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List of ACRONYMS

2OCMA	2 Oceans Cable Maintenance Agreement
APMMSA	Asia Pacific Marine Maintenance Service Agreement
ASN	Alcatel Submarine Networks
ACMA	Atlantic Cable Maintenance Agreement
CapEx	Capital Expenditures
CWDM	Coarse Wavelength Division Multiplexed
CIF	Contract in Force
EOT	End of Transmission
EOS	End of Service
EDFA	Erbium Doped Fibre Amplifiers
EMEA	Europe, Middle East Asia
ECAs	Export Credit Agencies
FP	Fibre Pairs
GMSL	Global Marine Systems Limited
HS	Hyperscaler
IBX	International Business Exchange
MECMA	Mediterranean Cable Maintenance Agreement
MW	Megawatt
MBD	Multilateral Development Banks
NAZ	North American Zone Cable Maintenance Agreement
OOS	Out of Service
OpEx	Operating Expense
PON	Passive Optical Networks
RTS	Request to Send
RFS	Ready for Service
SEAICMA	Southeast Asia/Indian Ocean Cable Maintenance Agreement
SLTE	Submarine Line Terminal Equipment
APMA	The Atlantic Private Maintenance Agreement
SPMA	The South Pacific Maintenance Agreement
TDM	Time Division Multiplexed

Exordium

Welcome to the 10th edition of SubTel Forum's annual "Submarine Telecoms Industry Report," which was authored by our analysts, without whom this report would not be possible.

2021 has turned into a year of perseverance for our world in the face of the pandemic, yet in our small, unique industry, we are still doing what we do best – designing, constructing, and maintaining cable systems around the world. The general pace of things has not slowed, and we have found workarounds for keeping factories open, and people and ships at sea. As a result, few systems have been irrevocably delayed due to COVID-19. As an industry we have much to be proud of.

Video 1: Wayne Nielsen, Publisher - Submarine Telecoms Forum, Inc.

We continually strive for our annual Industry Report to serve as an analytical resource within the trio of SubTel Forum products of Submarine Cable Map published every January, Submarine Cable Almanac published quarterly, and online Submarine Cables of the World Interactive Map. The Submarine Telecoms Industry Report features in-depth analysis and forecasts of the submarine cable industry and hopefully serves as an invaluable resource for those seeking to comprehend the health of the submarine industry. It strives to examine both the worldwide and regional submarine cable markets; including issues such as the new-system and upgrade supply environments, ownership, financing, market drivers, and geopolitical/economic events that may impact the market in the future.

The presentation of the annual Industry Report has been updated once again, drawing upon the highly successful formatting of our Submarine Telecoms Forum Magazine as inspiration, as well as including personal video commentaries from multiple industry representatives from around the world. The goal is for the Industry Report to be read online or downloaded for browsing elsewhere. As such we have attempted to make a significant, encompassing view of the submarine fiber industry available to you – our readers.

Last year's report was downloaded more than 500 thousand times and was quoted by numerous business journals and periodicals. We are optimistic, yet confident that this year's edition stands up to the same scrutiny. We hope you will agree.

We are thrilled that the Director of the Telecommunication Standardization Bureau of the International Telecommunication Union, Mr. Chaesub Lee, provided this year's foreword and accompanying video commentary, discussing the state of the ITU, the impact of COVID, and its submarine cable related initiatives.

In this annual Industry Report, we have identified more than $10 billion in new projects that are being actively pursued by their developers. Of those, some $3 billion worth are executed contract-in-force, and $1 billion of those new, contract-in-force systems are slated for 2022 alone.

We utilized insights from a number of articles from recent issues of Submarine Telecoms Forum Magazine and our proprietary Market Sector Reports, where necessary, allowing us to better discuss various industry topics. Thanks especially to Phillip Pilgrim for providing this year's reboot of the industry history section. We also received some excellent video commentary from several industry super stars, including:

- *Andrew Lipman,* Partner - Morgan, Lewis & Bockius LLP
- *Buddy Rizer,* Executive Director of Economic Development - Loudoun County
- *Chris van Zinnicq Bergmann,* Investment Development Manager - WFN Strategies, LLC
- *Didier Dillard,* Chief Executive Officer - Orange Marine
- *Greg Otto,* Technical Director - WFN Strategies, LLC
- *Guillaume Thrierr,* Director, Telecom & Tech Industry Group - Natixis
- *Hector Hernandez,* Projects Director – WFN Strategies, LLC
- *Kristian Nielsen,* Vice President - Submarine Telecoms Forum, Inc.
- *Laurie Miller,* President and Chief Executive Officer - Southern Cross Cable Network
- *Michael Thornton,* Data Analyst - Submarine Telecoms Forum, Inc.
- *Mike Last,* Director, Marketing and International Business Development - WIOCC
- *Patricio Rey,* General Manager - Desarrollo Pais
- *Rebecca Spence,* Project Manager - Submarine Telecoms Forum, Inc.
- *René D'Avezac de Moran,* Service Line Manager - Hydrography - Fugro
- *Ryan Wopschall,* General Manager - International Cable Protection Committee
- *Sean Bergin,* President - AP Telecom
- *Simon Webster,* Director, Submarine Networks EMEA - NEC
- *Stephen Grubb,* Global Optical Architect - Facebook
- *Stewart Ash,* Marine Design & Installation Manager - WFN Strategies, LLC

We would also like to say a special thank you to this year's sponsors as below who helped make the annual Industry Report possible:

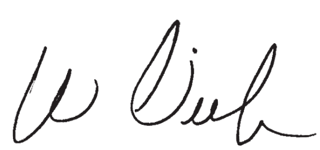
- BDA
- Ellalink
- Fugro
- Hexatronic
- Mertech Marine
- Nexans
- Ocean Networks
- OFS
- Optic Marine
- Parkburn
- Southern Cross Cable Networks
- WFN Strategies

While the crystal ball will rarely be completely clear, one fact remains – that our more than 170-year-old international enterprise continues to be a thriving, essential and ever-evolving industry.

In the coming months, we will continue to strive to make available as much new data as possible in a timely and useful fashion – as we say, an informed industry is a productive industry.

Thank you as always for honoring us with your interest in SubTel Forum's 10th annual "Submarine Telecoms Industry Report."

Good reading and stay safe, ■



Wayne Nielsen
Publisher & President, Submarine Telecoms Forum, Inc.

Foreword

Information and communication technology (ICT) has been our primary tool to contend with the COVID-19 pandemic and I would like to applaud you for the many years of innovation and investment in submarine telecoms that played such a large part in making this the case.

This Submarine Telecoms Industry Report shares insight on the latest innovations in submarine telecoms technology as well as the latest deployment projects. It highlights evolving business relationships and their implications for the future of the industry. It aims to offer a global view of the industry's technical and business dynamics to help all companies remain well positioned for success.

Video 2: Chaesub Lee, Director of the Telecommunication Standardization Bureau - International Telecommunication Union

This is an objective that ITU is pleased to support.

ITU is the United Nations specialized agency for ICT. We coordinate the global allocation of radiofrequency spectrum and satellite orbital positions. We develop international standards providing technical foundations for global growth and innovation in ICT. And we support countries around the world in advancing their ICT development.

Our global membership includes 193 Member States and over 900 companies, universities, and international and regional organizations. We are unique as the only ICT standards body with a membership including governments, and we are unique as the only United Nations body with a membership including the private sector.

The submarine telecoms industry remains integral to our work, participating in the development of ITU international standards for the design, construction, deployment, and operation and maintenance of submarine telecoms systems.

NEW WORK WELCOMING YOUR CONTRIBUTIONS

Space Division Multiplexing (SDM) is the subject of a new draft ITU technical report on optical fibre, cable and components for SDM transmission. The report will consider proposed SDM applications and clarify technical and commercial aspects of SDM to establish a roadmap towards a cost-effective future network and ecosystem utilizing SDM fibre and cable technologies.

An ongoing revision to a supplement to ITU standards – providing design guidelines for optical fibre submarine cable systems – will include a new section on colours and markers for the unique identification of fibres used in submarine telecoms systems, and updated OSNR (optical signal-to-noise ratio) measurement methods and GAWBS (guided acoustic-wave Brillouin scattering) coefficient are under study for possible inclusion.

And in our standardization work for submarine telecoms, we see a very compelling example of ICTs' value in contributing to climate action.

Two new ITU standards are under development to specify the route towards submarine telecoms cables equipped with climate and hazard-monitoring sensors to create a global real-time ocean observation network. One of these standards will address the integration of such sensors in submarine telecoms cables (working name G.smart), and the other will address cables dedicated to scientific sensing (working name G.dsssc).

Submarine cables are uniquely positioned to glean key environmental data from the deep ocean, which at present provides very few resources for monitoring the climate. This ocean-observation network would be capable of providing earthquake and tsunami warnings as well as data on ocean climate change and circulation.

This ambitious project began in 2012 with the establishment of the multidisciplinary ITU/WMO/UNESCO-IOC Joint Task Force on SMART Cable Systems dedicated to advancing the concept of 'Science Monitoring And Reliable Telecommunications (SMART) cables'.

The minimum set of requirements established by the Joint Task Force are now feeding into ITU's international standardization work, and we very much welcome your contributions.

NEW PARTNERSHIPS FOR A NEW ERA

Standardization processes must remain inclusive, with all voices heard and every step forward is determined by consensus decision.

As advances in ICT continue to introduce unprecedented capabilities to innovate, our work together in ITU standardization can help us to build consensus on how these capabilities should factor into our future.

Each year on World Standards Day, 14 October, we pay tribute to the many thousands of experts who work together year-round to develop international standards. This year's theme, "A shared vision for a better world", marked the beginning of a multi-year awareness campaign on how standardization can help to realize the United Nations Sustainable Development Goals (SDGs).

To the international standardization community, it is very clear why the SDGs emphasize the importance of partnerships.

We are seeing new partners moving forward together in ITU standardization work supporting ICT-enabled innovation in healthcare, financial services, transportation, energy, agriculture, education, and smart cities – as well as in our standardization work to help all sectors capitalize on advances in artificial intelligence and machine learning.

ICTs now form part of any discussion about our global future. ITU's neutral platform can help to unify such discussions. We convene at ITU in a spirit of collaboration and mutual respect. We learn from one another to advance together. This is exactly the spirit needed to achieve the SDGs.

WE WELCOME YOU TO JOIN US

We continue working to bridge the so-called 'standardization gap' to ensure that all countries share in the benefits of international standardization. We continue to bring together the many industry sectors innovating with ICT to learn from one another and coordinate convergence. And we continue to grow in inclusivity.

Last year, ITU introduced reduced membership fees for start-ups and small and medium-sized enterprises. Companies of all sizes in developing countries, as well as academia in all countries, also benefit from reduced fees.

Building back stronger from the pandemic, we will ensure that the ITU platform continues to grow in value to a growing number of stakeholders. ITU will continue setting the standard for international cooperation – at a time when this cooperation is more important than ever. ■

Dr. Chaesub Lee, Director, ITU Telecommunication Standardization Bureau

Chaesub Lee was elected Director of the ITU Telecommunication Standardization Bureau at the ITU Plenipotentiary Conference 2014 in Busan, Republic of Korea, and re-elected to this post for a second four-year term at the ITU Plenipotentiary Conference 2018 in Dubai, United Arab Emirates.

Dr Lee has contributed ICT standardization for over 30 years, specializing in areas such as integrated services digital networks (ISDN), global information infrastructure (GII), Internet protocol, next-generation networks (NGN), Internet protocol television (IPTV) and cloud computing.

He started his professional life in 1986 as a researcher at Korea Telecom. After 17 years he took up a role at the country's Electronics and Telecommunications Research Institute (ETRI), where he stayed for the next eight years.

Most recently he worked at the Korea Advanced Institute of Science and Technology (KAIST), and as a senior advisor to Korea's Ministry of Science, ICT and Future Planning (MSIP).

Within ITU Dr Lee served as Chairman of the ITU Focus Group on Next-Generation Networks (NGN) to address the growing need for international standards for NGN, including service requirements, functional architecture, mobility, security and Quality of Service (QoS). He was also Vice-Chairman of the ITU Focus Group on IPTV which worked to coordinate and promote the development of IPTV standards.

He acted as Vice-Chairman of ITU-T Study Group 13 (Future networks and cloud) from 2001 until 2008, becoming Chairman of that group in 2009. ITU-T Study Group 13 develops standards for NGN, future networks, cloud computing, Internet of Things (IoT) and mobile telecommunications, to ensure their smooth international deployment.

Dr Lee holds a PhD in Multimedia Engineering. He is married with two children.

Methodology

This edition of the Submarine Telecoms Industry Report was authored by the analysts at Submarine Telecoms Forum, Inc. who provide submarine cable system analysis for SubTel Forum's Submarine Cable Almanac, online and print Cable Maps and Industry Newsfeed.

For the Industry Report, we utilized both interviews with industry experts and our proprietary *Submarine Cable Database*, which was purpose-built by Submarine Telecoms Forum and provides analysis for the Submarine Cable Almanac, Cable Map, and Industry Newsfeeds, including offshore Oil & Gas submarine cable systems. The *Submarine Cable Database* was initially developed in 2013 and modified with real-time data thereafter. The database tracks more than 500 current and planned domestic and international cable systems, including project information suitable for querying by client, year, project, region, system length, capacity, landing points, data centers, owners, installers, etc. The Submarine Cable Database is purpose-built by a dedicated database administration team, powered by SQL and retained on a Microsoft Azure platform. Maps are produced with ArcGIS Pro, in the same format and visual style as Submarine Cables of the World print map.

Video 3: Rebecca Spence, Project Manager - Submarine Telecoms Forum, Inc.

To accomplish this report, SubTel Forum conducted continuous data gathering throughout the year. Data assimilation and consolidation in its *Submarine Cable Database* was accomplished in parallel with data gathering efforts. SubTel Forum collected and analyzed data from a variety of public, commercial, and scientific sources to best analyze and project market conditions.

For capacity growth, two different ways of determining Compound Annual Growth Rate (CAGR) are used. The first method calculates a CAGR for a given time period – e.g., a CAGR for the period 2015-2019. The second method calculates a rolling two-year CAGR to minimize extreme variance while also showing a useful year-to-year growth comparison. For 2019, publicly reported data was minimal, so modeling had to be used to approximate capacity growth. The average growth rates from 2015-2018 were applied to determine capacity growth numbers for 2019 and beyond.

For unrepeatered systems analysis, a maximum cable length of 250km with the exception of one system publicly announced as an unrepeated system was applied to the database to determine which cable systems to consider as unrepeatered.

Trending is accomplished using known data with linear growth estimates for following years.

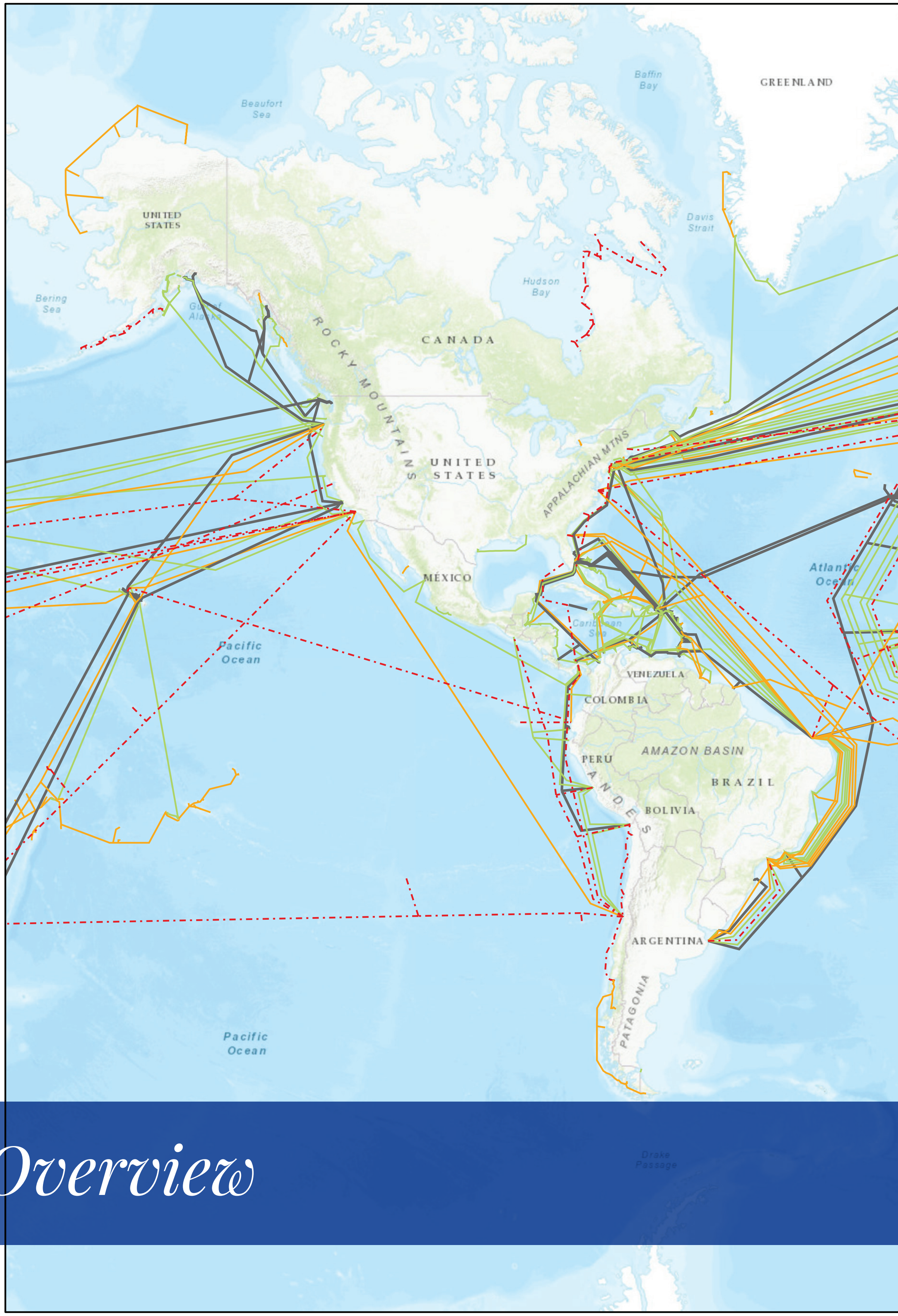
While every care is taken in preparation of this report, these are our best estimates based on information provided and discussed in this industry.

We hope you enjoy our report. ■

Regards,

Rebecca Spence
Project Manager, Submarine Telecoms Forum, Inc.

