation takes several years. On the other hand, most cables were introduced in an effort to increase diversity - where there were no landing points before or where new cables have not been established for a long time.[151]

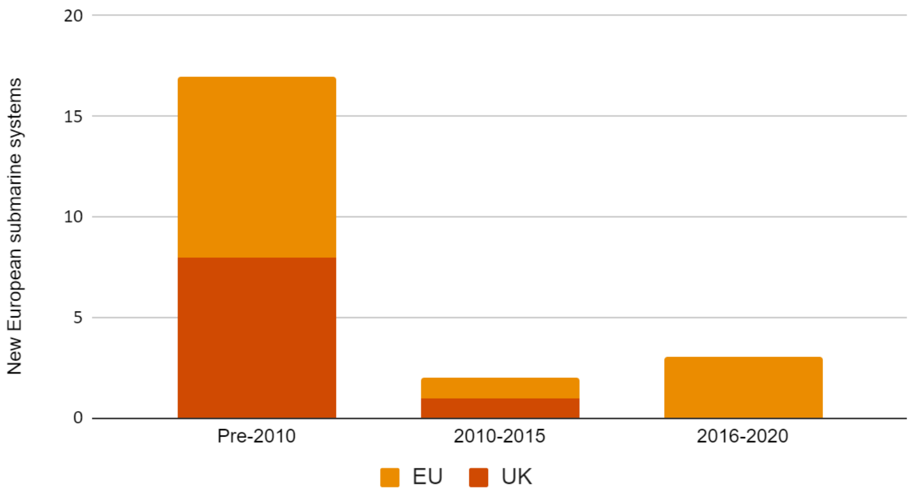


Figure 37: New systems by lading point in the Transatlantic region

Furthermore, there are only 2 cables that skip the EU but reach the UK (ATLANTIC CROSSING 2 / Yellow and TGN ATLANTIC) - and the two are in the Transatlantic region and have been built between 2000 and 2001. They represent only 76.24 Tbps capacity, - 0.64 Tbps, and 75.6 Tbps respectively - which takes up no more than 9.8% of the capacity of the Transatlantic region. **In a few years these cables will reach their maximum lifespan of 25 years** and given that maintaining old cables is often not economical, they may be decommissioned even before 2025.

Consequently, more cables are reaching the EU than the UK already - even in the traditionally UK-focused Transatlantic region - and this trend seems to continue, however it remains uncertain whether it is a consequence of Brexit. According to industry experts, **key market players will most likely choose France, Spain and Portugal rather than the UK,** - because of their geographic proximity to the US - **a trend that is already visible.**

[151] TeleGeography Blog: Are New Cables Avoiding Landing in the UK Because of Brexit?

3.3. Business model and stakeholder analysis

Summary - Stakeholders and business models in submarine cable systems

The main actors in the first mile value chain are the surveyors, the system suppliers, the installers, the owners, the maintenance providers, the customers and other stakeholders.

The clear leader in the surveyor market is EGS who owns more than half of the market but Fugro is also dominant. These market players operate globally while smaller companies focus on rather specific areas.

There are four major companies dominating the supplier market: the two market leaders are the EU-based Alcatel Submarine Network and the US-based SubCom (both active in all six regions), **however, the Japanese NEC** (mostly focusing on the Australasia, the Transpacific and the Indian Ocean Pan-east asian regions) **and the Chinese Huawei Marine** (active in Australasia, EMEA and the Indian Ocean Pan-East Asian regions) **are also key players.** The company with the most active EU connected cables is SubCom, however, ASN, Huawei Marine and Pirelli are also important suppliers.

The main installers are mostly the same as the suppliers. The key actors **are ASN, SubCom and Global Marine** and among the three, especially ASN is dominating the market, while Huawei Marine's role has weakened remarkably. ASN and SubCom are busy in most regions while Global Marine is mostly active in Australasia.

The market for **cable owners** is very diverse, however, **the traditional owners are telecommunications service providers,** among whom the most cables belong to Orange, TATA Communication, Telstra and AT&T. Nevertheless, **in the past decade content providers and Far Eastern-owned telecommunications companies emerged as new market leaders**. By 2017, **content providers have become the largest users of international capacity and consequently they started building their own cables.** In the period of 2016 to 2020 content providers were already the driving force behind 36% of systems that went into service. **The most relevant content providers are Google and Facebook,** but Microsoft and Amazon are also becoming more dominant. They have been mostly busy in the Australasia , the Transatlantic, the Transpacific and the Americas regions while Chinese telecommunications companies are active all over the world except the Americas region. In terms of EU connected cables, TATA and Telxius have built the most cables but Google as a content provider is also already among the top three owners.

The two common forms of maintenance agreements are club and private. The most important private maintenance provider is Orange while SubCom and ASN are the key actors in private maintenance agreements.

The customers of international connectivity are usually national backbone providers. Capacity on consortium cables is divided into Minimum Investment Units and sold in terms of Indefeasible Rights of Use through Capacity Purchase Agreements. The service gives a large-scale internet service provider the ability to assure its own customers of international service on a long-term basis.

Furthermore, there are other stakeholders in the international connectivity ecosystem as well, such as cable protection organizations and - international and national - regulators.

Investments in international connectivity are growing steadily, typical financing schemes are in close correlation with ownership structure. Submarine cables fall into three major categories of ownership: multi investors, single investors or Public Private Partnerships. The multi investor model has been the most common financing model by far, however, **in recent years, the single owner model has started gaining significant popularity due to the growing number of content providers entering the market with their own cables.** Furthermore, as most telecommunications service providers cannot afford to build their own network, **there are also an increasing number of joint developments with content providers.** Both multi and single owner investments are the highest in the Australasia region. Nevertheless, in case of multi investors there has also been a large amount of investment in the Indian Ocean Pan-East Asian region, whilst single

owned investment has grown significantly in the Americas. At last, nearly half of PPP investments have gone to the EMEA region.

3.3.1. International connectivity value chain

As elaborated in Chapter *3.2. Infrastructure*, the first mile is the main focus of the Study. Thus, the aim of this section is to explain the value chain and key market players of each element.

I. Surveyors: The surveyors' role is to develop optimized routing between defined landing sites. Prior to laying the cable on the seabed, the survey contractor should provide the installer with integrated geophysical and geotechnical data required to finalize the installation plan.[152] Therefore, a comprehensive desktop study is required before the start of the survey, to address the optimal route, the survey methodology and schedule of work. Then optimized routing of the new cables is developed between the defined landing sites. It has to meet the following economic and technical viability criteria.[153]

- Avoidance of or minimizing conflicts with other seabed users
- Minimizing exposure to natural and manmade risks and hazards
- Optimizing cable engineering and protection
- System maintainability
- Adherence to ICPC Protocols and Recommendations

Among surveyors the clear market leader is EGS who dominates more than half of the market. Beside the main competitor, Fugro also bears significant market share. The two key market players operate globally while smaller companies focus on rather specific areas.

II. System suppliers: Suppliers are companies producing submarine cables from raw materials and distributing them to installers. There are four major companies dominating the market: the EU-based Alcatel Submarine Network, the US-based SubCom - both active in all six submarine cable regions, the Japanese NEC mostly focusing on the Australasia, the Transpacific and the Indian Ocean Pan-East Asian regions and Huawei Marine from China, supplying the most cables to the AustraAustralasia, the EMEA and the Indian Ocean Pan-East Asian regions. The market leader in terms of number of supplied cables is ASN and their position has not changed compared to 2016. However, SubCom, NEC and Huawei are also potent actors. Besides, the latter company has shown a 60% increase in its activity in the past 5 years. In terms of length of supplied cables, SubCom produces the longest cables. NEC and ASN are also key players, however, both have shown a decrease in the produced length of cables.

[152] Hydro International: Subsea Cable Route Surveying
[153] EGS Survey Group: Overview of Submarine cable Route Planning & Cable Route Survey Activities

The company with the most active EU connected cables is SubCom, which more than doubled its market share in recent years, however, ASN, Huawei Marine and Pirelli are also important actors.

III. Installers: The role of installer companies is to fix the submarine cable in position ready for use. (Several installers also manufacture cables themselves, so the players are overlapping in those two groups). The key market actors are ASN, SubCom and Global Marine and among the three, especially ASN is dominating the market. In the meantime, Huawei Marine's role has weakened remarkably. ASN and SubCom SubCom are busy in most regions while Global Marine is mostly active in Australasia.

IV. Owners: The traditional owners of submarine cables are telecommunications service providers, among whom the most cables belong to Orange, TATA Communication, Telstra and AT&T. However, in the past decade, Far Eastern-owned telecommunications service providers emerged as new market leaders, especially from China.

Besides Chinese telecommunication companies, in the past five years, content providers have also become important market players.[154] By 2017, content providers had surpassed internet backbone providers as largest users of international capacity and consequently they started building their own cables. In the period of 2016 to 2020 content providers were already the driving force behind 36% of systems that went into service. The most relevant content provider is Google, but Facebook, Microsoft and Amazon are also becoming more dominant. In the 2016 to 2020 period content providers have been busy mostly in the Australasia, the Transatlantic, the Transpacific and the Americas regions. Chinese telecommunications service providers are active all over the world except the Americas region, but their growth rate is less significant.

In terms of EU connected cables, the ownership structure of cables is very diverse. Among the telecommunications service providers, TATA and Telxius have built the most cables but Google as content provider is also already among the top three.

V. Maintenance providers

The two common forms of maintenance agreements are club and private. Orange is the most important private maintenance provider while the two largest suppliers and installers - SubCom and ASN - are the most important actors in private maintenance agreements.

[154] Content provider: a company that supplies material such as text, music, or images for use on websites. They may be referred to by other names such as hyperscale, web-scale companies, OTTs (over-the-top providers), ICPs (internet content providers), or CSPs (cloud service providers) as well.

- **Traditional club agreements**[155]: In this model each owner nominates a representative to act as the main point of contact between itself and the marine service provider and the depot operator. Orange is the busiest globally - in the EMEA, Transatlantic and Indian Ocean Pan-East Asian regions, however, Global Marine is also active in multiple regions (Transatlantic, Transpacific and Australasia).
- **Private agreements:** There are several types of contracts in place, but the most common model is typically offered by the ship operators and are usually tailored to the needs of the individual system owner. SubCom provides the most services globally - in the Transatlantic, Indian Ocean Pan-East Asian and Australasia regions, but ASN is also a significant actor, mostly in the Transatlantic region.

VI. Customers

Traditionally national backbone providers are the ones purchasing capacity from submarine cable owners. Capacity on consortium cables is divided into Minimum Investment Units (MIUs) and sold in terms of Indefeasible Rights of Use (IRU) through Capacity Purchase Agreements (CPAs). Capacity on private cables may be also sold but mostly on different terms. IRU is the effective long-term lease of a portion of the capacity of an international cable and specified in terms of a certain number of channels of a given bandwidth. The CPAs often forbid resale of the capacity ownership and usually grant ownership for 25 years. The service gives a large-scale internet service provider (ISP) the ability to assure its own customers of international service on a long-term basis.[156]

VII. Other stakeholders

- **Cable protection organizations:** The aim of these organizations is to promote the protection of international telecommunications and power submarine cables against human and natural hazards and to address issues related to submarine cable security and reliability. Among the largest organizations are the International Cable Protection Committee (ICPC), the North American Submarine cable Association and the Oceania Submarine cable Association.
- **Regulators:** The role of regulators is to control and synchronize interstate and international communications. There are two main types of regulations: International Treaties such as the International Convention for the Protection of Submarine cables and National Regulatory Authorities like the Federal Communications Commission in the US.

3.3.2. Stakeholder analysis

3.3.2.1. Surveyors

In terms of the number of systems surveyed, between 2016 and 2020 reported activity shows that **EGS**[157] **has been the busiest surveyor** by a large margin. The company **accounts for half of all survey activity** by itself, while **Fugro**[158] **has performed the second most** number of surveys. Besides the two

[155] Submarine Telecoms Report: Submarine Telecoms Industry Report
[156] ITU: Enhancing access to submarine cables for Pacific Island Countries
[157] EGS Group is a privately owned company. It was founded in 1974 and is headquartered in the United Kingdom.
[158] Fugro is a Dutch multinational public company with a mixed ownership structure. It was founded in 1962 and headquartered in the Netherlands.

key players, there are other actors with minor roles in the surveying "sector", such as Elettra, IT International Telecom, Gardline, ASN, Ocean Engineering and the US government.[159] [160]

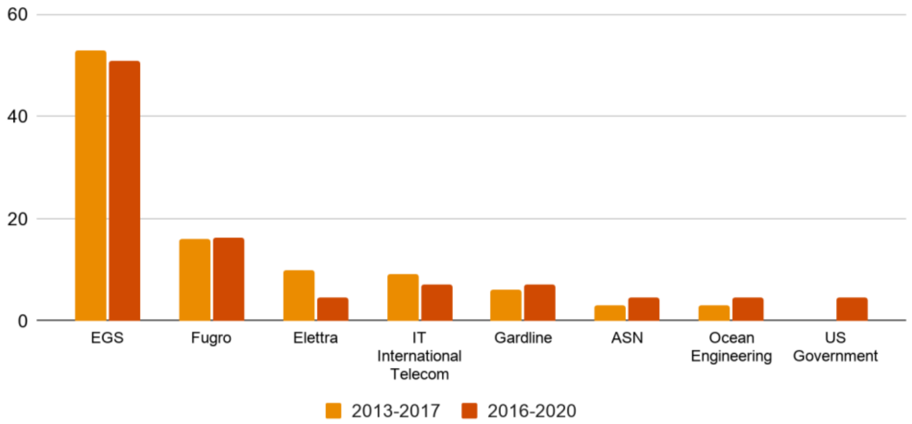


Figure 38: Market share of system surveyors (%)

The activities of the actors overlap in several regions, enabling a comprehensive global survey capability for the industry at large. The **real global providers are the two market leaders**: EGS and Fugro, which have survey experience in nearly every region of the world. Gardline's and Elettra's activity is also quite diverse, while smaller companies tend to focus more on specific regions. This compares well with regional capability, as those that can serve the most regions tend to be the busiest.

3.3.2.2. System Suppliers

In terms of the **number of systems supplied between 2016 and 2020, ASN was by far the busiest supplier** in terms of new projects. They built 18 submarine cable systems which is more than double compared to the second biggest actor. **The second largest suppliers are Huawei Marine, NEC and SubCom** with each supplying 8 submarine cable systems. There was no significant change in NEC's and SubCom's activity compared to the period of 2012 to 2016, however, **Huawei Marine demonstrated a 60% growth**. [161] [162]

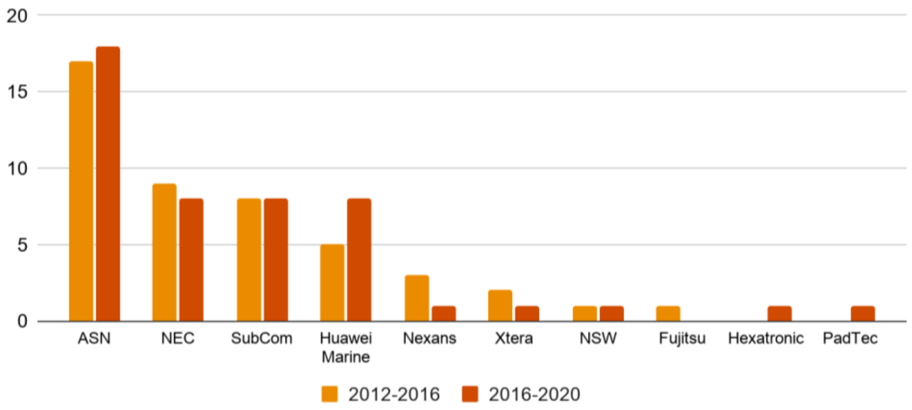


Figure 39: Number of systems supplied by company

In terms of the length of systems supplied between 2016 and 2020, SubCom takes the lead with over 100,000 km of cables. **This is a significant increase** compared to the period between 2012 and 2016, when they were only the third largest player. **ASN** produced the second most cables at 93,500 km and **lost their market leader position**. The third largest player, **NEC** had to face **the largest decrease**

[159] Submarine Telecoms Report: Submarine Telecoms Industry Report
[160] Submarine Telecoms Report: Submarine telecoms Industry Report - Issue 5
[161] Submarine Telecoms Report: Submarine Telecoms Industry Report
[162] Submarine Telecoms Report: Submarine telecoms Industry Report - Issue 5

compared to the period of 2012 to 2016 (35% decline). These companies have been very dominant in recent years, being some of the few companies that can produce cables at a high enough volume to meet demand for large systems.

Although **Huawei Marine produced** only 11,700 km between 2016 and 2020, the company has **more than doubled the km of cable produced** compared to the previous period. Furthermore, there are some other players among the smaller suppliers such as PadTec, Nexans or NSW who are diversifying their portfolios to include other markets as well – such as offshore wind power – because these markets can be more lucrative for them. Overall, their participation in submarine communications is low for the period of 2016 to 2020.

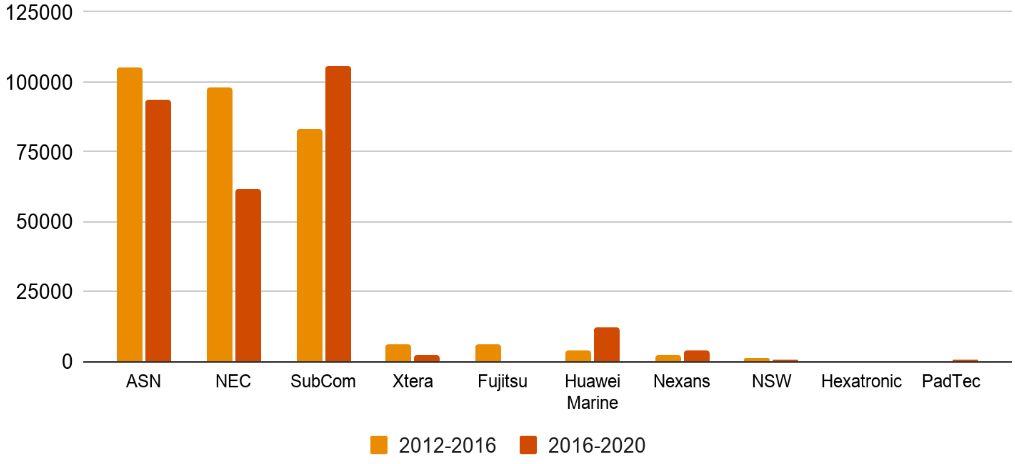


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Figure 40: Km of cables supplied by company

While **SubCom and ASN are highly active in all six regions,** NEC is mostly focused on the Australasia , the Transpacific and the Indian Ocean Pan-East Asian regions, Huawei Marine supplies the most of its cables to the Australasia , the EMEA and the Indian Ocean Pan-East Asian regions. Besides, there are several small to mid-size companies almost exclusively focusing on their “home” regions.[163]

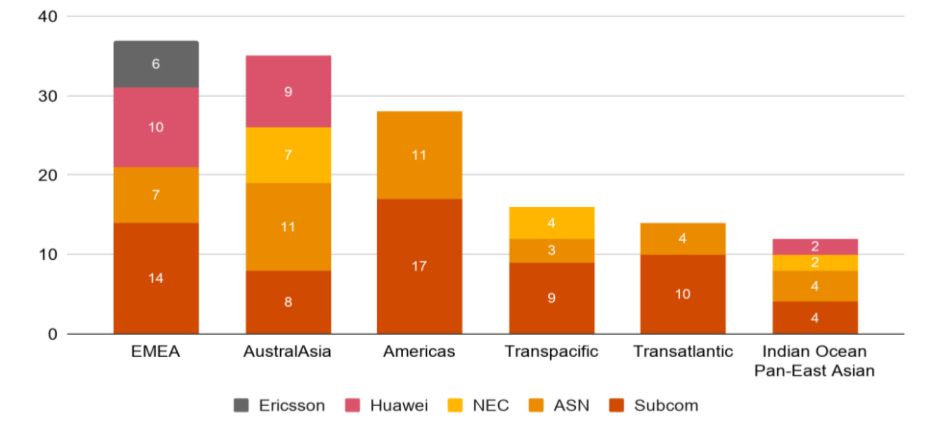

Figure 41: Number of active cable systems of largest suppliers by region

The company with the most active EU connected cables - supplied since 1989 - **is SubCom**, however, ASN’s, Huawei Marine’s and Pirelli’s market share are also at least 10%.

[163] SubTel Forum: Submarine cable Almanac

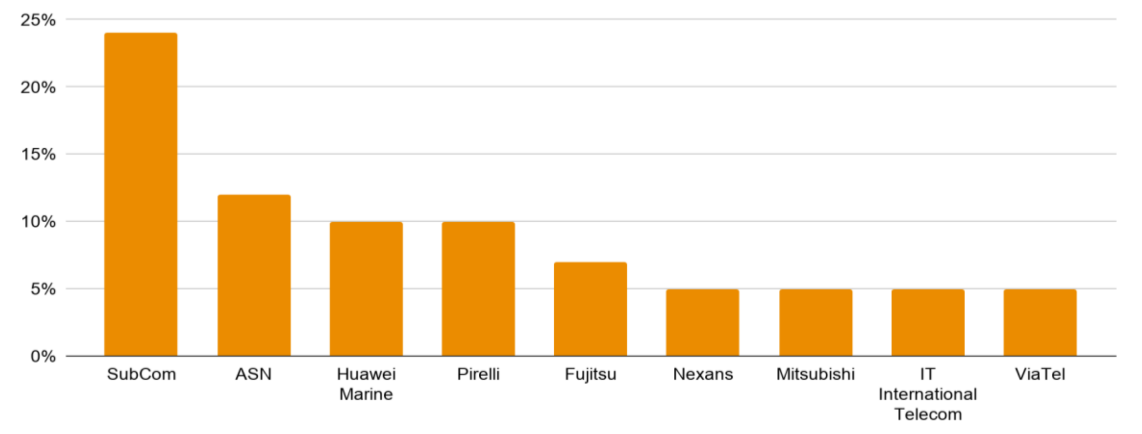

Figure 42: Market leaders in terms of all active, supplied EU connected cables

Furthermore, examining the trends of the last 10 years, it is clear that **SubCom** achieved a huge growth. While in the 2012-2016 period, together with Huawei Marine, they were market leaders with a market share of 30% -30%, the company **more than doubled its market share in recent years by reaching 73%.** Besides SubCom, **ASN has been a significant player** and NEC has appeared as well. Huawei Marine, Nexans and Xtera did not supply any cables in the examined period.

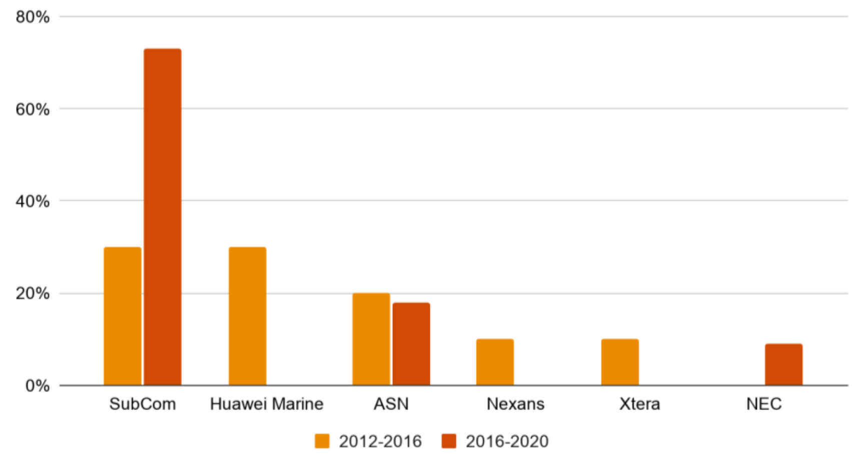

Figure 43: Market leaders in terms of supplied EU connected cables

3.3.2.3. Installers

Due to the closely related activities of suppliers and installers, there is a large overlap between market players. Accordingly, in the period of 2016 to 2020, 67 new cables have been deployed globally and based on announced information, the **market leader in terms of number of installed cable systems was ASN with** 19 new cable systems. **This is a 11.3 percentage point growth** compared to the period of 2012 to 2016 **and thanks to this increase they dominate the market with a 41.3% market share.** Behind ASN, **SubCom has been the next busiest** with 7 cable systems implemented, however, Global Marine, IT International Telecom and Orange are also significant market players. In terms of length of installed cables, SubCom and ASN have been the market leaders. **The largest decrease had to be faced by Huawei Marine.** While they were key players in the period of 2012 to 2016 owning 10% of the market, they were pushed back to 2.17% in the past five years. The remaining companies are about equal in system activity. This compares well with regional capability, as those who can serve the most regions tend to be the busiest.[164] [165]

[164] Submarine Telecoms Report: Submarine Telecoms Industry Report
[165] Submarine Telecoms Report: Submarine telecoms Industry Report - Issue 5

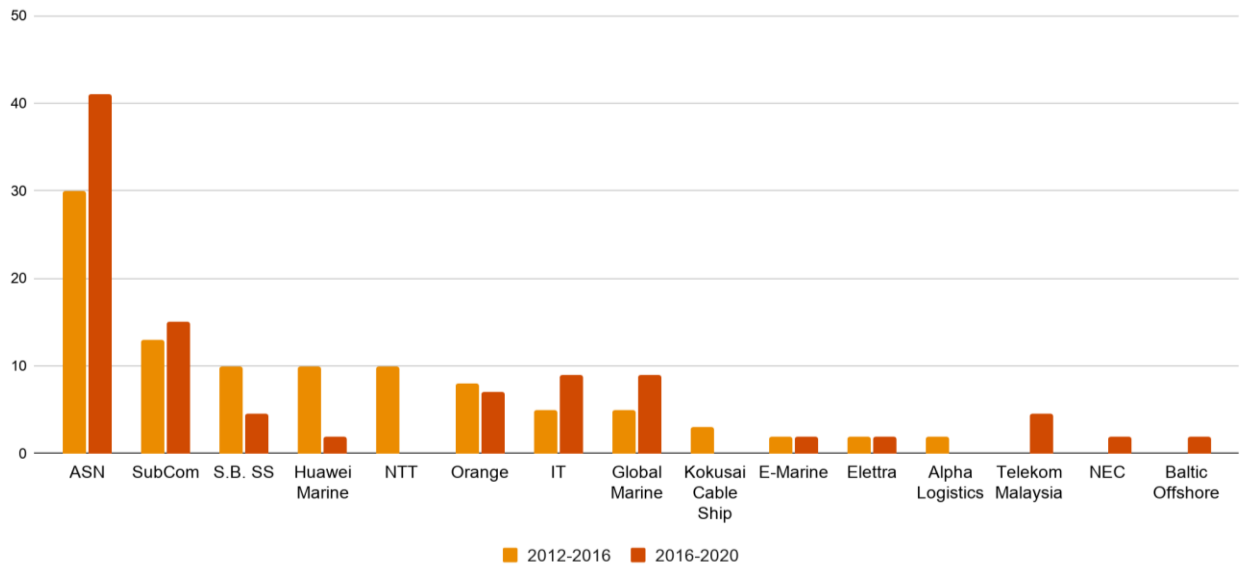

Figure 44: Number of systems installed by company

Furthermore, the **number of cable ships owned** does not correspond to the amount of system installations performed per company. However, it **is also an important aspect to examine because the more cable ships a company owns, the more capacity they have for new installation projects**. According to announced information **ASN, SubCom and Global Marine** own the largest portion of the global cableship fleet. Combined, these three companies account for more than one-third of the global fleet. **The largest increase was achieved by ASN,** expanding its fleet nearly threefold. Meanwhile, E-marine was pushed back from 2nd place to 4th due to the heavy investment of other competitors.

In terms of firms, their regional capabilities typically overlap. This provides a comprehensive installation experience to the submarine fibre industry. With several companies being able to serve each region, a prospective cable owner can be sure that an experienced installer will be available regardless of the timeline of their system. **However, the most active company is ASN in all regions but SubCom is also very dominant. Global Marine and Telekom Malaysia Berhad are mostly active in the Australasia region, while IT International Telecom's Focus region is the Americas**.

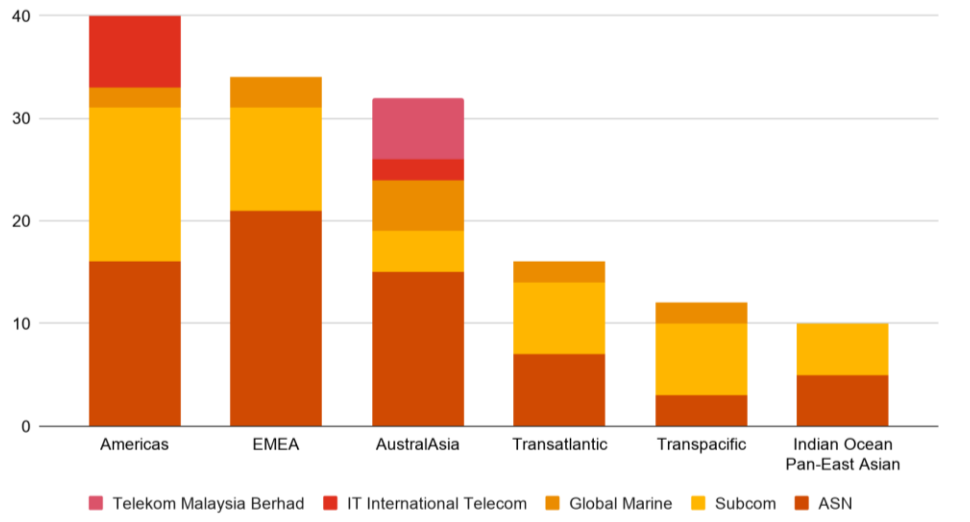

Figure 45: Number of cables installed by company in each region

3.3.2.4. Owners

Taking into account the currently active cables, built since 1989 and planned until 2025, it is clear that **the biggest owners are still traditional telecommunications service providers, however, content**

providers are on the rise.[166] There are several large cable owners among whom five companies have at least 20 cables and another 19 providers have at least 10. The market leader is **Orange** with 28 cables owned currently, **Telecom Italia Sparkle** is also very close with 27 cables. The third largest player, **TATA** Communications owns 25 cables.[167] **In terms of length of owned cable systems, the list of key market players is similar**. Of the 406 providers, 8 have ownership in at least 200,000 km of cables, while another 21 have built at least 100,000 km of cables. The market leader is Tata Communications; however, Orange and **Telstra** are not far behind either.

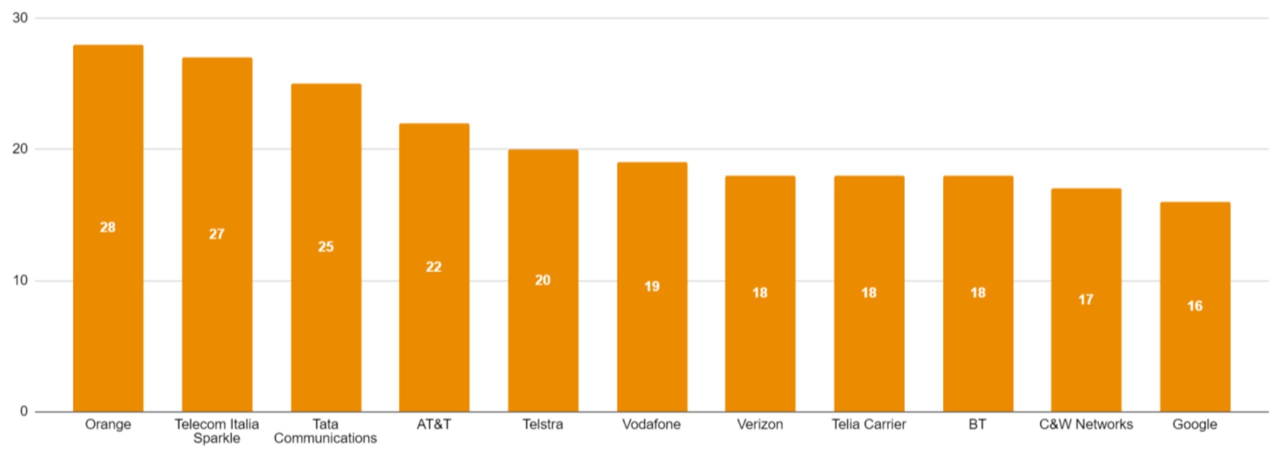

Figure 46: Market leaders in terms of number of owned active cables

However, important to note that - as of 2020 - while the cables of non-content providers (mostly traditional telecommunication companies) were on average 12.8 years old, those of content providers were only 2.5 years old. **This indicates that the cables of telecommunication companies will be withdrawn in an average of 10-15 years.**

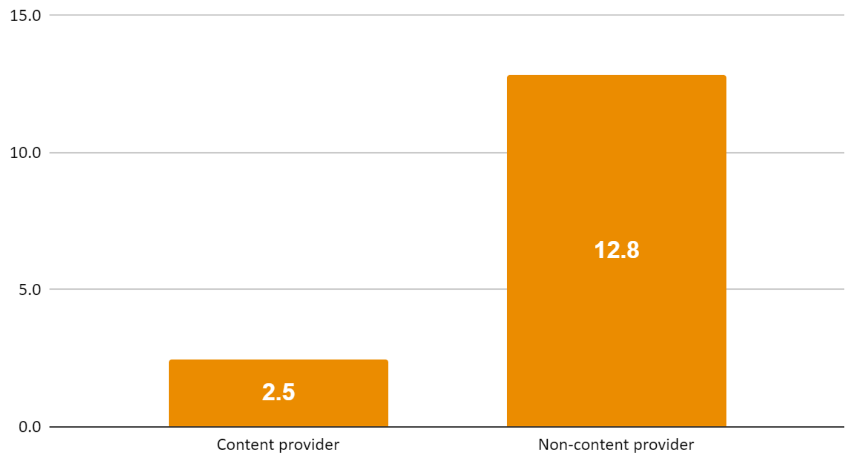

Figure 47: Average age of cables by ownership type

In recent years, a highly significant change in market trends can be observed. On the demand side, global internet traffic is growing exponentially and entails the need for significant capacity growth - as elaborated in Chapter *3.2. Drivers of the digital connectivity developments*. At the same time, on the supply side the cable ownership structure is undergoing a significant transformation and changes the traditional business model. **By 2017, content providers had surpassed internet backbone providers as the largest users of international capacity.** Having accounted for less than 10% of total usage prior to 2012, content providers' share of total capacity surged to 64% in 2019 (Figure 48).[168] This is the main reason why content providers started building their own cables.

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166 Single owners and consortium owners are equally included in the analysis of ownership structure.
167 TeleGeography: Submarine cable Map
168 TeleGeography Blog: A Complete List of Content Providers' Submarine cable Holdings

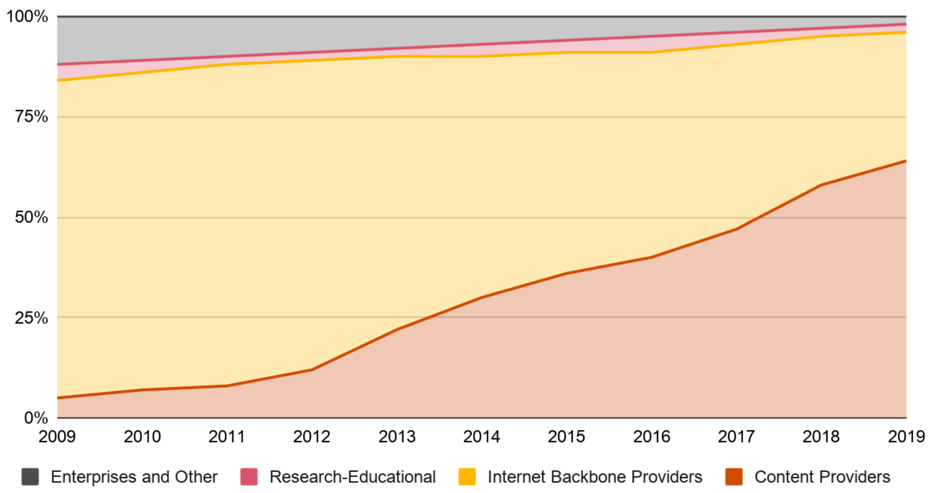

Figure 48: Used international bandwidth by source

The two largest content providers - Google and Facebook - have grown to become two of the most significant owners of new cables in the period of 2016 to 2020. It is important to note that streaming service providers are an exception because they deliver one-way static videos and their video library does not change every minute, hence customer needs can be predicted effectively. These companies, like Netflix and video providers have rather been investing in the so-called edge networks or Content Delivery Networks.

According to interviewed experts, while a traditional telecommunications service provider invests on average around $50 million a year into submarine cables, a content provider is investing over one billion yearly. **However, not only the level of investment but also the motivation differs for the investors.** Telecommunication carriers traditionally build business cases to attract customers and their goal used to be to reach the least expensive possible units that still provide reliable connection. Capacity then was resold, and a big percentage of their revenues used to come from content providers. However, as content providers have started building their own networks, these revenue streams are now at risk. **This also indicates that a huge part of traditional internet service providers' business model has changed as their revenue streams disappeared, and they need to reassess their role in the market. In the period of 2016 to 2020, content providers were the driving force behind 36% of systems that went into service** - in terms of investment value - **which is 16 percentage points higher compared to the period 2012 to 2016**.

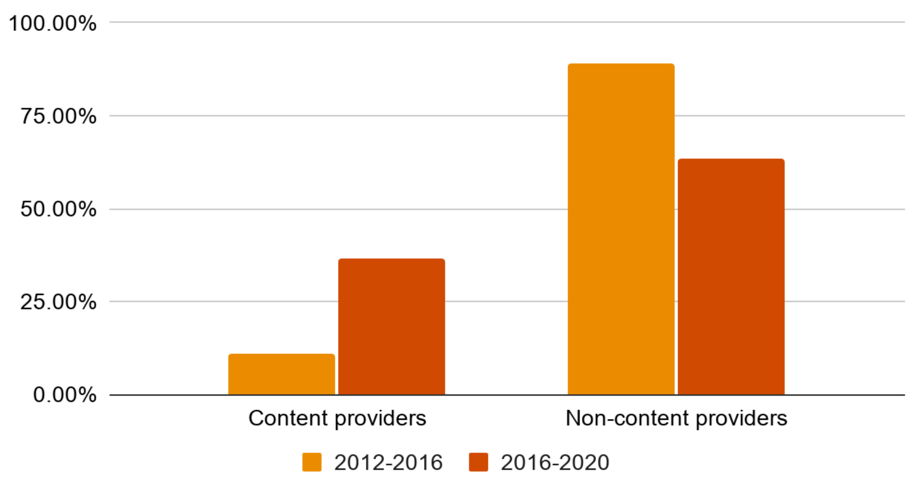

Figure 49: Systems driven by owner types

Content providers have significant funds for investments, therefore they are not limited to short term business considerations. Facebook and Google **build cables for their own use** and their aim is to connect their own data centres. They want to ensure that the infrastructure is reliable and if they do not

invest enough it will constrain their growth. Thus, they would rather overinvest than not be able to serve their user's demands at least on the same level as their competitors. Besides, content providers have also started shifting the focus from city-to-city connections to data centre-to-data centre connections. Unlike traditional cable owners, they do not necessarily need to build infrastructure in locations with a variety of interconnect options. Instead, they favour locations that provide economic and cost saving benefits to reduce the operational expenditure impact of their data centre facilities. The arrival of a major content provider not only brings new telecoms infrastructure to a region but also the cloud services that the company provides.

The most relevant content providers investing in new submarine cables are Google, Facebook, Microsoft and Amazon. Among these four, **Google owns the major share** of more than 90,000 km of active submarine cables. Besides, other companies such as Apple, LinkedIn (now owned by Microsoft), Dropbox, IBM, OVH, Chinese content providers (including Alibaba and Tencent), content delivery networks (including Akamai, Cloudflare and Limelight) and many others are also entering the market.

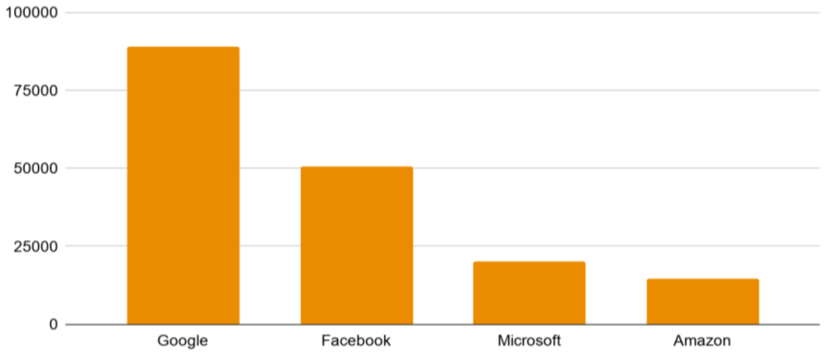

Figure 40: Length of cable systems owned by the largest content providers

As a result, in terms of the ownership structure of submarine cables, in the period of 2016 to 2020, the **market leaders have been mainly content providers and Far Eastern-owned telecommunications service providers, especially from China.** The role of content providers is particularly noteworthy because they were not even among the top 10 owners in the period of 2012-2016, while **in the past five years Google built 10 new cables - twice as many as the second largest owners,** China Telecom, China Unicom and Facebook.

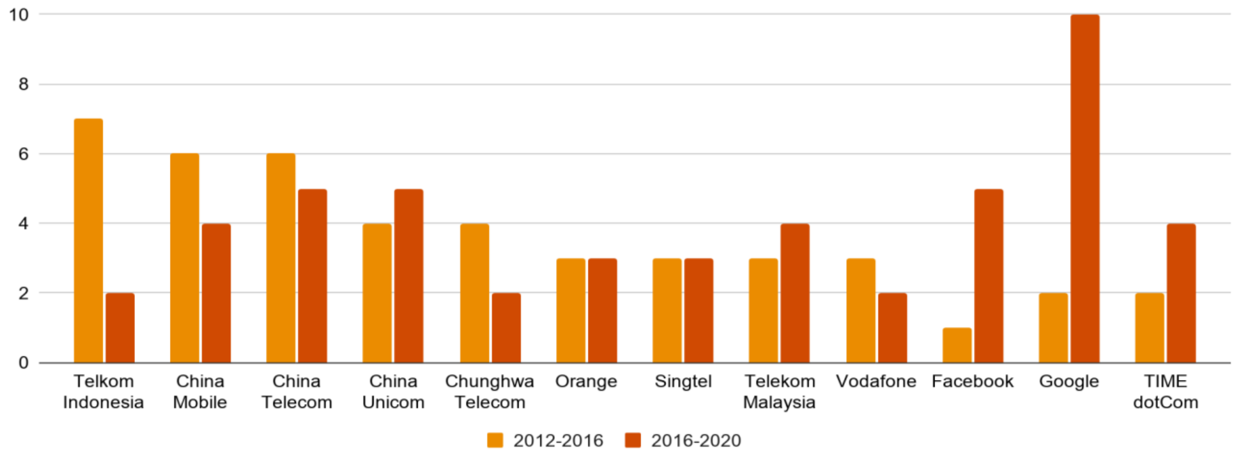

Figure 51: Market leaders in terms of number of new owned cables

In terms of length of owned cable systems, the same pattern appears: Far Eastern-owned companies already had a high market share in the 2012-2016 period, while content providers, especially Google, only burst into the submarine cable market in the last few years. In the 2016- 2020 period, China Unicom - an actor who used to be the 7th strongest player - had the highest market share, owning 78,850 km of new cables. The second place was taken by Google while China Telecom, who used to be the strongest player, took the third place.

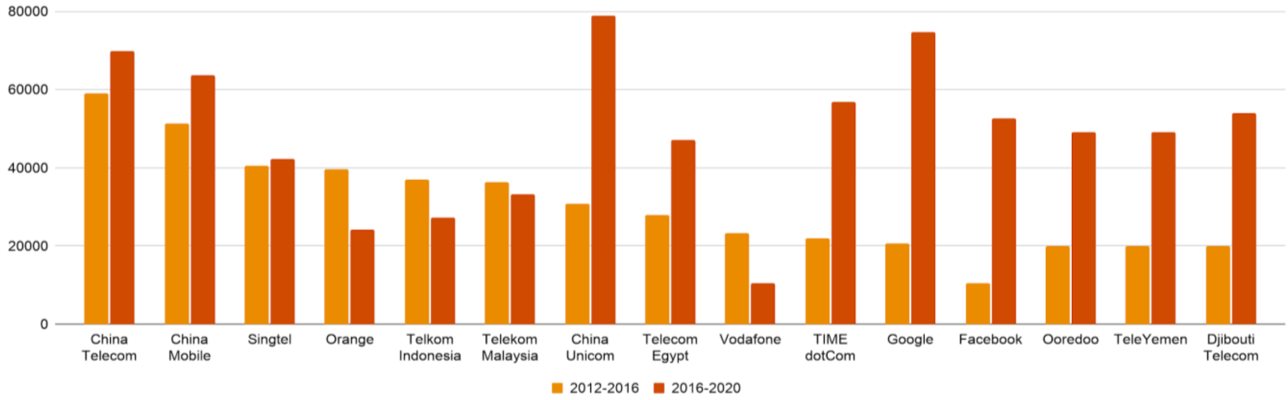

Figure 52: Market leaders in terms of km of new owned cables

In the 2016 to 2020 period, **content providers have been the most active in the Australasia region,** however, the Transatlantic, the Transpacific and the Americas regions have been busy as well. **This is a large-scale expansion in terms of both regions and the number of new cables within regions compared to the previous period.** Chinese telecommunications service providers are active all over the world except the Americas region, but their growth rate is less significant.

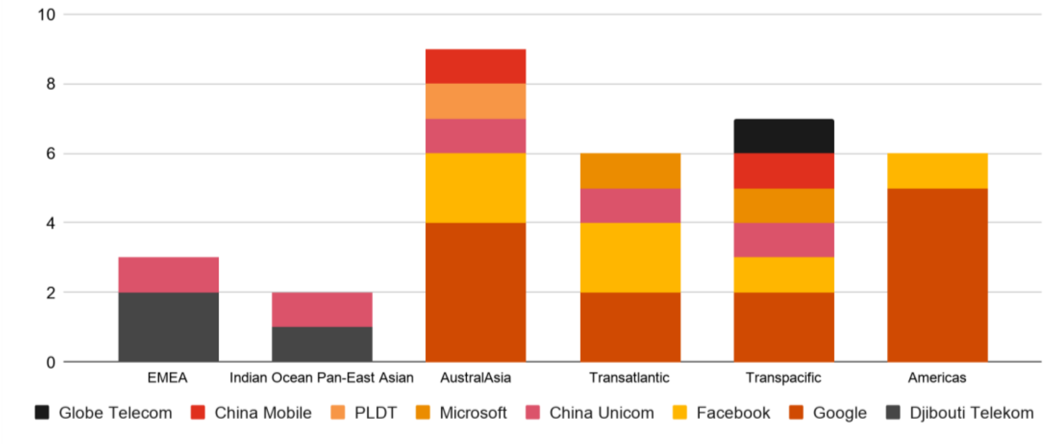

Figure 53: Number of main owners' new cables by region

In terms of all active cables - built between 1989 and 2020 - **the ownership structure of cables connected to the EU is very diverse**: a total of 61 companies have EU connected cables. Out of these, **TATA stands out, while Telxius and Google are also among the top three.**

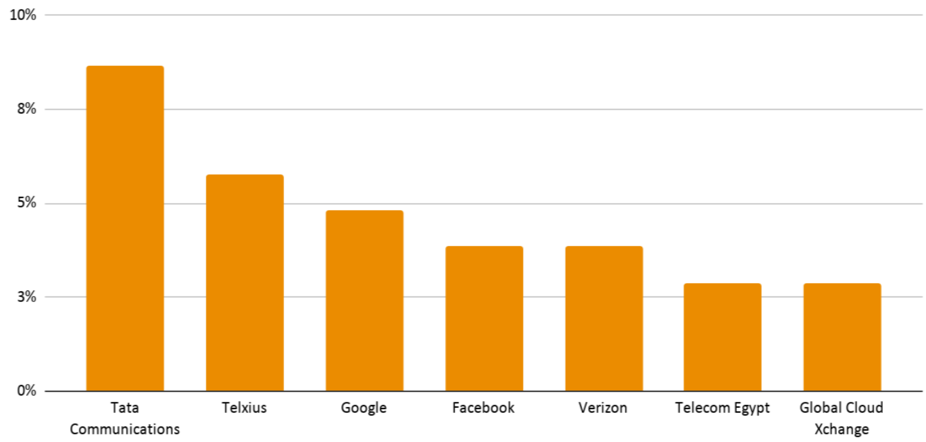

Figure 54: Market leaders in terms of all active, owned EU connected cables

Furthermore, the activity of the last ten years also shows that it is a very diverse market - telecommunications service providers tend to build one cable per period. However, as seen below, **content providers have become very strong in the EU.** While Google and Facebook were not even

active in the period of 2012 to 2016, between 2016 and 2020 they built two cables each. **The strengthening of their activity is particularly significant: in terms of all currently active EU connected cables they own only 11% of the cables, however, regarding cables built between 2016 and 2020, they own 36% already.**

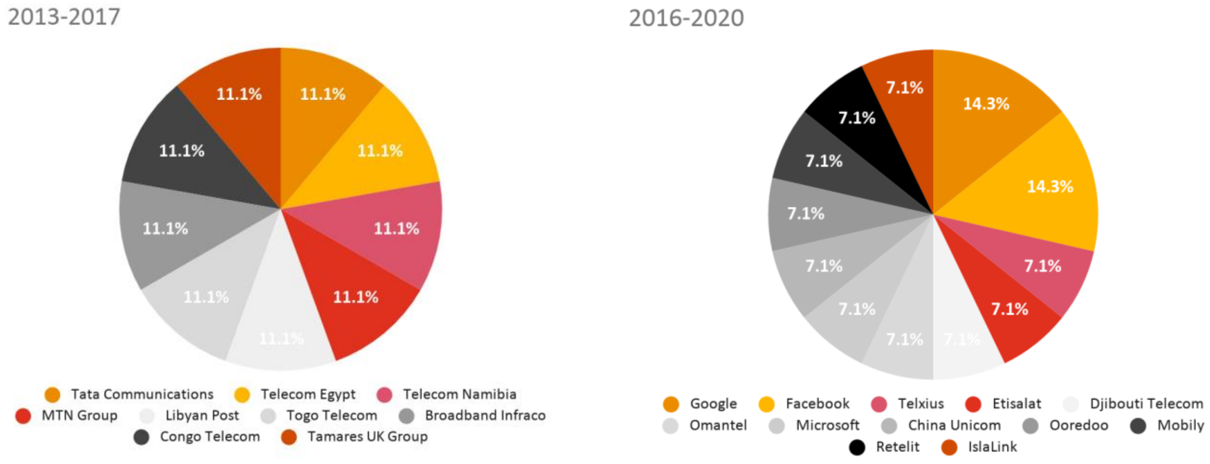

Figure 55: Market leaders in terms of owned EU connected cables

3.3.3. Financing and investments

Investment in international connectivity is growing steadily and **submarine cables are financed in three ways. They can be investments by multi investors, by single investors or financed with the help of Multilateral Development Banks. The multi investor model has been the most common financing model by far, however, in recent years, the single investor model has started gaining significant popularity** due to the growing number of content providers entering the market with their own cables. Furthermore, as most telecommunications service providers cannot afford to build their own network, there are also an increasing number of joint developments - hybrid model - with content providers.

Both multi and single investor investments are the highest in the Australasia region. Nevertheless, in case of multi investors, there has also been a large amount of investment in the Indian Ocean Pan-east Asian region, whilst single investor investments have grown significantly in the Americas. At last, nearly half of Multilateral Development Bank investments have gone to the EMEA region.

Financing models:[169]

- **Multi investor**: In the multi investor model, **multiple market players cooperate in order to build a common cable on a given route and then share capacity**. These investments are **typically self-financed,** and this is the most common type of financing. Generally, the owners use a prospective system for their own traffic, diversifying risk generally through self-finance among its members and affording a range of expertise.
- **Single investor:** The second most common type of financing and the one that has started to grow intensively in recent years is the private ownership model. These cables are usually **financed through a combination of an investment bank capital and capacity pre-sales and consist of a single or very few owners.** Submarine cables offer tremendous economies of scale, so it is often worth investing in the optical technology to support significantly more capacity than a single firm needs, then reselling that capacity to others.[170]
- **Public Private Partnership (PPP)[171]**: There are also projects implemented jointly by private and public actors, where public authorities are most typically Multilateral Development Banks (MDBs). However, their size and frequency are still marginal compared to the other two models. MDBs usually offer lower interest rates and more flexible terms than commercial financing but this type

[169] Submarine Telecoms Report: Submarine Telecoms Industry Report
[170] ITIF: Submarine cables: Critical Infrastructure for Global Communications
[171] Salience Consulting: Submarine Cables: Structuring and Financing Options

of funding can also lead to higher administrative burdens. MDB investment has been sporadic since 2010, accounting for only a handful of systems. An as example, some of the most recent projects are listed below:

- The **Asian Development Bank** approved a total of $36.6 million in grants to help fund the delivery of the Improving Internet Connectivity for Micronesia Project in 2019.
- The **Australian Government Official Development Assistance** provided two-thirds majority funding of the Central Sea submarine cable system to support the economics of Papua New Guinea and the Solomon Islands, also in 2019.
- The government of Cook Islands has requested the **Asian Development Bank** to support a $37 million submarine internet cable project, which links the islands of Rarotonga and Aitutaki in the Cook Islands to Samoa.

Global investments

The industry has invested nearly $50 billion in 324 submarine communication cables since 1990. As investments in the industry react very sensitively to economic changes, they varied significantly year by year in the past 30 years. The investments were especially high around 2000, with the peak point being 2001, when the amount of system investments was $7.7 billion. This is considered an overinvestment that was followed by a financial crash. The economic crisis in 2018 and the oil price crash of 2014 also resulted in significantly decreasing system investments.

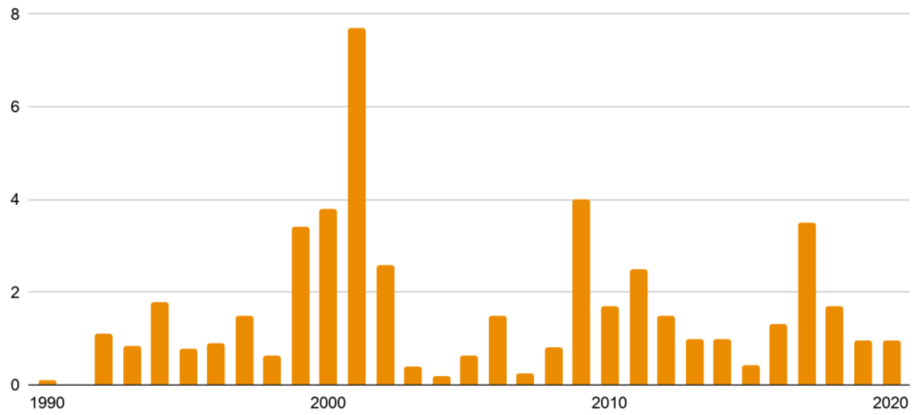

Figure 56: System investments (billions of $)

In the period of 1990 to 2020, almost 90% of this total investment has been made by multi investors, while single investors and PPP systems have accounted for 6% and 5% of total investment respectively. Comprising more than 1.3 million km in total and averaging $1.6 billion worth of investment annually.

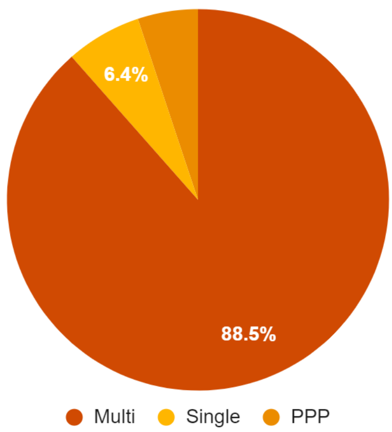

Figure 57: Distribution of financing models by investment value

However, in terms of number of cables built, only 32% of the cables were built by multi investors. **This implies that multi investors traditionally build fewer, yet longer and more investment-intensive cables.**

More recently, in the 2016 to 2020 period, the industry has invested $8.4 billion in submarine telecoms cables and over 67,000 km per year. Multi investors account for 61% of total investment, which is 10 percentage point lower compared to the period of 2012 to 2016, while **single investor investments have increased by 10 percentage point, reaching 28%.**[172] As for most telecommunications service providers it is not viable to build their own network, **there are an increasing number of joint developments with content providers.**

Current examples of developments representing those trends:

- Facebook, STC, China Mobile, Telecom Egypt, Orange, and Viacom are jointly investing in 2Africa with ASN.
- EllaLink is an instructive example for hybrid funding. The main equity provider of the cable is Marguerite, a Pan-European infrastructure fund. The EU has invested €26.5 million within the BELLA consortium (Building the Europe Link with Latin America) for a 25 Tbps capacity in the EllaLink cable.

In terms of PPP funding, it can be stated that their share is not increasing significantly for two reasons. MDBs and investment banks such as the EIB or the World Bank only provide funding if the viability of the project initiative can be demonstrated. Content providers typically do not take advantage of the opportunity because public funding usually increases the complexity of the projects and the administrative burden while content providers prefer simpler and quicker solutions.

Regional investments

Over the period of 2016 to 2020, the largest investment has been made in the Australasia region, accounting for 26%. **This is a significant increase, as in the period of 2012 to 2016 it was only 15%**. The second most popular is the **EMEA region** even though the region **had to face a 17 percentage point decline**. The Indian region also did not receive as much investment as before, reducing the rate of investment from 23% to 17.91%.

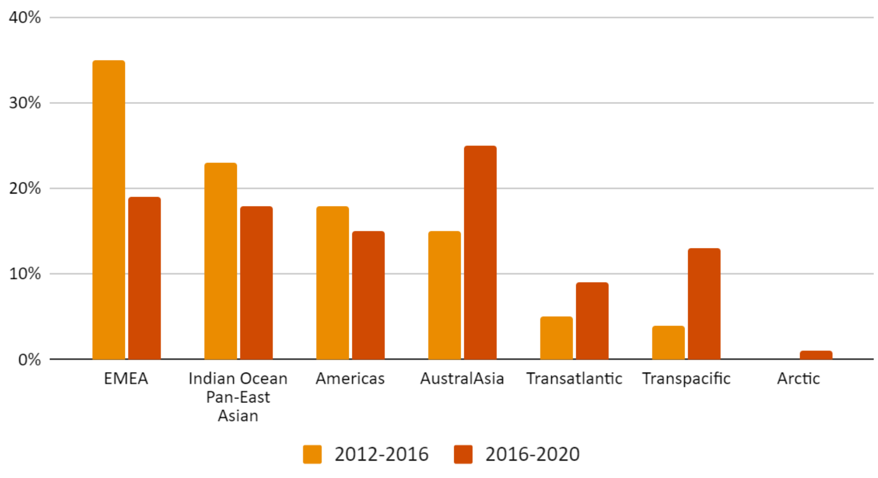

Figure 58: Regional investments in submarine cable systems (%)

In terms of financing models**, multi investor investments have grown greatly in all regions in the period 2016 to 2020. There has been a strong focus on the Australasia region** which is the most traditional region as it mostly consists of traditional ISPs - for example Singtel in Singapore, NTT, or China Mobile, China Telecom in China - while content providers still have to go through traditional carriers if they

[172] SubTel Forum: Submarine Telecoms Industry Report

want to buy capacity. Other focus areas have been **the Indian Ocean Pan-East Asian and the EMEA regions where investments have also significantly increased compared to the period of 2012 to 2016.** Although the total value of investments lags behind in the previous three regions, it is also worth keeping an eye on the Americas and the Transatlantic regions. While investment has tripled in the Americas region, a significant amount of investment appeared in the latter for the first time.

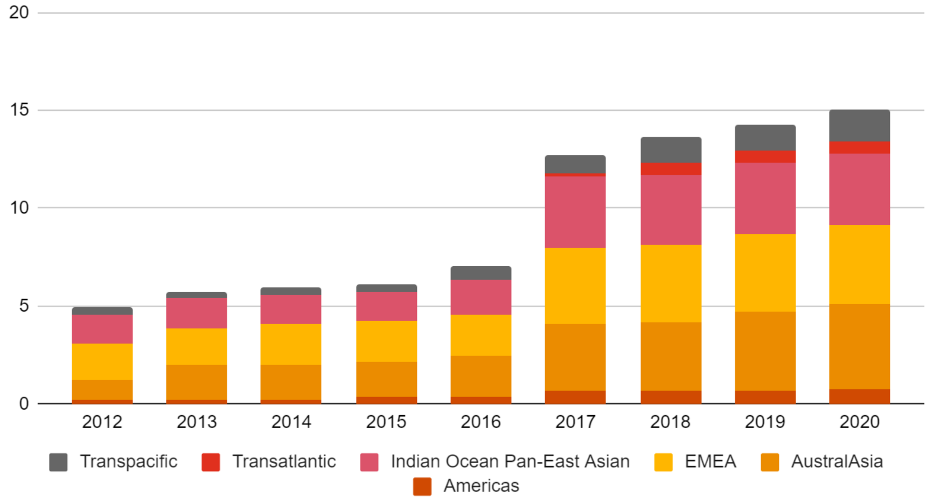

Figure 59: Regional distribution of multi investor investments (cumulated value, billions of $)

Single investor investments have also grown in all regions in the period 2016 to 2020, especially in the Americas and the Transatlantic regions. The most investment happened in the Australasia region in the period of 2016 to 2020. The investment also has tripled in the Transatlantic region, although its total value lags behind that of the larger regions. They have started in the Transpacific and Arctic regions as well.

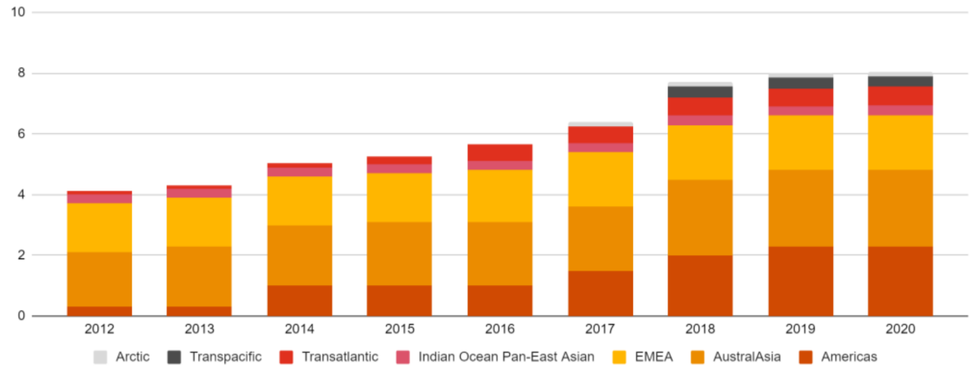

Figure 60: Regional distribution of single investor investment (cumulated value, billions of $)

In the case of PPPs, most of the investment (46%) has been made in EMEA with a focus on systems located primarily in Africa. 20% went to the Americas region and 19 % to the Transatlantic submarine cables. Only 15% of total PPP investment has been made in Australasia in the period of 2005 to 2020. There have been no investments in the Transpacific and Indian Ocean Pan-East Asian regions.