1



Global Overview

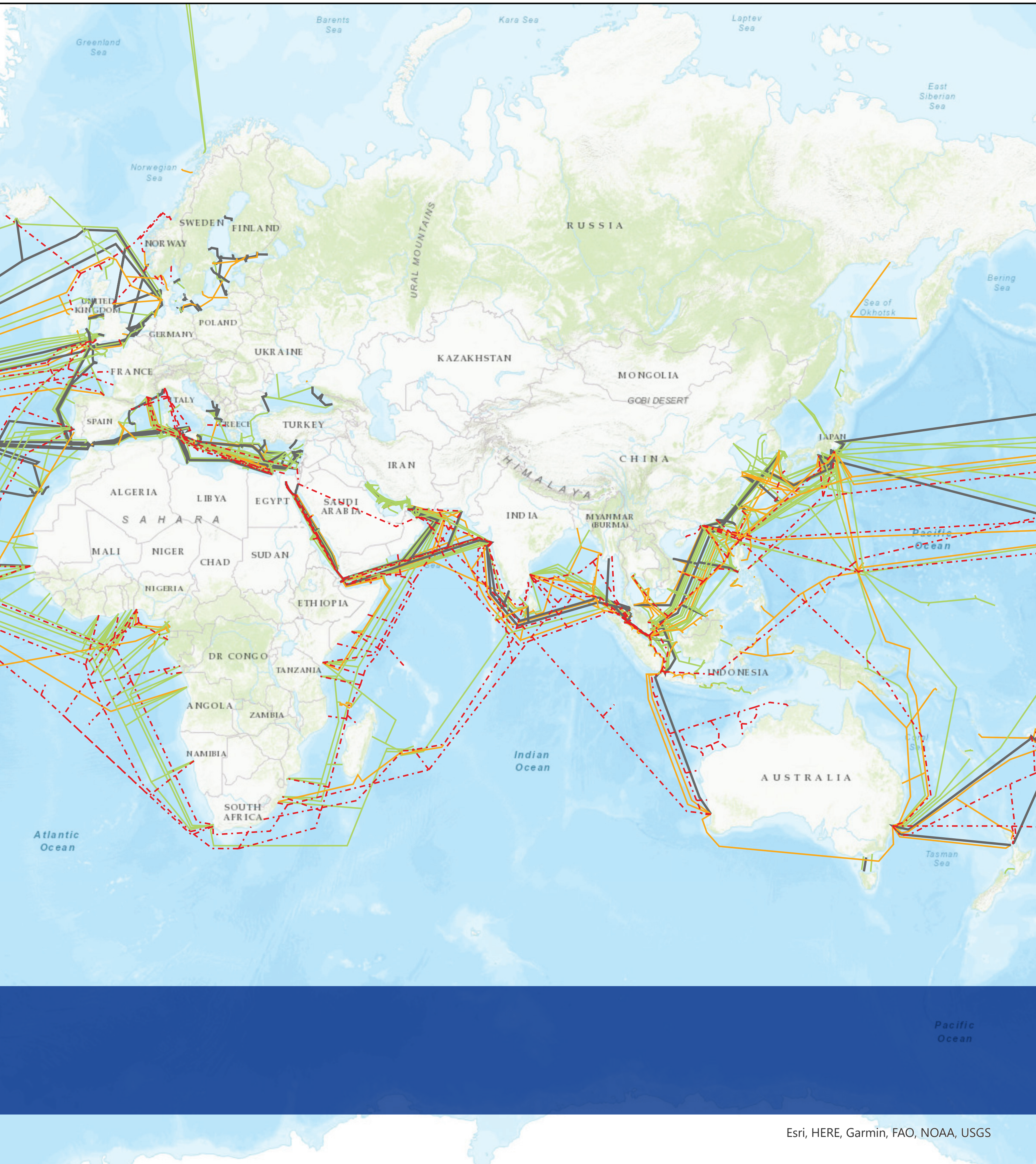
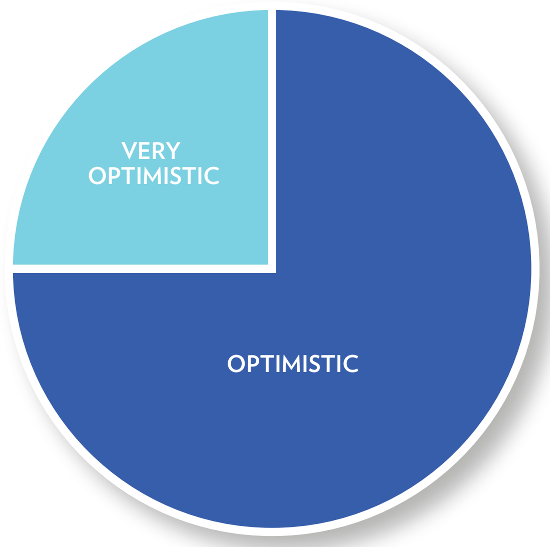


Figure 1: Worldwide Map of Submarine Cable

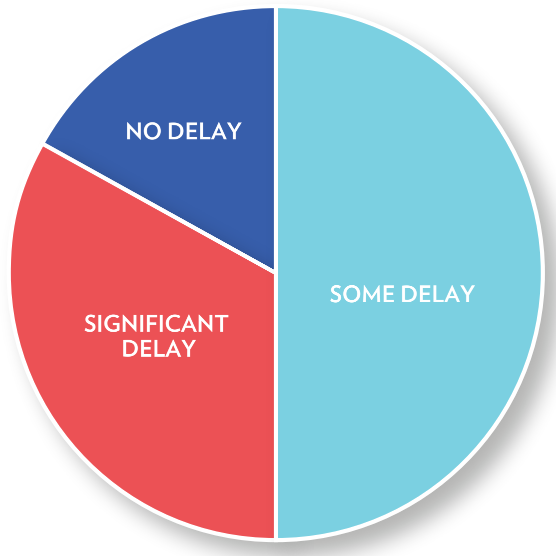
1.1

Industry Sentiment

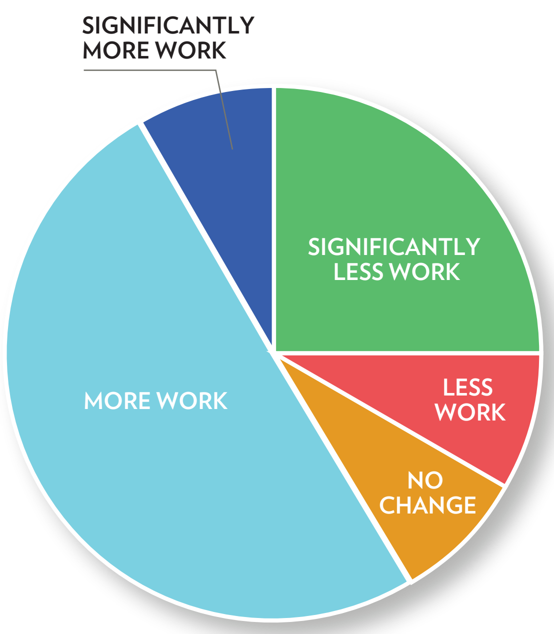
OVERALL STATE OF THE INDUSTRY



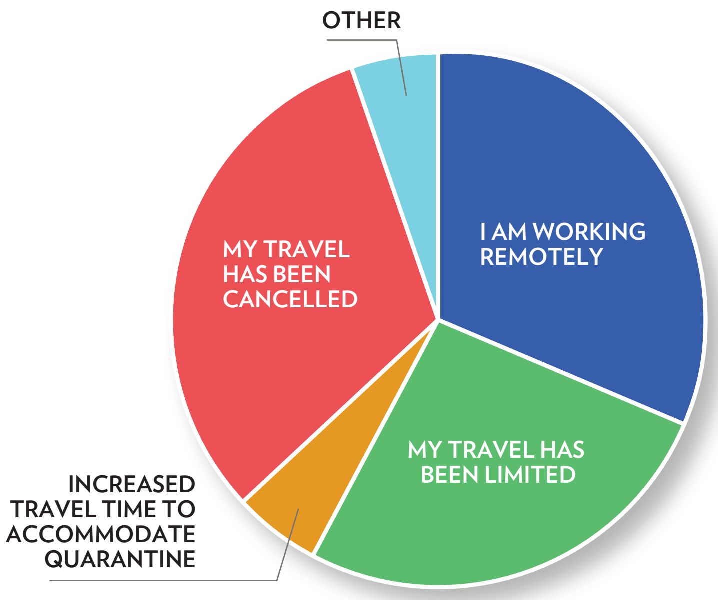
PROJECT STATUS



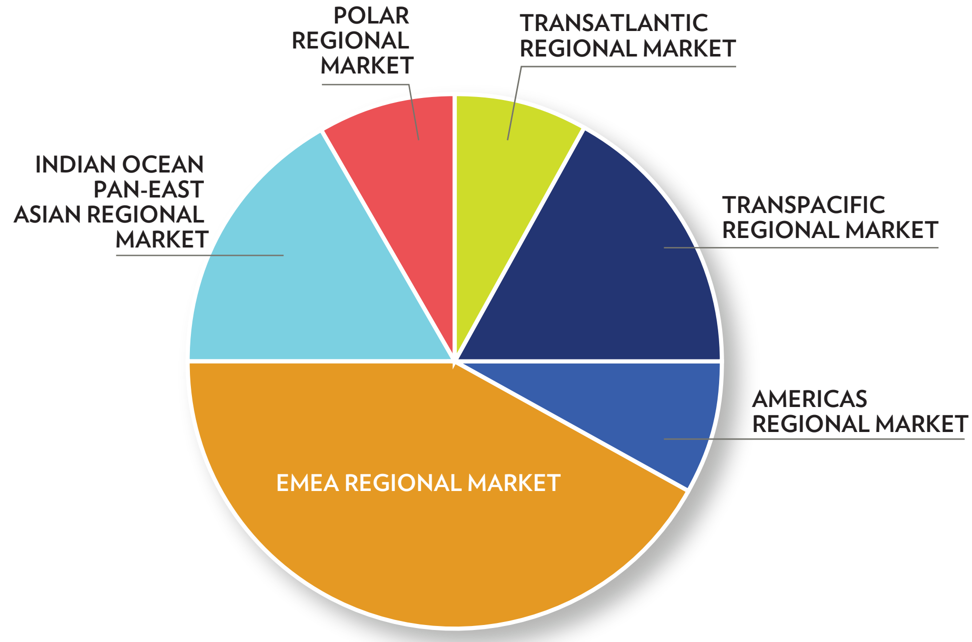
MARKET ACTIVITY



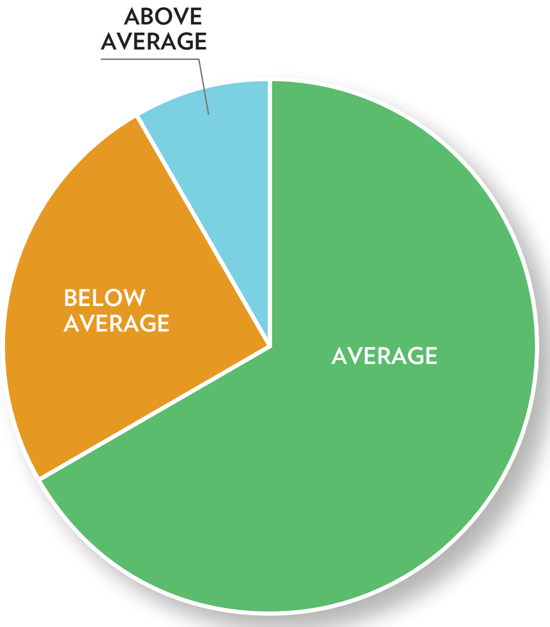
WORK STATUS



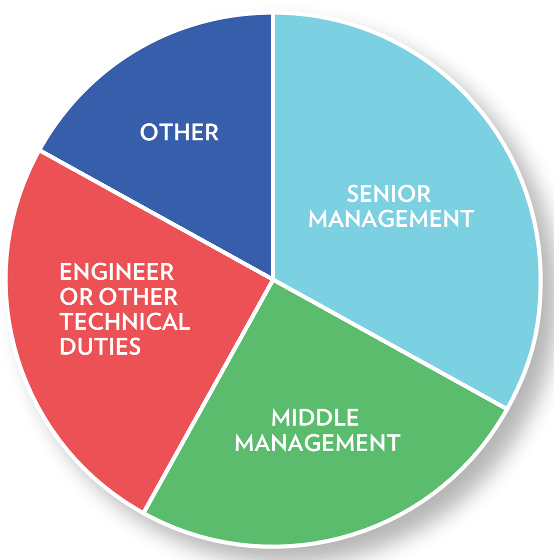
REGIONAL ACTIVITY



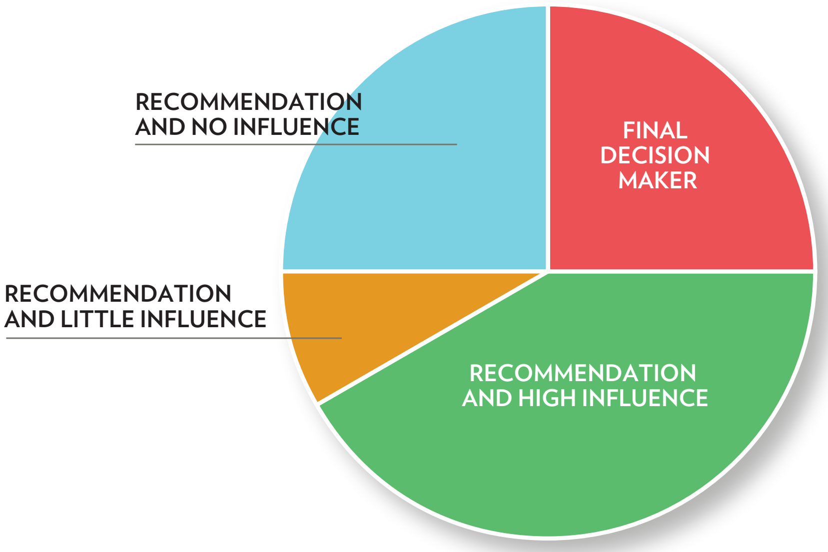
INDUSTRY INVESTMENT



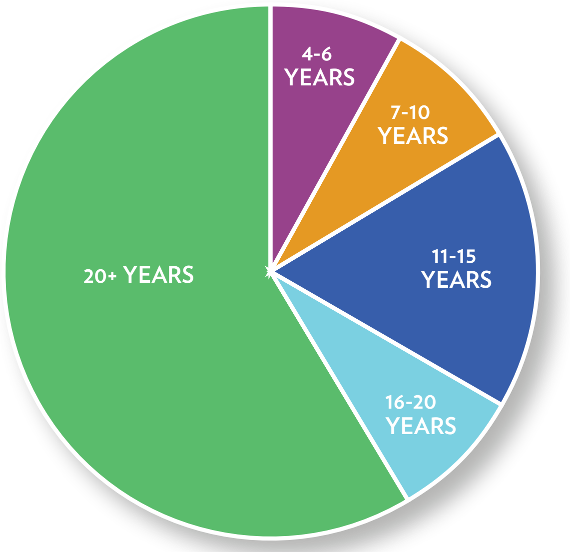
WHAT IS YOUR JOB FUNCTION?



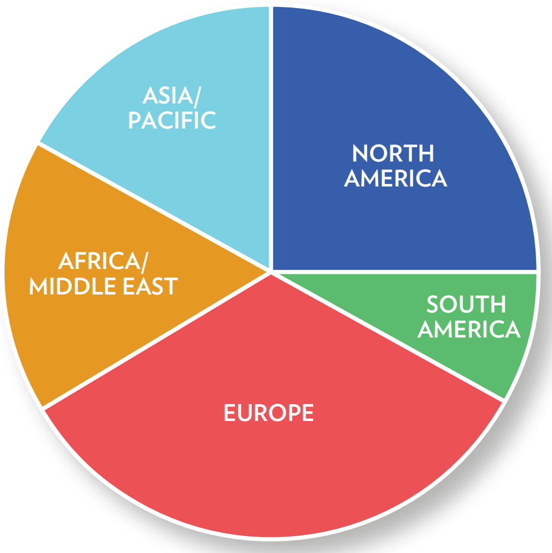
WHAT IS YOUR PURCHASING POWER WITHIN YOUR ORGANIZATION?



HOW MANY YEARS HAVE YOU BEEN IN THE SUBMARINE TELECOMS OR RELATED INDUSTRY?



WHERE DO YOU RESIDE?



1.2

Phillip Pilgrim's Look at Submarine Telecoms and Our Technology Roots

As this is Submarine Telecoms Forum's year in review, it becomes challenging for a subsea history enthusiast to write about the small changes in the past 365 days. Also, as I currently work in the industry, there are legal complexities to reporting such a modern history. So, to be fair to my colleagues, and companies in this sector, let's expand the review beyond one year. If we look back a little further, we can easily contrast aspects of today's subsea industry with those of the past. Hopefully this trivia will help one to appreciate where we are today in this wonderful niche of international telecommunications.

As fair warning, I will take liberties to stretch some of the examples, so please be accommodating to this and perhaps we can discuss the matter further at a post-COVID conference. I'm certain you will win the argument but until then, let's have a lark and look back.

TECHNOLOGY

GUNS & ARMOURED CABLE

Today's cables have wraps of armouring wires and metal tapes to protect them from the harsh marine environment. Wave action, tides, currents, icebergs, rockslides, fishing activities, and marine activities all test the armour of a modern cable. The first application of armoured cable was in 1846 in New York, where a lead sheath surrounded and sealed the four copper conductors of a cable connecting Long Island to Fire Island. This cable was laid by Samuel Colt and Samuel Morse (yes it was the same Colt who invented the revolver and the same Morse who invented the Morse Code).

Figure 2: 1846: The World's First Armoured Submarine Cable, Samuel Colt (N.Y.)

But it was the application of wire rope (developed by Wilhelm Albert ~ 1831 for the mining industry to replace metal chains) that was the keystone for armoured cable. The first application of a submarine cable made with "wire rope" was in September 1851. It was Robert Stirling Newall who, after a friend, L.D.B. Gordon, told Newall about the application of wire rope in Germany, built a wire rope machine, and then a factory for making wire rope in England. Newall went on to develop an armoured submarine cable where the wire rope's core had a copper conductor for signaling and a natural latex insulating coating (gutta percha) to insulate the copper conductor. All modern cables closely resemble this first armoured cable, and we must thank Newall for this gift.

CANDLES & OPTICAL AMPLIFICATION

Today's submarine cables enjoy the amplification of light using Erbium Doped Fibre Amplifiers (EDFA). This technology was invented in 1986 and was first deployed in submarine cables ~ 1994. EDFA amplifiers are contained within water-tight pressure housings (repeaters) that are spaced every 30km to 120km along a submarine cable. Optical amplification is a critical requirement for contemporary cables to function. Optical amplification works by taking a weak signal and increasing its power so that it can be detected and understood by a receiver. The first application of optical amplification in a subsea cable goes back to 1857, nearly 130 years before the invention of the EDFA! OK, we can discuss this in person in the future, but I kid you not. Here is the dope: the first transatlantic telegraph cable (The Atlantic Cable) suffered setbacks in 1857 when several attempts to lay it failed, due to weather and cable handling challenges onboard the ships. Although 1857 was seemingly a bad year for the cable, enough of the cable was finally in the water (momentarily) to expose a new problem; the saltwater now surrounding the cable increased its capacitance and made for very sluggish signalling this was remarkably different from its performance in the factory, its performance in the ship's hull, and its performance on a terrestrial test bed. Fortunately, a clever engineer at the time, William Thomson (aka Lord Kelvin of thermodynamics fame), was supporting the lay and realized that the way to deal with the capacitance was to transmit weak signals. In 1857 he refined a test instrument called the Mirror Galvanometer for subsea work. Let's first step back and explain that for terrestrial telegraph communications at the time, the transmitting terminal applied a strong signal to the line and a receiver at the far end was simply an electromagnet that would clap a slug of metal when the coil in the receiver was energized by the received signal. The typical "click click click" sound of the telegraph receiver would then be decoded. The submarine cable, with its significantly larger resistance and capacitance, prevented normal terrestrial terminal functioning, so a special, and very sensitive, subsea terminal was needed. Thomson's "submarine terminal receiver" consisted of a magnet suspended by a wire that was then encircled by a coil. When the far end of the cable applied a signal, current flowed through the receiving coil and the induced weak magnetic field cause the suspended magnet to rotate fractions of a degree. To detect the small, nearly imperceivable deflection, Thompson placed a mirror on the magnet and shined a beam of candlelight on the mirror. When the magnet and mirror deflected the light, the beam would sweep across a scale.