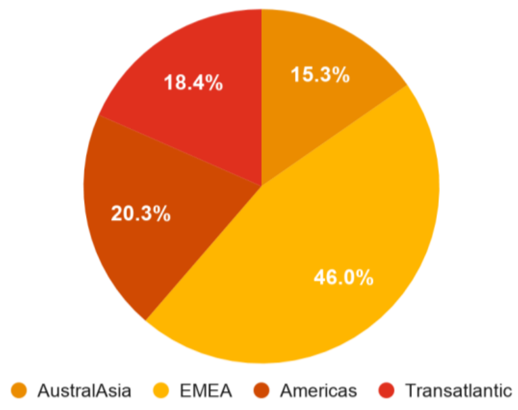

Figure 61: Regional distribution of PPP investments since 2015

3.4. Regulatory environment and international partnerships

Summary - Regulatory environment and international partnerships

Currently, there are only broad and general international treaties and varying national level regulations on their construction, landing rights and development. There is a fragmented regulatory landscape and there is a growing need for a comprehensive, and consolidated regulatory framework for international connectivity, and balanced, fair and transparent contractual conditions and similar approaches for submarine cable landing rights or accessibility. **There is a need for a comprehensive, common EU approach towards the regulation of submarine cable landing and accessibility rights that ensures the integration into the global ecosystem and maintains the EU Digital Single Market and sovereignty.** The EU has already taken steps towards its objective, the enhancement of international connectivity, as well as the EU digital sovereignty, and security with partnerships (e.g. Connecting Europe and Asia: Building blocks for an EU Strategy), and regulations (e.g. GDPR).

Sound regulatory frameworks and cross-continental partnerships are essential in establishing fair market conditions for international digital connectivity. The chapter aims to assess the regulatory and strategic perspectives of the EU in connection with international connectivity partnerships and EU sovereignty, and provide an overview of the international and national level regulatory background of submarine cable infrastructures. The main topics to be covered are the following:

- **EU partnerships:** Assessment of the EU partnerships, strategies and regulations that reflect key EU objectives, and aim at strengthening the EU Digital autonomy, while at the same time, enhancing international connectivity.
- **Regulations and treaties related to submarine cable infrastructure:** An overview of international treaties related to submarine cables and regulatory environment concerning the development and licensing of submarine cables.

3.4.1. EU approaches and partnerships

The EU is highly committed to be an indispensable part of the international connectivity ecosystem, share best practices, and help the continuous improvement of the world economy directly. International digital connectivity is one of the key pillars of the global economy, and hence has a significant impact on the competitiveness and position of each country and region. EU plays an active role in the ecosystem by creating partnerships, strategies, and engagements in order to achieve these objectives:

Digital economy dialogue between the EU and several countries: official dialogues on digital policy and regulation take place regularly between the EU and the following counties: Argentina, Australia, Brazil, Canada, China, India, Japan, Mexico, Republic of Korea, Taiwan, and the United States. Furthermore, there are also ad hoc bilateral policy exchanges with other countries and exchanges at region-to-region level between the EU and African Union, Western Balkans, Eastern Partnership ASEAN and the Pacific Alliance. For instance:

- **EU-Africa cooperation:** covers several fundamental areas of development, including the work of the EU-Africa Infrastructure Trust Fund (EU-AITF), which supports the improvement of interconnectivity through the enhanced access to energy, transport, water, sanitation, and communication services.[173]

[173] EC: International Partnerships - Africa-EU Cooperation

- **The EU-African Union Digital Economy Task Force (EU-AU DETF):** works actively to harness the digital transformation in the African continent guided by EU support.[174]
- **The EU-ASEAN digital cooperation** includes support to the development of an ASEAN digital index (ADIX), technical and regulatory workshops and support to the Master Plan on ASEAN connectivity.
- **Eastern Partnership (EaP):** includes six eastern EU Neighbours whose goals, together with the EU, is to share the experience of the EU Digital Single Market and advance the digital economy in the EaP region. It consists of initiatives such as the Broadband Strategy in the EaP region[175], and the Eastern Partnership Connect.[176]

While being an integral part of the global connectivity market, the EU also aims to ensure a secure data economy for its citizens and establish digital sovereignty and a digital single market. These intentions are reflected in many of the EU regulations established in the last few years:

- **The General Data Protection Regulation (GDPR)** is an important step towards the establishment of fundamental rights in the digital age. It eliminates the fragmented Member State level legislations and secures the data of EU citizens that is facilitating the development and reservation of the Digital Single Market. It is considered as Europe's flagship data regulation, establishing a higher level of trust among foreign partners.[177]
- **The European Electronic Communications Code (EECC)** is a continuation of Article 13a and Article 13b of the Framework Directive, and strengthens the regulatory environment of the telecommunication sector by including major security supervision changes, such as the incorporation of content providers in the EU telecom rules; establishment of EU-wide definition of security requirements; requirement of state-of-the-art measures to protect privacy; proactive mitigation of cyber threats; and the incentivization of Member State level cooperation among authorities for better cybersecurity, more secure EU data economy.[178]
- **The Directive on Security of Networks and Information Systems (NIS Directive)** helps in enhancing the level of cybersecurity in the EU, and ensures that EU Member States have strong governmental bodies supervising cybersecurity, cross-border collaborations are established, and that there is a sound culture of security requiring operators of essential services to take appropriate security measures.[179]

To ensure the improvement of international connectivity, but at the same time, respect the EU's approaches, values and digital sovereignty, the EU has already taken steps through fruitful partnerships:

- **Connecting Europe and Asia: Building blocks for an EU Strategy,** (2018). The EU strategy is a Joint Communication to develop sustainable, comprehensive, rules-based connectivity between the two regions through interoperable transport, energy and digital networks. The partnership aims to promote three key approaches to connectivity:
    - **Sustainable Connectivity** - Ensuring economical, fiscal and social sustainability through market efficiency, job creation, decarbonisation, transparency, good governance and public consultations.
    - **Comprehensive Connectivity -** Taking people's interests and rights, the crucial human factors into account and putting them into the centre of policies.
    - **Rules-Based Connectivity** - Promoting open, transparent, and non-discriminative regulations to enable efficient and fair interoperability of networks, and create a level playing field for stakeholders.[180]
- **The Partnership on Sustainable Connectivity and Quality Infrastructure between the EU**

[174] EC: Shaping Europe's Digital Future: Africa
[175] EU4Digital: EU4Digital: Broadband Strategies in the EaP region
[176] EU4Digital: EaPConnect
[177] EC: Data protection in the EU
[178] ENISA: Security supervision changes in the new EU telecoms legislation
[179] EC: Shaping Europe's Digital Future - The Directive on security of network and information systems (NIS Directive)
[180] EEAS: Connecting Europe & Asia: The EU Strategy

and Japan (2019) **and India** (2021). The partnership highlights the importance of sustainable connectivity and confirms the commitment to the implementation of 2030 Agenda for Sustainable Development. Furthermore, the cooperation aims to improve sustainable digital connectivity through policy and regulatory frameworks, digital and data infrastructures, and emphasizes the significance of open, free, stable, accessible, interoperable, reliable and secure cyberspace, and the data free flow with trust (DFFT).[181]

3.4.2. Regulations and treaties related to submarine cable infrastructure

Submarine cables have been protected by international treaties since the 19th century:

- **The International Convention for the Protection of Submarine cables (1884)** - The multilateral treaty is the first to protect submarine cables. The treaty made the damage, break or injury of the submarine cable a punishable offence.[182]
- **The United Nations Convention on Law of the Sea (UNCLOS) (1982)** - The convention replaced **The Geneva Convention of the Continental Shelf and High Seas**, which codified the definition of 'the high seas' in 1958, the rights of Coastal States and the access to the sea for landlocked countries among others. The UNCLOS replaced the older concepts of the freedom of sea and set new limits, such as the internal waters, territorial waters, archipelagic waters, contiguous zones, exclusive economic zones, and the Continental Shelf. It includes the rules and rights to lay submarine cables in each area, the freedom of high seas, the consequences of injuring cables, the rights and duties of distinct states in terms of existing submarine cables.[183]

The EU pays a growing attention to critical digital infrastructure and expresses the need for appropriate cybersecurity measures in place.[184] For the period of the rotating presidency, the Portuguese Presidency of the Council of the EU has also set a trajectory emphasizing digital competitiveness and incentivizing a European data gateway platform based on submarine cable links to ensure the EU digital autonomy, whilst increasing data protection.[185]

There is no comprehensive regulatory framework that ensures balanced, fair and transparent contractual conditions and similar approaches for landing rights or accessibility yet. The treaties and directives set the foundation for generally accepted rules and norms. However, there is a fragmented regulatory landscape of specific landing and accessibility rights worldwide and also in the EU, as the applicable rules differ across countries.[186]

- In the United States, there are stringent rules applicable to all operators applying for submarine cable landing licenses, as the owners of cable landing stations, as well as the affiliation of consortium partners are strictly monitored.[187]
- For Africa, all countries charge for the landing rights of submarine cables except for the EU.
- There are different challenges coming from EU Member State level rules as well. Different regulations and processes are in place, relevant for submarine cable system development and operations, such as the terms of permitting landing rights, entering in the landing stations or for the protection of the cables. In addition, the support of governments and different authorities varies across the EU Member States.[188]

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[181] EEAS: The Partnership on Sustainable Connectivity and Quality Infrastructure between the European Union and Japan
[182] Convention for the Protection of Submarine Telegraph Cables
[183] United Nations Convention on the Law of the Sea
[184] European Commission: Proposal for a Directive of the European Parliament and of the Council on measures for a high common level of cybersecurity across the Union, repealing Directive (EU) 2016/1148
[185] Portugal's Council Presidency: Mapping the Priorities and Some Thoughts on the Outlook
[186] Information received through expert interviews.
[187] Information received through expert interviews.
[188] Information received through expert interviews

The difference between the national level regulations serves as a challenge and risk in both regulatory and business perspective. The procedures of getting permissions and licenses on building or landing submarine cables is becoming increasingly challenging as countries develop stringent and distinct regulations. This slows down all procedures which also affects business decisions as there are examples of denied or delayed permissions, resulting in changes to project plans. Due to the lack of common, comprehensive regulatory requirements, the EU does not have adequate rights to control Non-EU operators and owners. The absence of such a common approach could put the fair and balanced market, the EU digital sovereignty and the security of citizens' data into jeopardy.

Submarine cables are not considered as critical infrastructure, thus there are no incident reporting requirements and common cybersecurity approaches. The European telecommunication market is regulated strictly as critical infrastructure. However, the submarine cables systems are not part of this category, and lack the regulation in terms of cyber security, service continuity and fair market conditions. In addition, in certain cases the EU is not in a position to regulate non-EU operators and owners, which increases the EU's dependence on them.

A comprehensive, common EU approach towards the regulation of submarine cable landing and accessibility rights would ensure the key goals of the EU to help in the improvement of international digital connectivity as an integral part of the global data economy, and maintain the EU Digital single market and sovereignty.

4. Future trends and forecasting

4.1. Drivers of digital connectivity developments

Summary - Drivers of digital connectivity developments

The growth of internet traffic is indisputable. However, it is important to have a clear understanding on the extent of growth, since it contributes to a better understanding of the future digital connectivity infrastructure developments.

Based on the forecast the global internet traffic is expected to grow more than 6-fold by 2030, reaching 1,629 exabytes/month. Consumer and business internet traffic are expected to grow on an absolute level, however, their share is expected to decrease, since one third of the internet traffic is projected to be generated by M2M connections.

The Middle East and Africa region's share in the total traffic is forecast to increase the most by 2030, however, the internet traffic will increase on an absolute level in each territory.

Every factor that influences the internet traffic is forecast to increase:

- **The internet penetration is projected to reach 93.9% by 2030.** However, this immense growth of internet penetration presumes considerable infrastructural developments and improvements in the affordability of the internet, especially in digitally underserved regions.
- **The number of devices is projected to increase, reaching on average ca. 5 devices per capita by 2030.**
- Assuming a steady growth rate the **internet traffic generated from video is expected at least 3.4-fold** growth by 2030, however, in case of a more dynamic growth it can reach **even a 6.2-fold growth.**
- The average time spent online by users is expected to reach **~6 hours in 2030,** doubling the 2020 average amount of hours spent on the internet.

The increasing IP traffic entails the **need for more data centres and faster connection between them.** The hyperscale data centre market is forecast to grow continuously, which will be driven mainly by cloud service providers / OTTs. Major content providers operate and plan to launch several hyperscale and high power data centres in Europe. However, in order to remain competitive as a global data manager and provider and to decrease the dependencies on foreign players, there might be a **need for increasing the capacity of EU data storage and processing services.**

Operation of data centres requires a considerable amount of energy, which besides representing significant operational costs, has **negative environmental impacts.** Therefore, in the future there will be a huge focus on increasing sustainability of operation, which can be also seen in the increased interest for the Arctic region.

4.1.1. Internet traffic forecasting

The growth of internet traffic is unquestionable. The trends of increasing internet penetration, growth of connected devices, increase of time spent on the internet and the shift of the content type consumed there indicate further growth in internet traffic. However, it is important to understand the extent of growth, since it contributes to a better understanding of the future digital connectivity infrastructure developments that will be necessary to serve the increasing demand for internet traffic.

The global internet traffic is expected to grow 6.4-fold by 2030, reaching 1,629 exabytes/month.[189] Based on the calculations the global internet traffic is expected to increase steeper than in the previous decade. Even in a conservative scenario the internet traffic growth rate will remain steady with 1,120 exabytes/ month by 2030. In the optimistic scenario a more ambitious growth is forecast, predicting 2,177 exabytes/ month by 2030.

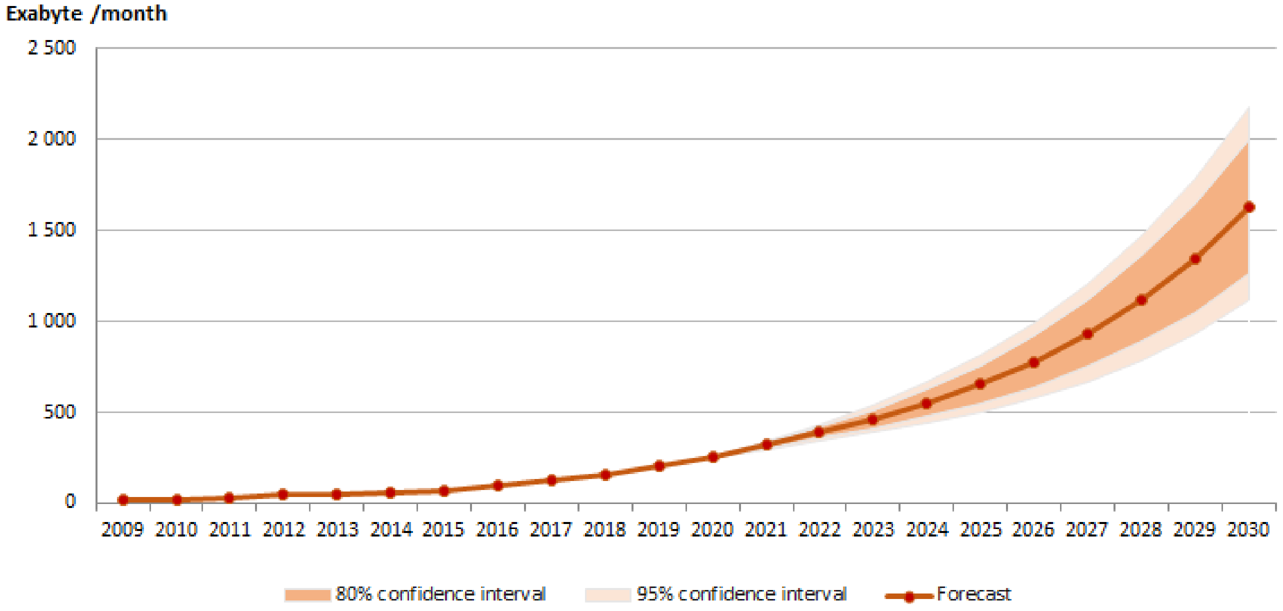

Figure 62: Global internet traffic forecast

One third of the internet traffic is expected to be generated by M2M connections. Consumer and business internet traffic are expected to grow on an absolute level. Consumer internet traffic is projected to reach 899.5 exabytes/month and the business internet traffic 178.2 exabytes/month having 4.2-fold increase. However, the relative share of consumer and business generated IP traffic is expected to decrease due to the increase of the M2M connections. Although currently the traffic generated from M2M connections is low, the forecasts indicate that it will experience a rapid growth by 2030 accounting for 33% of the total internet traffic.

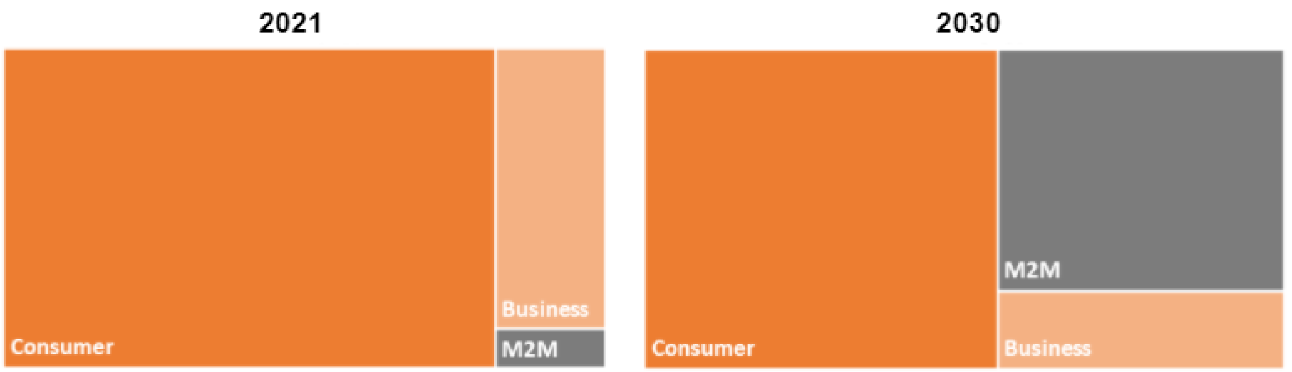

Figure 63: Internet traffic by type 2021 and 2030[190]

Although each regions' internet traffic will grow on an absolute level, the Middle East and Africa region's share in the total traffic is forecast to increase the most by 2030. The forecasts based on historical data indicate that the internet traffic will continue to grow in each region. In developed regions where the internet penetration is already high, the internet traffic increase is expected to be driven by the increasing number of digital services and the spread of several technological developments, such as

[189] The methodology used for the forecasting is included in the Annex 6.3.
[190] The methodology used for the forecasting is included in the Annex 6.3.

cloud services, IoT or UHD Video streaming. In developing regions the traffic growth is expected to be driven mainly by the increase of the penetration. On a relative level, the most increase in the share of total internet traffic by 2030 is forecast for the Middle East and Africa, due to the dynamic developments expected in the regions. The share of Europe, North America and Latin America in the total internet traffic is projected to decline with a few percentage points. According to the forecast based on historical data, Latin American region is expected to have slower pace of developments, which will affect its share of the total internet traffic.

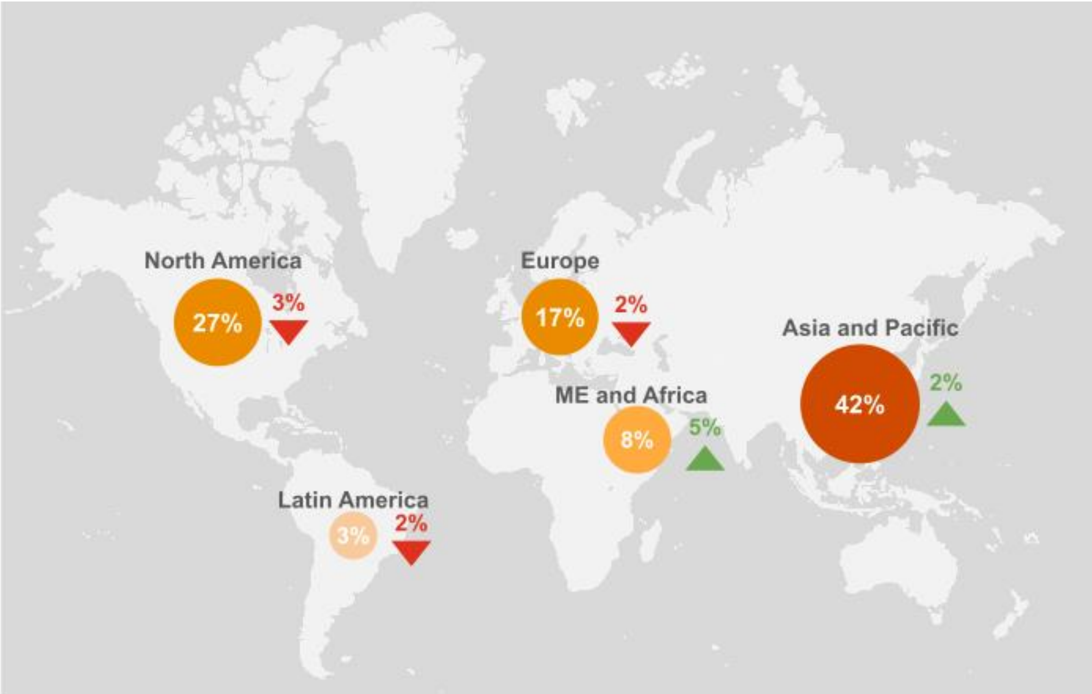

Figure 64: Changes in the share of internet traffic by regions between 2020 and 2030[191]

The noticeable differences between the internet traffic forecast scenarios are due to the fact that several factors influence the growth of the internet traffic. In the following section these factors will be presented and analysed.

4.1.1.1. Internet penetration, access and affordability

93.9% of the total population is expected to have internet access by 2030, the number of global internet users reaching 8 billion people. The internet penetration shows the strongest correlation with the amount of internet traffic, thus reaching universal internet access might have considerable effect on it. Major stakeholders, such as ITU, UN and The World Bank show strong commitment for connecting every person aged ten years and above to broadband internet by 2030. Based on the projections of historical data, this ambitious goal of connectivity is approximated by the estimations of the optimistic projection, forecasting 98.3% of penetration rate**.** The expected value based on the forecast is not significantly lower, showing 93.9% of expected penetration rate by 2030**.** The conservative scenario shows slightly slower growth, however, 89.4% of the population is expected to be connected by 2030. This result is in line with the estimates of Cisco Annual Internet Report, which predicts 66% global internet penetration by 2023.[192]

Penetration rate

[191] The methodology used for the forecasting is included in the Annex 6.3.
[192] Cisco Annual Internet Report (2018–2023) White Paper

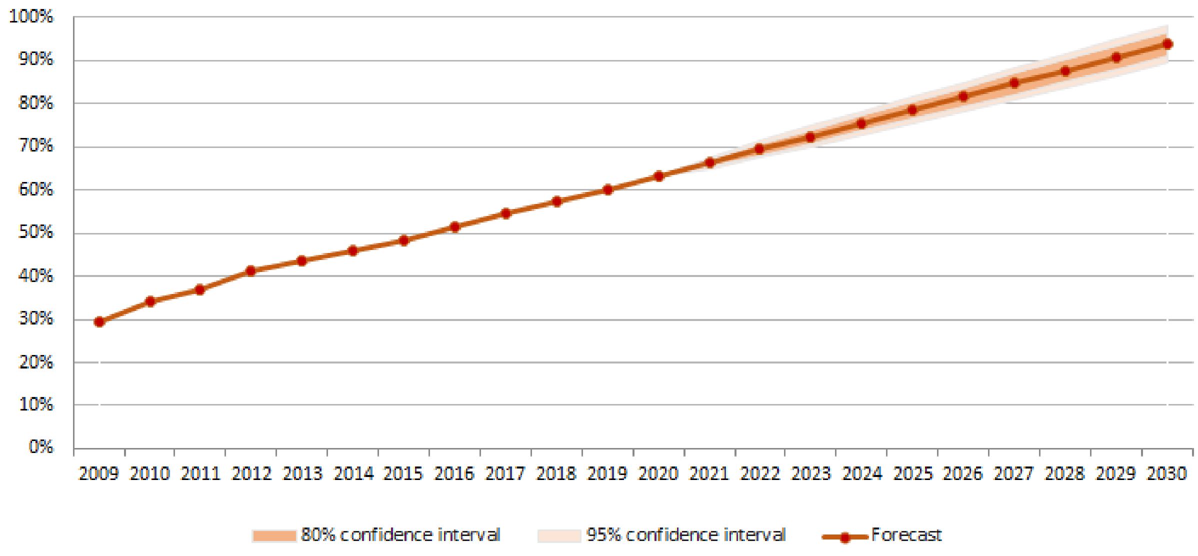

Figure 65: Internet penetration forecast[193]

This immense growth of internet penetration presumes considerable infrastructural developments ensuring accessibility and high quality of broadband internet and also improvements in the affordability of the internet, especially in digitally underserved regions. ITU's "Connect 2030 Agenda for Global Telecommunication/ICT Development**"** strategy sets ambitious targets for both bridging the digital divide and providing broadband access for every person. It comprises targets, for both infrastructure development and increase of the affordability, namely:

- "By 2023, the affordability gap between developed and developing countries should be reduced by 25% (baseline year 2017)
- By 2023, broadband services should cost no more than 3% of average monthly income in developing countries
- By 2023, 96% of the world population covered by broadband services." [194]

The infrastructural developments are expected to affect not only the accessibility of the internet, but also the average speed. Based on the Cisco predictions, global fixed broadband speeds will reach 110.4 Mbps by 2023. A more intense increase is expected in mobile speed tripling by 2023. The average mobile network connection speed was 13.2 Mbps in 2018 and it is expected to be 43.9 Mbps by 2023. [195]

In terms of affordability, A4AI's 2020 Affordability Report highlights that besides the general technological developments, strong government policy is the key to ensure the affordability of the internet to everyone. A4AI found that "US$428 billion additional funding is needed over the next 10 years to connect everyone to quality broadband by 2030".[196] The Report clearly states that this funding needs to be **paired with urgent governmental actions, including inter alia effective policy, digital skill development frameworks, strong national broadband plans and effective implementation.**[197]

4.1.1.2. Number of devices and connections

The number of devices is projected to increase, reaching on average ~5 devices per capita by 2030.[198] Cisco's Annual Internet Report estimates 8.7 billion handheld or personal mobile-ready devices by 2023. A considerable growth is forecast in the number of smartphones, from 4.9 billion in 2018 to 6.7 billion by 2023, ensuring mobile internet connections for underdeveloped regions. However, the most

[193] The methodology used for the forecasting is included in the Annex 6.3.
[194] Connect 2030 – An agenda to connect all to a better world
[195] Cisco Annual Internet Report (2018–2023) White Paper
[196] A4AI 2020 Affordability Report
[197] A4AI 2020 Affordability Report
[198] The methodology used for the forecasting is included in the Annex 6.3.

noticeable growth is expected in the category of M2M connections, such as GPS systems in cars, asset tracking systems in shipping. ITU estimates a dramatic growth in M2M traffic after 2020. Cisco forecast 4.4 billion of M2M devices by 2023, and more than 17.4 billion of M2M connections by 2023.[199] This immense amount of M2M devices and connections contributes to the following:

- **Shift in digital device mix:** Number of smartphones are projected to grow, however, their share in the connected devices is expected to decline with 5% points due to the intense increase of the M2M devices.[200]
- **A significant increase in IP traffic:** one third of total internet traffic in 2030 is predicted to be generated by M2M connections.

The number of personal computers is expected to continue to decline. However, the number of connected TVs, including flat-panel TVs, set-top boxes, digital media adapters and gaming consoles are expected to grow to 3.2 billion by 2023. This is expected to have a considerable impact on traffic generated from video streaming. According to Cisco Annual Internet Report "an internet-enabled HD television that draws three hours of content per day from the internet would generate as much internet traffic as an entire household today, on an average."[201]

4.1.1.3. Video consumption

Assuming a steady growth rate the internet traffic generated from video is expected at least 3.4-fold growth by 2030, being a significant driver of consumer data consumption increase.[202] Video consumption has a multiplier effect on internet traffic. The trends that users are favouring smartphones over other devices for media consumption, especially video is expected to continue, allowing flexibility for users to watch more video content.[203] In addition, the growing number of connected TVs contributes to the growth of video consumption. If the increase remains constant, the calculation based on historical data shows that video traffic will reach 482 exabytes/month by 2030. However, optimistic projections indicate a potential of 6.2- fold growth by 2030, video streaming and consumption generating 858.6 exabytes/month by 2030.

4.1.1.4. Time spent on internet

The average time spent online by users is expected to reach ~6 hours in 2030 doubling the 2020 average amount of hours spent on the internet. Due to the Coronavirus people spend a record amount of time online during lockdowns affecting several areas of their life. Many activities moved online, including the work, education but also their leisure time activities. Based on historical data if the trends continue, an internet user is expected to spend 302 minutes online on average.

4.1.2. Data centre developments

The forecast of the increasing IP traffic entails the need for more data centres and faster connection between them. With the increase of the number of internet users, connected digital products and digital services the reliance on data centres will grow significantly. Thus, considerable capacity developments are expected in terms of data centres. In North West Europe the capacity of data centres is projected to increase with more than 15% by 2025, and the global increase of data capacity is expected to have a five-fold growth by 2030. [204]

Hyperscale data centre market will grow continuously, which will be driven mainly by cloud service providers / OTTs (Amazon, Microsoft, and Google). Sources agree that the hyperscale data

[199] Cisco Annual Internet Report (2018–2023) White Paper
[200] Cisco Annual Internet Report (2018–2023) White Paper
[201] Cisco Annual Internet Report (2018–2023) White Paper
[202] The methodology used for the forecasting is included in the Annex 3.
[203] PwC Global Entertainment & Media Outlook 2020–2024
[204] Deborah Andrews: Data Centres in 2030: comparative case studies that illustrate the potential of Design for the Circular Economy as an enabler of Sustainability, 2018

centre market is expected to grow, however, the predictions differ in terms of the extent of the increase. Optimistic predictions estimate a CAGR of more than 10% during 2017-2023[205], reaching even $57.47 billion by 2025 with a CAGR of 19%.[206] The conservative predictions forecast that the hyperscale data centre market will grow at a CAGR of over 2% during the period 2019-2025.[207] According to the Synergy Research group more than 200 data centres are at various stages of planning or building, in addition to the number of 541 hyperscale data centres that already operated in 2020. Major cloud service providers, such as Amazon, Microsoft, and Google continue to be significant drivers of growth, having strong plans for developments worldwide.[208] The major cloud service providers have the following known developments plans across the regions:

- **Europe:** Google is the most active in the region, it plans to construct new facilities in four countries: Poland, Italy, France and Spain. Amazon plans to build data centres in Spain, Oracle in the UK and Microsoft in Poland and Spain.
- **Middle East:** Oracle plans to construct data centres in four different locations and Google also plans to build data centres in Saudi Arabia.
- **Asia and Pacific**: Amazon and Google have plans to expand their number of facilities building new ones in Asia. Microsoft and Google also have plans to expand in Australia.
- **Latin America:** Three cloud service providers plan to build new data centres: IBM, Google and Oracle.
- **Africa:** Oracle is the only major cloud provider that has plans to construct a data centre in Africa.
- **North America**: According to the plans Microsoft, Google and IBM will be active in expanding their data centres.

Since the market is driven by major content providers, there is an increased risk for the EU due to the dependencies on foreign actors. The European data centre market is considered moderately consolidated.[209] In order to sustain its competitiveness of the data centre market and to decrease the dependency on vendors, the EU needs to have a common approach on expected developments to strengthen its position and continuously develop the capacity of EU data storage and processing services. With the Ministerial Declaration on "European Data Gateways as a key element of the EU's Digital Decade" the EU started to have a special focus on the data centre market by defining initiatives strongly related to data centres, such as expanding the reach of EU data storage and processing services.[210]

Considering the significant effect on operational costs and environmental impacts of the data centres' high-power requirements, there is a huge focus on increasing sustainability and reducing the carbon footprint. Operation of data centres requires a considerable amount of energy. Although the facilities are becoming more energy efficient, due to the increase of their numbers, the energy consumption will also grow significantly. Based on predictions of the experts, 20% of global energy will be consumed by the sector by 2025.[211] Researches have shown that there is a clear need for adoption of sustainable practices in terms of energy consumption and in the design of data centre equipment.[212] Innovation in energy efficiency is mainly driven by the major industry players, such as Microsoft, Google,

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205 Research and Markets: Global Hyperscale Data centre Market 2018-2023 - Increase in Adoption of OCPs and Hyperscale Specific Infrastructure

206 The Business Research Company: Hyperscale Data Centres Global Market Report 2021: COVID-19 Growth And Change To 2030

207 Research and Markets: Hyperscale Data centre Market - Global Outlook and Forecast 2020-2025

208 TeleGeography: Global Internet Map 2021

209 Europe Data centre Power Market - Growth, Trends, Covid-19 Impact, And Forecasts (2021 - 2026)

210 Ministerial Declaration: European Data Gateways as a key element of the EU's Digital Decade, 19th of March 19,2021

211 Deborah Andrews: Data Centres in 2030: comparative case studies that illustrate the potential of Design for the Circular Economy as an enabler of Sustainability, 2018

212 Deborah Andrews: Data Centres in 2030: comparative case studies that illustrate the potential of Design for the Circular Economy as an enabler of Sustainability, 2018

Facebook and Amazon Web Services.[213] These players invest to identify alternatives that serve their huge energy requirements for their existing and new hyperscale data centres.[214]

There is an increased interest for the Arctic region due to its optimal settings for operation of data centres. Building data centres in areas that enable the decrease of energy consumption by its settings or by renewable energy, can be used has a great economical potential with less negative environmental impact. Competitiveness between Europe, Canada, especially the northeastern part, and Japan for attractive data centre locations with natural cooling and renewable energy makes this an area to engage. Major players such as Google, Facebook and Amazon have already constructed[215] and also plan building hyper data centres in the Arctic regions.[216] Although these data centres cover millions of square meters, most operations are automated employing only a few people.[217] In addition, according to NORDUnet there are 900 planned projects in the region presuming a remarkable amount of investments. The high activity in the region may also indicate further data centre developments since they are important actors of the ecosystem.[218]

4.2. Analysis of the infrastructure

The Future trends analysis of the submarine cable infrastructure is mainly based on the information available on future systems already announced. However, the report also aims to provide a forecast beyond this period until 2030, though this has a higher level of uncertainty. Therefore, the chapter comprises two key parts:

- **Infrastructure by 2025 based on announced systems:** the analysis of all cables announced and ones likely to be decommissioned based on their age by 2025.[219]
- **Infrastructure by 2030:** a long-term, rather uncertain projection for the next ten years based on assumptions.

The first part of the analysis is conducted until the year of 2025 as due to the duration of building a cable system, this is the furthest possible time in the future we have information on cable deployments.[220]

Although there are many submarine cable projects announced for the following years, these do not reflect the future with absolute certainty owing to the following reasons:

- **Low number of announced systems actually enter service** - There is uncertainty in the actual deployment of announced cables, as based on previous experience, many cables are installed with different parameters or not installed at all.[221]

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[213] Data centre Frontier: The Eight Trends That Will Shape the Data centre Industry in 2021

[214] The Business Research Company: Hyperscale Data Centres Global Market Report 2021: COVID-19 Growth And Change To 2030

[215] Deborah Andrews: Data Centres in 2030: comparative case studies that illustrate the potential of Design for the Circular Economy as an enabler of Sustainability, 2018

[216] BBC News: Record-sized data centre planned inside Arctic Circle, 2018

[217] Deborah Andrews: Data Centres in 2030: comparative case studies that illustrate the potential of Design for the Circular Economy as an enabler of Sustainability, 2018

[218] NORDUNET: Arctic Connect - Reinventing A European Connectivity Strategy

[219] We consider cables likely to be decommissioned (or retired in other words) over the age of 25 which is the average lifespan of submarine cables.
The analysis is based on several verified sources and will give an overview of new connections and available levels of design capacity in submarine cable regions and EU routes, resiliency and diversity of EU routes and Member States, as well as the impact of content providers' activity and Brexit on the accessibility of the future infrastructure. There are many uncertainties involved in the analysis of the next five years already. However, based on the examples of the past years, the cables that are already announced and the currently accepted 25 year lifespan of submarine cables provide a reliable base to predict future trends and make relevant observations

[220] It takes approximately 3 years to build a new cable system: a year is needed for survey and permitting, and additional 2 years for manufacturing and installation. It might take even more time as delays occur many times during the permitting and legal phase or throughout the long approval process of large consortium. If time for marketing, selling and funding are also considered, any new cable project starting today will most likely go live around 2025. Source: AquaComms: Future Submarine cable Networks, the Year 2030

[221] Submarine Telecoms Forum: Submarine Telecoms Industry Report – Section 6.1: Over-The-Top providers

- **Unannounced content provider owned systems** - Content provider backed systems are generally not announced until they enter the contract in force (CIF) status.
- **Delayed cable deployment** - Delays occur many times during the legal and permitting phase or throughout the long approval process of a large consortium, which extends the average three years of building period.
- **Limited information available about announced systems -** In many cases, there is no detailed information available, such as planned capacity, fibre pairs, suppliers etc., even about announced systems which brings uncertainty to future projections.
- **Uncertainty of cable retirements -** Despite the 25 years lifespan of submarine cables, not every cable gets decommissioned once they become older than 25 years.

4.2.1. Infrastructure by 2025 based on announced systems

Summary - Infrastructure by 2025

Connections

Based on cable announcements, **more submarine cables are planned to be installed in the period of 2021-2025** than in the previous 5 years in every submarine cable region, except for the Australasia regions.

These developments will result **in the increase of the active cable numbers by 2025 in the majority of submarine cable regions**. The **EMEA is the only region where a decrease in the number of active cables is projected.**

The **number of active cables on the majority of the EU routes is expected to decrease by 2025.** Although the **EU - Non-EU Europe** route has the most announced cables, it is **not enough** to compensate for the **high number of old cables** that are likely to be decommissioned in the period.

The **EU - Latin America** route has the **highest ratio of cables that are likely to be retired**, thus **these routes bear the highest risk** when considering resiliency.

Besides the EU - Latin America route, the **EU - Far East** route is the only one with a single **planned submarine cable** (SEA-ME-WE 6 cable connecting Singapore and France) - apart from the additional hybrid one (PEACE cable which will reach China by a terrestrial link).

The **EU - Africa** and the **EU - Asia-Pacific** routes are the **only ones where growth is expected by 2025** in terms of the number of cables.

Capacity

The overall design capacity in all submarine cable regions is expected to more than **double by 2025,** and the **retiring design capacity** will be marginal, **only 0.29%** of the total design capacity available by 2025.

The EMEA region alone will account for 48.4% of the total global design capacity (12,143 Tbps) **by 2025** owing to the **Skagenfibre and Havtor** cable investments. The design capacity shares across the remaining regions will be distributed relatively equally (1,100-1,300 Tbps), except for the Arctic region with a share of 1.14% in 2025.

There will be **4,377 Tbps additional total design capacity on EU routes by 2025,** meaning an almost **threefold increase** from the levels in 2020. The **design capacity subject to decommissioning on EU routes** over the period of 2020-25 is only **0.36%** of total design capacity in 2025.

The **design capacity of the EU - Non-EU Europe will develop the most, at the fastest rate, and by the most capacity added,** reaching 4,150 Tbps, and **70.6% share of total design capacity** on EU routes.

The **average design capacity of submarine cables** is expected to **more than double to approximately 269 Tbps** between 2020 and 2021.

Resiliency and diversity

Assuming that each cable above the age of 25 will be retired, the **average age of cables among EU routes seems to drop by 2.5**, however, the **average number of cables will also decrease from 20.1 to 17.7**. In **overall resilience,** this brings a **slight increase**.

Based on the number of cables and their average age, **EU - Non-EU Europe has the best resiliency score**, which is mostly the result of high number of cables. **EU - Latin America has the lowest score**, with only a couple of operating cables and a rather high average cable age of 18.5. **EU - Far East route also bears a high risk** based on its resiliency score.

When examining age composition, the **EU - Non-EU Europe route seems to have a strong league of young cables, just as the EU - Asia-Pacific route**. The routes with the least balanced age composition include **the EU - Latin America, the EU - Far East and the EU - English North America ones**.

Approximately 5% less coastal EU Member States will have interregional submarine connections by

2025 caused by the expected retirement of three cables. **France overtakes Italy** as the EU Member State with the **most interregional submarine connections**. **EU Member States with the highest number of submarine cables** (France, Portugal, Spain and Italy) **supplemented with the data centre paradise, Ireland, and Denmark play an important role in the EU's interregional connectivity.** In contrast, **Baltic** Member States and Member States in the **Balkans** seem to have a more **important role in terms of Intra-EU connections.**

Accessibility

Content providers plan to install 1,040 Tbps of new capacity, 18.5% of the total development in 2021. This share is significantly lower than in previous years owing to several non-content provider-owned high-capacity investments as well as to the fact that content providers tend not to announce new systems and their details until they enter the CIF status. **Content providers will enter a new submarine cable region, the EMEA**, with the 2Africa, Blue-Raman and Equiano cables.

In most cases of capacity deployment, content providers will appear as consortium members rather than sole cable owners.

Although the number of cables landing in the UK has been decreasing since around the Brexit vote, it is hard to say whether it is an impact of Brexit or more of a result of diversification endeavours. There are several announced cables for the 2021-2025 period that will have landing points in the UK, unlike between 2016 and 2021, when there were not any newly added cables here. However, the **number of cables landing in the EU will still overtake that of those in the UK**. The most increase will be seen in the EMEA region, similar to previous years, with 37 active submarine cables landing in the EU, and 2 in the UK. When comparing the number of active systems in the Transatlantic region, there is a slightly smaller difference, but there will still be more landing points in the EU (12), than in the UK (9)

4.2.1.1. Connections

New connections by submarine cable region

There are announced cables in every submarine cable region for the period of 2021-2025. Some of them are long-missing systems, connecting remote or uncovered routes and areas (e.g. the Arctic region), and some of them are reactions to the constant changes of the market (e.g. in Australasia).

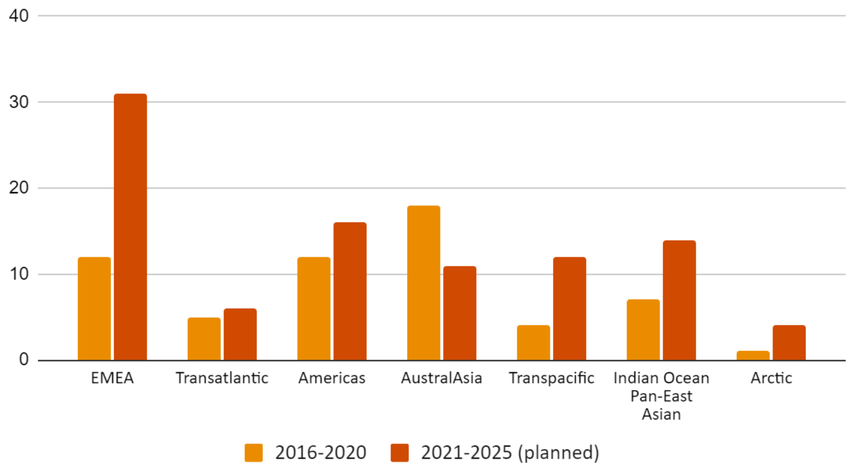

Figure 66: New submarine systems by submarine cable region

The number of planned cables between 2021 and 2025 exceeds the number of new cables deployed in the previous period in every submarine cable region, except for the Austral Asia region.

The **increase in the EMEA region is the most significant**. There were already a **high number of new cables in the 2016-2020** period, however, **in the next 5 years, this number will grow by 250%** according to the announcements.

2Africa cable is one of the most significant announced cables in the region, which will have a **remarkable length of 37,000 km**. The cable will go around Africa, connecting African countries to Europe and the Middle East.

The **Transatlantic** region **had a smaller amount of new cables added in the earlier period,** but this number **slightly increases between 2021 and 2025**.

One of the most important planned cables here is **SAEx 1**. It is to be built in 2023 and it will connect Cape Town, Brazil and the US East coast.

Dunant is an example for a high capacity long distance cable which was deployed very recently, in 2021. The system is **owned by Google** and **connects Virginia Beach in the U.S. and Saint-Hilaire-de-Riez on the French Atlantic coast** with a **6600 km l**ong cable. It has **12 fibre pairs** and **250 Tbps design capacity**.[222]

On the contrary, the **Australasia region** seems to have a **decrease in the number of announced cables** for the upcoming period, despite it having **the highest amount of new cables** added in the previous period.

A notable cable here is **Southeast Asia–Japan 2**, which will have landing points in **nine different countries** (Taiwan, Cambodia, Vietnam, China, Hong Kong, Singapore, Thailand, Japan, South Korea) and is owned by a consortium including **China Mobile** and **Facebook**.

The **Arctic region** and the **Transpacific** will have the **highest growth ratios** between the two periods. One contributing factor to the growth of the former region is the melting ice cap over the North Pole which will likely lead to new trading routes, as well as new submarine cable routes according to experts. However, it should be noted that the amount of **growth in the Arctic region is less telling**, since the **baseline of existing cable is much more modest** than in any other region.

A planned cable in the **Transpacific** region is the **Transpacific Networks (TPN)** that will be the first subsea route to directly connect Singapore, Indonesia, and the U.S.
The longest and most expensive announced cable in the **Arctic** region is the **10,500 km long Arctic Connect Northeast Passage** which is planned to be ready for service in 2023.

The **Indian Ocean Pan-East Asian** and the **Americas** will both have between **33% and 86%** more cables added in the 2021-2025 period, than in the earlier one.

In the **Indian Ocean Pan-East Asian** region, there are **only four announced cables that will not have a landing point in India**, out of the thirteen. The longest cable interconnecting India is the ~16,000 km long **Trans Europe Asia System** which will have landing points in Saudi Arabia, France, India and Italy.
One of the future cables in the Americas is **ARBR,** connecting Argentina and Brazil.

Based on the above, **new system demand seems to decline** the most in the **Australasia region** and the **emphasis will be on the EMEA region**, where **replacement of aging infrastructure** is needed just as well as **new systems to meet growing data centre demand**.

The following figure shows the **number of cables available by 2025** in each submarine cable region based on the number of existing, planned and likely retiring systems:

[222] Google Cloud: The Dunant subsea cable, connecting the US and mainland Europe, is ready for service

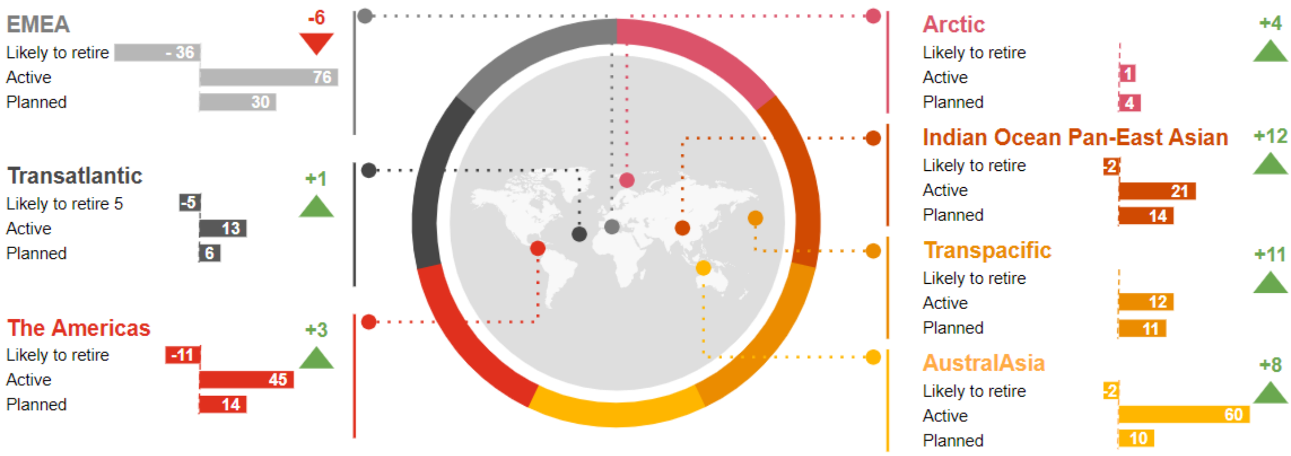

Figure 67: Number of cables available by 2025

Based on the aforementioned **25-year lifespan**, the cables marked as *Likely to retire* on the figure are likely to be decommissioned by 2025. It helps to maintain a healthy level of resilience if the number of announced cables is close to covering that of cables likely retiring in the given period. As it was described in the Current State analysis, newer cables usually have higher capacity, thus they can replace several older cables at the same time. However, **maintaining a certain number of cables** is still important, since it **lowers the chances of being completely cut from the internet in case of a cable failure**.

The number of active cables will increase in all of the submarine cable regions, except the EMEA region.

The number of **announced cables is the highest in the EMEA region**, **however**, it is smaller than the number of retiring cables, resulting in the **decrease of the overall number of cables** in the region.

Currently, the **Arctic** region has very few systems, but there are several plans for further cables in the region. Thus, it has the **highest proportion of planned cables** compared to existing cables among the regions.

When comparing the percentage of announced cables to that of cables to be retired, the **Transpacific** and the **Indian Ocean Pan-East Asian** regions show the **highest growth** in terms of active systems by 2025.

In the **Australasia,** the **Americas,** and **Transatlantic** regions, the number of cables seems to **increase more modestly,** by 13%, 7%, and 6% respectively.

New connections by EU route

The number of announced cables for the 2021-2025 period exceeds or is equal to the number of cables added between 2016 and 2020 on every route, except for the EU - Far East one.

The **highest number of announced cables** is on the **EU - Non-EU route**, which also has the **highest growth** compared to the previous period. This indicates that the **high number of planned cables in the EMEA region** is **strongly driven by the EU - Non-EU Europe route**.

The **EU - Africa, EU - Asia-Pacific and the EU - Central Asia** routes also have **significant** and similar **growth** in terms of planned cables, all **between 200-300%.**

On the **EU - English North America route** the number of **planned cables is stagnant when compared to the previous period**. This information complements the fact that the Transatlantic region also has a lower number of planned cables than in the previous period.

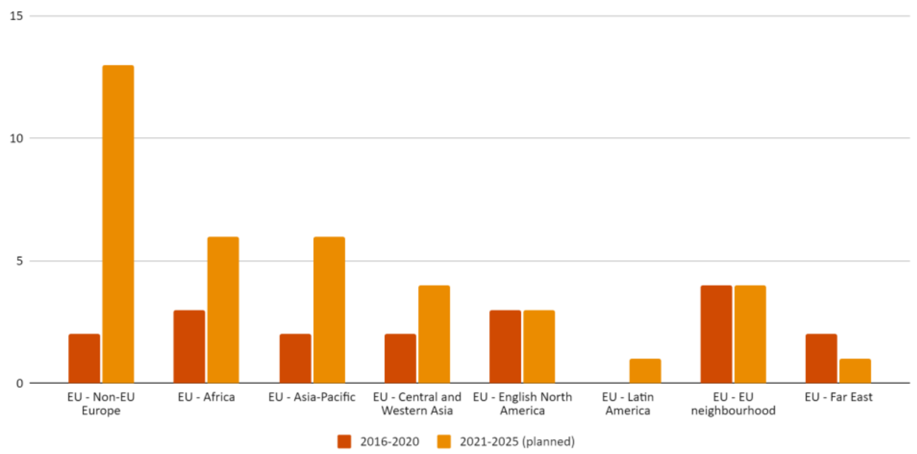

Figure 68: Newly built connections of the last five years and the announced systems for the 2021-2025 period by EU route

Regarding submarine cables in the so-called overlapping regions, **growth seems to stagnate** on the **EU - EU Neighbourhood route** and decrease can be seen on the **EU - Far East route**. However, there will be a submarine system (PEACE) ready for service in 2021, linking France and China, which is planned to have both submarine and terrestrial cable parts.

As already pointed out in the Current State analysis, the **EU - Latin America route is critical** since there has **not been any growth in the number of cables in the last few years**. Between 2021 and 2025 there is a remarkable increase on this route, but **only in the form of one** cable (EllaLink).

The **EllaLink** submarine cable will be ready for service in 2021 and will connect Europe to Brazil directly with 72 Tbps capacity. The new cable does not transit in the US - as other cables on the route - and therefore the **latency time is halved** owing to the shorter length of the system. The reduced latency will be in favour of many crucial sectors, such as the financial or gaming industry.

Overall, the emphasis **shifts from the EU - English North America route to the EU - Non-EU Europe, the EU - Africa, the EU - Asia-Pacific and the EU - Central Asia routes**. This might change, however, as a consequence of not yet announced content provider cables.

The following figure depicts the **number of cables presumably available by 2025** on the EU routes based on the number of existing, planned and likely retiring systems:

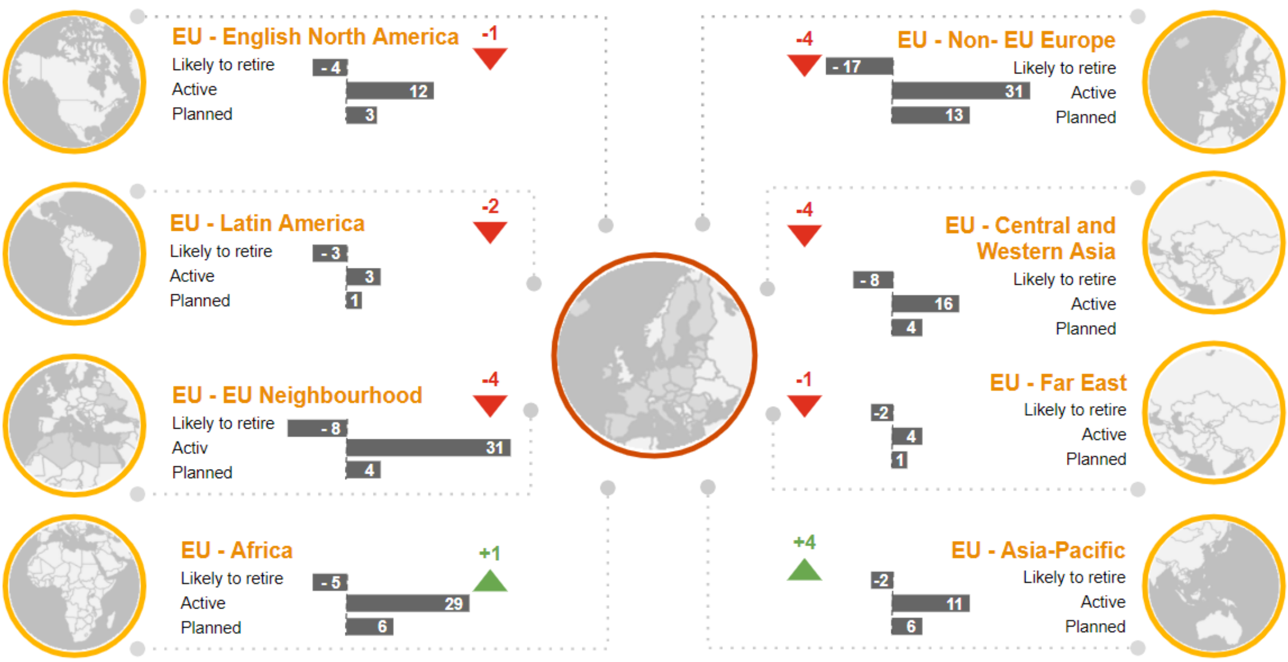

Figure 69: Number of cables presumably available by 2025 on the EU routes

There are only two routes where the number of planned systems exceeds that of cables likely to be decommissioned by 2025.

On the **EU - Africa** and the **EU - Asia-Pacific** routes, the number of cables will **increase** in contrast to other routes.

The total **number of systems available will decrease** on the **EU - Non-EU Europe** route, as there will be a relatively large number of new cables but not as many as will probably be retired.

The same can be said about the **EU - EU Neighbourhood** route as the number of planned cables make up only half of the number of cables retiring. However, since the **number of active cables is the highest in this route**, this does **not pose a high risk**.

The **EU - Latin America** route not only has one of the **smallest numbers of planned cables** among the EU routes, it also has the **highest ratio of retiring systems by 2025**, when compared to the number of active systems, making it a **critical region**.

Besides the EU - Latin America route, the **EU - Far East** route is the only one with a single **planned submarine cable** (SEA-ME-WE 6 cable connecting Singapore and France) - apart from the additional hybrid one (PEACE cable which will reach China by a terrestrial link[223]). As half of the existing cables will likely be retired by 2025, it will be almost as critical as the EU - Latin America route.

4.2.1.2. Capacity

Capacity by submarine cable region

The overall design capacity in all submarine cable regions is expected to more than double by 2025, growing at a CAGR of 20% between 2020 and 2025.

The less advanced regions are continuously catching up with those with higher design capacity, which is expected to result in a **more even capacity distribution across submarine cable regions** by 2025 than it was in 2020. The only **exceptions** are the two outlier regions, the **Arctic region**, with high growth rates, but low capacity levels, and the **EMEA region** with substantial design capacity investments.

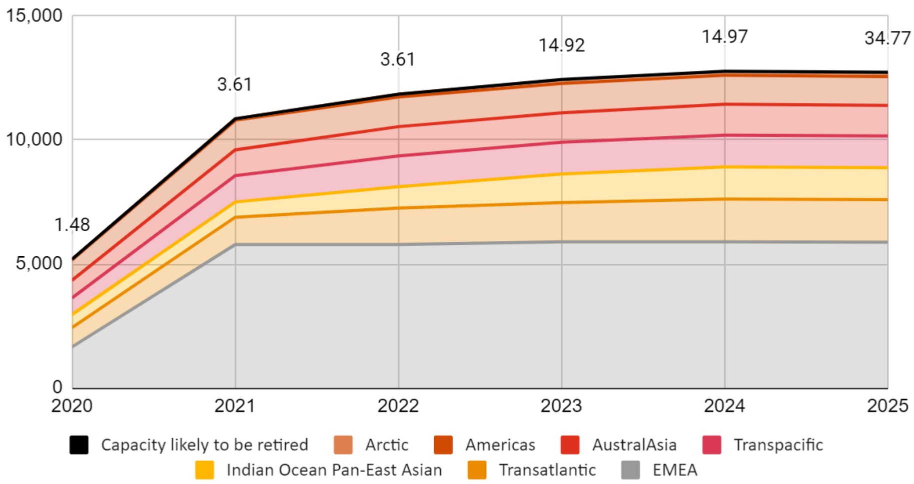

Figure 70: Design capacity by submarine cable region 2020-2025[224]

[223] Since the study focuses on submarine cables rather than terrestrial ones, accordingly, the database that is used to produce the figures only contains submarine cables. Although hybrid cables (like PEACE) contain both submarine and terrestrial links, only their submarine parts show up on these figures. On the EU - Far East route in particular, while there is only one through and through submarine cables announced, we felt it important to mention this significant hybrid cable.

[224] Sorted by size of design capacity. The sum of design capacity of submarine cable regions depicted here is not equal to the total global capacity because of submarine cables connecting multiple submarine cable regions,

The total design capacity on retiring cables (aged above 25) **will be 34.77 Tbps by 2025, which is considered marginal as it only makes up 0.29% of the total design capacity available by the same year.** Hence, the possible cable retirements only slightly affect the planned cumulative capacity in the next 5 years. **Proportionally, the most submarine cable decommissioning is expected to happen in the EMEA** (14.55 Tbps)**, the Americas** (13.53 Tbps), **and Australasia** (13.80 Tbps), which still only means 0.25%, 1.17% and 1.13% of the overall regional design capacity respectively. In the Arctic and Arctic regions, based only on the age of the cables, no decommissioning is expected in the next five years.

The EMEA region alone will account for 48.4% of the total global design capacity (12,143 Tbps) **by 2025, maintaining its position with high growth rates with 250% increase only in 2021.** The design capacity shares across the remaining regions will be **distributed relatively equally** with the Indian Ocean Pan-East Asian region catching up and even overtaking many regions at a CAGR of almost 20%. The **only exception is the Arctic region with a share of 1.1%** in 2025. Despite the highest growth rates (CAGR of 35.7%) among all regions, the Arctic region will still fall short when compared to more advanced regions, starting from a substantially higher capacity level.

Based on information on announced cables, the expected growth and design capacity levels are the following:

- The **EMEA region** will continue to have a substantially higher level of capacity in the next five years, with **5,878 Tbps in 2025,** with an increase of 4,224 Tbps. The overall design capacity will **increase by a factor of 2.5 only by 2021**, which can mainly be attributed to two cables in the region, both planned to be ready for service in 2021: the **Skagenfibre** with a planned 1,920 Tbps design capacity with landing points in Denmark and Norway[225], and the **Havtor** cable with 1,440 Tbps design capacity, with landing points in the similar regions.[226,227] Being the most developed region by 2025, the average growth rates are high accordingly, with a **CAGR of 28.9%** in the period given.
- The **Transatlantic region** will maintain its steady second place in design capacity levels, although it will grow at a CAGR of only 17%, with 936 Tbps additional capacity, reaching **1,718 Tbps design capacity** by 2025. The most investments are expected in 2021 and 2022 (growth of 41.20% and 33.35% respectively) owing to the **cable Amitié,** for example, (owned by a consortium with OTTs, including Microsoft and Facebook), connecting the US, UK, and France with 368 Tbps (16 fibre pairs of up to 23 Tbps) design capacity.
- The **Indian Ocean Pan-East Asian** region is expected to develop with **763 Tbps additional capacity**, **overtaking more advanced regions** such as Transpacific, Australasia, and the Americas region by 2025, reaching 1,289 Tbps.[228]
- The **Transpacific region** will **outpace Australasia and the Americas** in terms of planned design capacity already in 2022, with a growth of 58% only in 2021. An additional 607 Tbps of capacity have been announced to be added after 2020 to the already existing systems, **reaching 1,278 Tbps of design capacity** by 2025, with a CAGR of 13.75%
- The **Australasia** region will remain close to the Transpacific region in terms of design capacity with **1,235 Tbps** in 2025, and a **moderate CAGR of 11.7%,** which is projected to be insufficient to keep its fourth position relative to other submarine cable regions.

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however, they do not differ significantly. Design capacity of submarine cable regions is subtracted by retiring capacity.

[225] It comprises Skagenfiber West and East, out of which the former was ready for service already in November 2020

[226] These cables will strengthen the connections between Norway and mainland Europe, and allow the country to have its international data traffic go directly to key EU data links, instead of going through Sweden. The cables are planned with such high levels of design capacity to meet the robust first-class Norwegian demand, and connect businesses to the world.

[227] Submarine cable Networks: Altibox Acquires Skagenfiber AS

[228] The reason behind the Indian Ocean Pan-East Asian region overtaking other significant regions lies behind major investments in 2022 and 2023 in the region (an increase of 39% and 33% in these years respectively). Although the developed regions mentioned have growth of at least 45% in 2021, the level of design capacity deployed after this year shows a huge decrease - presumably because of cables not yet announced -, leading to lower overall capacity by 2025.

- The **Americas** region will experience the **lowest growth rates (CAGR of 7.2%)**, **losing shares to the Transpacific and Australasia** region by 2025 compared to year 2020. In the region, there is only 340 Tbps capacity announced to be added through submarine cable investments, meaning that **the total design capacity will reach only 1,200 Tbps by 2022,** with no information on the capacity of announced cables after this year. This lack of information may be the cause of the moderate growth of the region when compared to other regions which already have available data on their future submarine cable instalments.
- The **Arctic** region will continue to **lag behind** despite the **highest growth rates** (CAGR of 35.7%, and 100% and 80% growth in 2021 and 2022) among all submarine cable regions as it only means **138 Tbps of announced design capacity to be installed by 2023.** Although this is considered relatively high, when compared to the 30 Tbps overall capacity in 2020, it is still far from the capacity levels of other main regions.

Capacity by EU route

There will be 4,377 Tbps additional total design capacity on EU routes by 2025, meaning an almost threefold increase from the levels in 2020 (1,749 Tbps).[229]

The design capacity of the EU - Non-EU Europe will develop the most, at the fastest rate, and by the most capacity added, reaching 4,150 Tbps, and 70.6% share of total design capacity on EU routes. The currently most developed route, the EU - English North America will lose significant shares to the EU - Non-EU Europe route, maintaining only the second place in terms of development. Although growing significantly in 2021 from a low design capacity base, **the EU - Latin America route will remain the least advanced** among all.