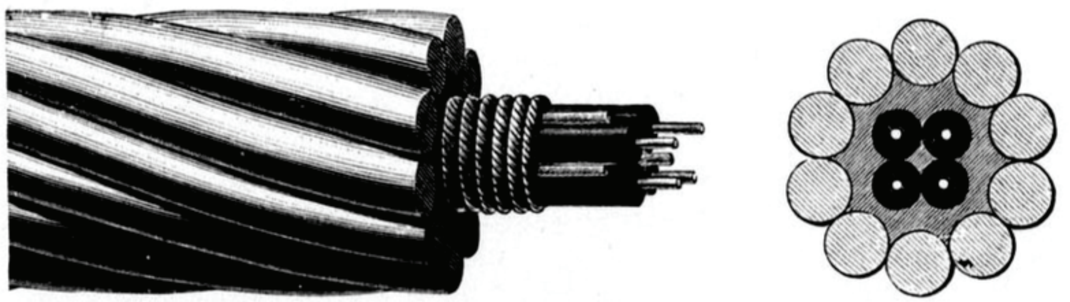


Figure 3: 1851: The World's First "Wire Rope" Single-Armoured Cable (UK-France)

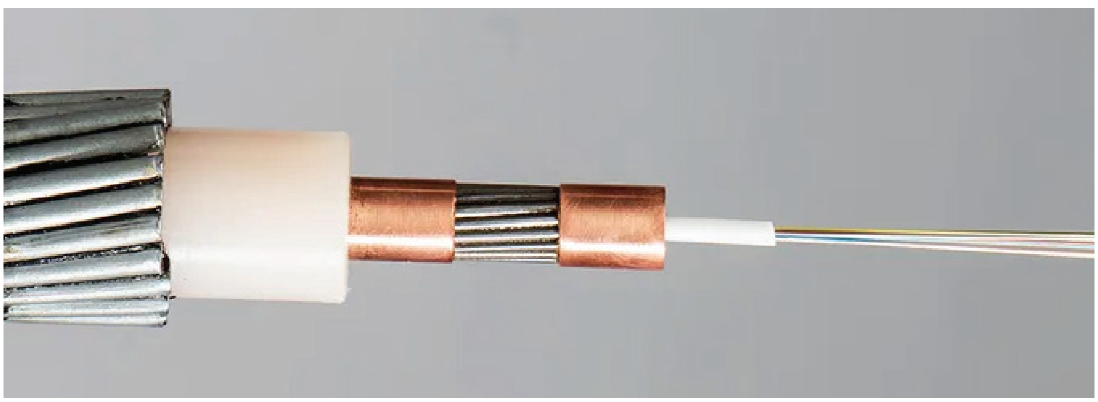


Figure 4: 2021: Contemporary Single-Armoured Cable

This angular amplification of light was how weak signals "optical" signals were amplified thus, optical amplification in 1857.

MONSTER IN THE BASEMENT, BIDIRECTIONAL TRANSMISSION, AND EARLY ETHERNET

Today's optical networks can enjoy bidirectional transmission over a single fibre; but it is only practical in special applications. Typically, it is used by Coarse Wavelength Division Multiplexed (CWDM) systems within co-location facilities (to reduce room-to-room fibre rental charges) and it is also used in passive optical networks (PON) to deliver fibre to the curb, home, etc. For contemporary transoceanic subsea applications, bidirectional transmission over a fibre is technically possible, but it is not practical as the needed couplers, splitters and directional filters add extra loss compared to conventional fibre-pair interworking using two unidirectional fibres. In contrast, telegraph systems quickly evolved to adopt bidirectional transmission (referred to as duplex). The early cables across the Atlantic were Time Division Multiplexed (TDM) where one side of the cable would have exclusive control to transmit a message. When finished, the far end could gain control to send a message back. This arrangement could be based on slots of time or using a signaling hand off such as "request to send" (RTS) or "end of transmission" (EOT). By the early 1870's, companies were experimenting with duplex transmission over terrestrial telegraph lines and the technique was made practical for transatlantic cables in 1878 by the work of Joseph Barker Stearns. For bidirectional transmission, both ends apply signals to the cable. This seemingly caused confusion to the two receivers, as they were energized by both the near and far end signal at the same time and were not able to discern one from the other. The "trick" to make bidirectional transmission over a single wire is to virtually annihilate the transmitted signal as it is transmitted. The trick is done by a technique called Common Mode Rejection. To do this, a virtual cable (artificial line), made of resistors, capacitors, and inductors, is built to replicate the cable's resistance, capacitance, and inductance. This huge contraption was housed in the basement of one cable station thus the title of this section. By connecting the receiver (electromagnet) across the real cable and virtual cable, no current will flow when the near transmitter energizes both lines, however when an incoming signal comes in on the cable line only, it will not be present on the virtual cable in the basement so current will flow through the receiver and "click". All of this "balanced circuit" technology is now widely used in op-amp technology

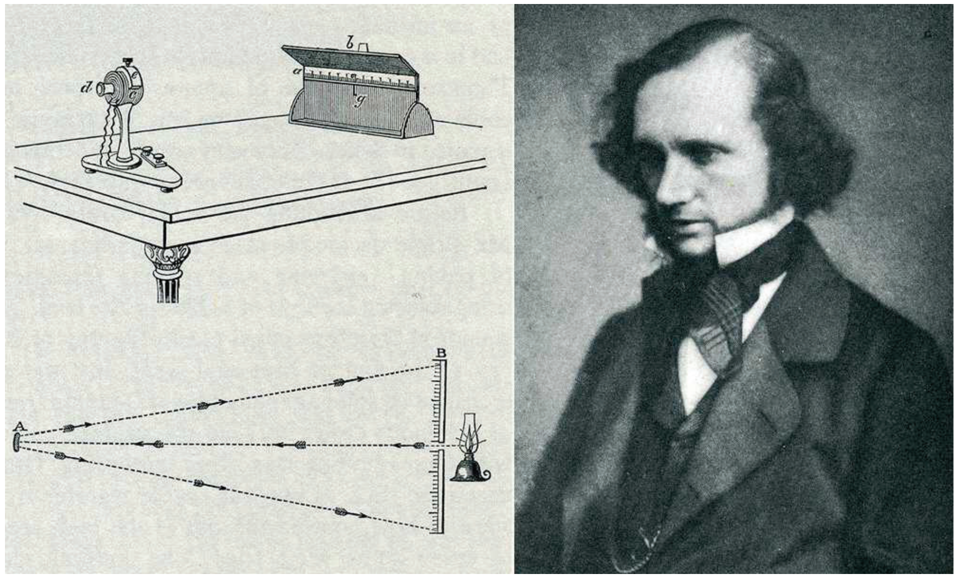


Figure 5: Lord Kelvin and the Mirror Galvanometer's Principal

Figure 6: 1857: "Optically Amplified" Submarine Terminal

and in audio systems (such as microphone cables). The fundamental balanced circuit was developed by Charles Wheatstone and is know as the Wheatstone bridge. This circuit has become universal in all linear power supplies in your electronics equipment. The Wheatstone Bridge Circuit is still used today to locate electrical faults in submarine cables as these cables still have a copper conductor to power the wet plant's repeaters and branching units.

So, by now, you are either bored or amazed by this fundamental transmission trivia and will think of a submarine cable every time you see a microphone or flick a power switch but, you are thinking he can't be serious about Ethernet? Well, I am. If your read about Robert Metcalfe and the first Ethernet, it was basically two devices exchanging data over a copper medium (folklore is a computer and printer interworking over a copper pipe). It was not duplexed, but it was TDM just like the very first transoceanic cables. If there was a collision of data when both ends tried to use the link at the same time, each would relinquish, and one would inevitably restart before the other to gain control.

Finally, if you think Duplex was significant, how about Quadruplex? By using "Bipolar" line signals of positive and negative signalling voltages, and leveraging magnetic polarization at the receiver, one could send four signals over a single wire. Quadraplex was invented by Thomas Edison in 1874, four years before he invented the light bulb.

Figure 7: 1865 Atlantic Cable Station Ireland: Two submarine line terminals each with a Mirror "Galvo" and Lanterns

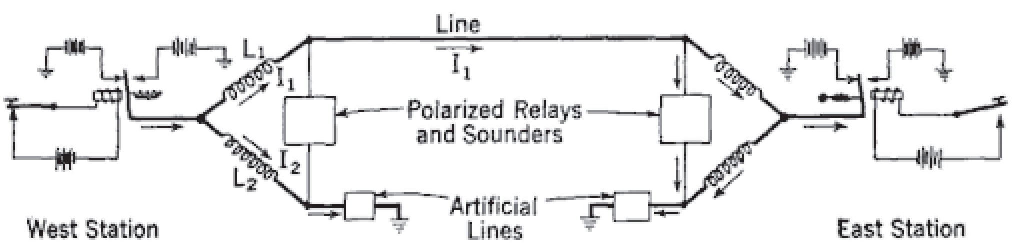


Figure 8: 1874: Duplex Telegraph Concept

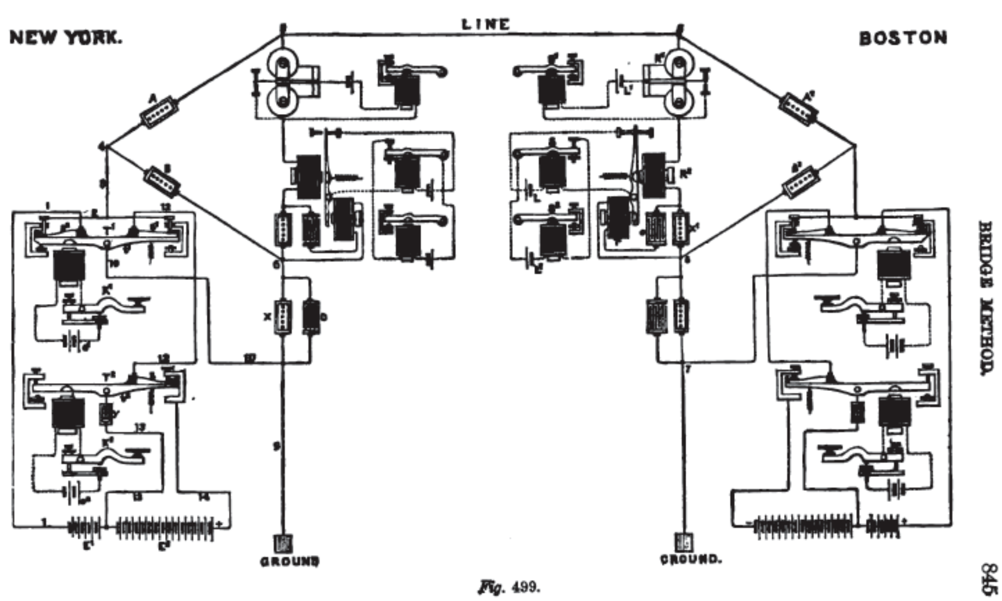


Figure 9: 1874 Quadruplex (4 signals on one line) by Thomas Edison

CONSTELLATIONS

Surely you must think I am mad at suggesting that the telecommunications concept of constellations existed in early submarine telegraphy? Well, I am not mad, and I am not going to claim it was used in the mid 1800's. It was used in the late 1700's. As with the previous topics, lets look at the current application of constellations then look back in time. Today, we exchange symbols representing a value. Constellations are simply gridded patterns used to represent the set of possible values of an incoming symbol. The points in the grid pattern can be represented by changes in amplitude, changes in phase, or changes in some other physical quality of the signal. The grid can take many shapes but let's stick to the more common checkerboard pattern for simplicity. A simple binary system used in early optics consisted of blinking a laser off and on. This system would have just a two block (binary) constellation. One block would r epresent an off or zero symbol and the other would represent a high or one state symbol. Placing all possible symbols on gives the following constellation grid:

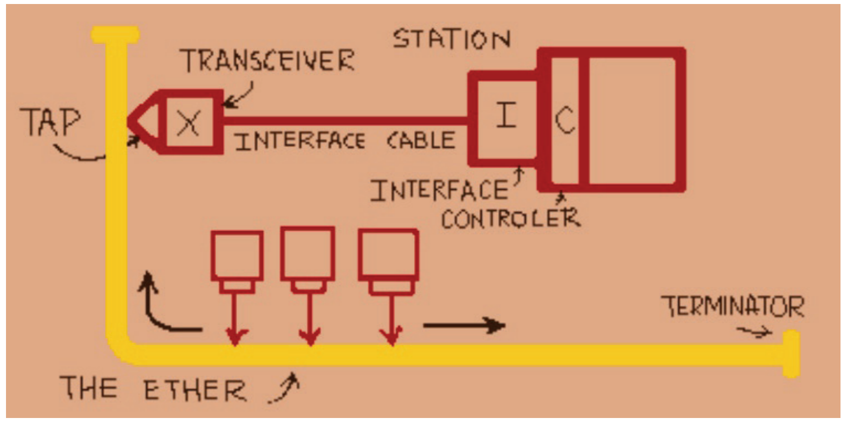


Figure 10: 1974: First Ethernet Drawing (Showing 4 devices on one line/ether)

Now if we have a binary transmission system and wanted to send a number 4 to a receiver, we could agree upon an (inefficient) code to be utilized and say the code is to sum the numbers in block of 10 contiguous signals. So, if we send the ten signals as 1,1,1,1,0,0,0,0,0,0 the four ones in the block sum to "4" and we have communicated to the far end the number "4" using 10 steps.

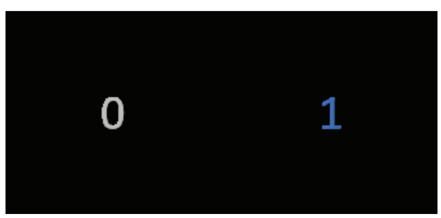


Figure 11: Binary Constellation

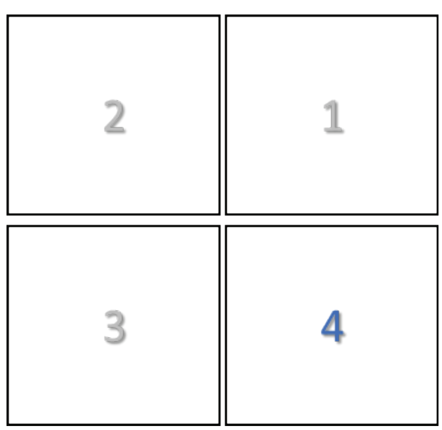


Figure 12: Quad Constellation

Now if we used a method of communicating where the constellation had a pattern of 4 possible symbols, and we assign the number 1 to the first block, 2 to the second and so on, then in one step, we could send a signal pattern of just the 4th block and the far end would receive it efficiently. Using constellation codes improves the throughput of a transmission system. We exploit the complexity of the symbol sent to increase the information it contains.

In modern telecommunications, constellations of 128 X 128 are possible and represent both phase and amplitude of the incoming signal. In 128 X 128 constellations, there would be 16,384 points where each is a unique symbol made from a unique combination of phase and amplitude.

A representative constellation in optics is shown below. It is 16 X 16. When data is received, only one point in the constellation is lit up (tine blue specks), however by integrating incoming data points over time, all the locations in the constellation will eventually be illuminated by clusters of data points (specks).

Hopefully this explanation was not too difficult. If it was, just think that an incoming signal is no longer a just one or a zero but as a larger number.

In the 1790's France's Claude Chappe developed an Optical Telegraph where a windmill like station on a high point of land communicated with other similar stations. The windmill-like structure had a long crossbar (like an airplane propeller) and there were two arms at each end of the crossbar. With just these three movable parts, they could be articulated to form 196 different patterns/symbols. Each pattern was therefore a data point in a 192-point constellation.

SPATIAL DIVISION MULTIPLEXING

Today's cable designs are shifting priorities. In many cases, for a fixed budget, maximizing highest performance would give the highest capacity, however, recent studies have shown that, by dialing back some of the performance, more capacity could be realized as the saved performance costs could be channeled to add more fibres to the system. Also, as the cost to build a system is great, significant savings can be realized by squeezing two or more cables into one cable build. This is done by simply adding more fibres and EDFAs to the system while dealing with the extra power required for the EDFAs. If we look at the first significant optical cable, TAT-8 of 1988, it was constructed with two working Fibre Pairs (FP). This enabled two bidirectional circuits: USA-France and USA-UK. These days, SDM cables have fibre pair counts in the twenties.

The first significant telegraph cable in 1851 connected UK to France and had 4 conductors. This enabled two bidirectional circuits just like the first transatlantic optical cable. Later telegraph submarine cables (in shorter applications) had up to 20 conductors. If quadruplexing was applied, this would allow for 40 bidirectional telegraph circuits over one cable and exceed our current optical SDM circuit count capabilities of ~ 24 bidirectional circuits.

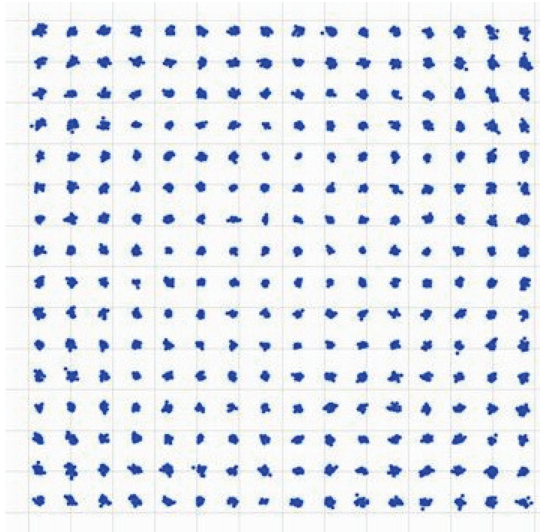


Figure 13: 2021: 256 Point (16 X 16) Constellation

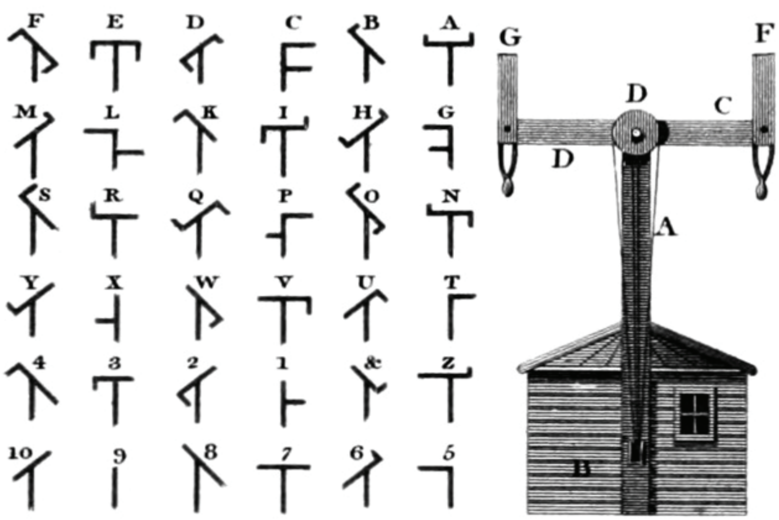


Figure 14: 1792: Up to 192 Point (7 X 7 X 4) Constellation (6 X 6 above)

DATA STORAGE

Thanks to many years of transistor and media development, we can record streaming data in real time as it is received from a digital line system such as from a modern submarine cable.

The first data recorder for telegraph was invented by Samuel Morse in 1837 and first used commercially in 1844 on a terrestrial line in the U.S.A. As telegraph signals arrived, the receiver would record the message by embossing a rolling strip of paper. Records show that a similar ink-based paper recorder integrated with a sensitive receiver was developed by William Thomson (improver of the mirror galvanometer). Perhaps his device was similar to a data centre? OK I am stretching it a bit too far here, but data is captured, stored, and retransmitted.

Figure 15: 1851 First Successful Submarine Telegraph Cable (4 conductors) Thanks to Bill Burns atlantic-cable.com

HERO EXPERIMENTS (REACH, DATA RATE, AND LATENCY)

These days, manufactures of telecom equipment often like to demonstrate their experimental products in development to give the public a glimpse of what is to come. These demonstrations usually exhibit a product's reach, speed, or traffic capacity. Generally, these experiments involve temperamental lab equipment that can not be productized as is. Often the equipment must be coaxed by a team of scientists, or the equipment requires a special condition to operate at maximum performance. We refer to these as "Hero Experiments". The demonstrated product is often commercialized a year or more after the demo. Sometimes it is never commercialized. An example of a hero experiment would be to send a 10Tb/s on a single transponder. Currently, commercialized subsea transponders operate under 1Tb/s.

Here is an example of a Nov. 1866 telegraph hero experiment reported in a newspaper. In this experiment, New Orleans was connected to the terrestrial end of the Atlantic Cable System, in Nova Scotia, with no regenerator stations operating between (>3,600km).

Less than two years later, on Feb. 1, 1868, the "Hero" bar is raised to ~ 7,800km (~ 4,700miles) when the cable station in Newfoundland is connected to San Francisco. The report muddies the claim to ~ 23,300 km (14,000 miles) by sending the signal back then forth. However, it is very interesting to see that "data rate" (words transmitted in ~ two minutes) and "latency", aka transmission time, are reported, and that these performance metrics were as important back then as they are today!

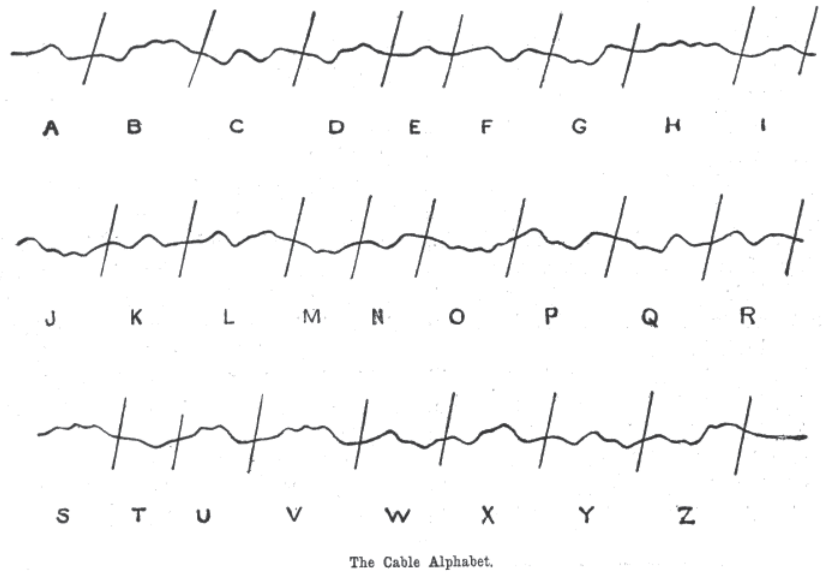
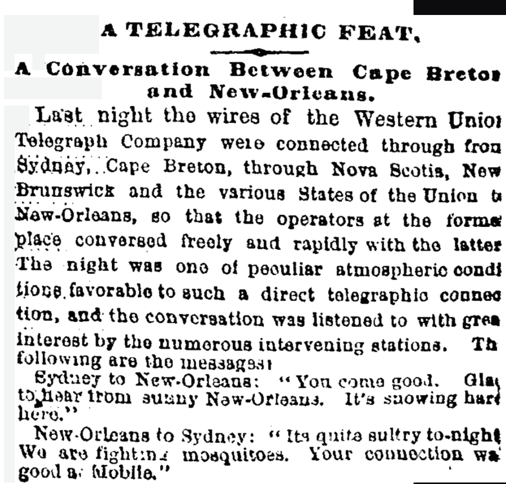


Figure 16: The telegraph alphabet transmitted over a transatlantic cable and "digitized" by a Syphon Recorder

TEST BEDS

Today's manufacturers of submarine line terminal equipment (SLTE) have test beds to develop and qualify their transmission equipment. These test beds consist of fibre spools and optical amplifiers that represent a long submarine cable but without the armour. In a linear configuration, the test bed lengths are in the thousands of kilometers and take up much space in a lab. There are also more compact recirculating architectures where the length of fibre and amplifiers are only ~ 1,000km or less. These systems are looped on themselves. The signal is injected into the loop then extracted after a certain number of excursions through the loop.



A TELEGRAPHIC FEAT.

A Conversation Between Cape Bretoı and New-Orleans.

Last night the wires of the Western Unioı Telegraph Company were connected through fron Sydney, Cape Breton, through Nova Scotia, New Brunswick and the various States of the Union t New-Orleans, so that the operators at the forme place conversed freely and rapidly with the latter The night was one of peculiar atmospheric condi tions favorable to such a direct telegraphic connec tion, and the conversation was listened to with grea interest by the numerous intervening stations. Th following are the messages:

Sydney to New-Orleans: "You come good. Gla to hear from sunny New-Orleans. It's snowing har here."

New-Orleans to Sydney: "Its quite sultry to-nigh We are fighting mosquitoes. Your connection wa good at Mobile."

Figure 18: November 1866 Newspaper Article On Atlantic Cable System

In planning the first Atlantic Cable, the company was not 100% certain that telegraph transmission could be possible over such a long span. A test bed was used to prove the transmission technology. The test bed consisted of a working subterranean (buried cable) telegraph

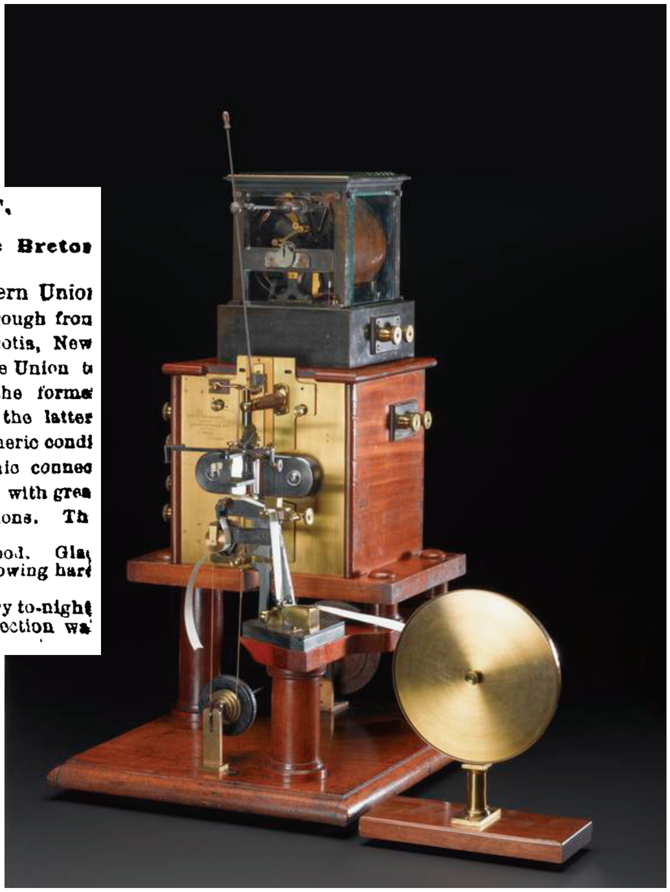


Figure 17: A Thomson Syphon Recorder from 1870

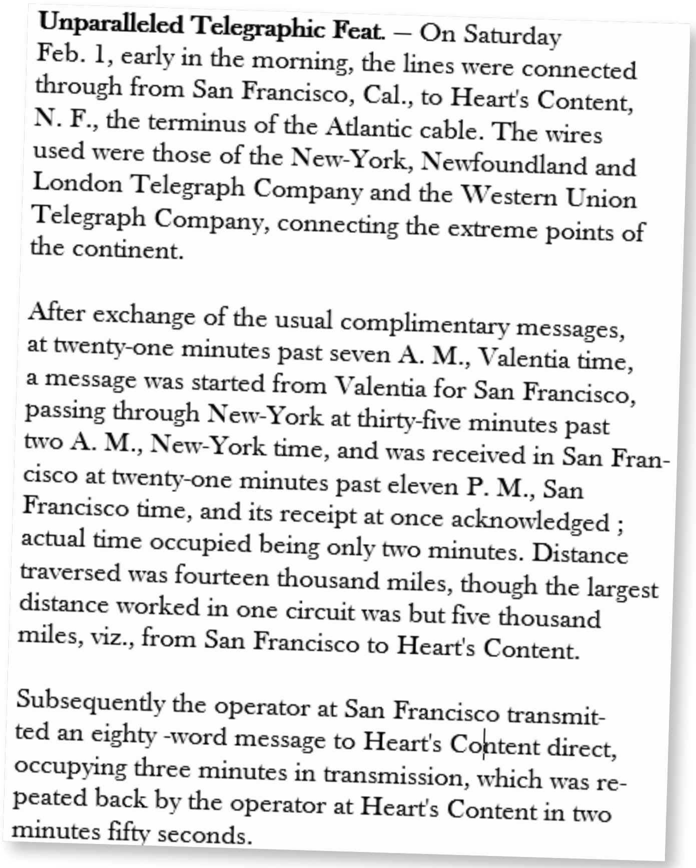
system in England. Ten cables of ~ 320km each were daisy chained to create a single span of 3,200km that exceeded the planned submarine cable's length. In Oct. 1856, Samuel Morse reported that the test bed tests were successful, and they could transmit just over 200 characters per minute that were recorded by his paper recorder. The tests were done overnight when the telegraph offices were closed.

25 YEARS TO END OF LIFE (EOL)

Putting objects on the ocean floor is nearly as complex and as expensive as putting objects in Earth's orbit. Once placed, they are very difficult, and are very expensive, to retrieve and to repair. It is for these reasons that rigorous qualification processes and quality standards have evolved to ensure the longevity and snag-free operation of our subsea wet plants. In fact, the current industry requirements for wet plants are to operate at a certain level of performance for 25 years with no interventions or repairs. This means that if components age or fail, the design must include these eventualities and continue to operate. Repairs due to fishing, shipping, rockslides, etc. are beyond the designer's abilities to predict however, they must still include x number of repairs across the cable in their design to maintain a minimum level of performance for 25 years.

The first significant cable laid in 1851 operated from 1851 to 1875 (24 years) requiring only minor repairs due to fishing and shipping interventions. Since then, some telegraph cables operated in use for over 50 years. Wet plant cable's longevity has been proven over and over throughout history.

Well, that is it for this article. A more complete article contrasting the then-and-now business, legal, routing, science, and military aspects will be published in a future Submarine Telecoms Forum bi-monthly magazine.



Unparalleled Telegraphic Feat. — On Saturday Feb. 1, early in the morning, the lines were connected through from San Francisco, Cal., to Heart's Content, N. F., the terminus of the Atlantic cable. The wires used were those of the New-York, Newfoundland and London Telegraph Company and the Western Union Telegraph Company, connecting the extreme points of the continent.

After exchange of the usual complimentary messages, at twenty-one minutes past seven A. M., Valentia time, a message was started from Valentia for San Francisco, passing through New-York at thirty-five minutes past two A. M., New-York time, and was received in San Francisco at twenty-one minutes past eleven P. M., San Francisco time, and its receipt at once acknowledged; actual time occupied being only two minutes. Distance traversed was fourteen thousand miles, though the largest distance worked in one circuit was but five thousand miles, viz., from San Francisco to Heart's Content.

Subsequently the operator at San Francisco transmitted an eighty -word message to Heart's Content direct, occupying three minutes in transmission, which was repeated back by the operator at Heart's Content in two minutes fifty seconds.

Figure 19: February 1, 1868 Follow-up Newspaper Article On Atlantic Cable System

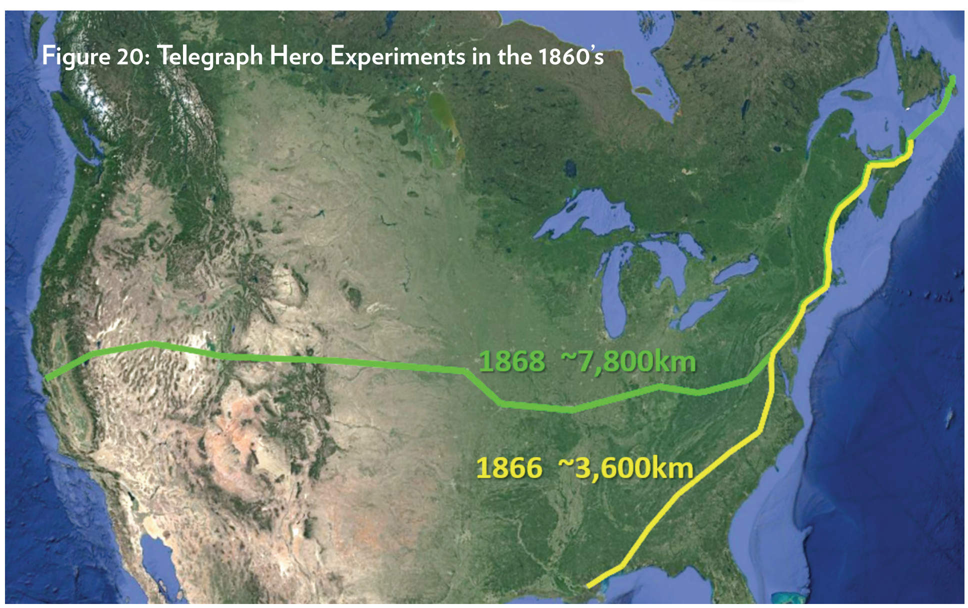
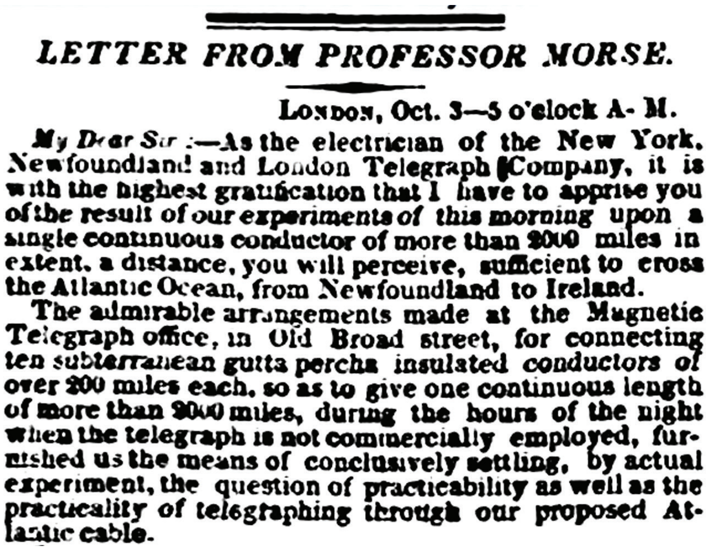


Figure 20: Telegraph Hero Experiments in the 1860's

I will leave you with one last jaw dropping claim: Optical Communication and Wireless Communication first occurred on February 19th, 1880. From a wireless perspective, this would occur seven years before Heinrich Hertz's radio experiments and fourteen years before Marconi's first radio experiments. From an optical perspective, it was 72 years before Narinder Singh Kapany's


LETTER FROM PROFESSOR MORSE.

LONDON, Oct. 3—5 o'clock A. M.

My Dear Sir:—As the electrician of the New York, Newfoundland and London Telegraph Company, it is with the highest gratification that I have to apprise you of the result of our experiments of this morning upon a single continuous conductor of more than 2000 miles in extent, a distance, you will perceive, sufficient to cross the Atlantic Ocean, from Newfoundland to Ireland.

The admirable arrangements made at the Magnetic Telegraph office, in Old Broad street, for connecting ten subterranean gutta percha insulated conductors of over 200 miles each, so as to give one continuous length of more than 2000 miles, during the hours of the night when the telegraph is not commercially employed, furnished us the means of conclusively settling, by actual experiment, the question of practicability as well as the practicality of telegraphing through our proposed Atlantic cable.

Figure 21: Excerpt from Morse presenting the results using the First Subsea Test Bed (At 5AM!)

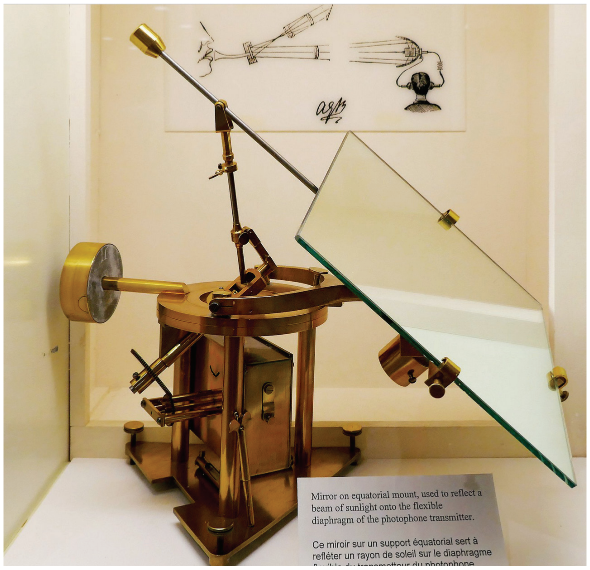


Figure 23: Sun tracking portion of the Photophone (Alexander Graham Bell Museum, Baddeck, Nova Scotia)

Figure 22: A damaged section of the 1851 cable recovered during a repair

invention of optical fibre in 1952.

The inventor Alexander Graham Bell gave us the photophone. He said it was his greatest invention. He transmitted voice over a beam of light a distance of ~200m. As the lightbulb was only invented the year before, he used a beam of sunlight as the medium, thus it was a fully "green" communication. His apparatus was further developed by others, and by the early 1910's, ranges of up to 15km day or night (using light bulbs) were achieved. Bell's foray into "Free Space Optics" predates the current efforts to build similar laser networks between satellites, between earth stations and satellites, and between the moon and earth. Mankind has continuously overcome technical challenges, so it seems that free space optics may one day supplement terrestrial and subsea cable-based communications and possibly replace it. ■

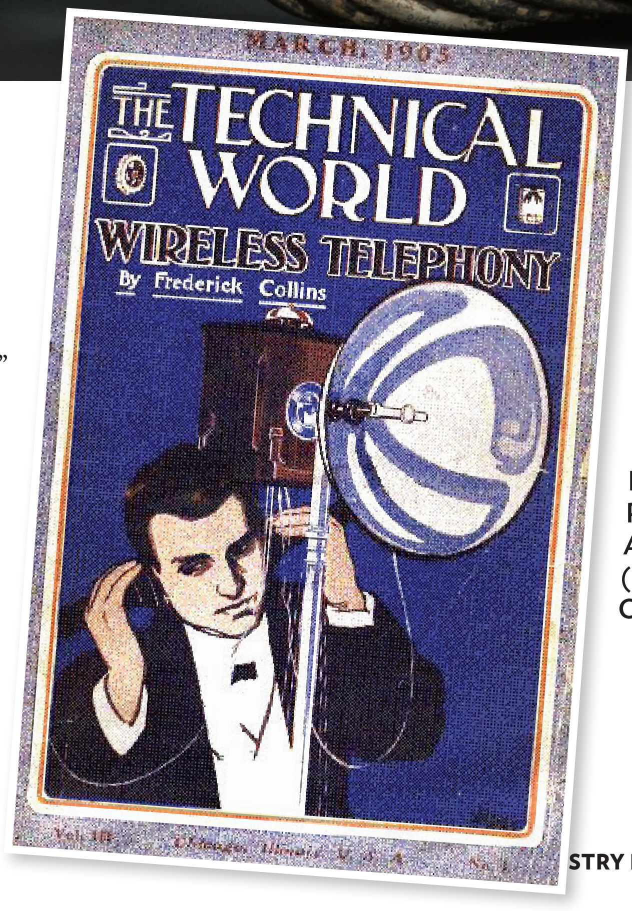


Figure 24: 1905 Lightbulb based Photophone Adaptation (Free Space Optics)

1.3

Capacity

1.3.1 GLOBAL CAPACITY

The world continues to consume ever-increasing amounts of data, with bandwidth demand projected to almost double every two years for the foreseeable future. This demand – largely driven by a continued shift towards cloud services, continued explosion of mobile device usage and mobile technology like 5G, provides numerous opportunities for the submarine fiber industry. Hyperscalers continue to post strong earnings reports and grow at a rapid pace, which indicates that this bandwidth demand will not be tapering off any time soon.

Video 4: Sean Bergin, President - AP Telecom

For the period 2017-2021 submarine fiber design capacity on major routes has increased at a Compound Annual Growth Rate (CAGR) of 18.2 percent, including upgrades and new system builds. (Figure 25) This is down as compared to the same analysis at this time last year, when the CAGR along major submarine cable routes was 26.4 percent.

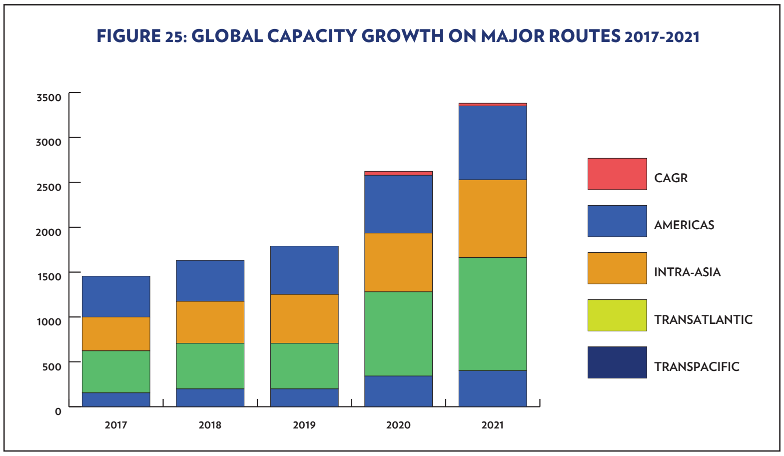


Figure 25: Global Capacity Growth on Major Routes, 2017-2021

With global demand increasing at such a rapid pace, sustaining infrastructure growth will be challenging, potentially causing demand to exceed supply. To date, the industry has been able to keep up with demand— but it will be necessary to continue focusing on increasing capacity in order to continue to meet the increasing demand.