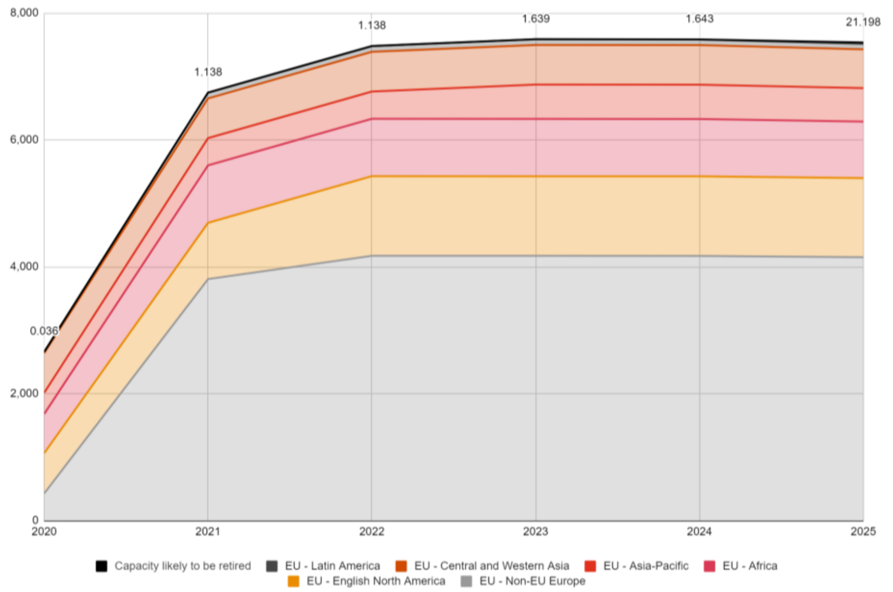

Figure 71: Design capacity by EU route 2020-2025 (Tbps)[230]

The design capacity that is subject to decommissioning on these EU routes over the period of 2020-2025 is only 21.2 Tbps by 2025 (approximately 0.36% of total design capacity in 2025), and hence it **decreases the overall capacity with no significant amount.** Proportionally, the most retiring capacity will be on the EU - Central and Western Asia and the EU - Asia-Pacific routes (13.30 Tbps and 13.46 Tbps, 2.5% and 1.5% of total capacity), while on the EU - English North America route, and the EU - Non-EU Europe route this percentage will be as low as 0.5%.

[229] Information on the planned design capacity installation is only available until 2023, and hence between 2024 and 2025 we assume approximately the same level of design capacity on EU routes adjusted with the subtraction of retiring capacity each year.

[230] Sorted by size of design capacity. The sum of design capacity of EU routes depicted here is not equal to the total capacity on EU routes because of submarine cables connecting multiple regions. Design capacity of EU routes is subtracted by retiring capacity.

Based on information on announced cables, the expected growth and design capacity levels are the following:

- The **EU - Non-EU Europe route** design capacity will develop at a fast rate and take up **70.6% of the total capacity** on all EU routes compared to that of 28.5% in 2020. This increase can be attributed to the same submarine cable investments as the ones mentioned above related to the EMEA region, the Skagenfibre, and Havtor cables. The submarine cable instalments in the region are expected to result in an **increase by a factor of 7.9 only in 2021,** and a growth of a CAGR 113.6% between 2020 and 2023. The overall design capacity will reach **4,150 Tbps by 2025** (additional 3,722 Tbps compared to 2020, of which the two cables mentioned above represent 3,360 Tbps), which is almost **four times more** than in case of the EU - English North America, the second most developed route.
- The **EU - English North America route,** which is currently the most advanced EU connection with 636 Tbps design capacity, is expected to **comprise only 21.3%** of the total design capacity by having **1,249 Tbps capacity** by 2025 and therefore losing its leading position (42.5% of total capacity in 2020) to other regions. This trend can be attributed to the moderate growth rates expected on this route, which will be a CAGR of 25.38% between 2020 and 2023. The low level of growth is owed to the fact that **there is information about only two submarine cable deployments** (Amitié with 368 Tbps, and Grace Hopper with no information on design capacity) **in 2022.**
- The **EU - Africa route** contributes to the total capacity levels with **15.15%, 890 Tbps by 2025,** with a growth of 47% (288 Tbps additional capacity) in 2021, overtaking the EU - Central and Western Asia route in terms of total design capacity. There is, however, no further announced submarine cable deployment in the following years.
- The **EU - Asia-Pacific routes** will also contribute to the total capacity levels at a lower extent with **9%, 527 Tbps design capacity in 2025,** increasing at a CAGR of 17.5% between 2020 and 2023, by the **deployment of 195 Tbps** new capacity.
- The **EU - Central and Western Asia** route follow the contribution levels of the EU - Asia-Pacific closely with **10.41% share**, yet with stagnant design capacity over the period given, as there are **four investments in pipeline** (2Africa, Blue-Raman, TEAS, and Africa-1), out of which none has design capacity announced. Hence, the total design capacity on this route seemingly remains around 625 Tbps (and even decreasing to **611 Tbps by 2025** owing to cable retirements). However, these numbers will actually be higher once information on design capacity becomes available regarding these four cables. The conclusion seen from this limited information that the EU - Central and Western Asia route will be outpaced by three other regions, cannot be stated with certainty either.
- The **EU - Latin America** routes will still contribute little to the overall design capacity, as the route lags behind **with a share of as low as 1.5% in 2025.** This means that this route also has **the lowest design capacity (86 Tbps)** with only a 71 Tbps increase in 2021, and 5.6 Tbps of decommissioned capacity over the examined years. Although EllaLink, which will be ready for service in 2021, means **an increase by a factor of 3.6,** this growth is not sufficient to catch up with more advanced routes.

Figure 72: Design capacity by EU route in other Focus regions (Tbps)[231]

The two overlapping regions (Far East and EU Neighbourhood), examined in the Current State analysis, are also analysed in the Future trends analysis as both routes are strategically significant from the EU's perspective.

Information on planned investments and installed capacities only shows a slight increase in design capacity (96 Tbps) **on the EU - EU Neighbourhood** route in 2021. Except for this single case, both routes remain around at the same level in the following years and only vary a little over years due to the capacity decommissioned. This means that the **design capacity on the EU - EU Neighbourhood route will remain substantial with 871 Tbps in 2025,** while **the EU - Far East** route will only have about one quarter of the EU - EU Neighbourhood routes' capacity (220 Tbps).

The capacity on systems which are presumably subject to decommissioning, is around **13.30 Tbps on both routes by 2025.** This level is rather **marginal on the EU - EU Neighbourhood route,** as it accounts for about **1.5%** of the total design capacity in 2025, while it is **relatively substantial for the EU - Far East routes** when compared to any other route as it comprises **6% of the overall capacity.**

Capacity growth enablers and examples of high-capacity systems

The technological advancements continue to allow the increase of maximum available capacity on new cables.

The **average design capacity of submarine cables** is expected to **more than double to approximately 269 Tbps** between 2020 and 2021 (growth of 130%). This growth is mainly driven by the **increase in fibre pairs**, which is projected to be **18 FP on average** in 2021 after as low as 7 FP in 2020.[232]

[231] Sorted by size of design capacity. The sum of design capacity of EU routes (other Focus regions) depicted here is not equal to the total capacity on these EU routes because of submarine cables connecting multiple regions. Design capacity of EU routes to other Focus regions is subtracted by retiring capacity.

[232] Presumably, capacity per fiber pair will also increase in the future, however, the currently available data about the planned capacity of announced systems does not underpin this growth yet.

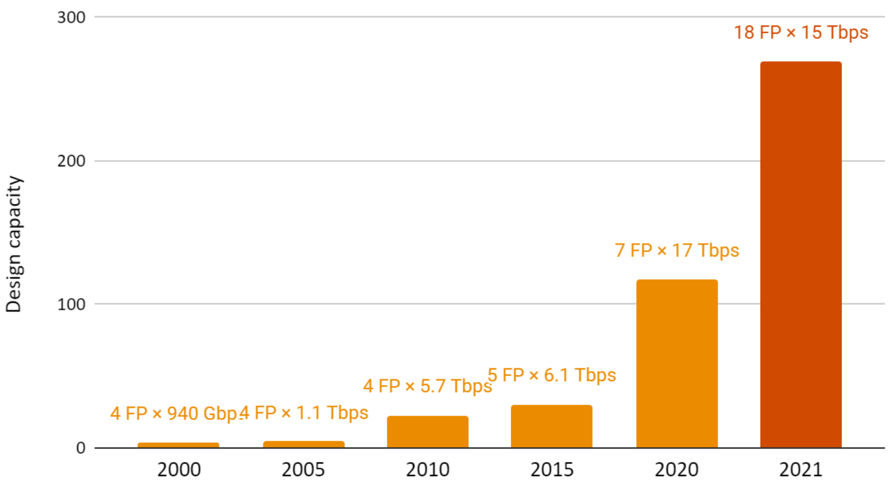

Figure 73: Average design capacity of submarine cable systems 2000-2021

The **overall design capacity on submarine cables** including upgrades and new systems is expected to **grow at a CAGR of 20% in the period of 2020-2025**. A slight increase can be seen when we compare this rate to that of the period of 2016-2020 (15.8%), meaning a growth in investment and capacity.

Two examples of **extremely high design capacity** are **the Skagenfibre and Havtor cables**, which were already mentioned in relation to the development of the EU - Non-EU route.

The **Skagenfibre** submarine cable is planned to have a design capacity of **1,920 Tbps with 48 fibre pairs.** This cable, which will have landing points in Denmark, and Norway, is owned by Altibox and Lyse. It comprises Skagenfibre West and East, out of which the former was ready for service already in November 2020.
The Havtor submarine cable is planned to have **1,440 Tbps** of design capacity, **with 48 fibre pairs (30 Tbps per fibre pair**), and with a **total length of 165 km**. The Havtor cable will land in Hanstholm, Denmark, and Lista, Norway.

Besides these two cables with above average planned capacity, there are **many cables planned to be built with average design capacity**.

Two examples are the **Bluemed** and the **NO-UK submarine cables**, with design capacities of 240 Tbps, expected to be ready for service in 2021. The Blumed cable is an Italian investment with landing points in Genoa and Palermo, while the NO-UK is a Non-EU European submarine cable with landing points in Stavanger, Norway, and Newcastle, UK.

4.2.1.3. Resiliency and diversity

Resiliency of EU routes

To examine the resiliency of EU routes, a resiliency score is calculated based on the number and age of cables.[233]

[233] Resiliency score is determined on a scale of 1 to 10 where 10 means the highest resiliency. For a more detailed methodology, please see Annex 6.4.

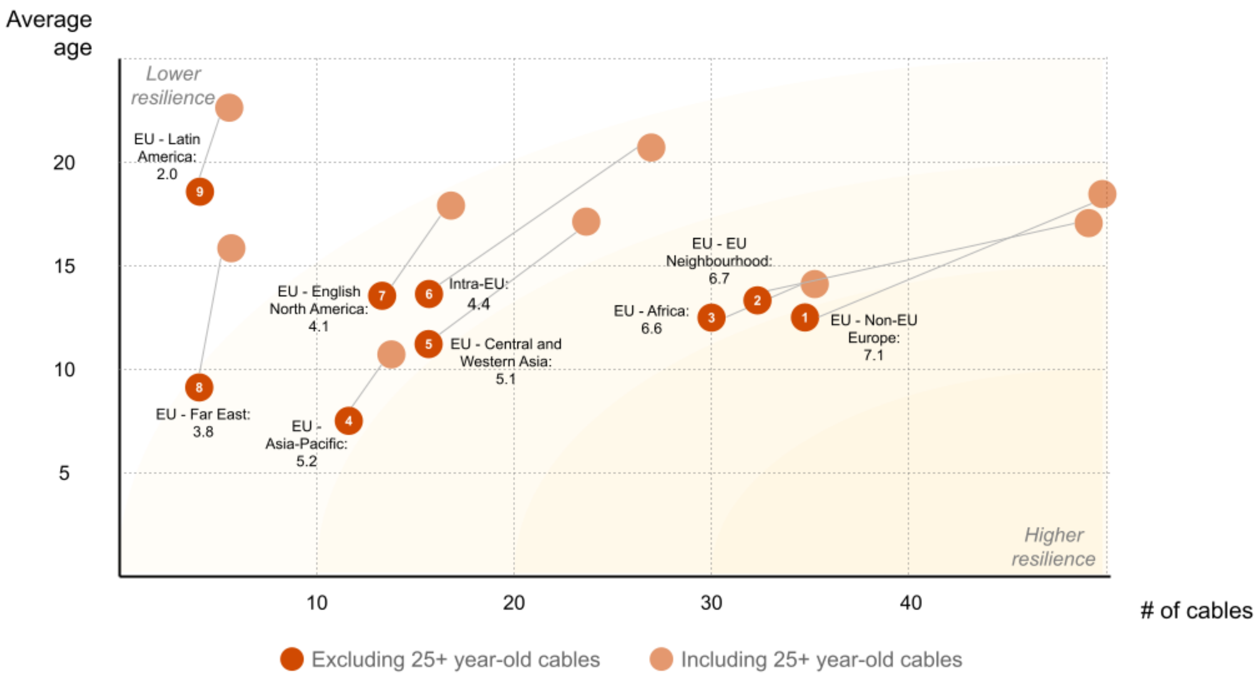

Figure 74: Overall resilience of EU routes (as of 2025)

Assuming that each cable above the age of 25 will be retired, the order of EU routes based on their resiliency scores follows the results of the examinations in the earlier chapters.

- The scores of EU routes in the **EMEA submarine cable region** imply that this region **is relatively strong in resiliency. The EU - Non-EU Europe route** in particular has earned the **highest score**, followed by the **EU - EU Neighbourhood** and the **EU - Africa routes**. On these routes, the average age of cables is between 12.7 and 13.5 years and their number is between 30 and 34.
- The lower average points in the middle field of Figure 74 are **mainly due to the lower number of cables** (around 11-16). On average, the cables on the **EU - Central and Western Asia, EU - Asia-Pacific, Intra-EU and the EU - English North America routes are aged between 7.5 and 14.3**.
- Regions that already showed to be challenging in the Chapter 4.2.1.1 *Connections* are likely to have the lowest resiliency scores in 2025 as well. The **EU - Far East and the EU - Latin America routes** both have a very **low number of cables** (4) and the **EU - Latin America route's average cable age** is very high, **18.5 years**.

If we disregard possible decommissioning and include cables over the age of 25 in the analysis as well, resiliency scores are slightly lower (as indicated with light orange on Figure 74). The reason behind is that although the number of cables is higher, the average age increases more.[234]

To be able to predict the future resiliency of EU routes it is necessary to have a comprehensive picture of the age composition of cables. This way it is possible to identify routes where new cables will probably be needed in the near future. The even distribution of age groups among a certain route's cables implies that the route is under continuous and balanced development. The following figure shows the age composition of EU routes as of 2025:

[234] As the age of 25 is more of a general indication than a hard set rule, actual resiliency scores will probably fall somewhere between the two scenarios, presumably closer to the first one that excludes old cable systems.

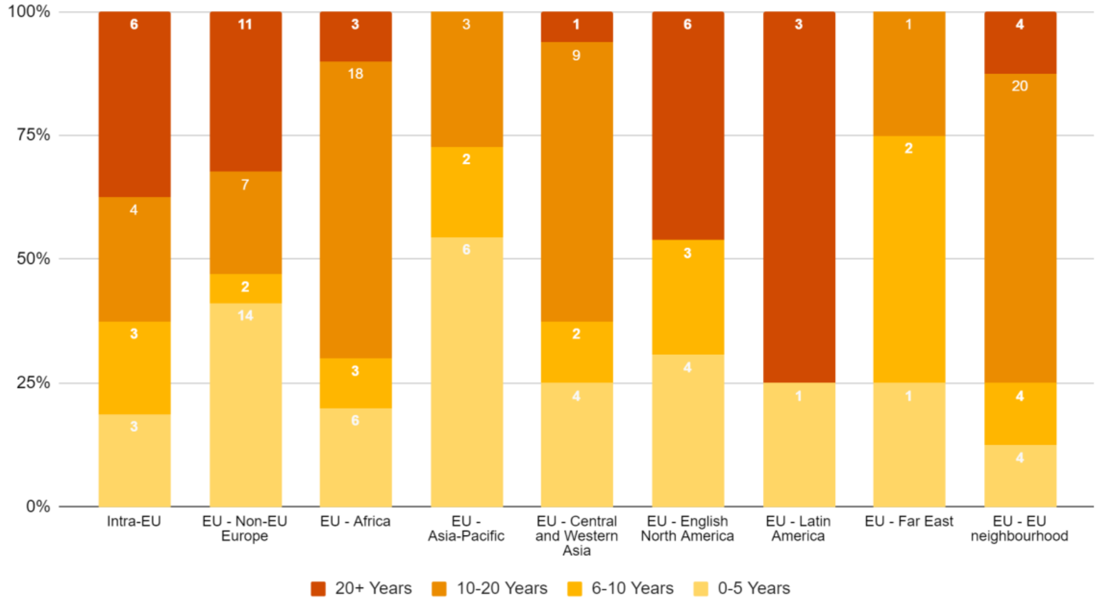

Figure 75: Submarine cables by age and EU routes (as of 2025) [235]

The assessment of age composition further reinforces conclusions of the previous analysis: the **EU - Latin America and the EU - Far East routes bear a high risk** in terms of resilience. However, in case of the other regions, this figure shows that the previously examined **average age hides several issues related to age composition**. For example, although the EU - Africa and the EU - EU Neighbourhood routes have a high aggregated resiliency score, their unbalanced age composition might pose a risk.

The **most even age composition is on the Intra-EU routes**, but there will be **twice as much cables aged over 20 by 2025 as 0-5-year-old cables**. The cables on the **EU - Non-EU Europe and the EU - Asia-Pacific routes** are likely to be quite **young on an average by 2025**. On both routes most cables (41% and 55%) will be under the age of 5.

The **EU - Central and Western Asia route** will have **more than 50%**, and the **EU - Africa and the EU - EU Neighbourhood route** will probably have **more than 60%** of their cables in the **10-20 years age group**. The problem with the absolute majority of cables belonging to only one age group is that **they are likely to be decommissioned around the same time**. The parallel need for their replacements could be challenging in terms of available resources.

There are three routes where not every age group will be represented by 2025.

- On the **EU - Far East** route, there will only be four active cables, one 0-5 years old, two 6-10 years old and one 10-20 years old.
- **46%** of the **EU - English North America** route's cables will be **more than 20 years old by 2025**, which could pose a potential risk. However, most of the cables that are likely to be decommissioned in the period after 2025 **will be substituted with young**, 0-5 years old **cables**.
- **75%** of the **EU - Latin America** route's cables **will be more than 20 years old by 2025** and there will be **only one 0-5 years old cable**. This poses a risk because even if further planned cables would be announced until then, it would have a very unbalanced age composition.

Resiliency of EU Member States

Almost half of the EU Member States lack submarine cables connecting them to landing points outside the EU. Five of these 13 countries are landlocked, but the **sea connections of the remaining seven Member States** (Sweden, Finland, Latvia, Estonia, Lithuania, Poland and Slovenia) **are not being fully utilized** by 2025 in terms of **providing routes for internet cables coming from outside of the**

[235] The figure excludes cables that are older than 25 years.

EU. The following figure shows the number of connections by EU Member States, excluding Intra-EU connections and more than 25-year-old cables:

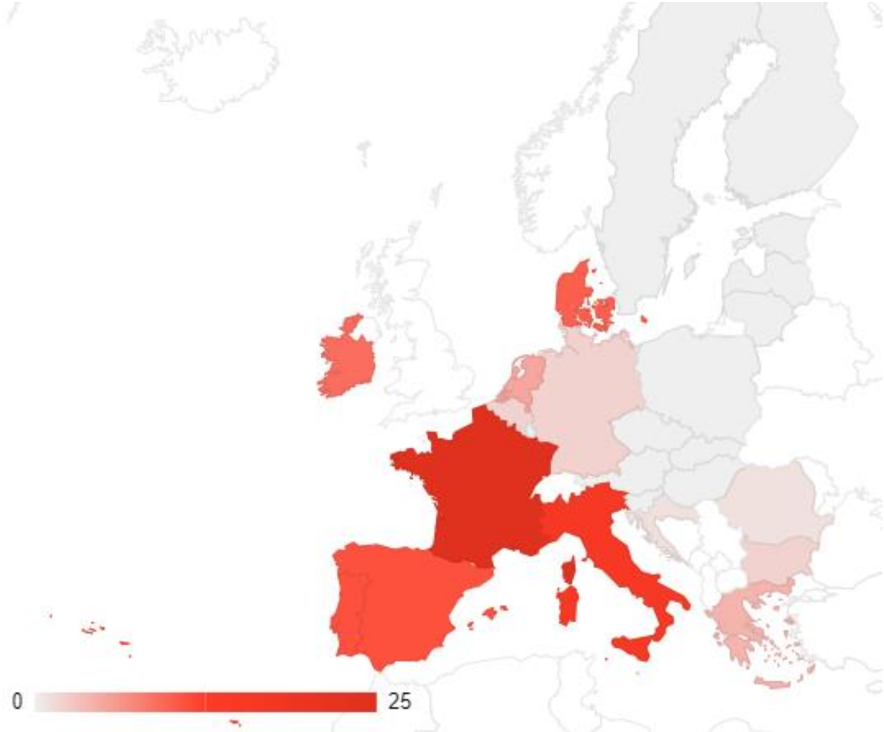

Figure 76: Resiliency of EU Member States[236]

While in 2020, 73% of coastal EU Member States had interregional connections[237], by 2025 this number drops to 68%. The **highest amount of decrease** (46-60%) is expected in **Cyprus[238], the Netherlands, Germany, Belgium and Romania**. In the case of Cyprus and the Netherlands, this is the result of 5, in case of the other three countries, this is the result of 3 or less cables retiring by 2025.

France, Spain and Portugal are the most important Member States in the matter of interregional connections, since the vast majority of their cables - 90% or more - provide connections to regions outside of the EU. The decrease caused by retiring cables and the increase thanks to new cable roll-outs changes the order of countries with the most submarine cables as well. One of the most prominent changes is **France overtaking Italy significantly by having nine more interregional cables**. The number of interregional EU submarine cables will **decrease in Portugal, Italy and Spain**. Two additional countries that have a high percentage of interregional connections are **Ireland and Denmark**. **Ireland's connections are 90% interregional** which is not surprising considering its location and its neighbouring country, the UK. It also might play a role that Ireland is known as a **data centre paradise**. **Baltic countries** and Member States from the **Balkans** are **more important in the matter of Intra-EU connections**.

Geographical choke points

The cables planned for the period of 2021-2025 do not seem to avoid **geographical choke points** (e.g. the Gulf of Suez, the Strait of Malacca) explained in Chapter 3.2.4.4.

- The **PEACE** and the **2Africa** cable will both go through the **Gulf of Suez**, where there are **more than 10 cables landing** already.

[236] The figure excludes cables that are older than 25 years. The figure only includes cables that connect the EU to outside regions. Solely intra-EU cables are disregarded on this figure.
[237] Meaning cables that connect the EU to outside regions
[238] Cyprus is likely to lose 7 cables by 2025 because of their age. However, thanks to the PEACE cable, which will come into service in 2021, available capacity is likely to increase by 64%.

- Similarly, the Myanmar/Malaysia India Singapore Transit **(MIST)** cable**,** ready for service in 2022, will join the over 10 existing cables in the **Strait of Malacca**.

These geographical choke points could **pose a high risk with regards to resilience** as - although the connectivity increases with more cables and capacity deployed - many connections can be affected with the elimination of only a few landing points or regions.

4.2.1.4. Accessibility

The impact of content providers on access to capacity

Content providers drive the submarine cable capacity increase substantially. They have entered an increasing number of submarine cable regions in the previous years, which they continue to do so, also establishing substantial dominance in most of them. Yet, in the Indian Ocean Pan-East Asian and Arctic regions, there are no submarine cable systems announced which would be either single or co-owned by content providers.

As the Current State analysis has already covered, the capacity of their investments accounted for more than half of the total newly installed capacity in certain years (856 Tbps in total between 2016 and 2020), and there is **a total of 1,408 Tbps additional content provider driven capacity planned for the next two years.**

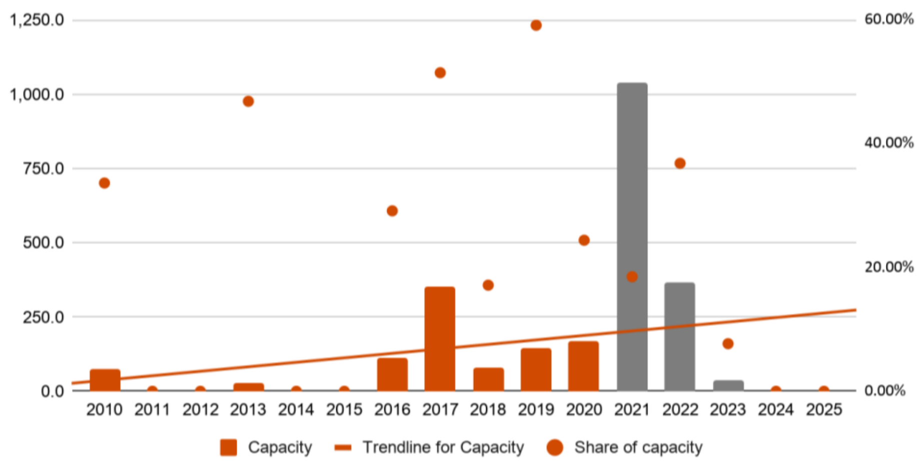

Figure 77: Content provider driven new submarine cable capacity by years (Tbps)

In 2021, content providers plan to install approximately 1,040 Tbps of new capacity, which comprise only 18.5% of the total capacity of systems being built in that year. The relatively lower share in newly installed system capacity can be attributed to several **non-content provider owned high-capacity investments** (Skagenfibre, Havtor, EllaLink) as well as to the fact that **content providers tend not to announce new systems** and their details until they enter the CIF status.

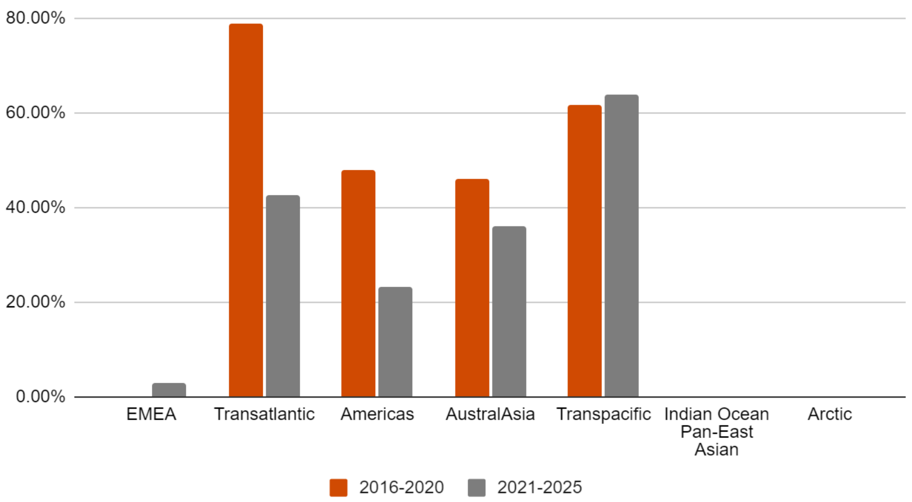

Figure 78: Content provider driven new submarine cable capacity

Content providers also plan to enter a new submarine cable region, the EMEA, in the next five years. The systems to be installed in the EMEA include **2Africa** (owned by a consortium with the participation of Facebook), **Blue-Raman** (owned by a consortium with the participation of Google), and **Equiano** (solely owned by Google).

A decrease can be seen in content provider driven capacity installed in almost all regions, in which they had already taken up a substantial share of the total capacity of new systems built in previous years.[239] The **only exception is the Transpacific region** where the share of content provider driven capacity is expected to grow from 61.7% to 64%. There are **four systems** that contribute to this increase, planned to be ready for service already in 2021: **BtoBE, HKA, JUPITER** and **PLCN**.

The **Bay to Bay Express Cable System (BtoBE)** will have 108 Tbps of design capacity, connecting landing points in the US, Hong Kong and Singapore, owned by Facebook as a consortium member.
The **Hong Kong-American Cable System (HKA)** will have 76.8 Tbps of design capacity, connecting the US and Hong Kong, owned by Facebook as a consortium member.
The **JUPITER** will have 60 Tbps of design capacity, establishing connection between the US and Japan, owned by Facebook as a consortium member.
The **Pacific Light Cable Network (PLCN)** will have 144 Tbps of design capacity, landing in four countries, the Philippines, Taiwan, Hong Kong, and the US, owned by Facebook and Google as consortium members.

In most cases of capacity deployment, content providers will appear as consortium members rather than sole cable owners. Out of all newly installed design capacity on cables owned by content providers, 80% will be attributed to consortiums with content provider participation, while this ratio was only 70.1% between 2016 and 2020. This means that the content provider dominance in certain regions will be backed and compensated by other types of stakeholder ownership.

[239] Again, this decline can be attributed to the increasing non-content provider investments in these regions and the presumably unannounced systems installed in the future.

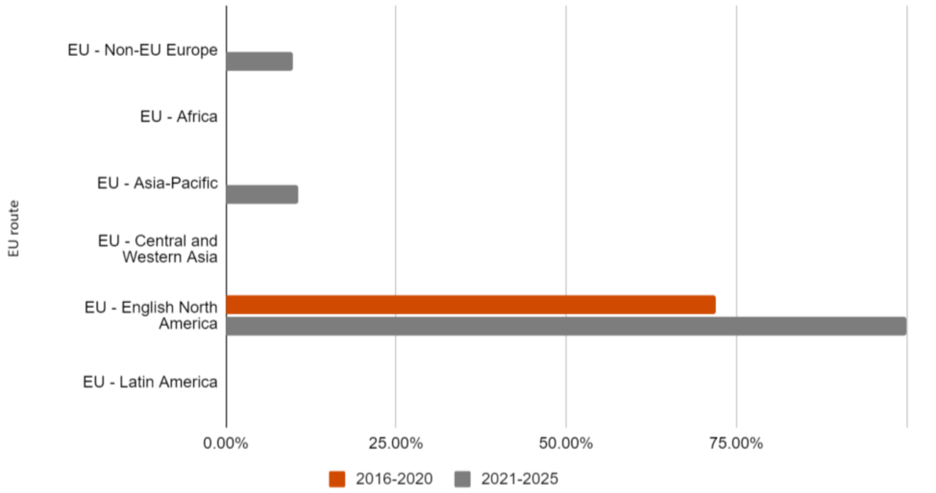

Figure 79: Content provider driven new submarine cable capacity on EU routes

As a consequence of the content providers' planned EMEA investments, they will enter the EU - Non-EU Europe route as well, although with a relatively low share of total new capacity installed. The system that we already have details about is the **AMITIÉ cable.**

AMITIÉ will have 368 Tbps of design capacity, connecting landing points in the US, UK and France, owned by Facebook as a consortium member.

Furthermore, **content providers will also enter the EU - Asia-Pacific route**, as a result of the South East Asia–Middle East–Western Europe 6 (Sea-Me-We 6) investment.

Sea-Me-We 6, owned by Microsoft and other non-content provider consortium members, is planned to be ready for service in 2023 with 12 Tbps of design capacity and will connect landing points in France and Singapore.

Content providers already dominated the EU - English North America route with their investments between 2016 and 2020 and they will further expand their dominance by participating in 100% of newly built systems in the period of 2021-2025. The cables to be installed over the following years are the Grace Hopper owned by Google and the aforementioned Amitié.

The impact of Brexit on accessibility

As it was already stated in the Current State Analysis, **there is a shift from the UK towards the EU**. In terms of **new landing points,** this **trend is expected to continue in the future** as well. Nonetheless, it is **hard to say whether it is an impact of Brexit or more of a result of diversification endeavours.** Especially since **there are several cables announced for the 2021-2025 period that** will have **landing points in the UK** - compared to the 2016-2020 period, when there were none. However, with the **continuation of the aforementioned trend** and the **aging submarine infrastructure of the UK**, in the **next five years,** the **number of cables landing in the EU will overtake substantially that of those in the UK**.