Based on reported data and future capacity estimates, global capacity is estimated to increase up to 100 percent by the end of 2024. (Figure 26) Despite multiple systems planned over the next three years boasting design capacities of more than 100 terabits per second, overall capacity growth will plateau based on currently announced planned system data.

However, not all announced systems are far enough along in the development process to have decided things like fiber pair counts and design capacity, so expect to see an increase in projected bandwidth as these details are finalized and new systems are announced. The prevalence of 200G and higher wavelengths will also impact these numbers as several of these currently planned systems are being design with only 100G wavelengths in mind. Additionally, the demand impact brought about by COVID-19 has forced many people to re-evaluate their bandwidth needs and gear up for additional capacity to facilitate remote working environments.

1.3.2 LIT CAPACITY

Since 2015, major submarine cable routes have averaged 18 percent lit of total design capacity. A large capacity buffer is designed for cable systems to deal with sudden spikes in demand, such as handling rerouted traffic due to a cable fault.

1 .3.2.1 TRANSATLANTIC REGION

The Transatlantic region has seen steady design capacity growth at a CAGR of 22.9 percent due to regular upgrades and a new system each year for the period 2015-2019. (Figure 27) This is down from last year where the CAGR for the period 2014-2018 was 29.7 percent. On average, the Transatlantic route has maintained a lit capacity at 21 percent of total for this five-year period, well over the global average of 18 percent. The last two years have seen 18.7 and 23.4 percent, respectively. Transatlantic routes are the most competitive globally – especially those connecting the two biggest economic hubs in the world (New York and London), and carry traffic between the highly developed economies and technology markets of North America and Europe.

Capacity growth in the Transatlantic region is expected to continue over the next few years through 2023, fueled by new routes across the South and Mid Atlantic, which are under consideration. (Figure 28) Based on publicly announced planned system information this route will observe a CAGR of 22.7 percent for the period 2019-2023.

Additionally, Hyperscalers continue to focus on building new infrastructure across the Atlantic, which raises the probability that growth will increase more dramatically than currently predicted; for example, NEC's recently announced contract with Facebook to build an ultra-high performance transatlantic cable (half Petabit per second) connecting the USA and Europe.

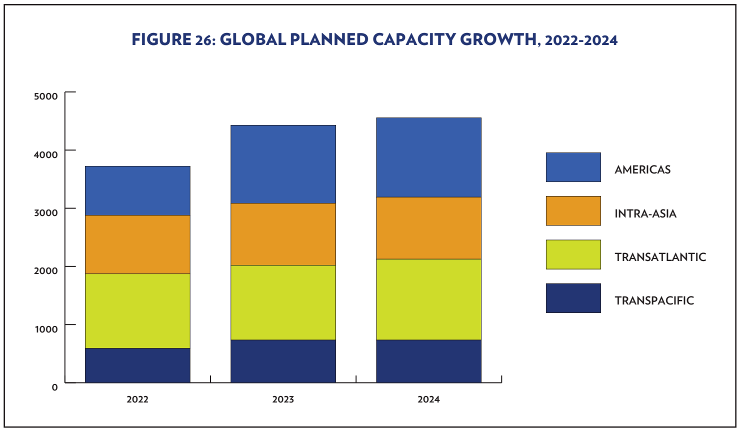


Figure 26: Global Planned Capacity Growth, 2022-2024

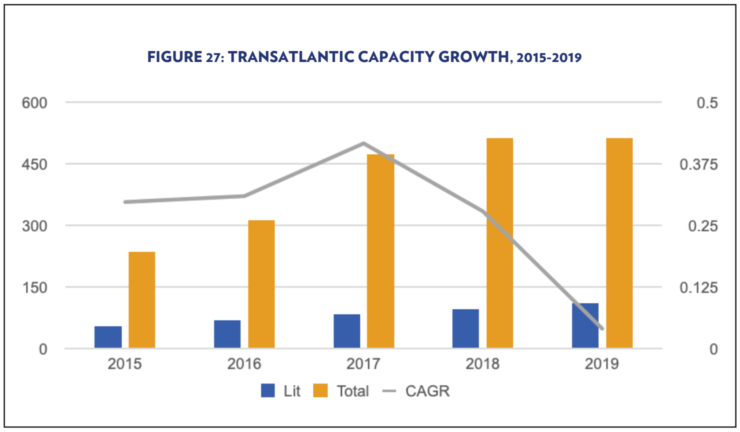


Figure 27: Transatlantic Capacity Growth, 2015-2019

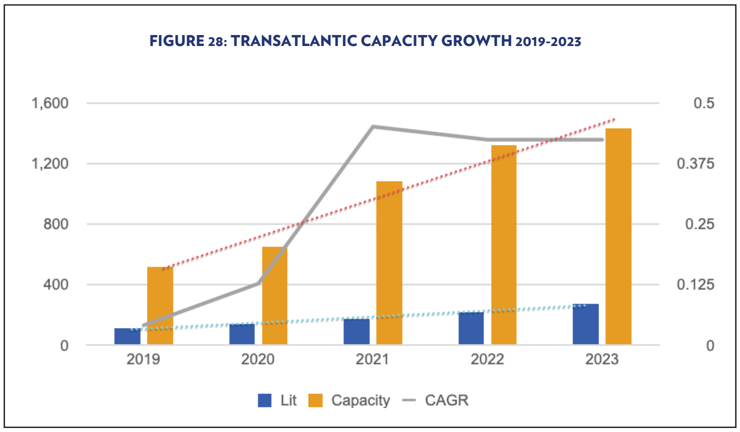


Figure 28: Transatlantic Capacity Growth, 2019-2023

1.3.2.2 TRANSPACIFIC REGION

The Transpacific has observed a design capacity growth at a CAGR of 15.7 percent for the period 2015-2019. This is significantly lower than last year where the CAGR for the period 2014-2018 was 25.1 percent. The region has maintained an average of 18.1 percent lit capacity during this time – right in line with global averages. (Figure 29) In 2015, lit capacity was as low as 13 percent, indicating a short-term capacity overbuild in this region that has only recently begun to recede with 2018 and 2019 observing lit capacities of 20.7 and 23.9 percent, respectively. Like the Transatlantic region, Hyperscalers are looking to expand their infrastructure in this region — especially with recently announced systems.

As one of the more competitive regions in the world – with a diverse number and type of both systems and customers – the Transpacific is expected to increase from its CAGR of 15.7 percent to 21.3 percent through 2023 based on publicly announced system information. (Figure 30) New, high-capacity systems are beginning to come into service, and lit capacity seems to be back on track or even slightly ahead of global trends. If Hyperscalers continue to focus on this region, expect lit capacity growth to accelerate to the levels seen in the Transatlantic region.

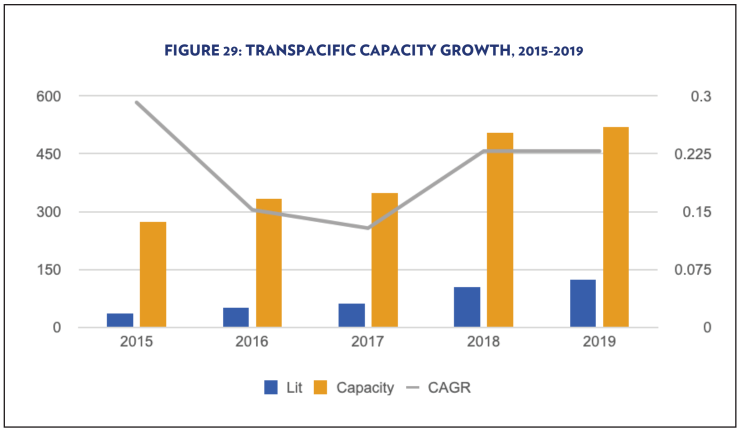


Figure 29: Transpacific Capacity Growth, 2015-2019

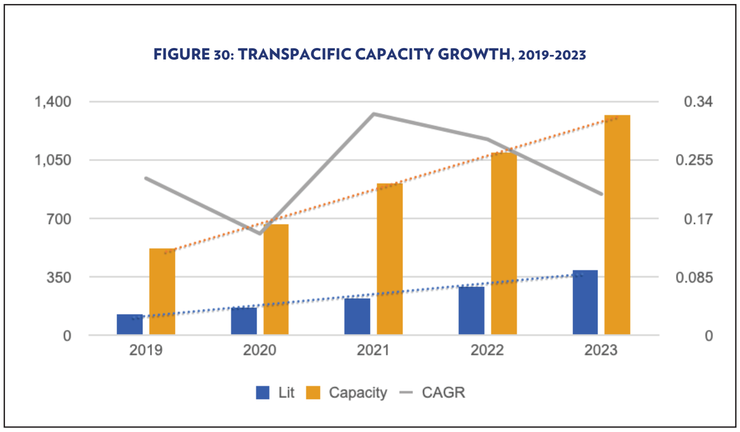


Figure 30: Transpacific Capacity Growth, 2019-2023

1.3.2.3 AMERICAS REGION

The Americas region has seen significant growth in the last few years, almost tripling in total capacity from 184 Tbps to 520 Tbps along major routes. This region has observed a CAGR of 28.5 percent for the period 2015-2019. (Figure 31) This is down significantly from last year where the CAGR for the period 2014-2018 was 38.9 percent.

The region has maintained an average yearly lit capacity of 18.4 percent, in line with the global trend. Much of this growth has been spurred on by growing markets in Latin America, with new systems and upgrades increasing flow of traffic between these countries and the United States. Hyperscalers have been especially interested in the Brazil-US route, adding several high-capacity systems in 2017 that increased the total capacity along this route by over 50 percent. Typically, Hyperscalers have partnered with traditional telecoms carriers that add this capacity to the general market but moving forward Hyperscalers are primarily building cables entirely for their own use. However, in May of 2020, Google has sold a fiber pair to Sparkle on the Curie submarine cable system, showing that Hyperscalers may be willing to monetize these assets.

Based on publicly announced planned system information this route will observe a CAGR of 27.79 percent for the period 2019-2023. (Figure 32)

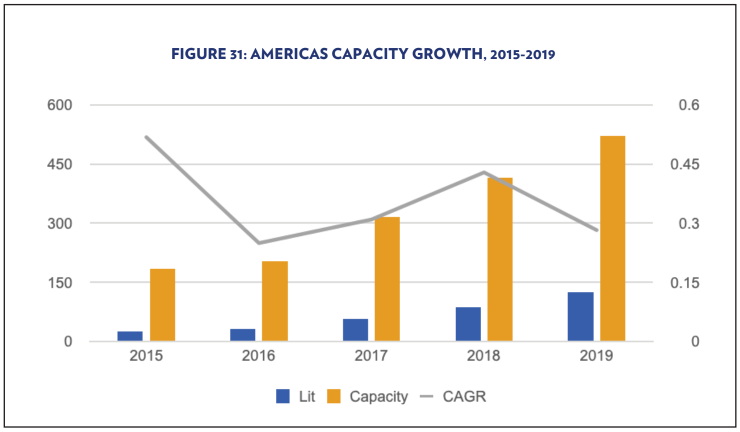


Figure 31: Americas Capacity Growth, 2015-2019

While only a handful of systems are announced through 2023, there is still time for some to be announced this year or next as cable systems typically have a two to three-year development cycle. Growth in this region is fueled by growing markets in Latin America – typically Brazil, Argentina, and Chile – and helped by the expansion of Hyperscalers in South

America. However, growth has slowed down since 2018 – potentially because the growth spurt observed from 2016-2018 which added seven cables and 360 Tbps of capacity has satisfied capacity needs for the immediate future.

1.3.2.4 INTRA-ASIA REGION

The Intra-Asia route has maintained minimal to moderate design capacity growth since 2015 with a CAGR of 19.5 percent for the period 2015-2019. (Figure 33) This is down from last year where the CAGR for the period 2014-2018 was 24.3 percent.

Growth along this route largely depends on huge infrastructure builds connecting major hubs throughout Asia and Southeast Asia – something that does not happen every year. Lit capacity stays in line with global trends at 18 percent of total.

Over 360 Tbps capacity is already available along these routes and 520 Tbps will be added through 2023, adding a sizeable increase of nearly 140 percent. There is no indication that demand trends along the routes are changing in any meaningful way, so expect the annual average of 18 percent lit capacity to continue.

Based on publicly announced planned system information this route will observe a CAGR of 24.6 percent for the period 2019-2023. (Figure 34)

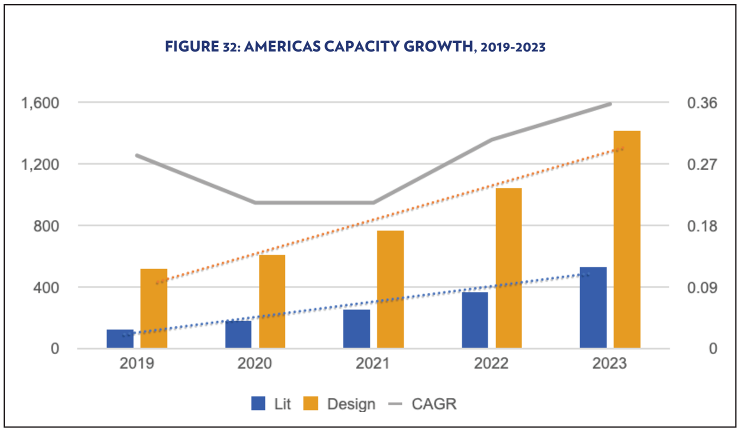


Figure 32: Americas Capacity Growth, 2019-2023

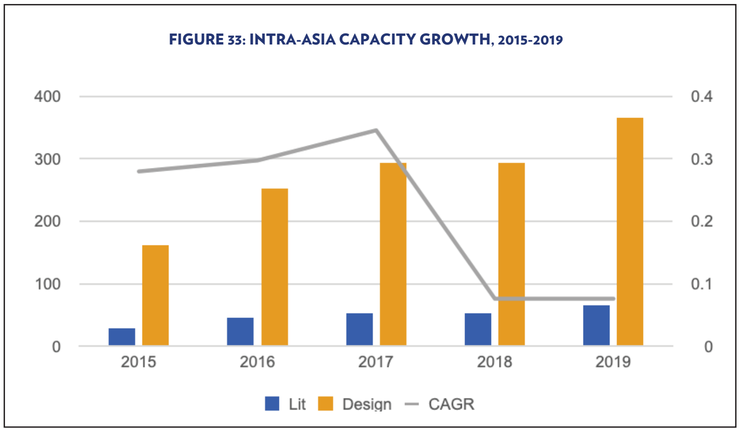


Figure 33: Intra-Asia Capacity Growth, 2015-2019

1.3.3 CAPACITY PRICING

It all starts in the Atlantic. Transatlantic routes have set trends throughout the history of the submarine fiber industry and will continue to do so in the future. The New York – London route is the most commercially competitive in the world and will continue to be so through the foreseeable future as it is the oldest route and carries traffic between the two biggest economic hubs.

> *The OTT providers such as Amazon, Facebook, Google and Microsoft are completely transforming the submarine cable market. They are no longer reliant on Tier 1 network operators to provide capacity and are simply build(ing) the necessary infrastructure themselves. This is likely to have a long-term impact as the largest consumers of bandwidth are essentially exiting the market. A side effect of this is that traditional carriers may have a harder time developing a business case for new cable systems. (SubTel Forum Analytics Division of Submarine Telecoms Forum, Inc., 2020)*

The Transatlantic market is shifting from connecting population centers for traditional telephone carriers to connecting data centers for Hyperscalers. As Hyperscalers like Amazon, Facebook, Google, and Microsoft continue to expand their infrastructure and drive cable development, continue to expect new cables that do not follow the more traditional routes between New York and London such as those from Virginia Beach to France and Spain, Brazil to Europe and Brazil to Africa.

Like the Transatlantic routes, Transpacific routes will be shaped by the market shifting towards interconnection of data centers instead of connecting population centers. Cloud service providers are developing infrastructure in a major way all throughout East Asia and the Pacific with numerous new data center builds announced for places like Indonesia, Singapore, and Hong Kong. Multiple cloud providers such as Alibaba, Amazon Web Services and Google Cloud have all announced new data center facilities in Indonesia (Mah, 2019). Singapore's colocation market is expected to grow 14 percent by the end of 2019 and nearly double in size by 2023 (Wong, Singapore's Colocation Market to Nearly Double by 2023, 2019). The amount of hyperscale data center capacity has increased by

42 percent over the past year in Hong Kong (Wong, Hong Kong's Cloud Data Center Boom, 2019). (Figure 35)

Capacity pricing for routes in the Americas region will depend heavily on economic health in South America. While these routes may never see the same level of demand as the Transatlantic and Transpacific, they are becoming increasingly important to Hyperscaler provider infrastructure plans and global economic development as these companies look to increase their presence in places like Brazil, Argentina, and Chile to take advantage of the growing economies in this region.

Intra-Asia routes will continue to provide paths between three major cities – Tokyo, Singapore, and Mumbai. While the Tokyo – Singapore route should remain relatively unchanged in the future, the Singapore – Mumbai route has the most potential for growth. As new cables and telecoms development turn towards India's growing technology sector, this region is prime for growth. (Figure 36)

Europe, Middle East Asia (EMEA) routes have been well established for decades and carry traffic between Europe and Asia. However, they are high latency and expensive to operate. Threats to the commercial viability of this route will be planned systems that bypass the Suez Canal to avoid the sustained economic and political instability in the Middle East and Polar routes that connect Europe to Asia via much shorter pathways. Should these alternatives become truly competitive, these EMEA routes will be negatively impacted.

Overall, there seems to be a healthy global capacity market, but this is dependent on Hyperscalers' plans for their excess capacity and how cost-effective system upgrades and new cables will be implemented. ■

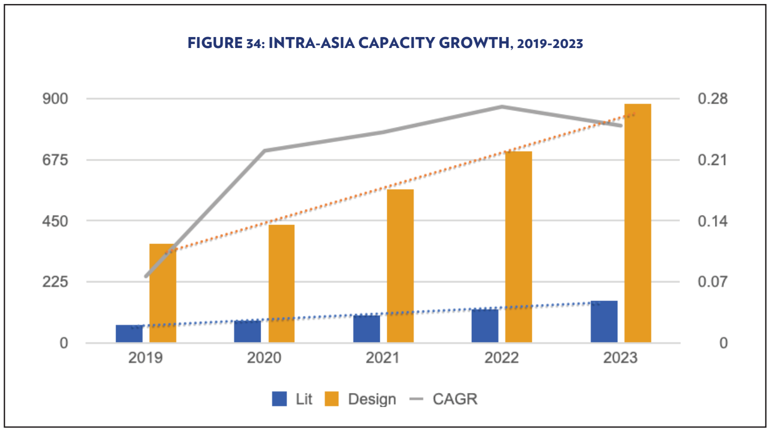


Figure 34: Intra-Asia Capacity Growth, 2019-2023

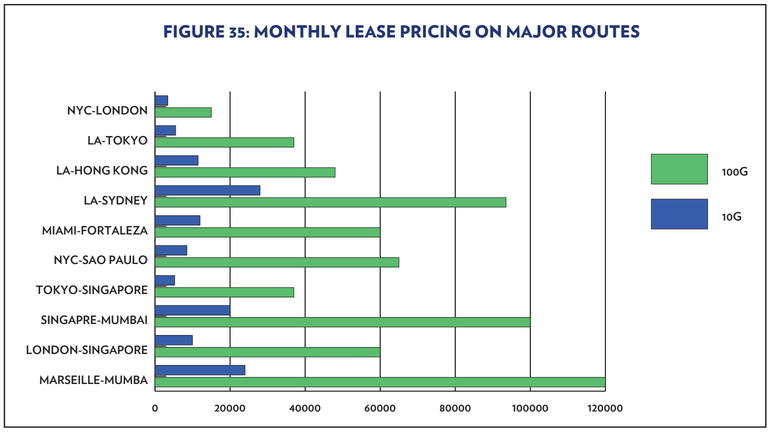


Figure 35: Monthly Lease Pricing on Major Routes Capacity Growth, 2015-2019

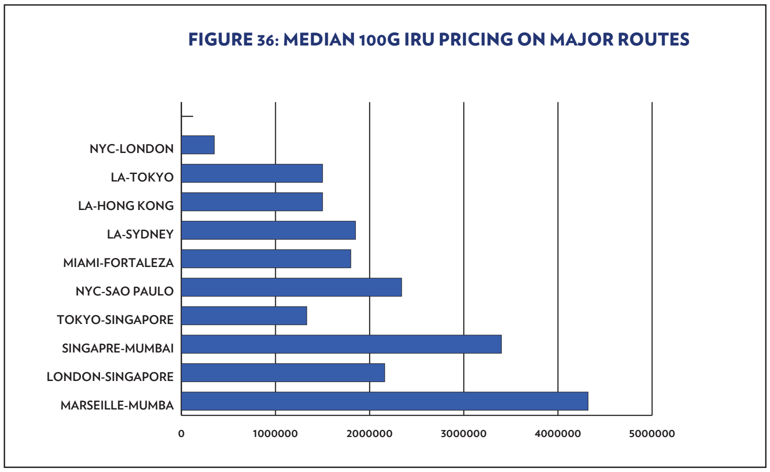


Figure 36: Median 100G IRU Pricing on Major Routes

1.4

System Growth

The steady growth in new system deployments caused by a greater demand in new markets and route diversity, continued in 2020 despite the delays caused by the Pandemic. The impact of those delays has been felt more in 2021 than in 2020 as cable laying operations take months to schedule, and crews and equipment were already prepped when Covid-19 really hit. Thus, the number of systems that have gone into service in 2021 has drastically dropped compared to previous years with only eight having been announced so far this year. 87 total new systems will have been added to the global network during the period 2017-2021 but should have been closer to 100 at this time. (Figure 37)

The period 2017-2021 saw an average of 50,000 kilometers added annually, despite only adding 27,000 kilometers so far in 2021 and 33,400 in 2019. The greatest amount of cable was clearly added in 2018 with a total of 76,000 followed by the 56,000 added in 2020. (Figure 38) The effects of the Pandemic are likely to ripple across the industry in various ways over the coming years. As projects attempt to push forward, long distance systems such as 2Africa and Humboldt for example might enhance these numbers.

Video 5: Stephen Grubb, Global Optical Architect - Facebook

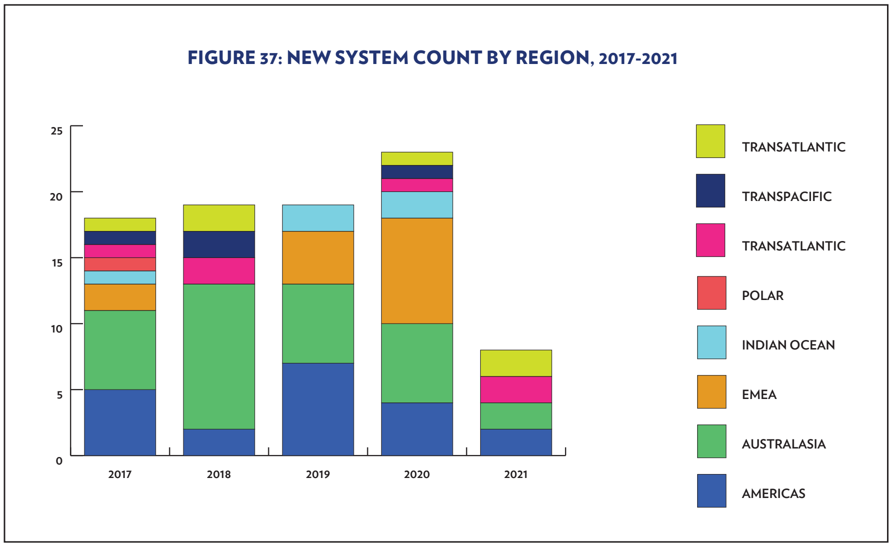


Figure 37: New System Count by Region, 2017-2021

Shifting slightly away from recent trends observed last year, significant system growth through 2024 will take place in the Americas, and EMEA regions as systems such as Southern Cross Next, Confluence-1, Amitie and Grace Hopper reach completion. Another large growth will come in the form of the multitude of cables announced this year by Google and Facebook. This Hyperscaler driven growth will provide both traffic diversity and connect growing markets in South America, Europe, and Africa more robustly. (Figure 39)

The Polar region is currently the only area of the world planning a system with an RFS date past 2024 with the Polar Express Cable.

The Indian Ocean region maintains steady growth and has several planned systems coming including MIST, SING, and SAEx East among others.

One of the first major hurdles every system must overcome is the Contract in Force (CIF) milestone. A system is typically considered CIF when it has secured all project funding and has begun cable manufacturing. CIF rates are reasonably healthy, with 42 percent of the 66 planned systems for the period 2021-2026 having achieved this milestone. (Figure 40) This is a slight increase over last year's rate of 38 percent, indicating relatively little change in financing and investment availability. For 2021, there are still 10 planned systems that have not announced having reached the CIF milestone. For 2022, 50 percent of planned systems are already CIF though this might increase if 2021 projects are pushed into 2022 and are added to the pool. ■

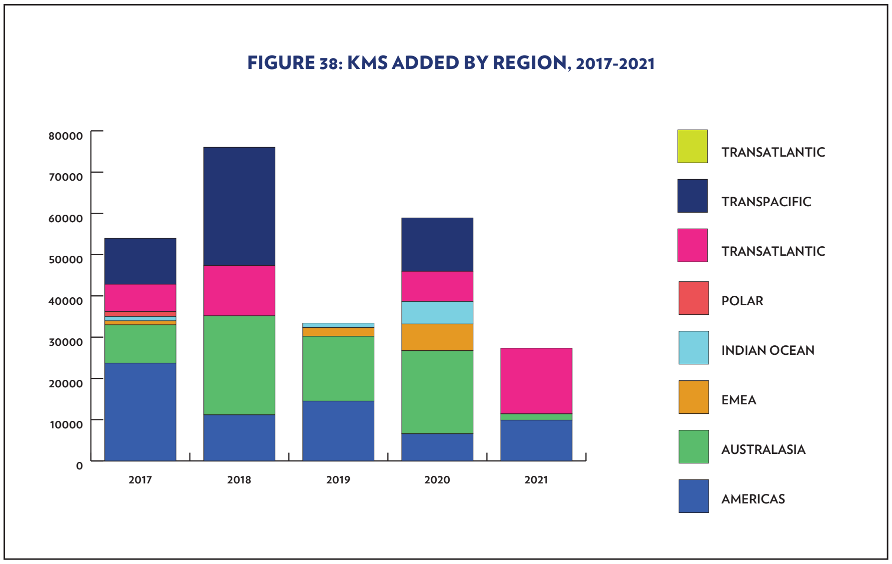


Figure 38: KMs Added by Region, 2017-2021

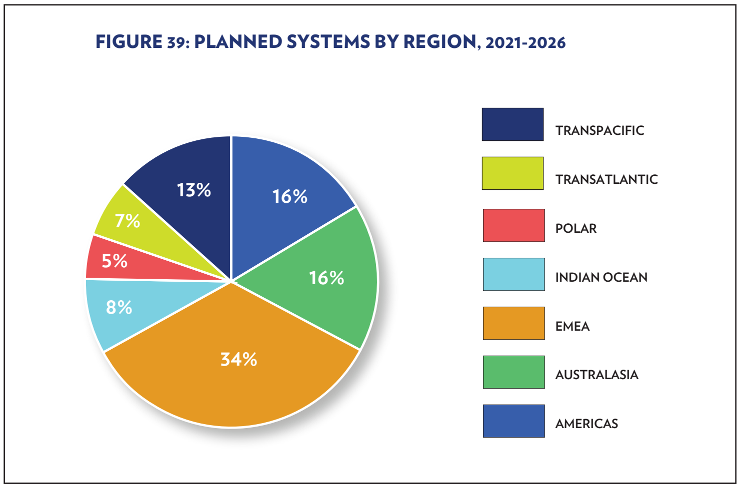


Figure 39: Planned Systems by Region, 2021-2026

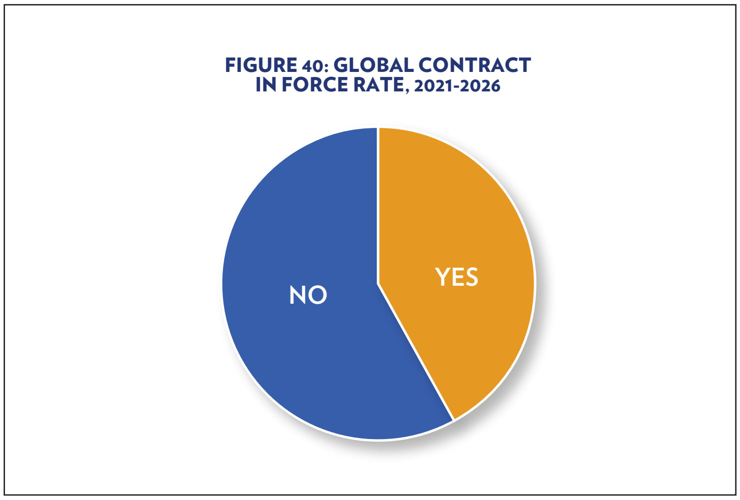


Figure 40: Global Contract in Force Rate, 2021-2026

1.5

Out of Service Systems

Submarine cable systems that are taken Out Of Service (OOS) are harder to quantify as there is generally little to no publicity about them. So far in 2021 the only story published for a decommissioned system was that of TAT 14 in April. It would be a wonderful addition to the subsea industry to see more notices of decommissioned systems as it would allow for better planning opportunities in the coming decade.

Over the last 20 years, just over 30 systems have been taken OOS according to the International Cable Protection Committee. (Figure 41) (ICPC List of Cable Systems, n.d.) The majority of these systems were in the EMEA, AustralAsia, and Transpacific regions, and a handful in the Indian Ocean and Americas.

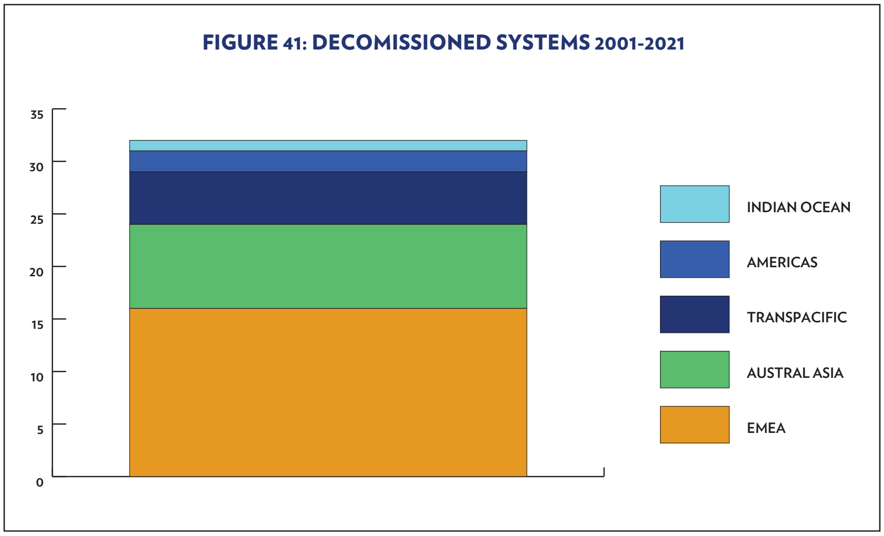


Figure 41: Decommissioned Systems 2001-2021

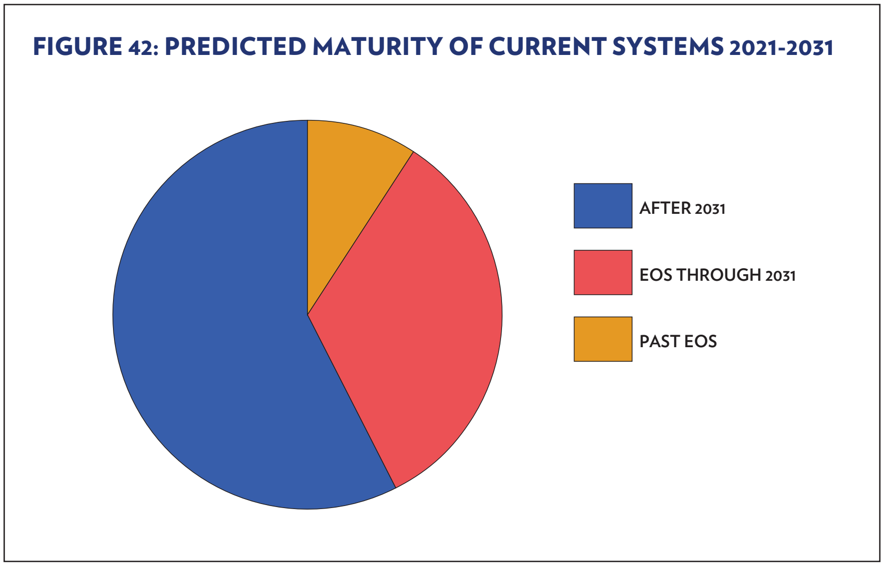


Figure 42: Projected System Maturity 2021-2031

Submarine Cable Salvage repurposes OOS submarine cable systems for ocean science community environmental studies. Utilizing OOS submarine cable systems is a cost effective solution for cabled ocean observatories, which are positioned on the ocean floor and continually gather data in real-time for scientific research. The data collected is used for ocean management, disaster mitigation (earthquake/tsunami detection) and environmental protection. Repurposing OOS submarine cable systems is a cost effective and green solution for the ocean observatories by reducing the requirement for the manufacturing of new systems. Submarine Cable Salvage owns more than 8,000 kilometers of submarine cable systems that are being repurposed for ocean science and is currently purchasing an additional 2,000 kilometers of such cable.

Mertech Marine recovers OOS cables using its own marine fleet and dismantles and recycles cables in its own factories. Mertech Marine owns OOS cables across the globe (Atlantic Ocean, Mediterranean Sea, Pacific Ocean, and Indian Ocean), which will be recovered for recycling and in certain instances re-use/re-lay in cases where the business case makes sense. Since 1998, Mertech Marine has recovered and recycled 60,000 kilometers of cable and currently recover/recycle approximately 15,000 kilometers per year using its own resources. Since 2004 Mertech Marine has recovered in excess of 20,000 kilometers of OOS cable which was acquired from cable owners.

Since 2014, Subsea Environmental Services has successfully completed 16 projects in the Atlantic, Pacific, and Mediterranean, recovering more than 27,000 kilometers of OOS cable.

Though previously decommissioned, sections of the following cables were removed and scrapped, and/or in some cases, repurposed by the likes of Mertech Marine, Submarine Cable Salvage, Subsea Environmental Services, and others in 2021:

- BRUS
- China – US
- Columbus-3
- France-Israel
- HAW-2
- HAW-4
- MAT-2
- TAT-3
- TAT-4
- TAT-5
- TAT-7
- TAT-10
- TAT-11
- TAT-14
- TPC-3

In the coming decade three times as many systems will be reaching the standard 25 year mark that most in the industry consider the design lifespan for a submarine cable system. Almost 40 systems have already reached their 25-year projected system maturity dates and are still in service. These 40 systems represent 18,000 kilometers of submarine cable currently in use out of roughly 1.4 million total kilometers currently in service. As these systems have already reached the average lifespan, they will probably be the first to be taken OOS as they are the oldest and will likely need to be replaced in the coming years. Almost 150 more systems will reach their projected end of service date by 2031 totally close to 470,000 kilometers of cable. In total, 43 percent of in-service systems will need to be upgraded or replaced in the next ten years. Though some of the 43 percent will stay in service past the average 25-year span, there is a still a significant amount of capacity that will need to be replaced. (Figure 42) ■

1.6

Evolution of System Ownership and Customer Base

In recent years a paradigm shift had been noted in the way people use, and access data, shifting from local or personal data storage to cloud-based file services and applications. During the pandemic, working from home increase cloud usage exponentially, which has led to some ownership paradigm shifts in the submarine fiber industry as data and application services become more distributed and cloud based.

Historically, there have been two different types of system ownership – Consortia and Private. A Consortium is a group of companies coming together to build a cable system in such a way that the risk is spread out amongst the members, and system management decisions need to be made by committee so as not to negatively impact any one member significantly. Private cables by contrast are comprised of a single or very few owners, and while this reduces the complexity of managing a system it greatly increases the financial risk to any single company.

Though still around, fewer systems are operation under a traditional Consortium model. As the "buy in" for a cable system these days trends towards a full fiber pair rather than a handful of wavelengths, the need for all owners to agree on how their system is managed has reduced substantially. Individual owners are able to manage their fiber pairs how they see fit without worrying about impacting other owners on the cable system. This reduces administrative complexity and streamlines network operations. As a result, cables should now be considered either Single Owner or Multiple Owner.

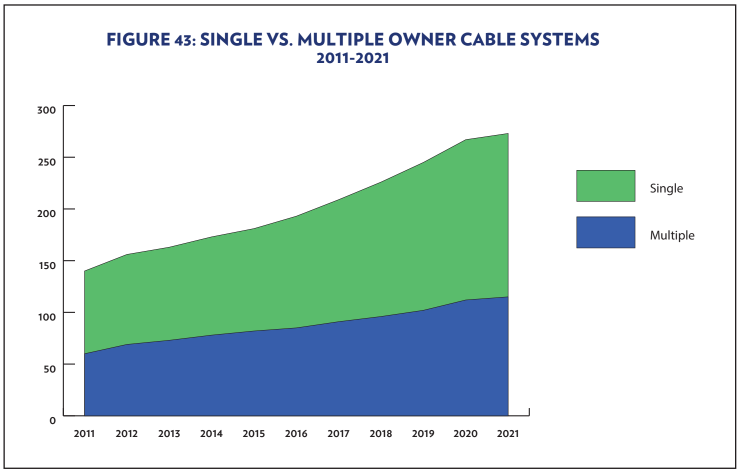


Figure 43: Single vs Multiple Owner Cable Systems, 2011-2021

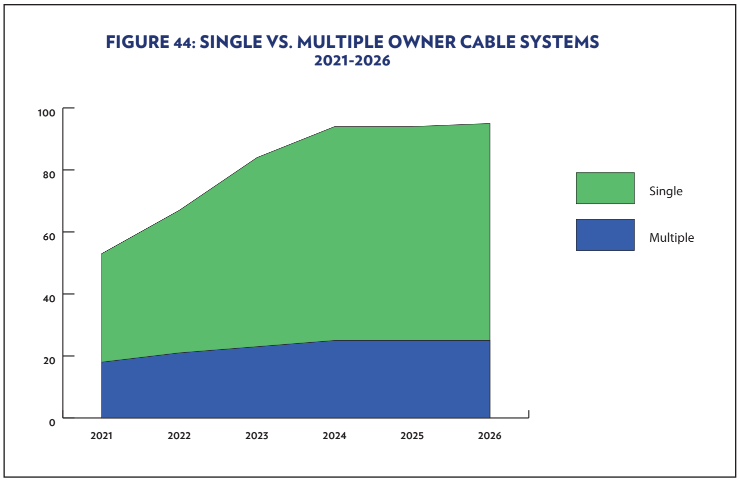
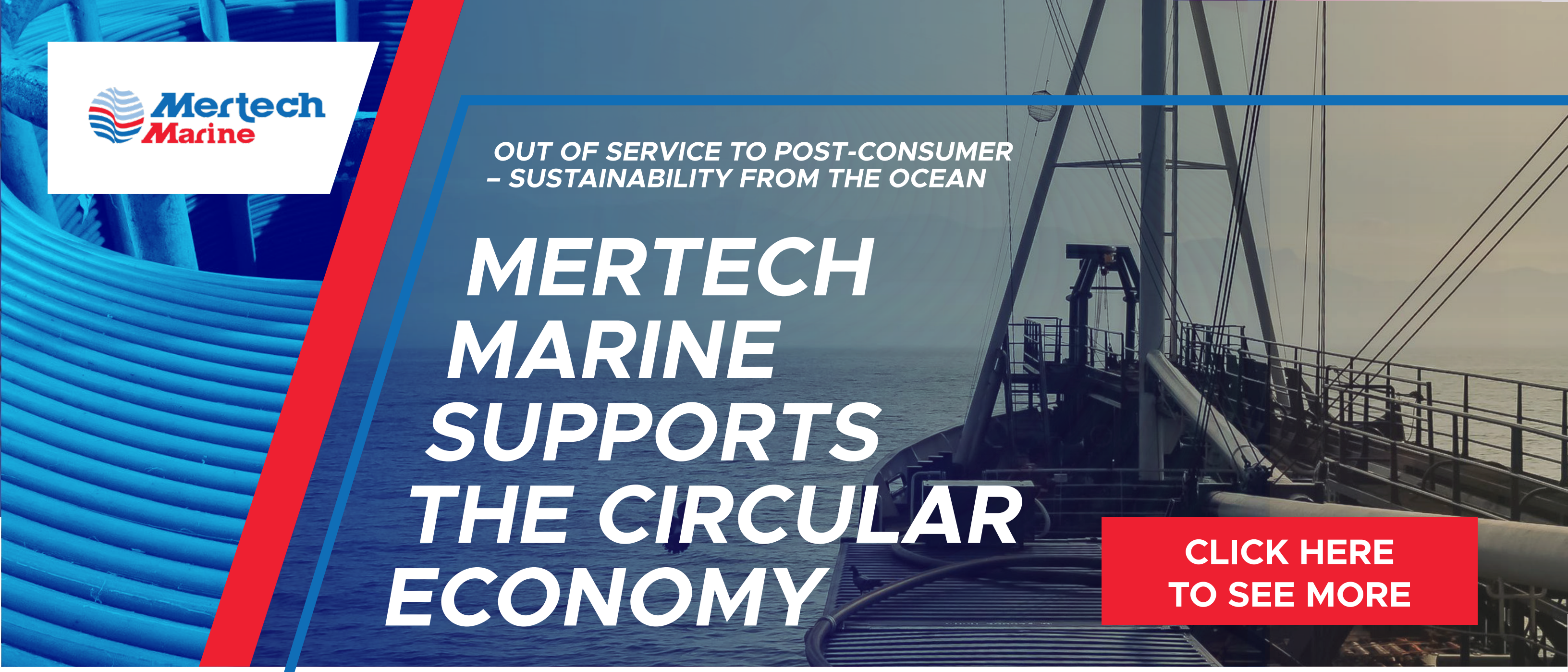


Figure 44: Single vs Multiple Owner Cable Systems, 2021-2024

Historically, Single Owner cables have made accounted for roughly 56 percent of all cable builds. This percentage has seen little increase from 56 percent in 2011 up to 58 percent in 2021. (Figure 43) Multiple Owner cables help to spread out financial risk so the increase in these types of systems indicates that cable owners are less willing to take on the risk of a cable system by themselves. Additionally, as Hyperscalers have entered the market, they have been partnering with traditional carriers and increasing the number of multiple owner cables – though this will change moving forward.