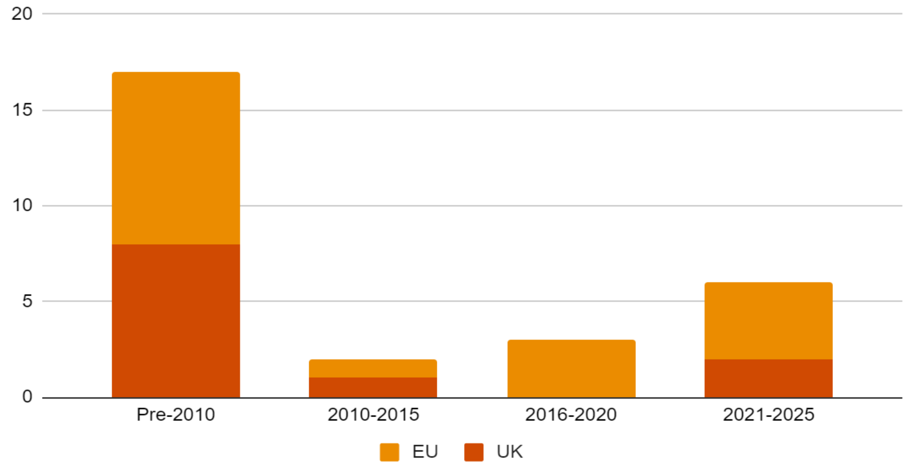

Figure 81: New systems by landing point in the Transatlantic region

The share of cables likely to be decommissioned by 2025 is also relatively smaller in those cases when the landing point is in the EU (approximately 24% of the existing cables, while 37% in the UK). This, compared with the number of investments with EU and UK landing points (15 and 3 cables respectively), imply a **competitive advantage for the EU.** The number of active systems per submarine cable region are as follows:

- **The most increase will be seen in the EMEA region,** similar to the previous years. The region will have **37** active submarine cables landing in the EU, and 2 in the UK, despite the huge number of cables presumably being retired by 2025 in the EU (10 cables), compared to only 2 in the UK.
- **The Transatlantic region will still remain competitive,** with a difference of only 2 cables between the two landing points (9 in the UK, and 12 in the EU), out of which there are 2 newly installed ones in the UK, and 4 in the EU.
- **All other submarine cable regions relevant** (Indian Ocean Pan-East Asian, Americas, and Australasia) **are continued to be dominated by the EU.**

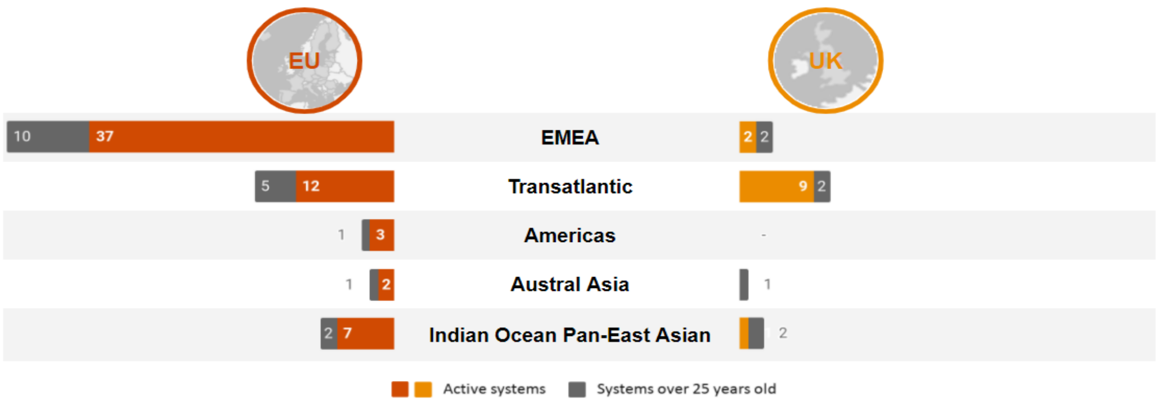

Figure 80: Active systems by landing points by 2025

Although investments in the Transatlantic region with landing points in the UK increased compared to the period of 2016-20, their number is still slightly lower relative to those with an EU landing point. (Figure 81) The total investments between 2016 and 2025 show the trend of decreasing cables with landing points in the UK, however, the more balanced number of planned systems may stress the concern of the enduring importance of the UK against the EU if all submarine cable regions are considered. Yet, as mentioned above, if the number of cables retired and installed are compared, the EU will probably have a competitive advantage over the following period in the region.

4.2.2. Infrastructure by 2030

Summary - Expected cable retirements by 2030

Considerable retirements are expected both on a global level and in terms of EU-routes. Considering the increase of forecasted internet traffic, these infrastructural elements will need to be replaced.

Proportionally, the highest capacity retirement (18.5%) is expected to happen in the Transpacific region, followed by the Transatlantic region with 14.8% of capacity decommissioned. Major capacity retirements are expected in case of the Indian Ocean Pan-East Asian region as well, where 14% of the submarine cables will be decommissioned representing around 11% of the total number of connections.

The Transatlantic region is expected to have proportionally the most retirements in terms of number of submarine cables by 2030 as it is expected that almost half of the cables operating today will be decommissioned (45.8%) in the region. Although the highest number of cables (58) is expected to be retired in the EMEA region (accounting for over 40% of its total cables), this will only decrease the region's capacity with less than 3%.

In terms of EU connections, the ones **most affected by retirements by 2030 are the EU-Latin America, EU - Central and Western Asia and EU-English North America routes.** In case of the EU - Latin America route, a staggering 85% of the cables is projected to be decommissioned, which will decrease the total capacity by 21.5%. The number of cables on the EU - English North America route is expected to decrease by 59% reducing the total capacity with 16%. Similar decrease in capacity is forecasted in case of the EU - Central and Western Asia with the presumed retirement of one third of its cables and 17.5% of its capacity.

Trends affecting submarine cable system developments

The future of submarine cable investments is shaped by four key trends: the increase in international bandwidth demand, rising cable utilization, long-term technological developments, and decreasing wavelength prices.

The used international bandwidth has been doubling every 18 months in the Intra-Asia, Europe-South Asia, and Europe-Sub-Saharan Africa regions between 2010-2020.

The utilization of cable capacities is rising as the growth of design capacity has failed to outpace that of lit capacity.

Technological improvement is a must to develop enough capacity in the long term and drive down construction and unit costs, as well as allow better diversity and resilience.

Technology improvements and the increasing number of investments and competition results in wavelengths price declines, attracting an increasing customer base thus also driving submarine cable infrastructure investments.

Required new cable systems and the expected system landscape by 2030

The growing demand for international bandwidth use leads to increasing requirements for new cable investments and technological improvements.

The total number of cables required in the period of 2021-2030 **is expected to remain around 370-400** with a **steadily increasing demand for new cable investments.** The projected number of **cables newly installed** varies a lot annually; on average it is **around 14 cables per year.**

Regions with the fastest growing routes, Transatlantic, Transpacific, and Intra-Asia, **will need more cable installations** than what is already planned **in the following ten years** to compensate for the commissioning

of old ones and meet the need for international bandwidth. Capacity requirement in the Transatlantic region, for example, will accelerate at an unprecedented pace - to around 12 Pbps by 2030.[240]

4.2.2.1. Expected cable retirements

In the previous chapter, the importance of cable age was already introduced. Analysing the number and capacity of retiring cables provides a strong base to predict which areas are endangered by aging cables and the lack of their replacement.

Expected cable retirements by submarine cable region

The following figure shows the number and percentage of systems and capacity that are likely to be retired by 2030 based on their life span by submarine cable region[241]:

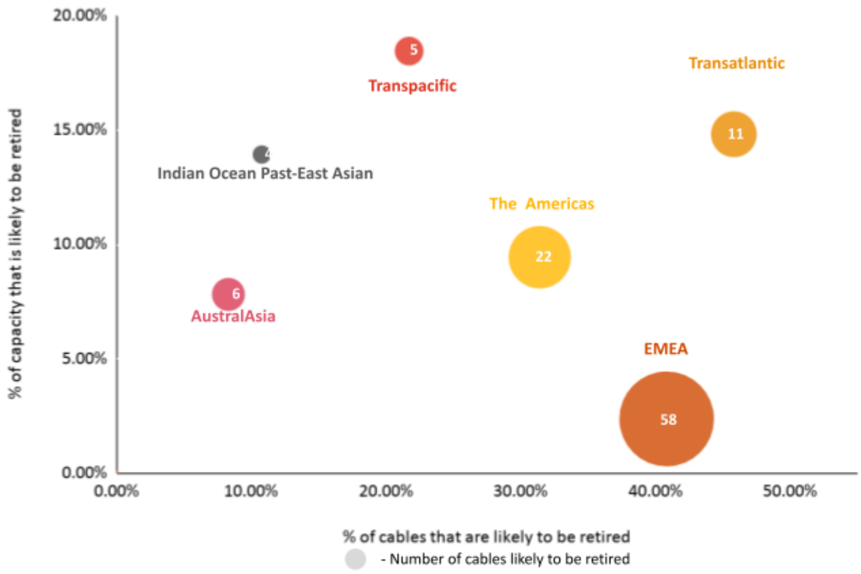

Figure 82: Expected cable retirements by submarine cable regions by 2030

The EMEA region has the highest number of cables that are likely to be retired and the second highest percentage (41%) among regions. However, **the percentage of retiring capacity** by 2030 **is the smallest** in the EMEA region after the Arctic region. With the 2.4% capacity decrease, cables in the EMEA region would likely be able to serve today's demand in 2030. But since demand is ever increasing (as detailed in the next chapter), **additional capacity would be required in this region as well.**

The **Americas region is similar** in a way that although the percentage of systems to be retired is quite high (31%), the capacity is much lower, only around 9.5%. However, it is important to note that **some of the most significant connections** in this region, such as the two cables between Miami and New York **will be likely out of service by 2030**.[242]

Since the **Arctic region** did not get as much attention in the past as other regions, there are **no cables that will reach the age of 25 by 2030**. Although this means that this region has the best values in terms of system and capacity retirement, there are **only a very few cables** in this region.

In case of **Australasia and the Indian Ocean Pan-East Asian regions**, there are not **any big differences** between the **percentage of systems and capacity that are to be retired** by 2030.[243] This

[240] Telegeography: Pacific Telecommunications Council - Telegeography Workshop 2020
[241] The figure includes all cables that are either in service today or are announced.
[242] Aquacomms: Future Submarine cable Networks, the Year 2030
[243] The difference between these two values is under 3% in each region.

means that **new cables in these regions have similar capacities to old cables** which implies that **new cables are technologically not as advanced as they could be**.[244]

The **Transatlantic region bears a high risk** since the cables from the DotCom era will be retired already around 2023.[245] With other systems over the age of 25 as well, this means that almost **half of the currently known cables are retiring by 2030**. Unfortunately, in this region, the remaining **cables are also quite old**, thus they have **lower capacity and less competitive pricing**.[246] The **percentage of retiring capacity is also high**, **over 14%**. This means that the **region will need a lot of additional capacity** not only to serve the demand levels of today but the probable increased demand of 2030 as well.

The **highest level of capacity retirement** (more than 18%) is to be expected **in the Transpacific region**. Furthermore, in the Transpacific, the **available capacity might be endangered** in the future by **strict US ownership regulations as well**.[247]

Expected cable retirements by EU route

On average, **EU routes seem to be more endangered by the loss of capacity than the submarine cable regions**. Proportionally, twice as many systems are to be retired on EU routes than in the submarine cable regions previously covered. The **average capacity to be retired is also higher** along the EU routes.

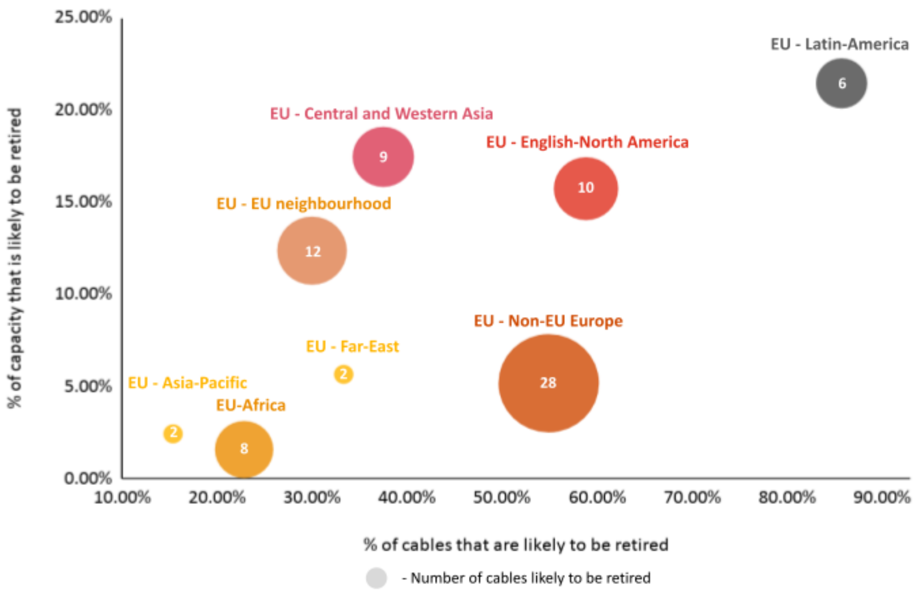

Figure 83: Expected cable retirements by EU routes by 2030

The **EU - Non-EU Europe route** will account **for more than half of the EMEA region's retiring cables**. Almost **55%** of currently known cables will be retired by 2030. Luckily, similarly to the EMEA region in the previous analysis, **retiring capacity is much lower, only around 5%**. However, **capacity is not evenly distributed among the cables of this route**. For example, the connections between the UK and mainland Europe are relatively older, thus operational costs of these cables might be higher.[248]

The **EU - Far East route is similar** to the EU - Non-EU Europe route in having **a high percentage of systems (33) and a much lower amount of retiring capacity (5.7%)**. Although this may sound

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[244] The average capacity of cables that were ready for service between 2016 and 2020 in the Australasia, Transpacific and Indian Ocean Pan-East Asian regions is lower than the global average. While the average capacity of these recent cables is 103 Tbps among the EMEA, the Transatlantic and the Americas regions, this number is 60 Tbps lower among the discussed three.
[245] Aquacomms: Future Submarine cable Networks, the Year 2030
[246] Aquacomms: Future Submarine cable Networks, the Year 2030
[247] Aquacomms: Future Submarine cable Networks, the Year 2030
[248] Aquacomms: Future Submarine cable Networks, the Year 2030

reassuring at first, it should be noted that **resilience depends a lot on the number of cables** available in a region. Since having less cables increases the impact of cable failures in a region, **one new cable with very high capacity, unfortunately, cannot really substitute** a great number of low capacity cables without resilience suffering as a result.

The EU - English North America route also has the second highest percentage of retiring cables, **almost 60%**. In this case, the **capacity to be retired is also high, around 16%**. This is not surprising after examining the similar numbers of the Transatlantic submarine cable region. Hence, this route will also need more capacity to be able to serve the demand of 2030.

Although on the **EU - EU Neighbourhood** and the **EU - Central and Western Asia** routes, the percentage of **retiring cables are considered low** compared to the other routes, **it is still around 30%**. The ratio of **capacity to be retired** is around the same as on the EU - English North America route, (**17%**), while on the EU - EU Neighbourhood route it is slightly lower, (**12%**).

The **EU - Africa** and the **EU - Asia-Pacific routes seem to be the best prepared for 2030** as the **percentage of retiring systems** (23%, 15% respectively) **and capacity** (1.6%, 2.5% respectively) both **are the lowest on these routes**. This is fortunate because African countries tend to rely more on submarine cables than the average since terrestrial networks are often hindered for geopolitical reasons.[249]

Just as previous analysis in the study, this one also points to the fact that the **EU - Latin America route needs the most attention**. This route has **both the highest percentage of retiring cables and capacity** (85% and 21% respectively) **among all EU routes**.

4.2.2.2. Trends affecting submarine cable investments

Submarine cable investments have been influenced by several factors over the last decades, such as **improved internet penetration,** analysed in previous chapters, and the increasing globalization requiring **growing availability of international digital communication.** Based on the trends observed in the last few years, the following trends are shaping the future of these infrastructural investments:

- **Increasing international bandwidth demand**

  The drivers of the increasing global internet traffic detailed in previous chapters (Chapter 4.1 *Drivers of digital connectivity developments*) **implies a growing demand for international bandwidth** and hence for the growth of worldwide submarine cable capacity. The rising penetration together with the content consumed with high-bandwidth requirements lead to a soaring international bandwidth use.

  The used international bandwidth has been doubling every 18 months in the Intra-Asia, Europe-South Asia, and Europe-Sub-Saharan Africa regions between 2010-2020 while in all other regions, it doubled at least every 2 years in the same period. This accelerated growth entails the demand for increase in not only submarine cables but also in infrastructure linking those together. The **activity of interconnection providers** (such as Microsoft Azure, Google, AWS) who massively invest for the long-term in frontier markets and establish data centres (see details in 4.1.2.), is also a projection of the ever-increasing international bandwidth demand needed to be supplied by additional submarine cable systems.[250]

- **Rising utilization**

  The rising utilization of the submarine cable systems also shows a need for increasing investments in submarine cables and capacity as the growth of design capacity has failed to outpace that of lit capacity - outlined in the Current State analysis - meaning that the international bandwidth actually used is increasing faster than the maximum capacity of cables.

[249] Aquacomms: Future Submarine cable Networks, the Year 2030
[250] Telegeography: Pacific Telecommunications Council - Telegeography Workshop 2021

The COVID-19 pandemic has strengthened this trend with unprecedented demand growth. As it was already covered in the Current State Analysis, the coronavirus pandemic significantly raised data traffic. This has required quick, thus short-term solutions which drew the attention to necessary long-term changes as well.

- **Long-term technological improvements**

  The submarine cable industry has been characterized by continuous technological developments. These improvements are becoming even more essential in the future to develop enough capacity in the long term and drive down construction and unit costs as well as allow better diversity and resilience. Better technologies that drive down costs (such as Spatial Division Multiplexing (SDM), or enhanced network design allowing landing in data centres directly)[251] establish more attractive investment opportunities, beneficial to a wider range of companies to invest. Also, there are some cutting-edge solutions (for example Science Monitoring and Reliable Telecommunications (SMART) cables)[252], which will be a necessity in the next 10 years to be integrated into cables and hence drive the new submarine cable investments.

- **Decreasing wavelength prices**

  Technology improvements and the increasing number of investments and competition results in wavelengths price declines. Some diverse paths command a premium but with more supply in those markets, this will also decrease in the future.[253]

  In rapidly growing developing markets, the unit costs are decreasing at a faster pace accordingly, resulting in lower prices passed on to customers. The convergence of prices in more developed and developing markets, although cannot lead to unified prices due to different demand, network topology and underlying costs, will attract a further increasing customer base, also driving submarine cable infrastructure and technological investments.[254,255]

Overall, the trends of accelerating international bandwidth use, increasing cable capacity utilization, the ever-growing need for technological advancements and the decreasing wavelength prices all shape the future of new submarine cable investments, by either attracting more investors or setting the minimum requirement for infrastructure needs.

4.2.2.3. Required new cables and the future landscape of submarine cables based on forecasts

The growing demand for international bandwidth use leads to increasing requirements for new cable investments and technological improvements. For better understanding of the global cable requirements and deployments, the assumptions of Telegeography[256] will be used:

- For faster growing routes, Transatlantic, Transpacific, Intra-Asia, the followings are assumed:
  - Now 30 Tbps cables are available with 20 Tbps per FP and 16 FP per cable on average.
  - Telegeography assumes 640 Tbps cables by 2023 owing to twice as many available fibre pairs per cable (32 FP x 20 Tbps).
  - By 2025, they project 1 Pbps cables with 50 FP per cable on average and 20 Tbps per FP to be available.
- For all other regions, Telegeography assumed a ratio of 1 to 1 cable replacement in the year of cable decommissioning, so 25 years after the RFS year.

[251] SDM allows a reduced cost per fiber pair, while landing in data centres avoids equipment costs.
[252] SMART solutions turn submarine cables into environmentally aware systems that can provide real-time data on ocean temperatures or sense man-made hazards and prelude of natural disasters.
[253] Telegeography: Pacific Telecommunications Council - Telegeography Workshop 2020
[254] For example, the 100 Gbps wavelength lease price converged from a gap of approximately $20-$250 in 2016, to as little as $10-$80 in 2020
[255] Telegeography: Pacific Telecommunications Council - Telegeography Workshop 2021
[256]The figure shows cumulative data. The forecast originally starts in 2020.

Based on these assumptions, the global and regional level calculations were conducted to project the future cable requirements, and the number of new cables added yearly.

Global overview

The overall requirement for submarine cables is projected to be rather stagnant in the next ten years, as it remains between approximately 370 and 400. Yet, as cables age, the ratio of existing cables to required new cables will continuously decline, implying an increasing demand for investments.

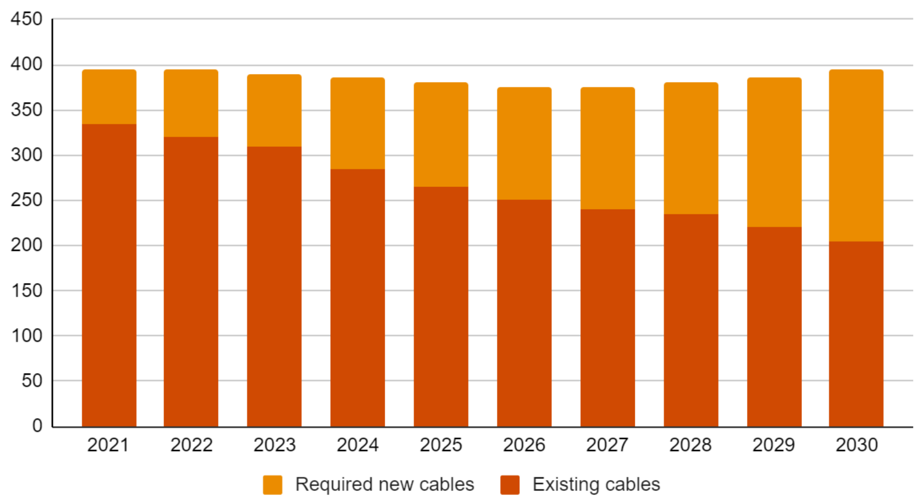

Figure 84: Global cable requirements (cable paths) 2021-2030[257][258]

The number of existing cable paths is expected to decrease with 5.3% on average each year in the period of 2021-2030, while the requirement for new cables is growing at a CAGR of about 13.7%. This pattern can be explained by the growing number of cables decommissioned as much of the connectivity infrastructure was installed around the 2000s.

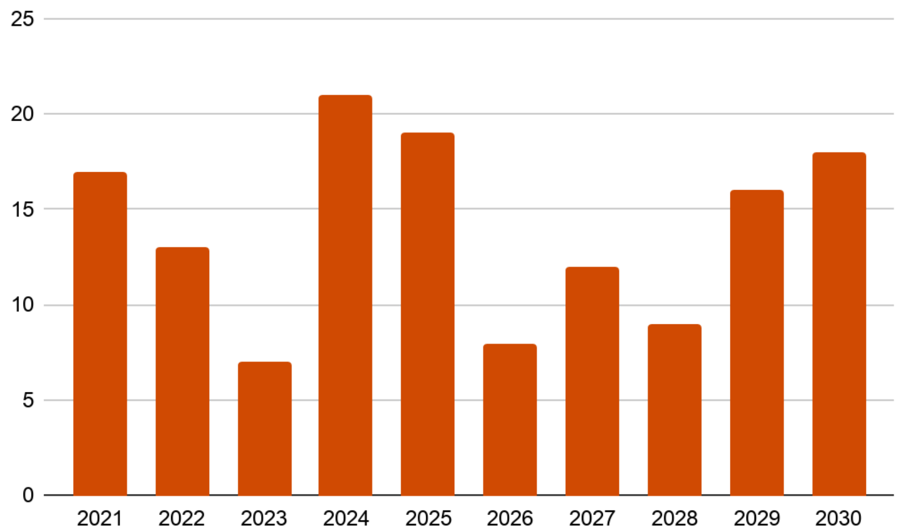

Figure 85: New cables per year 2021-2030[259][260]

According to Telegeography's forecast, **the number of cables newly installed varies annually; on average it is around 14 cables per year.**

[257]Telegeography: Pacific Telecommunications Council - Telegeography Workshop 2020
[258]The figure shows cumulative data. The forecast originally starts in 2020.
[259]Telegeography: Pacific Telecommunications Council - Telegeography Workshop 2020
[260]The number of projected new cables here and in the rest of the chapter may differ from numbers depicted in the chapter *Infrastructure by 2025* as the former is merely a forecast relying on assumptions that cannot describe the future with 100% accuracy while the latter is based on new submarine cable announcements which may not necessarily reflect reality perfectly either (owing to factors already covered at the beginning of that chapter).

Regional overview

The cable requirements and deployment needs vary across submarine cable regions. Regions with the fastest growing routes (Transatlantic, Transpacific and Intra-Asia) **will need more cable installations in the following ten years compensating for the commissioning of old ones and to meet the future need for international bandwidth.**

The growth of capacity needs for the most rapidly growing region, the Transatlantic will accelerate at an unprecedented pace. The cumulative capacity requirement in the region is expected to more than double between 2020 and 2025, reaching about 3 Pbps and further accelerating to around **12 Pbps by 2030.** Accordingly, the cable need will also grow further and approximately 15 additional cables will be required by 2030. This can be attributed to the declining number of existing cables and hence capacity.[261] As mentioned before, the magnitude of decrease in available cables in the region is a **consequence of these assets being built in the DotCom era, coming to the end of their life all approximately at the same time,** by 2023.[262] The mass number of decommissioned cables and the accelerating need for capacity and diversity can also be seen as an opportunity for stakeholders.[263]

In the Transpacific region, Telegeography estimates that the number of cables required will grow from 2027 to 2030, however, only to about 7 cables.[264] Regarding the number of cable spans, the expansion of other Asian countries than Japan is expected to continue with 3 cables owned by non-Japanese stakeholders in the period of 2019-2021, compared to only one cable being linked to Japan.[265]

In the Intra-Asia region, which is also one of those with rapid growth, although present higher need for additional capacity and number of new cables installed in the future, **there are many investments being made and announced, which all will help meeting this need.**[266]

Generally, the slower growing regions have newer systems installed and therefore the required cables are rather attributed to increased resilience and diversity to the decommissioning of already existing ones. For example, the cables in West Africa that currently exist will be aged around 19 years in 2030, system developers will rather invest in higher-capacity or extra cables for resilience.[267]

[261] Telegeography: Pacific Telecommunications Council - Telegeography Workshop 2020
[262] AquaComms: Future Submarine cable Networks, the Year 2030
[263] Telegeography: TeleGeography Workshop
[264] Telegeography: Pacific Telecommunications Council - Telegeography Workshop 2020
[265] Telegeography: TeleGeography Workshop
[266] AquaComms: Future Submarine cable Networks, the Year 2030
[267] AquaComms: Future Submarine cable Networks, the Year 2030

4.2.3. Non-submarine overseas connectivity developments

Until recently, satellite internet service only meant the use of **geostationary (GEO) satellites with high latency and low bandwidth**. **Technological advancement** enabled us to use satellites for internet connectivity that are **closer to the Earth**. These are the **Low-Earth-Orbit (LEO) and Medium-Earth-Orbit (MEO) satellites with lower latency and higher bandwidth**.

Increasing use of more advanced satellite technologies is expected, especially in reaching remote and rural areas. Although **satellite technology has developed greatly** in the past few years, **satellites are not likely to replace submarine cables in the next decade** as the bandwidth of submarine cable system increases fast due to technology advancements that rapidly increase submarine cable capacity.

Satellite internet service is typically provided by geostationary satellites, however, in the future, an increasing use of more advanced satellite technologies is expected. Geostationary satellites (GEOs) are at an altitude of 35,786 km, so they can cover a wider area permanently, but the long distance causes high latency.[268] As demand grows for real time connections, high latency is becoming more and more of an issue. This is why there is likely to be a growing number of Low-Earth-Orbit (LEO) and Medium-Earth-Orbit (MEO) satellites since they provide lower latency and higher bandwidth. They are both constellations of many smaller satellites. MEO satellites are usually at an altitude of above 2,000 km and below 35,000 km, the geostationary orbit,[269] and LEO satellites are defined as being deployed in the space below 2,000 km.[270,271]

Several major players are experimenting with LEO satellites. One of the most widely known projects is **Starlink by SpaceX**, the company of Elon Musk. SpaceX has **just launched 60 new internet satellites** on March 24, 2021, increasing the number of Starlink satellites in orbit to more than 1300**.** Starlink offers data speeds from 50 Mb/s to 150 Mb/s and latency between 20 ms to 40 ms and aims to reach near global coverage of the populated world in 2021.[272] The company already has **permission to launch 30,000 more satellites, which might have a significant contribution in the spread of satellite internet services**.[273] Another major player, the London-based **OneWeb**, **space industry rival of SpaceX**, launched 36 satellites on March 25, 2021, from Russia, increasing its number of satellites in orbit to almost 150.[274] OneWeb **plans to launch a constellation of 650 satellites** in its Phase One, between 2019 and 2022.[275] Besides the two biggest players, there are other companies having LEO satellites in orbit. For example, Iridium has 66 operational satellites in orbit, at an altitude of 780 km.[276]

An example for **MEO satellites is SES's O3b mPOWER**. **SpaceX** was chosen for launching the satellites, the first three late this year, six in 2022, and the last two in 2024.[277]

There are very promising and ambitious projects in this **new technologically advanced area of satellite internet service**. Despite LEO and MEO satellite constellations, **it is still not probable that satellites will substitute submarine cables as the backbone of internet data distribution in the next few years.**[278] New technologies in satellite systems, however, may achieve **great progress** in the matter of **providing internet in rural and remote areas**.

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[268] ScienceDirect: Geostationary Satellites
[269]The European Space Agency: Types of orbits
[270]The Washington Post: Why Low Earth Orbits Satellites Are the New Space Race?
[271] Simple Flying: LEO, GEO, MEO Satellites – What's The Difference?
[272] Official webpage of Starlink
[273] Space.com: SpaceX launches 60 new Starlink internet satellites, nails latest rocket landing at sea
[274] Space.com: Soyuz rocket launches 36 OneWeb satellites into orbit for modified satellite internet constellation
[275] Spaceflight Now: Starlink and OneWeb satellites ready for launch on opposite sides of the world
[276] Space News: Iridium ends legacy satellite service, switches all traffic to Next fleet
[277] Space News: SES orders four more O3b mPower satellites from Boeing
[278] TeleGeography Blog: Will New Satellites End the Dominance of Submarine cables?

4.3. Analysis of the business models

4.3.1. Stakeholders and business models in submarine cable systems

Stakeholders and business models in submarine cable systems

Surveyors

It is likely that EGS will stay the most dominant market player on the global scale while Fugro also remains a significant player. **The greatest challenge of the surveyor market is the timely completion of the planned surveys**. Until the end of 2020, only 27.7% of planned systems for the period 2020 to 2022 have performed this task.

System suppliers

No remarkable change can be expected on a global scale until 2025. The **most cables will be supplied globally by EU-based companies** (among which the largest supplier is ASN), **however, US-based suppliers will be also dominant** (including mainly SubCom) **and the Japanese NEC will be significant players as well.** Examining only the EU connected cables European companies will account for more than two-thirds of the investments.

For the period 2025 to 2030 it is a likely scenario that the trends of recent years continue. The key players keep their market position, while smaller players will operate at the regional level. However, it is also a conceivable scenario that either large suppliers will acquire the smaller, regional companies or content providers enter the supplier market.

Installers

In the period 2021 to 2025, **half of the cables will be supplied by EU-based companies, while US-based companies account for 25%. The greatest challenge of the installer market is the capacity of cable ships.**

Owners

No remarkable change can be expected on a global scale until 2025. Both on a global and European scale the most cables will be supplied globally by the “Other” group.