The prevalence is already beginning to show signs of return, as more niche and point-to-point systems are implemented. Based on currently announced systems, Single Owner cables will continue to climb from 63 percent of new system builds in 2021 to 80 percent by 2024. Much of this is driven by Hyperscalers who need to control their own infrastructure and may not necessarily have route needs that align with traditional carriers. (Figure 44) ■



OUT OF SERVICE TO POST-CONSUMER – SUSTAINABILITY FROM THE OCEAN

MERTECH MARINE SUPPORTS THE CIRCULAR ECONOMY

CLICK HERE TO SEE MORE

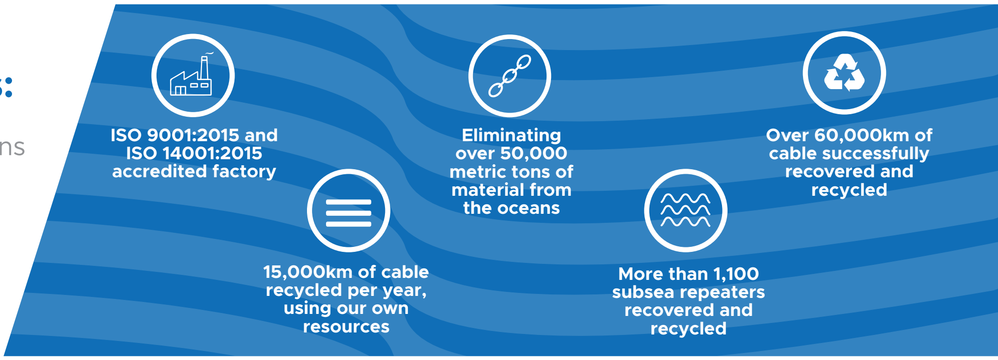
Mertech Marine, having pioneered commercial recovery and recycling of submarine telecommunication cables, is still the only turnkey provider utilising its own fleet of vessels and its own factories to perform end-to-end decommissioning and recycling of submarine telecommunication cables. Offshore cables come in all shapes and sizes and commodities such as polyethylene, lead, copper, aluminium and steel are extracted from them. Mertech Marine puts these materials from recycled cables back into the circular economy.

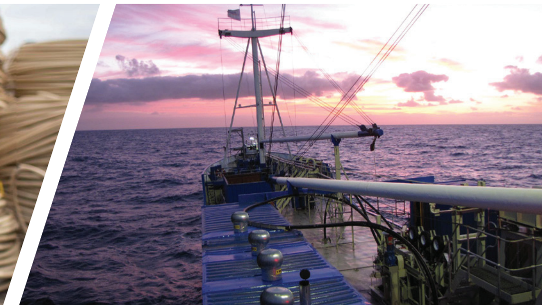
The company's factory, located in Port Elizabeth, South Africa, was custom designed and built by a team of engineers after many years of research and development. The facility pioneered the process of commercially dismantling submarine telecommunication cables in an environmentally friendly, yet fully mechanical way focusing on sustainability. Depending on the volume and type of cable being processed, Mertech Marine provides employment for between 150 and 200 factory workers.

"We believe that recovering cables that can be responsibly recovered and recycled, contributes to the industry by relieving congestion and positively impacting the environment through the circular economy," explains Alwyn du Plessis, Mertech Marine CEO.

Value added marine services:

- Route clearance and pre-lay grapnel runs
- Shore end recovery and installation
- Cable depot services
- Cable handling and logistics





2

Ownership Financing Analysis

2.1

Historic Financing Perspective

Like the ownership model, system financing is broken down into Multiple Owner versus Single Owner with the addition of Multilateral Development Banks (MDB). A Multiple Owner system is typically self-financed where the individual companies come up with the financing by themselves – generally without having to seek outside financial aid or rely on capacity pre-sales. A Single Owner system is usually financed through a project financing structure or alternative combinations of equity and debt (such as commercial bank loans), and capacity pre-sales. In the case of for example hyper-scalers, projects may get funded entirely through an owner's balance sheet or at the wholly-owned subsidiary level. Both Multiple Owner and Single Owner systems can receive funding from an MDB. Vendor financing, Export Credit Agencies ("ECAs") and Public-Private Partnership ("PPP") are also sources of funding which can be used in combination with other forms of financing. In recent years, there has also been increased interest from the investment fund sector (private equity, sovereign wealth, etc.) in system financing. It should be noted that the financing structure of a system may change over the course of its lifetime.

Video 6: Guillaume Thrierr, Director, Telecom & Tech Industry Group - Natixis

FIGURE 47: FINANCING OF SYSTEMS, 2011-2021

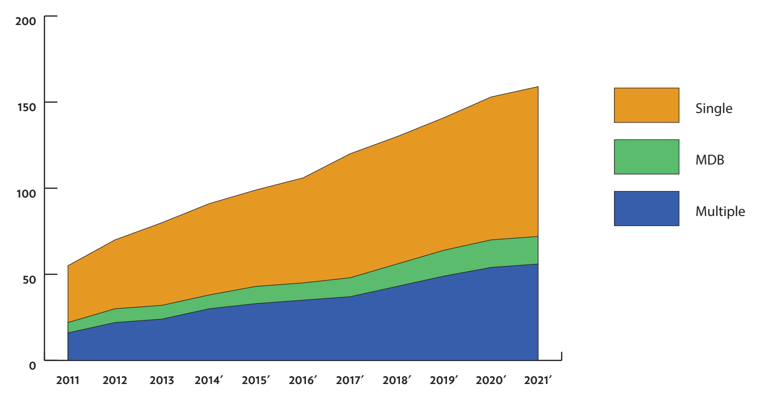


Figure 47: Financing of Systems, 2011-2021

MDBs such as the World Bank and its affiliates are increasingly willing to promote communications infrastructure and to lend in high-risk circumstances where commercial banks will not. MDB interest rates are typically lower than commercial financings and have a more lenient approach to waivers and default scenarios. However, social policy and development goals of those institutions can often impose additional reporting and compliance costs. (Gerstell, 2008) Even so, MDB investment has been sporadic since 2011, accounting for only one or two systems a year. (Figure 47)

Over the course of the past 18 months and triggered to a large extent by the pandemic situation, both the government in the United States and the European Union have announced massive investment schemes (for a total of more than US$2.5 trillion). Digital infrastructure projects have been identified as one of the purposes for which funding will be available. This could be an additional source of funding for specific subsea cable systems, provided that the criteria for such funding are being met.

Generally, Multiple Owner cables use a prospective system for their own traffic, diversifying risk generally through self-finance among its members and affording a range of expertise. Single Owner cables generally raise a system's capital for construction and operation of the network, though the securing of such funding can be a challenge. Single Owner cables also typically rely on sales to third parties and these systems tend to require outside equity investment more than Multiple Owner systems. However, this is changing as more Hyperscalers build systems for themselves as they generally do not need to rely on outside sales and use their systems for internal infrastructure.

The industry has invested nearly $50.7 billion in submarine telecoms cables since 1991. About 76 percent of this total investment has been by Single Owner systems, while Multiple Owner and MDB systems have accounted for 18 and six percent of total investment, respectively. (Figure 48)

In the recent 2017 to 2021 period, the industry has invested $9.1 billion in submarine telecoms cables. Single Owner systems account for 53 percent of total investment, while Multiple Owner systems are responsible for 33 percent and MDBs have accounted for 14 percent over this period. Multiple Owner and MDB financing have seen a noticeable increase over the last five years compared to historical trends. (Figure 49) ■

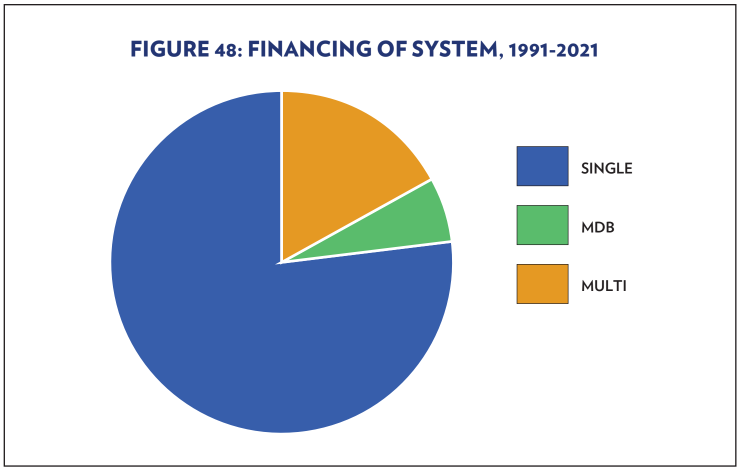


Figure 48: Financing of System, 1991-2021

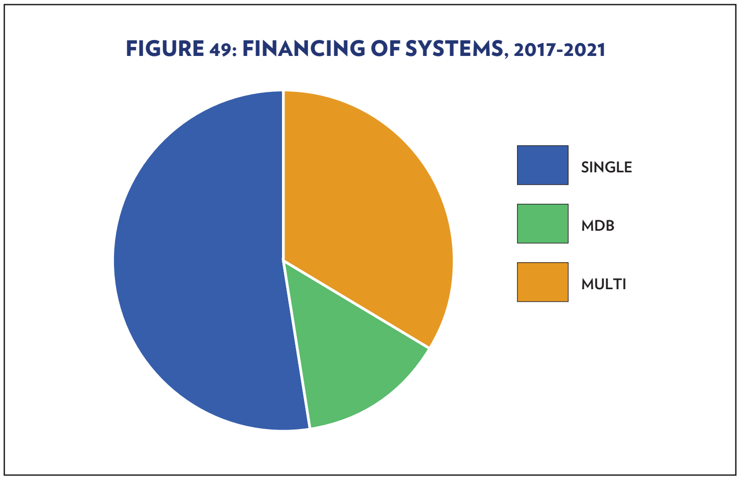


Figure 49: Financing of Systems, 2017-2021

2.2

Regional Distribution of Financing

2.2.1 MULTILATERAL DEVELOPMENT BANKS

The regional distribution of MDB investment for 2007 to present is presented below. MDBs have invested more than $2.9 billion in submarine telecoms cables. Most of this total investment — 51 percent — has been invested in EMEA projects with a focus on systems located primarily in Africa. Only 14 percent of total MDB investment has been made in AustralAsia, with 17 percent invested in the Americas and 16 percent in the Transatlantic. (Figure 50)

Video 7: Chris van Zinnicq Bergmann, Investment Development Manager - WFN Strategies, LLC

2.2.2 MULTIPLE OWNER SYSTEMS

The regional distribution of Multiple Owner investment for 1991 to present is presented below. Multiple Owner systems have invested $8.4 billion in submarine telecoms cables. The largest portions of this total investment — 50 percent — has been invested in AustralAsia projects. 22 and 16 percent of total consortia investment has been made in Transpacific and Americas systems, respectively. The Transatlantic region has received 7

FIGURE 50: DISTRIBUTION OF MDB INVESTMENT, 2007-2021

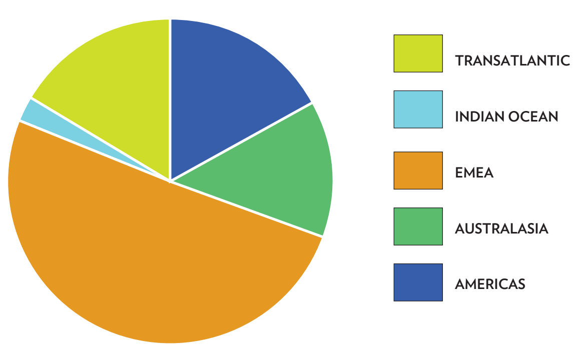


Figure 50: Distribution of MDB Investment, 2007-2021

FIGURE 51: DISTRIBUTION OF MULTIPLE OWNER INVESTMENT, 1991-2021

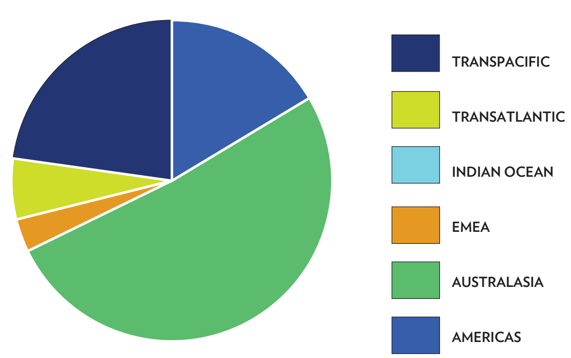


Figure 51: Distribution of Multiple Owner Investment, 1991-2021

percent of Multiple Owner investment, EMEA has received 3 percent and Polar has received 2 percent. (Figure 51)

Over the last 10 years, Multiple Owners have invested over $12.6 billion primarily focusing on the AustralAsia, Transatlantic and Transpacific regions at 26, 16 and 15 percent, respectively. Systems in these regions are typically much longer in cable length than in other regions which helps account for their large investment percentage. The Americas and EMEA regions have seen the next most investment from Multiple Owner systems at 13 percent each of the total dollar investment from Multiple Owner systems since 2011. (Figure 52)

2.2.3 SINGLE OWNER

The regional distribution of Single Owner investment for 1991 to present is presented below. Single Owners have invested $14.3 billion in submarine telecoms cables. Most of this total investment has been in Americas and Transatlantic systems at 37 and 22 percent, respectively. Similarly, 16 percent of total private investment has been made in the Transpacific region followed by 13 percent in the AustralAsia, 7 percent in EMEA, 4 percent in the Indian Ocean and 1 percent in Polar projects. (Figure 53)

Over the last 10 years, Single Owner systems are responsible for $5.6 billion worth of investment primarily focusing on the Americas, AustralAsia and Transatlantic regions at 46, and 16 percent each, respectively. The next most region is the Indian Ocean at 8 percent, followed by the Transpacific and EMEA each at 6 percent with Polar projects accounting for 3 percent of all investment. While Single Owners have more development flexibility than Multiple Owner systems, investment seems to have maintained a steady pattern over the last decade. (Figure 54)

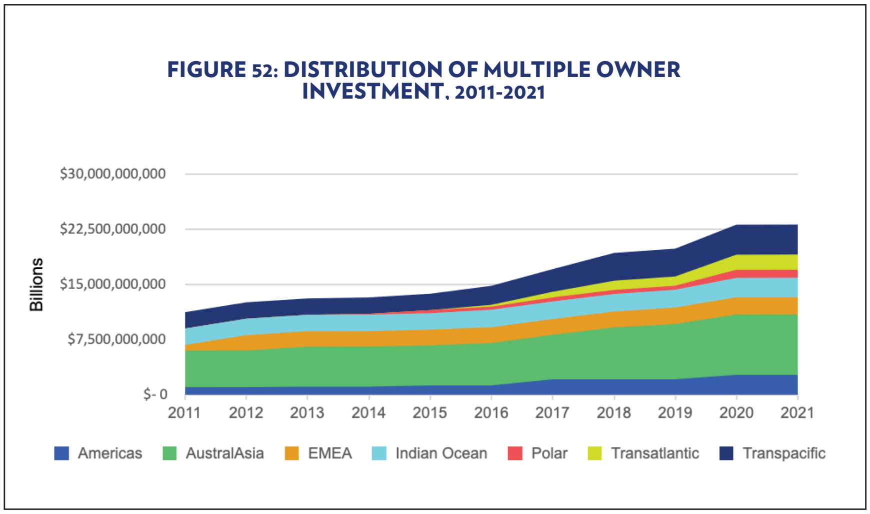


Figure 52: Distribution of Multiple Owner Investment, 2011-2021

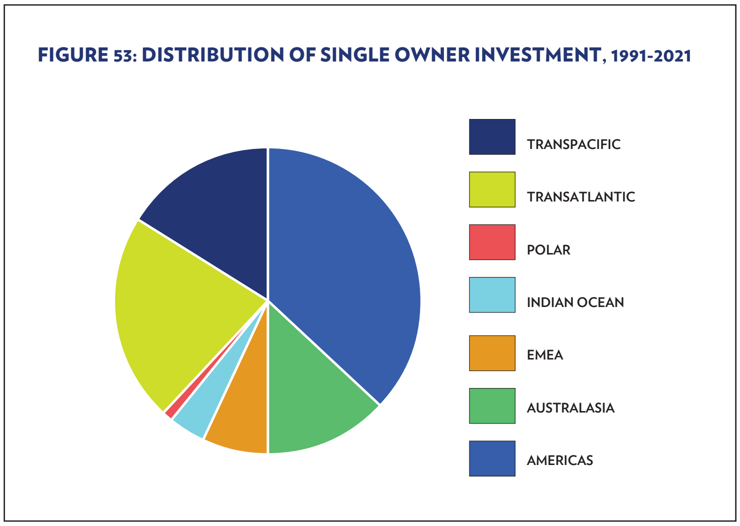


Figure 53: Distribution of Single Owner Investment, 1991-2021

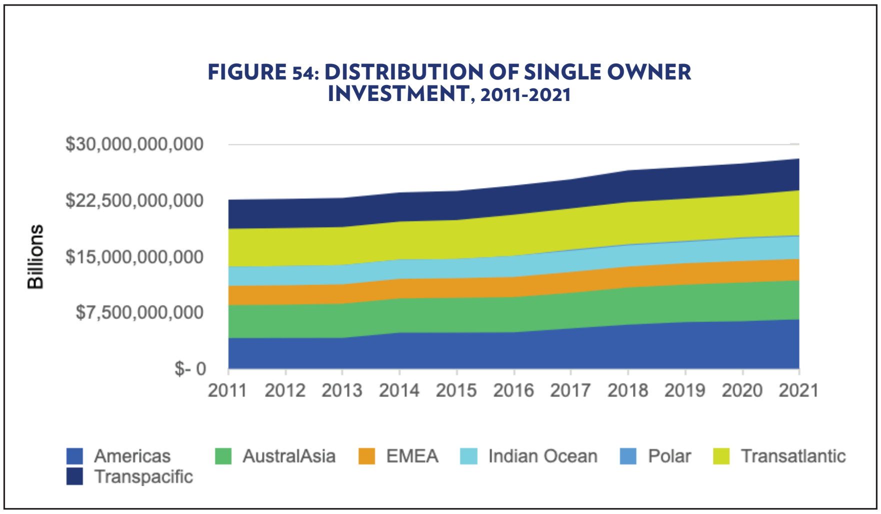


Figure 54: Distribution of Single Owner Investment, 2011-2021

2.3

Current Financing

Since 1991, the industry has invested nearly $50.7 billion in submarine telecoms cables — comprising more than 1.3 million route kilometers — annually averaging $1.6 billion worth of investment and 41,600 kilometers of deployed systems. (Figure 55) (Figure 56)