However, since the owner market is very diverse, a more accurate picture can be seen by looking only at the activity of the largest players:

- **Globally content providers are the key market leaders** and it is expected that the four key players (Google, Facebook, Microsoft and Amazon) will remain strong. Especially Facebook and Amazon will speed up their investments according to announced information. Furthermore, European and Non-EU European owned cables will be dominant as well.
- **In terms of EU connected cables European owned companies are planning to build the most cables by far,** however, the activity of Non-EU European companies and content providers will be also significant. However, in terms of km of cables, the “Other” group has the largest market share.

After 2025 it is likely that the role of content providers will be further strengthened and in the meantime the role of traditional telecommunications service providers will shrink in transcontinental connectivity. It is also possible that traditional telco providers will focus their investments more in national infrastructure and niche areas.

Maintenance providers

No remarkable change in key players can be expected, however, **there is an increased challenge of providers in being able to perform the required volume of maintenance activities**.

4.3.1.1. Surveyors

Based on the trends of the previous years, **it is likely that EGS will stay the most dominant market player** on the global scale while Fugro also remains a significant player. Smaller players (like Elettra, IT International Telecom, Gardline etc.) are more likely to remain regionally active or will be acquired by the larger companies. Regarding potential new entrants, no information has been published, however, due to the concentrated nature of the market, the chances are slim.

The greatest challenge of the surveyor market is the timely completion of the planned surveys. Until the end of 2020, only 27.7% of planned systems for the period 2020 to 2022 have performed this task. Additionally, only 41% of all systems planned for 2021 have completed a survey.[279] As the timeline for manufacturing and installing a typical submarine cable system is about 18 months from survey end to system completion, this means that only a few systems planned for 2021 are on track. In contrast, this time last year, 39% of systems planned for the following year had completed their survey.

4.3.1.2. System suppliers

In order to get a deeper understanding of greater regional mechanisms in the market**, systems suppliers were divided into categories** based on the focuses of the study and also taking into account the activity of the largest suppliers.[280]

In terms of the number of planned and announced cables in the period 2021 to 2025, **the most cables will be supplied globally by EU-based companies. The largest supplier is ASN**, however, Hexatronic, Cecon Contracting and N0r5ke Fibre have also announced cables. All together, they account for 44% of all planned cables. The second largest supplier category (31%) is the US-based companies, mostly driven by SubCom's activity, while the Japanese region has only a market share of 16.7%.

Regarding the length of planned cables, the global market share of suppliers is very similar. European companies have announced more than 140,000 km cables for the period 2021 to 2025, resulting in an even higher market share for them (50%). This is twice the size compared to the plans of US-based suppliers.

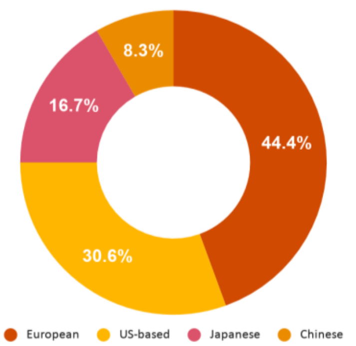

Figure 86: Global market share of suppliers (number of cables)

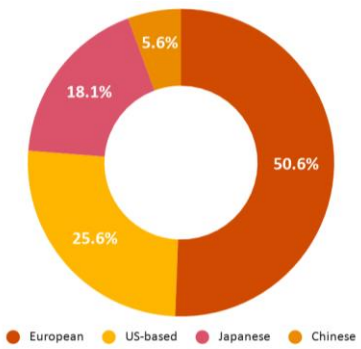

Figure 87: Global market share of suppliers (km)

Examining only the EU connected cables for the same period, only European, US-based and Chinese suppliers have announced cables. In this case **European companies account for more than two-thirds of the investments** and the proportion is the same when analysing the km of the planned cables.

[279] Submarine Telecoms Report: Submarine Telecoms Industry Report
[280] The examined regions' definitions, the countries and companies they include is explained in Annex 6.2.

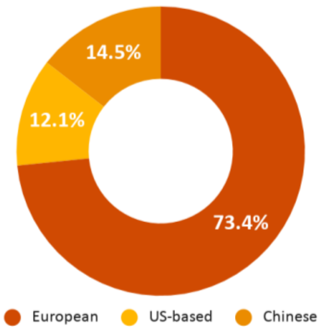

Figure 88: Market share of suppliers of EU connected cables (number of cables)

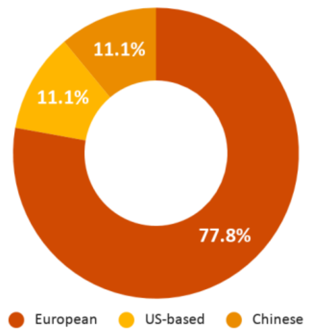

Figure 89: Market share of suppliers of EU connected cables (km)

Based on the trends of the previous 10 years and the announced information, **no remarkable change can be expected on a global scale until 2025,** however, it is conceivable that large players will acquire some smaller players in order to take advantage of economies of scale. Furthermore, as all system suppliers are composed of industry veterans with many years of experience in the submarine fibre industry - with innovative technologies and reliable production, - a healthy cable supplier industry can be expected.[281]

For the period 2025 to 2030 conclusions can be made on the basis of global market trends and experts' forecast and the following scenarios can be defined:

- **It is a likely scenario that the trends of recent years continue.** The four strong players (ASN, SubCom, NEC and Huawei Marine) keep their market position, while smaller players will operate at the regional level.
- **It is conceivable that regional system suppliers will be gradually pushed out of the market and the largest ones will become even larger** by acquiring them for more resources. The reasons behind can be the high pressure resulting from the increasing number of orders and the growing demand for global-sized cables and smaller companies most likely will not be able to meet these expectations
- **Content providers entering the supplier market as also possible**. On the one hand it is a common phenomenon for companies to extend their operations within the supply chain in order to gain more control. For example, in the international connectivity market AT&T is a good example who does not only own, but also manufactures cables for itself. Furthermore, it is also a common practice for content providers to acquire other actors - such as Google who bought Motorola in 2016[282]- and they have the financial resources as well. On the other hand, system suppliers are already very busy due to the growing demand and there is also a lot of pressure from content providers to work as low-priced and fast as possible. Beyond a certain point, they may not be able to meet the requirements and other players will be needed to enter the market. However, as no specific information has been received so far, this scenario seems the least likely at the moment.

4.3.1.3. Installers

During the analysis, **the same categorisation has been applied** as for the suppliers.[283]

[281] Submarine Telecoms Report: Submarine Telecoms Industry Report
[282] Google: Facts about Google's acquisition of Motorola
[283] The examined regions' definitions, the countries and companies they include is explained in detail in Annex 6.2.

For installers, a similar trend can be identified as in case of systems suppliers which is not surprising given that the activities of the two stakeholder groups are closely intertwined. In terms of the number of planned and announced cables in the period 2021 to 2025, **half of the cables will be supplied by EU-based companies, while US-based companies account for 25%.** No Chinese company has yet announced activity for this period. Regarding the length of planned cables, European companies still take the lead with more than 50% market share, however, US-based companies are also closely behind them with 43.5%.

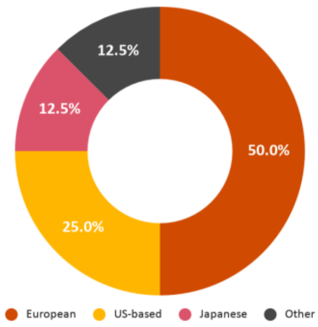

Figure 90: Global market share of owners (number of cables)

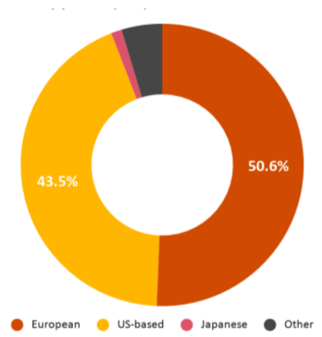

Figure 91: Global market share of installers (km)

The greatest challenge of the installer market is the capacity of cable ships. There has been a clear downward trend in new ships being commissioned and no cable ships were added to the global fleet from 2004 to 2010, while between 2010 and 2020 only four (and one sank). As of the latest information, no new submarine fibre cable ships are currently planned and, in the meantime, existing cable ships are getting older - the average age is more than 20 years. This is a potential cause for concern as the small number of vessels may not be able to meet the increased demand soon.[284]

4.3.1.4. Owners

During the analysis**, owners have been also divided into categories** based on the focuses of the study and also taking into account the activity of the largest owners.[285]

On a global scale and in the period 2021 to 2025, **both in terms of the planned number and km of cables, the most cables will be supplied globally by the "Other" group.** The reason behind this is that the market is very diverse, as there are a large number of telecommunication companies owning submarine cables. Furthermore, those in the "Other" category usually own only one or two cables each, which, in addition, are typically shorter cables. By looking at the length of the planned cables instead of the number of cables, it can be seen that the proportion of the "Other" category has decreased, which supports the previous argument. Moreover, the proportion of content providers (from 13.6% to 17.7%) and Chinese telecommunications companies (from 7.1% to 12.5%) are already showing a significant increase in this case.

[284] Submarine Telecoms Report: Submarine Telecoms Industry Report

[285] The examined regions' definitions, the countries and companies they include is explained in detail in Annex 6.2.

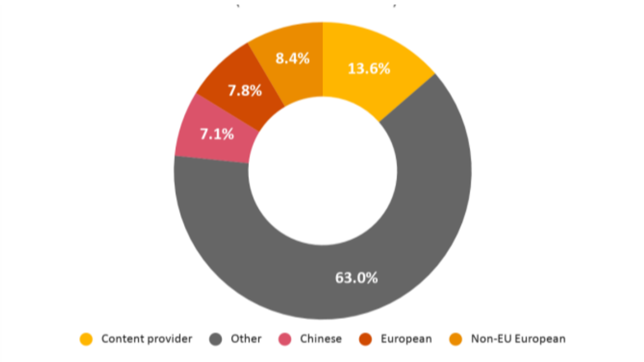

Figure 92: Market share of owner (number of cables)

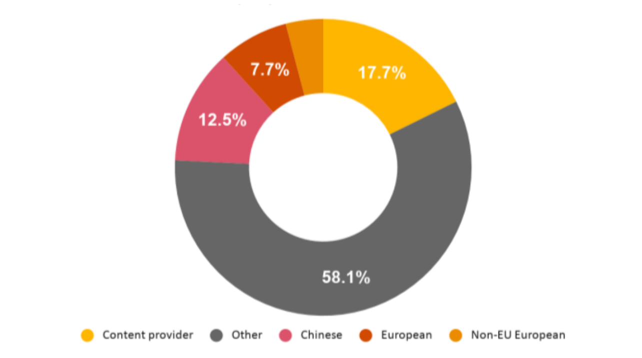

Figure 93: Market share of owner (km)

In order to counterbalance the bias resulting from high diversification, the largest owners - companies that have announced at least three cables for the period 2021 to 2025 - **have been also examined separately and content providers are the clear market leaders.** The figures below demonstrate the significant changes in the proportions. In terms of number of planned cables, content providers have announced 20 cables for the period thus achieving a market share of 53%. On the other hand, looking at the length of the cables, they own 43% of the cables, which means more than 200,000 km of cables. In both cases they are market leaders by a large percentage.

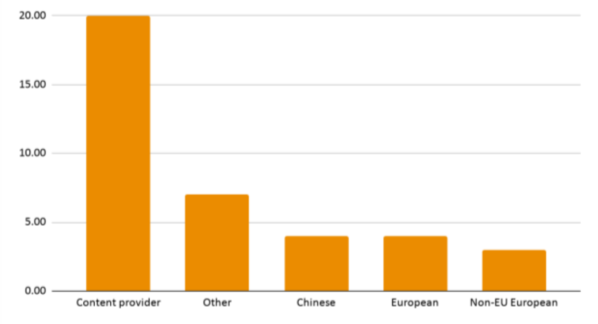

Figure 94: Market leaders in terms of largest owners (number of cables)

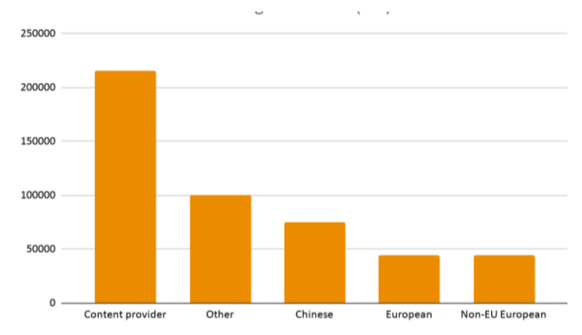

Figure 95: Market leaders in terms of largest owners (km)

It can be seen that content providers have reported a lower level of investment in their proportions than in previous periods regarding the planned investments of content providers versus non-content providers. However, as explained earlier, the level of investment actually planned by content providers is likely to be greater than what we know from the information published so far. Also, the fact that in this composition only 4 content providers are opposed to more than 100 telecommunication companies cannot be neglected: as a result, their significance may seem small overall, while they are very significant players individually.

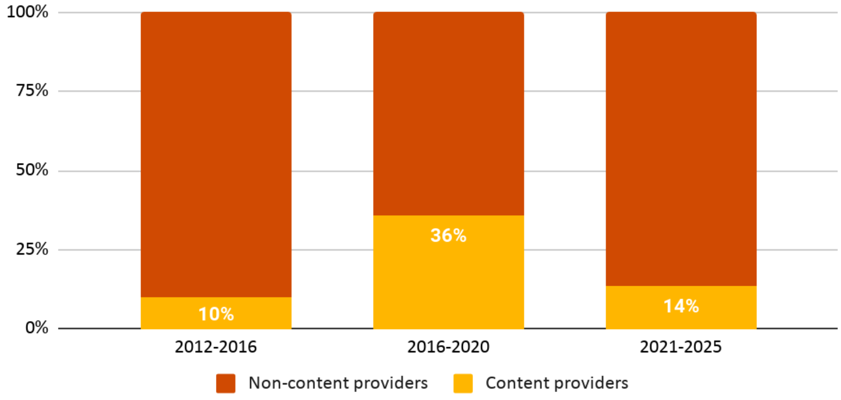

Figure 96: System driven by owner types (investment value, $)

Based on announced cables the most relevant content providers will stay the same four companies: Google, Facebook, Microsoft and Amazon and together they will build 21 more cables, of which 5 will connect with the EU (cf. Figure 101). However according to available information Google might reduce their investment and Facebook takes the lead. **Facebook announced to build almost three times more km of cables in the next 5 years as it has done so far**, as it can be seen in Figure 97. Furthermore, it seems **Amazon will also speed up their investments** and become the third largest among content providers. No new content providers have announced its entry into the market yet (e.g. Apple, Dropbox, IBM or Chinese content providers).

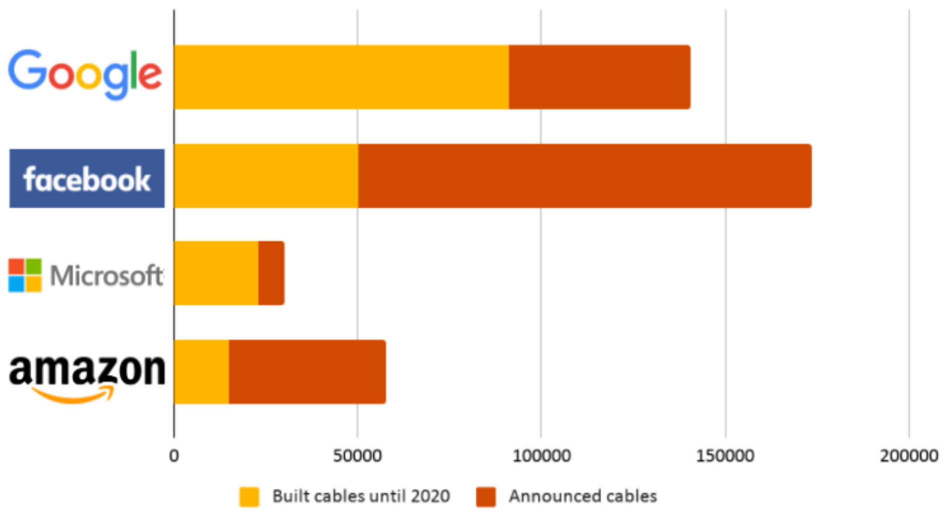

Figure 97: Cable owned by content providers (km)

In terms of content providers' regional activity, a change in their focus can be observed. While investments in the Transatlantic, Australasia and Americas regions are expected to decline, **significant growth can be seen in the Transpacific regions. Content providers will appear in the EMEA and the Indian Ocean Pan-East Asian regions as well.**

Figure 98: Regional activity of content providers (number of cables)[286]

Regarding EU connected cables for the period 2025 to 2030, the most cables are also planned by the "Other" group both in terms of planned number and km of cables, for the same reasons as elaborated in the global analysis. However different conclusions can be drawn when examining the number of planned cables and when looking at the length of the cables.

- The number of Non-EU European and European owned cables are also dominant with 22.2% and 20% market share, respectively.
- Looking at the length of the cables, the content providers (15.8%) seem to have a significant market share besides European owned cables (13.4%).

This indicates that although content providers do not build a large number of cables, their cables are typically longer, implying they are rather global in size. Furthermore, the market share of Chinese owned cables is not expected to be remarkable in either case.

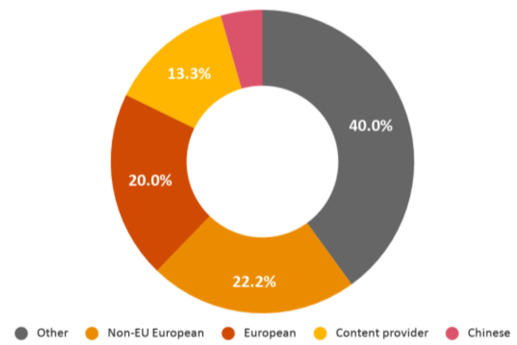

Figure 99: EU connected cables by owner category (number of cables)

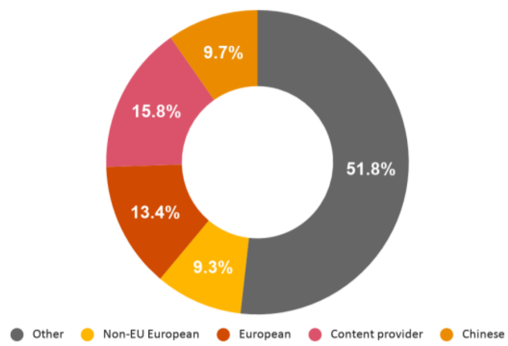

Figure 100: EU connected cables by owner category (km)

Examining only the largest owners with EU connected cables - those who are planning to add at least two cables - **either European companies or the "Other" group are the most dominant, however, content providers and Non-EU European owners will be significant as well:**

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[286] The figure shows the planned and announced regional activity of content providers in the period 2021 to 2025 and the growth/decline compared to the period 2016 to 2020.

- Regarding the number of cables, European owned companies (8 cables) are planning to build the most cables by far, however, the activity of Non-EU European companies and content providers is also significant with 5 cables each.
- In terms of km of cables however, the "Other" group has the largest market share with more than 150,000 km of cables which is twice as much as the second largest group, the content providers (77,000 km). This is mainly due to the 2Africa cable (37,000 km), which includes multiple companies from the "Other" category. Chinese players have primarily invested in the PEACE cable, but they have ownership in the 2Africa cable as well.

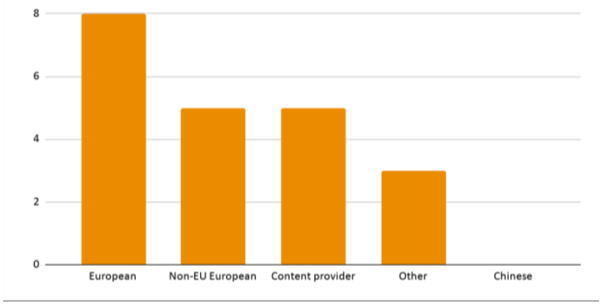

Figure 101: Market leaders in terms of largest owners with EU connected cables (number of cables)

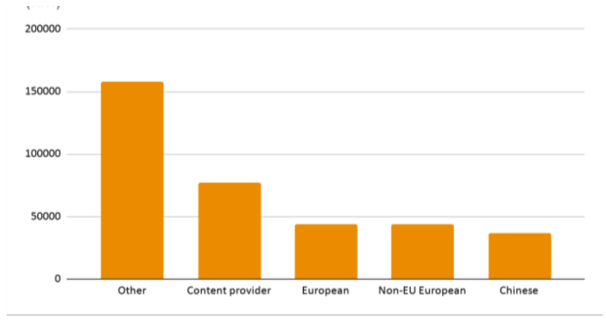

Figure 102: Market leaders in terms of largest owners with EU connected cables (km)

Based on the trends of the previous 10 years and the announced information - similarly to system suppliers -, **no remarkable change can be expected on a global scale until 2025.** As for the period 2025 to 2030 no specific data are available, the following scenarios can be defined based on the trends and experts' forecast:

- **It is a likely scenario that** the trends of recent years continue. **The role of content providers will be further strengthened** - **especially the role of Amazon and Microsoft**, who have only recently entered the market and have great growth potential. **In the meantime, traditional telecommunications service providers might have a shrinking role in transcontinental connectivity and enhanced roles in niche areas.** It is also possible that they will rather invest in national infrastructure to **provide local connectivity.** Furthermore, it is not clear yet if content providers will keep building cables solely for their own use or will share the available capacity with other market actors.[287] However this is also likely to depend heavily on regulations.
- According to another scenario, **it is also conceivable that new entrants will enter the market**. They can be either content providers who have not yet been present in the market, such as Zoom or Apple, or companies that create, transmit, or use a lot of data due to their activities (mainly activities related to AR/VR/MR, IoT). However, no specific information has been received so far, hence this scenario seems less likely at the moment.
- At last, **it is also a possible scenario that by 2025 content providers will have built all the necessary cables** - as they have connected all their data centres and facilities -, and their willingness to invest will subside. The power of traditional actors is strengthened again, and a balance is established between content providers and non-content providers. Based on the rapid growth of data consumption, the increasing amount of investments and expert opinions, this is the least likely scenario.

4.3.1.5. Maintenance providers

Regarding the maintenance market, no remarkable change in key players can be expected, however, **there is an increased challenge of providers in being able to perform the required volume of maintenance activities**. In one year, an average of 100 cables are damaged, usually due to fishing trawlers or anchors, but occasionally from natural disasters such as earthquakes. This number could

[287] Information received through expert interviews.

increase further with the number of cables expanding every year, which, moreover, will be less and less able to be served by the aging vessels.

4.3.2. Financing and investments

Total investment value shows a significant increase in 2021 and is expected to remain high in the following years as well. By 2025 the total investment value most likely will be four times more than it was in 2020. At the same time, **the market size is expected to** be between **$28-30 billion by 2025**.

The proportion of investments from private investors and hybrid financing will grow, while Multilateral Development Banks will focus on less developed regions.

Some experts also argue that **working capital finance** as an alternative funding mechanism should be introduced.

Based on the data published so far, in terms of global investments a significant increase is expected compared to the trends of previous years. **In 2021 the total investment value most likely will be four times more than it was in 2020** (from $1 billion to $4.3 billion) and the value will remain high in the following years as well.

At the same time, according to announced estimates the **size of the market is expected to grow by 7.1% to 12.1% CAGR by 2025** (depending on the calculation method of the current market size and whether an optimistic or conservative scenario is used). As a result, according to the conservative scenario the market size[288] will be at least $22 billion[289] while the optimistic forecast suggests $32 billion.[290] Most estimates have shown that the **market size is most likely to be around 28-30 billion by 2025.**[291] [292] Data on investments after 2025 are not yet available.

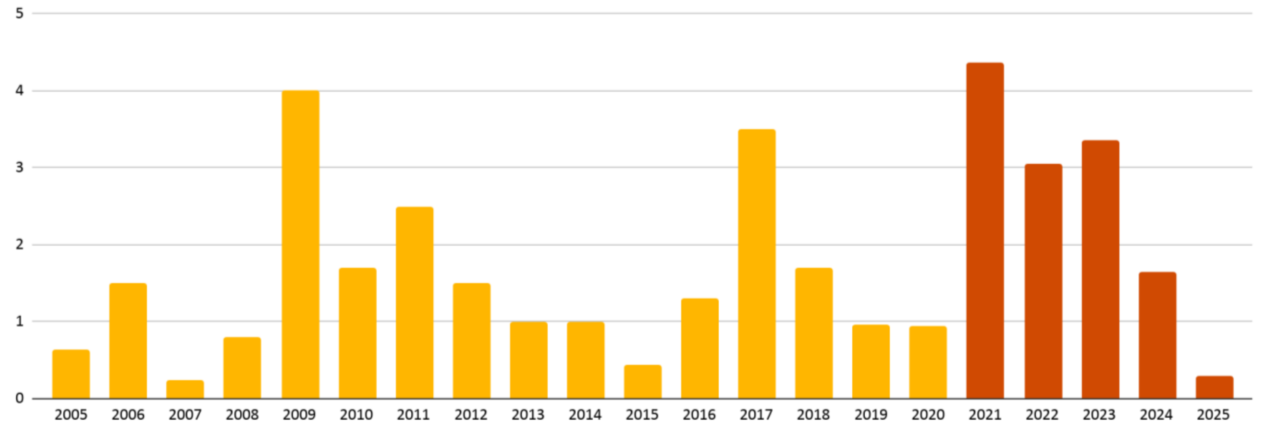

Figure 103: System investments (billion $)

Regarding financing models, **the proportion of investments from private investors most likely will grow** due to two main reasons. Content providers have high CAPEX budgets,[293] [294] thus they have the resources for investments in submarine cable systems, they do not have financial pressure to invite other market players or public funds to participate. At the same time, market actors are emphasizing the

[288] Market size refers to the total potential amount of sales or customers in a given industry over a given period of time, often a single year.
[289] Markets and Markets: Submarine Cable System Market
[290] Grand View: Market Analysis Report
[291] Verified: Submarine Cable System Market Size And Forecast
[292] Coherent: Submarine Cables Market Analysis
[293] Pacific Telecommunications Council (PTC), TeleGeography Workshop
[294] Platformonomics: Follow the CAPEX

importance of private investments and urge regulation authorities to encourage this type of investment.[295] Furthermore, **hybrid financing will also increase,** where content providers partner with traditional telecommunications service providers.

At the same time **the role of Multilateral Development Banks will not change significantly** as this is not part of their 2030 vision. However, they **will provide funding to rather less developed regions.** Key Non-European players, like the Asian Development Bank and the World Bank focus on the Pacific Island and Micronesia (e.g. Palau, Tonga, Samoa)[296], while the latter is also planning to provide additional financing to the Easter Caribbean region (e.g. Grenada, Saint Lucia, and Saint Vincent and the Grenadines).[297]

Moreover, **some experts argue that working capital finance as an alternative funding mechanism should be introduced** as well. The reason behind is the content providers' growing pressure on the market. They are pursuing the lowest 'cost per bit' and driving hard bargains with companies building, operating and leasing cable networks. This creates an imbalance between increased capacity requirements and the sector's ability to invest in order to meet the demand profile of the upcoming years. However, by establishing a wider pool of liquidity - more specifically adding working capital finance to the funding mix -, it could alleviate balance sheet pressure and free much-needed capital for new investment.[298]

[295] Information received through expert interviews.
[296] World Bank: New Digital Project to Connect Federated States of Micronesia
[297] World Bank: Financing for Telecommunications Development in the Eastern Caribbean
[298] Subtel Forum: Subsea Cable Sector Needs a New Financing Model

5. Findings and Recommendations

5.1. Gap and risk analysis

Drivers of digital connectivity developments

Significant differences between the regional internet penetrations widen the digital divide. This can be attributed to two main factors.

- **Underdeveloped intraterrestrial infrastructure hinders the accessibility of digitally underserved populations to high quality internet services.** Despite the considerable infrastructural developments of the networks in the last five years, Africa still lags behind the world average concerning network coverage and broadband speeds. Their share in internet traffic is expected to increase by 2030, however, this assumes considerable infrastructural development.
- **Trends for increasing the affordability of internet services remain slow, inhibiting the inclusion of people from lower socio-economic groups to the benefits from ICTs and the internet.** The effect of the underdeveloped network is also seen in the prices of internet services, especially in developing regions. Due to technological improvements the prices began to decline. However, key aspects of changes, strong planning and policy advancements related to internet infrastructure and access and real competition are still lacking in several countries.

M2M connections will contribute to a significant internet traffic increase, which needs to be served by the digital connectivity infrastructure. A dynamic spread of M2M connections and services is expected, which will generate considerable internet traffic growth. The digital connectivity infrastructure, including submarine cable system, intraterrestrial and other infrastructure, has to be designed in such a way that can serve the needs of disruptive services.

The driving force and pace of investments of foreign actors in the data centre market represents risk for the EU in maintaining sovereignty and independence. Considering that the data centre industry is critical to 21st century life and its importance will increase continuously. The major players that drive the market changes are foreign actors. They operate and plan to launch several data centres in Europe. However, the market power of European data centre players can be considered lower, since the market is moderately consolidated. This can be seen as a significant risk for the future decade and indicates clearly a need for intervention.

Infrastructure

Depending on the rate of technological progress, approximately an additional 140 cables are needed to be installed by 2030 worldwide.[299]

- **Continuous investment is needed to cope with the ever-increasing data demand growth** and reach suitable capacity levels on submarine cables that are able to serve the demand of 2030.
- **New cables are needed not only to assure a future-proof submarine cable infrastructure but also to make up for retiring cable systems and the resulting loss of capacity** as more and more submarine cables reach the age of 25. The regions most affected by cable decommissioning are the Transpacific, Transatlantic and Indian Ocean Pan-East Asian

[299] Telegeography: Pacific Telecommunications Council - Telegeography Workshop 2020

submarine cable regions where the expected capacity loss is around 14-19%. In terms of submarine cable routes where the EU is concerned, the most affected ones are the EU - Latin America, the EU - Central Western Asia and the EU-English North America routes with a capacity loss of as much as 16-22%.

On less lucrative routes or in so-called non-spot regions, submarine cable development may lag behind due to the changes in market dynamics.

- **Content providers are mainly focusing on connecting data centres** directly and establishing submarine cables on key routes, in an effort to serve their own infrastructure needs.
- **Telecommunication companies struggle to build a sound business case** for submarine cable investments, as their largest customers, content providers, slowly turning into submarine cable owners themselves. As content providers will not and telecom operators cannot invest in routes without data centre presence, at this point, it is unclear which player could fill this infrastructure gap.

Technological improvements in submarine cable systems opens the possibility of deploying a smaller number of cables, but diversity and resiliency still needs to be managed. Capacity improvements of submarine cables may make it possible to rely on less cables overall, however, in order to assure the resilience of the submarine cable infrastructure, diversity in routes (meaning multiple submarine cables between regions) and in landing points (meaning multiple cities with submarine cables in the same country or region) are still both important. In terms of EU related submarine cable routes, the EU - Latin America, the EU - Far East and the EU - English North America ones seem to have the lowest resilience. In case of the EU - Far East route, terrestrial cables through Russia or former Soviet states may alleviate this risk, however, this would not necessarily bring cost effective, stable, resilient and above all sovereign solutions for Europe. Cable paths linking the EU to regions located geographically closer generally do better when it comes to resiliency and diversity.

One possible future focus point of submarine investments that is gaining ground already is the Arctic region. The interest in the region is gradually increasing as it is seen as another way to connect Europe with Japan and northern countries such as Canada.[300] Taking advantage of the Arctic region could bring low latency, resilient direct connectivity between Europe and Japan within a few years if we take the right steps, with a possible breakout into Canada's and the US' West Coast. This connection will add substantially to the Digital Sovereignty for Europe. As of now, the region, however, is the most underdeveloped in terms of submarine cable infrastructure with only a rather low number of cables and capacity available there.

Technological improvements are necessary to keep up with growing capacity requirements.

- **Relying only on existing technology without any new advancements would require much more cables than financially feasible.** For example, during the period of 2000-2020, without technological advancements of recent years, 16-22 times more cables would have been needed to be deployed to reach satisfactory global design capacity.[301] Of course, this would have put a serious financial strain on market players: construction costs would have been 10 times higher than what was spent eventually.[302]
- **Spatial Division Multiplexing (SDM) advancement, is one of the most anticipated technological improvements that could result in a reduced cost per Gbit/s**, as it would increase overall system capacity by allowing an increased number of fibre pair count in SDM cables. This could help in establishing new financing models in addition to those existing (e.g. PPP funding, working capital finance) as it would allow other types of companies to invest at a lower cost, which would also drive the number of investments.

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[300] The Barents Observer: Major step towards a Europe-Asia Arctic cable link

[301] To put this into perspective: almost as many new cables would have been needed as there are today globally only to cover the capacity needed for the Transatlantic.

[302] Telegeography: Pacific Telecommunications Council - Telegeography Workshop 2021

It is expected that submarine cable systems will more and more frequently be equipped with sensing and monitoring capabilities that could pose further security risks.[303] Although such technological enhancements turn them into environmentally aware systems that can provide real-time data on ocean temperatures or sense man-made hazards and prelude of natural disasters, this exact technology can make submarine cables more susceptible to unlawful monitoring of traffic posing considerable cybersecurity risks, or exposed to other threats such as naval activity monitoring.

Business models

Delays in the surveyor market can lead to further delays in the entire construction chain. There are only two global surveyor companies and until the end of 2020, only 27.7% of planned systems for the period 2020 to 2022 have performed this task. As the timeline for manufacturing and installing a typical submarine cable system is about 18 months, this means that only a few systems planned for 2021 are on track. Due to the expected growing demand, this delay may further increase.

The system supplier market is also very busy and the growing pressure resulting from the increasing number and scale of orders - especially from content providers - may further enhance the problem. It is also a possible scenario that content providers enter the supplier market thereby further increasing their already significant influence.

The presence of Chinese service providers - mainly system suppliers and owners - in the submarine cable market is not significant in the EU. However, it is advisable to monitor the development of non-EU service providers' activities from a commercial, a geopolitical and a strategic point of view.

Capacity is also the main risk for the installer and maintenance market, especially due to the low number of cable ships. Only very few cable ships have been added to the global fleet since 2004 and as of the latest information, no new ships are currently planned. In the meantime, the average of the existing cable ships is already more than 20 years.[304]

The ownership structures of submarine cables experienced huge transformations with content providers owning a significant part of the infrastructure by now and it is not clear what role they want to play in the market. Looking at the largest owners globally for the period 2021 to 2025, content providers are expected to become the clear market leaders and most likely not even all of their cables have been announced yet. Furthermore, it is not clear what role they want to play in the market and whether they will take advantage of the situation if they get into a monopoly position in the international broadband wholesale market. Currently they are investing in infrastructure for their own internal needs, however, no information has been published whether they will share the available capacity in the future. If not, traditional players may face challenges having a much smaller role in international connectivity.

As content providers have already built a significant part of their own infrastructure, the customer base of traditional actors is disappearing. In the meantime, telecommunication companies seem to respond more slowly to the market changes and they still tend to look at infrastructure development from a shorter-term economy aspect and aim to reach economic solutions for providing reliable connection. If the trend continues, soon they might have a lessened role in transcontinental connectivity.

Appearance of new, unforeseen entrants as owners - similarly to the entry of content providers in the previous period - is conceivable. Due to technological developments and increase in demand and data traffic new companies (e.g. Zoom, Tesla, or IoT/VR companies) may even bring new trends and business models.

The financial strength of content providers compared to other stakeholders is a considerable risk

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[303] Science Monitoring And Reliable Telecommunications (SMART) cables are tested on out-of-service and shorter cables and there are only a few proposed of such cables (e.g. ANACOM proposal for connecting Lisbon-Azores-Madeira-Lisbon with a cable that includes optical fiber sensing and SMART capability). Source: Submarine Telecoms Forum: Submarine Telecoms Industry Report – Section 7.2: Smart Cables

[304] Submarine Telecoms Report: Submarine Telecoms Industry Report

for further investments. As their CAPEXs are, on average, significantly larger than most traditional players, primarily they are capable of influencing the market trends. In the meantime, it seems that telecommunication companies are not able to compete without EU support.

Traditional telecommunication companies tend to invest along other strategic considerations than content providers. As elaborated above, they invest more cautiously and primarily along short-term goals, however, if this business model remains unchanged, their lag may be further accelerated.[305]

Content providers build many cables in a multi investor model. However, this can easily be misleading and should be handled with caution according to experts. Content providers sometimes involve telecommunication companies mainly for technical reasons, e.g. to get landing right faster. Thus, it may appear to be a consortium, but in reality, the content providers are the dominant owners.[306]

Regulation

Lack of comprehensive and common regulatory frameworks poses significant risks for EU Digital Sovereignty.

The difference between the national level regulations for landing rights and accessibility slows down the procedures and affects business decisions.

- **The procedures of getting permissions and licenses on building or landing submarine cables is becoming increasingly challenging** as countries develop stringent and distinct regulations. This slows down all procedures which also affects business decisions as there are examples of denied or delayed permissions, resulting in changes to project plans.
- **Other regulations that may affect the submarine cables are not harmonized in the EU.** Such regulations are the ones related to fishing and fisheries.

Submarine cables are not considered as critical infrastructure, thus there are no common, comprehensive regulatory requirements for ensuring the security and decrease of dependency. European electronic communication service market is regulated strictly by being considered as critical infrastructure. However, the submarine cables system does not fall under this category, and lacks the regulation in terms of cyber security, service continuity and fair market conditions.

- **The EU does not have adequate rights to control non-EU operators and owners**. Although content providers are ruling the market of submarine cables, they are not regulated adequately in the EU. In certain cases, the EU is not in a position to regulate them, which increases the EU's dependence on them. The absence of such a common approach could put the fair and balanced market, the EU digital sovereignty and the security of citizens' data into jeopardy.
- **No incident reporting requirements and there are no common cybersecurity approaches.** Considering that the submarine cable system does not fall under the category of critical infrastructure, there are no common requirements of reporting any incidents that occurred on submarine cable systems, which might serve as a considerable risk in the future. The lack of common cybersecurity measures increase the exposure to cybersecurity threats and dependencies on the vendors' action.

[305] Information received through expert interviews.
[306] Information received through expert interviews.

5.2. Recommendations

The main instruments that the EU can use for strengthening its position and ensuring independence of the EU's connectivity can be classified into three major categories:

Strategy

Design a comprehensive strategy for ensuring the strong position of the EU on the international connectivity market, for promoting connectivity and for creating beneficial partnerships.

Regulation

Create a regulatory framework, guidelines and other instruments to ensure the harmonization of national regulation, fair market conditions, and the security of services and infrastructure.

Financing

Enhance the innovation and support the infrastructural developments, (including digital connectivity infrastructure and data centers) with different financial instruments.

In order to manage the potential risks and improve the competitiveness of the EU in the digital connectivity ecosystem, there is a need for well-defined, comprehensive strategy which comprise common approaches for strengthening the capabilities and capacities, managing stakeholders, providing support with different financial instruments and defining specific regulatory and technical guidelines for Member States.

Strategic recommendations

There is a need for a common approach to submarine cable system infrastructure of the EU. Based on strategic and geopolitical considerations, the EU needs to formulate a common group of requirements towards its international connectivity infrastructure defining principles of technological perspectives (such as technological standards, required capacity and landing infrastructure), guidelines on resiliency and security and cybersecurity. This approach can also cover specific requirements towards suppliers and owners with similar considerations to the 5G Toolbox, but should be preceded by a thorough assessment of technologies and risks.

Define the desired coverage the EU aims to reach and subsequently monitor infrastructure gaps continuously. The EU should be up to date with and support submarine cable developments, especially on routes that are crucial for providing sufficient connectivity for the EU but are lacking or are underdeveloped in some way. The gaps covered in Chapter 5.1 *Gap and risk analysis* chapter can be a basis of the definition of focus points, with high emphasis on regions and routes with high retiring capacity (i.e. the EU - Latin America, the EU - Central Western Asia and the EU-English North America routes), low resilience (i.e. the EU - Latin America, the EU - Far East and the EU - English North America routes) and ones that are financially more challenging. If the market seems unable to react in a satisfactory way, the EU should devise ways to facilitate development.

Examine whether a level playing field is equally accessible to owners and all other stakeholders (suppliers, surveyors, installers, customers). The EU should develop a clear vision on principles of assessing submarine system ownership structure and define measures to reach this vision.

Enhance the competitiveness of the EU in order to hinder the monopoly in developing countries. To serve the needs of the digitally underserved population of developing regions apart from international connectivity infrastructure development there is a huge need for intra-terrestrial infrastructure developments and for making the internet services more affordable.

Monitor the Transatlantic region and future submarine cable investment plans to keep up the EU presence in the submarine infrastructure of this region. Even though the recent years saw a higher increase in the number of Transatlantic cables connecting the EU than the ones linking the UK, the region should be paid special attention to. Furthermore, new entrants and with those new trends may emerge in the upcoming years and up to date market knowledge is essential for quick response capability.

Support market players in overcoming capacity issues in order to solve supplier capacity problems. This can be achieved either by supporting existing players (in building more capacity or making their operation more efficient, e.g. through the development and introduction of new technologies) or encouraging new players to enter the market. It is also suggested to support the commissioning of new cable ships.

Drive and support technological advancements, in order to make sure the EU remains at the forefront of submarine cable development.

Increase the use of encryption in the submarine cable infrastructure to secure the ever-increasing amount of data transmitted by the networks. Better encrypted infrastructure is an essential way of mitigating the growing security risks.

Become a significant player of the data centre market, by strengthening its infrastructure and creating legal frameworks to ensure digital sovereignty. In order to ensure the security of services and the competitiveness of the EU, there is a clear need for a legal framework and infrastructural developments that contribute to secure storage, processing and sharing of data. With the Ministerial Declaration on "European Data Gateways as a key element of the EU's Digital Decade" the EU started to have a special focus on the data centre market. The Declaration sets the goal to become a "competitive world-class data hub". Besides the initiatives strongly related to data centres, such as expanding the reach of EU data storage and processing services, the Declaration forms recommendations related to the international connectivity pillar.[307]

Regulatory recommendations

Rapid policy actions to create a comprehensive and common EU approach towards the regulation of submarine cable systems. It would ensure the key goals of the EU to help in the improvement of international digital connectivity as an integral part of the global data economy, and maintain the EU Digital single market and sovereignty.

Classify submarine cable systems as critical infrastructure, thus defining incident reporting and cybersecurity requirements for the actors. Designating submarine cable systems as part of the critical infrastructure would serve as a first step for increasing the security of infrastructure and services. Furthermore, it is recommended to define thresholds of incident and related reporting requirements and also cybersecurity guidelines and specifications for every submarine cable that lands on European territory. In order to ensure a smooth and coordinated adoption of regulation we suggest a strong focus on ensuring platforms for best practice sharing.

Creating regulation that ensures balanced market conditions. A comprehensive regulation needs to ensure the same rules and procedures to have all players start from the same base line. It is important to ensure for telecommunication service providers similar conditions as for the content providers in order to enable them remaining competitive on the market. In addition, creating conditions that support the European players may be beneficial for strengthening their position on the global market. Currently one of the most important/urgent is the access of the landing stations.

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[307] Ministerial Declaration: European Data Gateways as a key element of the EU's Digital Decade, 19th of March 19,2021

Examine the possibility of setting ownership requirements for content providers, addressing the risk of accessibility to content providers' systems, and clear security guidelines to all stakeholders.

Provide guidelines aiming to harmonize in the long-term national regulation related landing rights and accessibility. A comprehensive regulation needs to ensure the same rules and procedures to have all players start from the same base line. Currently one of the most important/urgent is the access of the landing stations, however, regulations in terms of fishing might be also important to consider. In the short term we recommend providing guidelines to Member States for creating adequate regulation for landing rights and accessing and ensuring platforms where best practices can be shared. In the long term, the harmonization of national regulations will be most beneficial for ensuring EU-wide fair market conditions and security of services.

Support the initiatives for increasing the affordability of internet services and policy making by sharing best practices. Developing countries will need to create policy reforms to reduce the costs of internet services and increase its affordability. Considering that the EU has several best practices in this field, it is recommended to provide professional support for developing countries in creating efficient legislative and regulatory framework, planning, and monitoring the implementation.

Financing recommendations

Have a comprehensive and common approach supporting financing decisions. Available financial resources should be aligned to the strategic priorities thus jointly supporting the EU's goals. This comprehensive investment strategy does not include only adequate investment in infrastructure, but also other financial support (funding, incentives and other support schemes) for EU-based companies or technological innovations, such as:

- Encourage and support the development and **construction of new cables,** especially in areas where market mechanisms are not adequate or on routes that bring the most new resilience, touch countries that currently do not have many intercontinental cables, and that bring connectivity to regions of the world where the EU does not have direct connectivity with;
- Drive the **development and introduction of new technologies**, especially Spatial Division Multiplexing (SDM);
- Support the **commissioning of new cable ships** and the maintenance of existing ones for surveying, installing and maintaining purposes in order to solve supplier capacity problems;
- Help **ease the pressure** (both in terms of time and working fees) **on system suppliers**, coming especially from content providers;
- To enable **European owners to make longer-term investments** (similarly to content providers' investments);
- To drive the **development of European data centre infrastructure;**
- To support the continuous **development of EU-level cybersecurity**.

Encourage private investments and some argue that working capital finance can also be a successful alternative funding mechanism because it could alleviate balance sheet pressure and free much-needed capital for new investment.

6. Annex

6.1. Interview participants list

#	Company name	Role
1	Orange	Telecommunications service provider, submarine cable system owner, installer
2	Vodafone	Telecommunications service provider, submarine cable system owner
4	AFR-IX Telecom	Internet Service Provider
5	Ericsson	Supplier
6	NORDUnet	Coordinator and service provider
7	GÉANT	Coordinator
8	T-Systems	Telecommunications and Cloud service provider
9	TATA Communications	Telecommunications service provider, submarine cable system owner, installer
10	SES	Satellite and terrestrial telecommunications network provider
11	European Data centre Association	Association of Data centre providers
12	European Investment Bank	Multilateral development bank
13	European External Action Service (EAAS)	EU Institution
14	A4AI	Global coalition
15	Nokia + ASN	Telecommunications service provider, submarine cable system owner
16	Portuguese Permanent Representation	
17	Farice	Telecommunications service provider, submarine cable system owner, installer

6.2. Regions examined

Submarine cable regions

In the study, the following submarine cable regions are examined:

- EMEA (submarine cables located in Europe, the Middle East and Africa),
- Australasia (submarine cables located in Australia, New Zealand and neighbouring islands),
- The Americas (submarine cables located in North and South America and associated islands),
- Indian Ocean Pan-East Asian (submarine cables located in South and East Asia),
- Transatlantic (submarine cables located in North America and Europe),
- Transpacific (submarine cables located in East Asia, Australia, New Zealand and the West coast of North and South America),
- The Arctic (submarine cables located in parts of Alaska (United States), Canada, Finland, Greenland (Denmark), Iceland, Norway, Russia, and Sweden).

The map of active cables in each submarine region is made available by several submarine cable-focused telecommunications market research companies (like Telegeography[308] or Submarine Telecoms Forum[309]), which the study relies on.

There are several cables that have landing points in multiple submarine cable regions. In case of these cables, they are considered in each region. For example, the Flag Europe-Asia cable has landing points in Spain, Japan, Jordan and many other countries. For this reason, in the database and in the study, the cable is represented in the EMEA and the Indian Ocean Pan-East Asian regions as well.

Regions

The study also assesses the EU's connectivity with the rest of the world. The submarine cable routes (referred to as EU routes) examined in the study are the ones located between the EU and the following regions:

- Latin America
- English North America
- Central and Western Asia
- Asia-Pacific
- Non-EU Europe
- Africa

This regional breakdown is meant to aid the future analysis of the four distinct platforms of connectivity networks around the EU established by the *Ministerial Declaration on European Data Gateways as a key element of the EU's Digital Decade*, adopted by 25 Member States in March 2021:

- the EU-Atlantic Data Gateway Platform;
- the EU-Mediterranean Data Gateway Platform;
- the EU-North Sea & Arctic Data Gateway Platform;
- and the EU-Baltic-to-Black Sea Data Gateway Platform.[310]

In case a cable has landing points in the EU and in multiple other regions, the cable is considered into the total number of submarine cables on each route. For example, the SEA-ME-WE 3 cable has landing points in the EU, the Asia-Pacific, Africa, Central and Western Asia and Non-EU Europe regions as well. This means that the SEA-ME-WE 3 cable is counted as a cable on all four routes.

The regions were appointed by comparing the organizing principles of existing data sets in the subject of submarine cables, then matching them with widely accepted and known regional breakdowns, all in the name of achieving the highest accuracy possible.

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[308] PriMetrica: Submarine Cable Map

[309] Submarine Telecoms Forum: Subtel Cable Map

[310] European Commission: Ministerial Declaration on European Data Gateways as a key element of the EU's Digital Decade

Considering their importance to the EU two other regions - the EU Neighbourhood and the Far East - are also examined in the study despite the fact that they heavily overlap with the 6 regions previously mentioned.

The following tables are meant to indicate which countries are included in the examined regions.

Region	Overlapping region	Country
Non-EU Europe		Albania
Non-EU Europe		Andorra
Non-EU Europe	EU neighbourhood	Armenia
Non-EU Europe	EU neighbourhood	Azerbaijan
Non-EU Europe	EU neighbourhood	Belarus
Non-EU Europe		Bosnia and Herzegovina
Non-EU Europe	EU neighbourhood	Georgia
Non-EU Europe		Iceland
Non-EU Europe		Liechtenstein
Non-EU Europe	EU neighbourhood	Moldova
Non-EU Europe		Monaco
Non-EU Europe		Montenegro
Non-EU Europe		North Macedonia
Non-EU Europe		Norway
Non-EU Europe		Russia
Non-EU Europe		San Marino
Non-EU Europe		Serbia
Non-EU Europe		Switzerland
Non-EU Europe	EU neighbourhood	Ukraine
Non-EU Europe		United Kingdom
Non-EU Europe		Vatican City
EU		Austria
EU		Belgium
EU		Bulgaria
EU		Croatia
EU		Czech Republic
EU		Denmark

EU		Estonia
EU		Finland
EU		France
EU		Germany
EU		Greece
EU		Hungary
EU		Ireland
EU		Italy
EU		Latvia
EU		Lithuania
EU		Luxembourg
EU		Malta
EU		Netherlands
EU		Poland
EU		Portugal
EU		Cyprus
EU		Romania
EU		Slovakia
EU		Slovenia
EU		Spain
EU		Sweden
Central and Western Asia		Bahrain
Central and Western Asia		Iran
Central and Western Asia		Iraq
Central and Western Asia	EU neighbourhood	Israel
Central and Western Asia	EU neighbourhood	Jordan
Central and Western Asia		Kazakhstan
Central and Western Asia		Kuwait
Central and Western Asia		Kyrgyzstan
Central and Western Asia	EU neighbourhood	Lebanon
Central and Western Asia		Oman

Central and Western Asia		Qatar
Central and Western Asia		Saudi Arabia
Central and Western Asia	EU neighbourhood	Syria
Central and Western Asia		Tajikistan
Central and Western Asia		Turkey
Central and Western Asia		Turkmenistan
Central and Western Asia		United Arab Emirates
Central and Western Asia		Uzbekistan
Central and Western Asia		Yemen
Africa	EU neighbourhood	Algeria
Africa		Angola
Africa		Benin
Africa		Botswana
Africa		Burkina Faso
Africa		Burundi
Africa		Cameroon
Africa		Cape Verde
Africa		Central African Republic
Africa		Chad
Africa		Comoros
Africa		Côte d'Ivoire
Africa		Democratic Republic of Congo
Africa		Djibouti
Africa	EU neighbourhood	Egypt
Africa		Equatorial Guinea
Africa		Eritrea
Africa		Ethiopia
Africa		Gabon
Africa		Gambia
Africa		Ghana
Africa		Guinea

Africa		Guinea-Bissau
Africa		Kenya
Africa		Lesotho
Africa		Liberia
Africa	EU neighbourhood	Libya
Africa		Madagascar
Africa		Malawi
Africa		Mali
Africa		Mauritania
Africa		Mauritius
Africa	EU neighbourhood	Morocco
Africa		Mozambique
Africa		Namibia
Africa		Niger
Africa		Nigeria
Africa		Republic of the Congo
Africa		Rwanda
Africa		São Tomé and Príncipe
Africa		Senegal
Africa		Seychelles
Africa		Sierra Leone
Africa		Somalia
Africa		South Africa
Africa		South Sudan
Africa		Sudan
Africa		Swaziland
Africa		Tanzania
Africa		Togo
Africa	EU neighbourhood	Tunisia
Africa		Uganda
Africa		Zambia

Africa		Zimbabwe
Asia-Pacific		Afghanistan
Asia-Pacific		Australia
Asia-Pacific		Bangladesh
Asia-Pacific	Far East	Brunei
Asia-Pacific	Far East	Cambodia
Asia-Pacific	Far East	China
Asia-Pacific		Cook Islands
Asia-Pacific		Fiji
Asia-Pacific	Far East	Hong Kong
Asia-Pacific		India
Asia-Pacific	Far East	Indonesia
Asia-Pacific	Far East	Japan
Asia-Pacific		Kiribati
Asia-Pacific	Far East	Laos
Asia-Pacific	Far East	Malaysia
Asia-Pacific		Maldives
Asia-Pacific		Marshall Islands
Asia-Pacific		Micronesia
Asia-Pacific	Far East	Mongolia
Asia-Pacific	Far East	Myanmar
Asia-Pacific		New Zealand
Asia-Pacific	Far East	North Korea
Asia-Pacific		Pakistan
Asia-Pacific		Palau
Asia-Pacific		Papua New Guinea
Asia-Pacific	Far East	Philippines
Asia-Pacific	Far East	Russia
Asia-Pacific		Samoa
Asia-Pacific	Far East	Singapore
Asia-Pacific		Solomon Islands

Asia-Pacific	Far East	South Korea
Asia-Pacific		Sri Lanka
Asia-Pacific	Far East	Taiwan
Asia-Pacific	Far East	Thailand
Asia-Pacific		Vanuatu
Asia-Pacific	Far East	Vietnam
English North America		Canada
English North America		United States
Latin America		Argentina
Latin America		Barbados
Latin America		Belize
Latin America		Bolivia
Latin America		Brazil
Latin America		Chile
Latin America		Colombia
Latin America		Costa Rica
Latin America		Cuba
Latin America		Dominica
Latin America		Dominican Republic
Latin America		Ecuador
Latin America		Grenada
Latin America		Guatemala
Latin America		Guyana
Latin America		Haiti
Latin America		Honduras
Latin America		Jamaica
Latin America		Mexico
Latin America		Nicaragua
Latin America		Niue
Latin America		Panama
Latin America		Paraguay

Latin America		Peru
Latin America		Puerto Rico
Latin America		Saint Kitts and Nevis
Latin America		Saint Lucia
Latin America		Saint Vincent and the Grenadines
Latin America		Salvador
Latin America		Suriname
Latin America		The Bahamas
Latin America		Trinidad
Latin America		Uruguay
Latin America		Venezuela

Region	Overlapping region	Territory
EU outermost regions		Azores
EU outermost regions		Canary Islands
EU outermost regions		French Guiana
EU outermost regions		Guadeloupe
EU outermost regions		Madeira
EU outermost regions		Martinique
EU outermost regions		Mayotte
EU outermost regions		Réunion
EU outermost regions		Saint Martin

Suppliers and installers

The owners have been also categorized according to their place of origin and five categories have been defined, as follows:

- European
- US-based
- Chinese
- Japanese
- Other

The following table contains all the countries of each region.

Region	Supplier/Installer
European	ASN

European	Cecon Contracting
European	Hexatronic
European	N0r5ke Fibre
US-based	SubCom
US-based	Xtera
Chinese	Huawei Marine Networks
Chinese	IT International Telecom
Japanese	NEC

Owners

The owners have been also categorized according to their place of origin and five categories have been defined, as follows:

- European
- Non-EU European
- Content provider
- Chinese
- Other

The following table contains all the countries of each region.

Region	Owner
European	Aqua Comms
European	Cinia Oy
European	IslaLink
European	Orange
European	Telxius
European	Telecom Italia Sparkle
Non-EU European	Altibox
Non-EU European	BKK Digitek
Non-EU European	BT
Non-EU European	Bulk
Non-EU European	Celtic Norse AS
Non-EU European	Farice
Non-EU European	Lyse
Non-EU European	NOR5KE Fibre AS

Non-EU European	NO-UK Com
Non-EU European	Vodafone
Content provider	Amazon
Content provider	Facebook
Content provider	Google
Content provider	Microsoft
Chinese	ADC Consortium
Chinese	China-ASEAN Information Harbour
Chinese	China Mobile
Chinese	China Telecom Corporation
Chinese	China Unicom
Chinese	Pacific Light Data Communication
Other	Africa Marine Express
Other	Alaska Power & Telephone Company (AP&T)
Other	America Movil
Other	AUSTRAL University of Magellan
Other	Azertelecom
Other	Blackburn Technologies, LLC.
Other	Campana Group
Other	CanArctic Inuit Networks
Other	CAT
Other	Chuan Wei
Other	Chunghwa Telecom Co.
Other	Cinturion
Other	CNT EP
Other	Confluence Networks
Other	Converge ICT
Other	Crosslake Fibre
Other	Djibouti Telecom
Other	Du

Other	Etisalat
Other	FB Submarine Partners, LLC,
Other	Fibre Expressway
Other	FP Telecommunications
Other	G42
Other	GCI
Other	GITGE
Other	Globacom Limited
Other	Golis Telecom
Other	Grupo
Other	H2 Cable
Other	Hormuud Telecom Somalia Inc.
Other	Interchange Limited
Other	IOX Cable Ltd
Other	Kakike, Lda.
Other	Kativik Regional Government
Other	KDDI
Other	KumoxiCom, Lda.
Other	LTD
Other	Magellan CPC
Other	Maple Leaf Fibre Ltd.
Other	Mobily
Other	MTN GlobalConnect
Other	NTT Communications Corporation
Other	Ocean Networks
Other	Okinawa Cellular
Other	Oman Telecommunications Company
Other	OPT
Other	Pakistan Telecommunications Company Ltd.
Other	PCCW Global

Other	Peace Cable International Network Co.
Other	PLDT
Other	PP Telecommunication Sdn Bhd
Other	Regional Council of Guadeloupe
Other	Reliance Jio
Other	RTI Connectivity
Other	SAEx International Limited
Other	Seabras Group
Other	Singapore Telecommunications Limited
Other	Singtel
Other	SK Broadband
Other	SoftBank
Other	Somtel Group
Other	Southern Cross Cables Limited
Other	STC
Other	SUB.CO
Other	TATA Communications
Other	Telebras
Other	Telecom
Other	Telecom Egypt
Other	Telesom Company
Other	Teletok
Other	TeleYemen
Other	Telstra
Other	TransPacific Network
Other	Transtelecom Kazakhstan
Other	Tropic Science
Other	Turkmentelecom
Other	Viettel
Other	VNPT

Other	Werthein
Other	Wi-tribe Pakistan
Other	WIOCC
Other	XL Axiata

6.3. Internet traffic forecasting methodology

Based on historical data forecasts have been conducted for internet traffic growth and other factors influencing it for the period of 2021-2030.

Forecasted global internet consumption was estimated by summing the consumer internet traffic, business internet traffic and the M2M traffic forecasts. For each above factor the following assumptions and considerations were taken into account:

- Consumer internet traffic was estimated upon the **number of internet users** (population multiplies by the internet penetration) and the **average internet traffic generated per user**
- Business internet traffic is approximated with the consumer and business internet traffic proportions. Due to the relative high volatility of this measure, the last known proportion was held constant in the analysis as an expected value.
- M2M traffic was forecast based on ITU and Cisco predictions and their average. ***

The correlation between each variable has been analysed and based on the result the results we created the forecast model using the technique of **ARIMA**[311]. ARIMA uses a moving average of the time series as its own predictor with a given lag period. For the predictor variable (population, internet penetration and average internet consumption) forecasts we used separate ARIMA models, with confidence levels of 80-95%. The forecasts therefore can be visualized as cones: as the uncertainty raises by time, the confidence levels widen along.

Besides historical data estimations of reliable sources, such as ITU, GSMA, Cisco etc., have been taken into consideration and the calculation was adjusted accordingly, if needed.

Considering the high level of uncertainty, the internet traffic forecast model presents three different scenarios: optimistic, realistic and conservative. The longer the time span is covered in the forecast, the greater the uncertainty. Considering that the prediction is made for the next 10 years, in order to manage the uncertainty, the model forecasts the expected values on 81-95% significance level. Possible uncertainty factors, that may have a considerable impact on the internet traffic, inter alia are the following:

- Effects of coronavirus and other pandemics on the online services and internet traffic;
- Effects and the take-up of 5G and spread of IoT;
- Intra-terrestrial infrastructure developments in digitally underdeveloped countries;
- Affordability of internet services in digitally underdeveloped countries.

The following table comprises the formula used for the calculations:

#	Calculation	Description and assumption	Confidence level
1.	**Internet traffic**	Consumer traffic + Business traffic + M2M traffic	**80%-95%**

[311] ARIMA: Auto Regressive Integrated Moving Average is a time series based forecasting method, which uses the time series' past values to predict future points.

1.1	**Consumer internet traffic**	Number of internet users x Average traffic per user	**90%**
1.1.1.	**Number of internet users**	Population x Internet penetration rate	**95%**
1.1.1.1	Internet penetration rate	Forecast based on historical data - ITU	**95%**
1.1.1.2	Population	UN forecast	-
1.1.2.	**Average internet traffic per user**	Forecast based on historical data - Consumer internet traffic / number of internet users.	**95%**
1.2.	**Business internet traffic**	Consumer internet traffic / 0.85. Considering that business traffic was volatile during the period of 2011-2020, predictions made for it assumed high uncertainties. Thus, we choose to calculate with the statistically most certain value of 16% for each year.	**95%**
1.3.	**M2M traffic**	Considering that until now the M2M connections generated only a very small percentage of internet traffic, the predictions for traffic generated from M2M connections was added to the calculation. For doing so, ITU and Cisco predictions were used.	**90%**
2.	**Average time spent on internet**	Forecast based on historical data.	**95%**
3.	**Average number of devices per user**	Forecast based on historical data.	**95%**
4.	**Video consumption**	Forecast based on historical data.	**95%**

6.4. Resiliency score methodology

Resiliency scores were calculated in 5 steps, building on the available data of submarine cable age and number on EU routes. The higher the score, the better the resiliency. For example, routes with more active connections and younger cables received a higher score.

#	Calculation	Description
1.	**Average age per region**	Calculating the average age of active submarine cables on each EU route
2.	**Number of connections per region**	Summarizing the number of active connections on each EU route

3.	**Average age sub-score**	Assigning a sub-score to each EU route based on the average age of the cables. $$P = \frac{A_{max} - A_{examined}}{A_{max} - A_{min}} * (P_{max} - P_{min})$$ where: P = average age sub-score of the examined EU route P_{max} = highest possible score (10) P_{min} = lowest possible score (0) A_{max} = highest data value (26 years) A_{max} = lowest data value (1 year) $A_{examined}$ = examined data value
4.	**Number of connections sub-score**	Assigning a sub-score to each EU route based on the number of the cables. $$P = \frac{A_{examined}}{A_{max} - A_{min}} * (P_{max} - P_{min})$$ where: P = number of connections sub-score of the examined EU route P_{max} = highest possible score (10) P_{min} = lowest possible score (0) A_{max} = highest data value (38 pcs.[312]) A_{max} = lowest data value (0 pcs.) $A_{examined}$ = examined data value
5.	**Total score**	Calculating the average of sub-scores.

[312] Number of connections on the EU - Non-EU Europe route in 2020

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