From 2017 to present, $8.1 billion was invested in submarine cable projects, or an average of $1.2 billion and over 50,000 route kilometers per year. Over the period, 30 percent was invested in systems in the Americas, 29 percent each in AustralAsia, 16 percent in Transatlantic, 15 percent in Transpacific systems and four percent in EMEA and Indian Ocean systems with the Polar regions seeing 2 percent of total investment. (Figure 57)

From 2019 to present, submarine system financings accomplished by MDBs include the following: ■

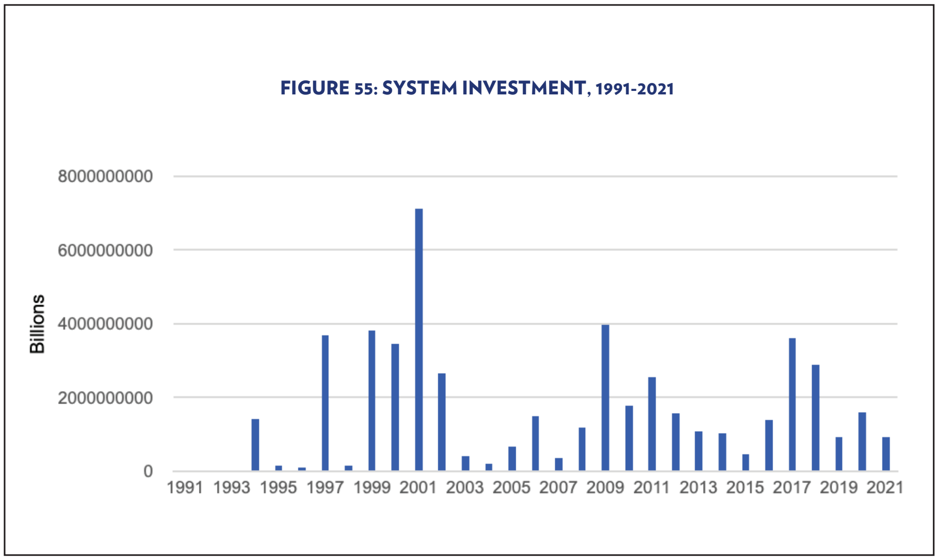


Figure 55: System Investment, 1991-2021

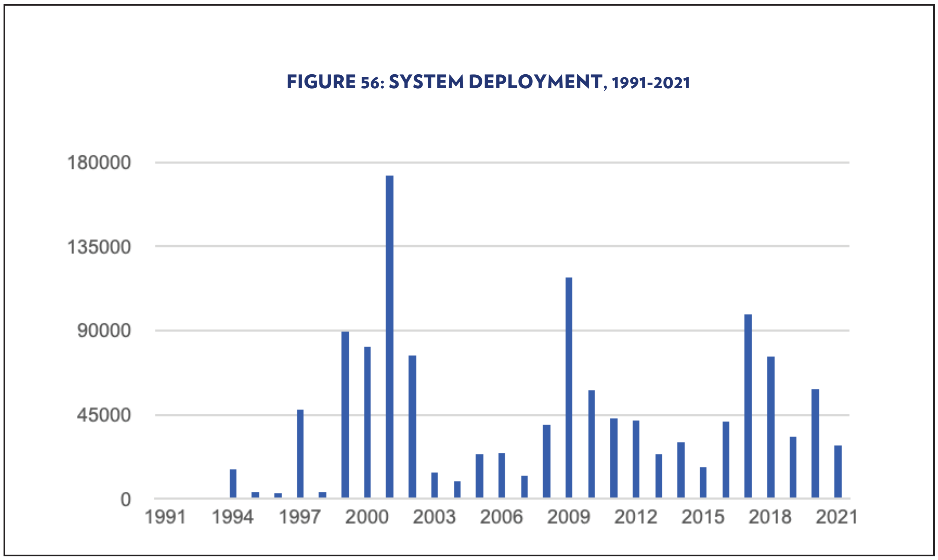


Figure 56: System Deployment, 1991-2021

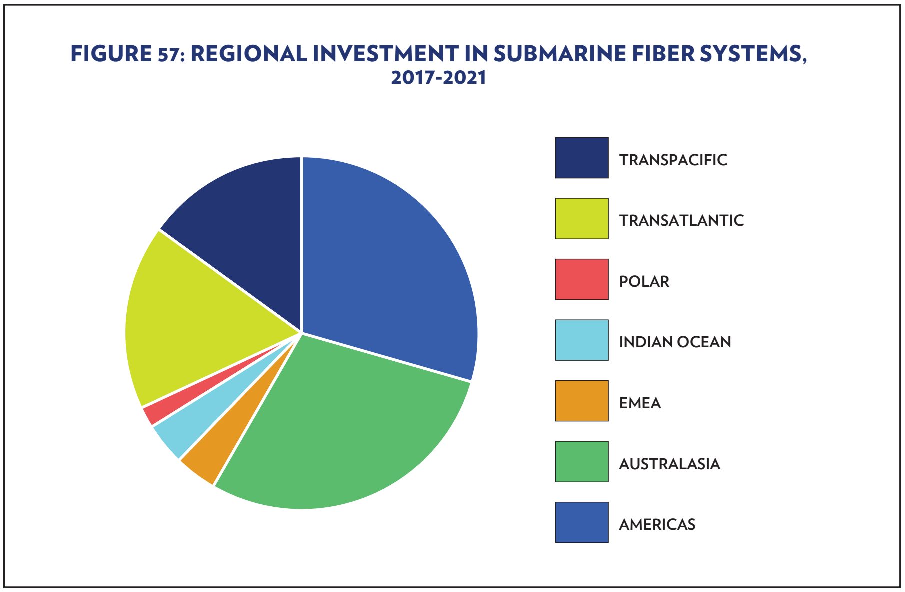


Figure 57: Regional Investment in Submarine Fiber Systems, 2017-2021

TABLE 1: RECENT MULTILATERAL DEVELOPMENT BANK PROJECTS

YEAR	PROJECT	MDB	DETAILS
2019	Improving Internet Connectivity for Micronesia Project	Asian Development Bank	The ADB Board of Directors has approved a total of $36.6 million in grants to help fund the delivery of the Improving Internet Connectivity for Micronesia Project. This project will help install a submarine cable connection between Micronesia and a proposed Transpacific cable system.
2019	Coral Sea	Australian Government Official Development Assistance $60 million	The Australian Government Official Development Assistance provided two-thirds majority funding of the Coral Sea submarine cable system to support the economies of Papua New Guinea and the Solomon Islands.
2020	Cook Islands to Samoa	Asian Development Bank $15; Gov. of New Zealand $20; Gov. of Cook Islands $2 million	The Government of Cook Islands has requested the ADB to support a $37 million submarine internet cable project, which will link the islands of Rarotonga and Aitutaki in the Cook Islands to Samoa, where interconnection to the international internet hubs in Fiji and Hawaii will occur.
2021	East Micronesia Cable system	World Bank	The East Micronesia Cable system was designed to improve communications in the island nations of Nauru, Kiribati, and Federated States of Micronesia.

3

Supplier Analysis

3.1

Suppliers

3.1.1 CURRENT SYSTEMS

Based on each supplier's reported activity by region for the period 2017 to 2021, companies are keeping a heavy focus on the Transpacific, EMEA and AustralAsia regions. ASN was by far the busiest supplier over this five-year period in terms of new projects. AustralAsia was the focus of several companies with 18 different systems going live during this five-year period. Mostly by HMN Tech (nee Huawei Marine). Another region that had several companies supplying systems was the Americas with 13 systems spread across seven companies.

Video 8: Simon Webster, Director, Submarine Networks EMEA - NEC

According to announced information on the amount of cable each company has supplied over the last five years, SubCom takes the lead — with almost 100,000 kilometers of cable produced. ASN produced the next most at 52,000 kilometers, with NEC rounding out the three busiest companies at 20,000 kilometers produced. These three companies have been very dominant in recent years, being some of the few companies that can produce cable at a high enough volume to meet demand for large systems. So, while some companies had a relatively high amount of activity, they were not always supplying large systems. (Figure 58)

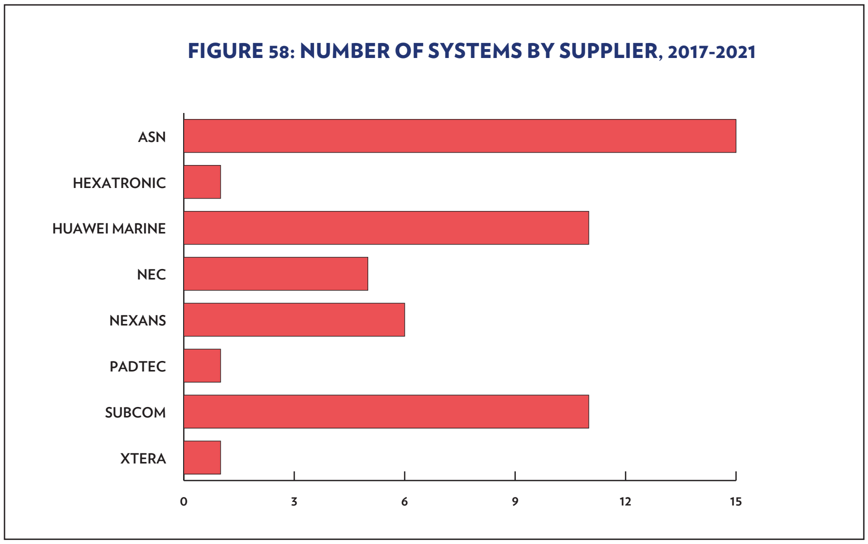


Figure 58: Number of Systems by Supplier, 2017-2021

Nexans, and PadTec are diversifying their portfolios to include other markets besides submarine fiber – such as offshore wind power – as these markets can be more lucrative for them. Overall, their participation in submarine telecoms is low for the period 2017 to 2021.

Over the last couple of years, there has been a renewed interest in Transpacific routes and routes connecting Asia and South America directly to Europe. This will involve vast systems, requiring thousands of kilometers of cable. Moving forward, the industry will have to rely on only three companies to tackle large projects while companies like Hexatronic become a crucial piece of the industry supporting shorter unreported systems. (Figure 59)

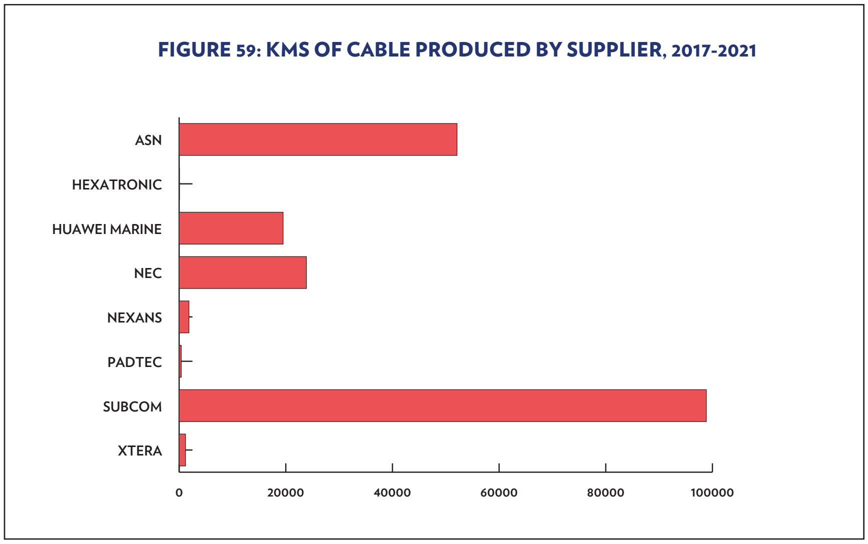


Figure 59: KMs of Cable Produced by Supplier, 2017-2021

3.1.2 FUTURE SYSTEMS

Regional plans will differ slightly compared to recent years. Previously AustralAsia drove the bulk of new system demand, but as the Pacific Island nations are nearly all connected, this demand has gone down. In contrast, there is renewed focus on the EMEA region to replace aging infrastructure or meet growing data center demand. 2Africa and Equiano are driving an increased interest by expanding the number of connections among various countries in Africa. The Indian Ocean region continues to observe muted growth as more owners and service providers look to circumvent the tumultuous Middle East, though systems like 2Africa are looking to change this. The Oil & Gas industry will maintain demand off the coasts of Africa and Australia if oil prices cooperate and business conditions and confidence exist. Expect emerging markets in South America to increase activity in the Americas and south Transatlantic regions as well. In addition, the emergence of wind and other offshore energy sources will incorporate fiber solutions, though many of these will be implemented as part of the power cable distribution system.

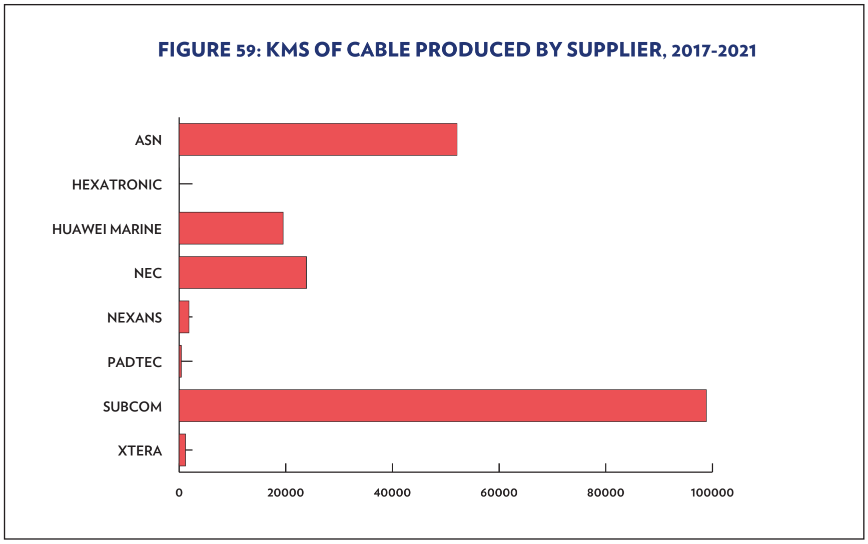


Figure 60: Planned Systems by Supplier, 2021-2026

Hyperscalers are becoming increasingly responsible for new system demand, especially for the Americas, Transatlantic, and Transpacific regions. These companies, specifically Facebook, Google, Microsoft, and Amazon, are consuming bandwidth at an increasingly rapid pace. Facebook and Google alone are sole or part owners in over a dozen submarine cable systems each. Rather than buying bandwidth on existing cables, these companies have found it easier and increasingly necessary to build and own international telecoms infrastructure and with the capacity demands seen in 2020 as more people connected to work from home than ever before, this is only likely to continue increasing.

Overall, ASN, NEC and SubCom will continue to be strong leaders in the supply industry. They have been the most active and can supply the largest volume of cable and equipment. (Figure 60)

Every one of these system suppliers is composed of industry veterans with many years of experience in the submarine fiber industry. Their innovative technologies and reliable production are what continue to drive the telecommunications industry forward into the future. With robust competition between numerous companies, we should continue to expect a healthy cable supplier industry. ■

3.2
Installers

OPTIC MARINE

3.2.1 REGIONAL CAPABILITIES

In prior years ASN, SubComm and Global Marine Systems Limited (GMSL) owned the largest portion of the global cable ship fleet. With the changes made to the global cable fleet in recent months, this has shifted to show SubCom maintains ownership over the most vessels with eight, then come Orange Marine and ASN with six each. Global Marine is close behind with five vessels. Combined, these three companies account for half of the global fleet. Optic Marine and E-Marine PJSC own four vessels each and the remaining 18 cable ships are owned by various individual companies. While these numbers illustrate the part of the fleet that is exclusively owned and operated by each installer, they can also make use of "vessels of opportunity". This allows for a high degree of flexibility to take on any type of project around the globe.

Companies no longer seem to have as many restrictions on where they can provide supplier services and are able to tackle projects farther away from their "home base.". This allows a cable owner a great deal of flexibility when choosing a supplier for their new system.

Video 9: Didier Dillard, Chief Executive Officer - Orange Marine

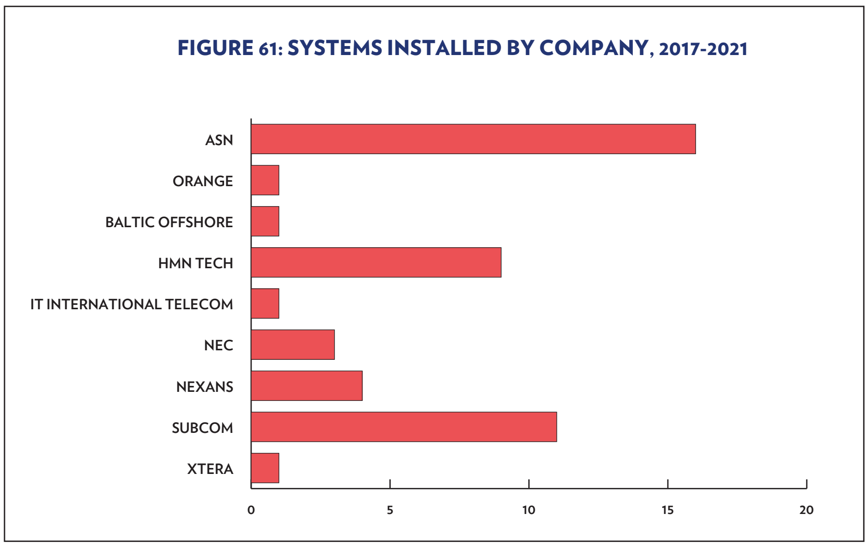


Figure 61: Systems Installed by Company, 2017-2021

3.2.2 CURRENT INSTALLATIONS

Based on announced systems installed for the period 2017 to 2021, ASN is shown to be the busiest at 34 percent, but the margin is less than in previous years with SubCom closer at 24 percent. HMN Tech has risen to 19 percent, with Nexans following at nine percent. This compares well with regional capability, as those who can serve the


OMS GROUP
"Your trusted partner for global subsea cable connectivity and next generation infrastructure"
ILE DE RÉ
MISSION STATEMENT
✓ Committing to reliable and innovative value added solutions.
✓ Growing an experienced and professional multicultural team.
✓ Developing strategic partnerships to enhance our value propositions
✓ Achieving the highest quality, health, safety and environmental standards
VESSELS & TUGBOATS
Ile De Re
Teneo
Cable Vigilance
Lodbrog
Peter Faber
TB Joyce
TB Janet
TB Sue Ann
Cable Empowered
Cable Orchestra
opticmarine.com

most regions tend to be the busiest. The remaining 14 percent are spread among the smaller installers such as ASN, Xtera, Orange Marine, Baltic Offshore, and NEC. (Figure 61) These figures relate to the number of systems installed irrespective of their length; therefore, suppliers that produce mostly very large systems, such as NEC, will be under-represented based on system length compared to system value.

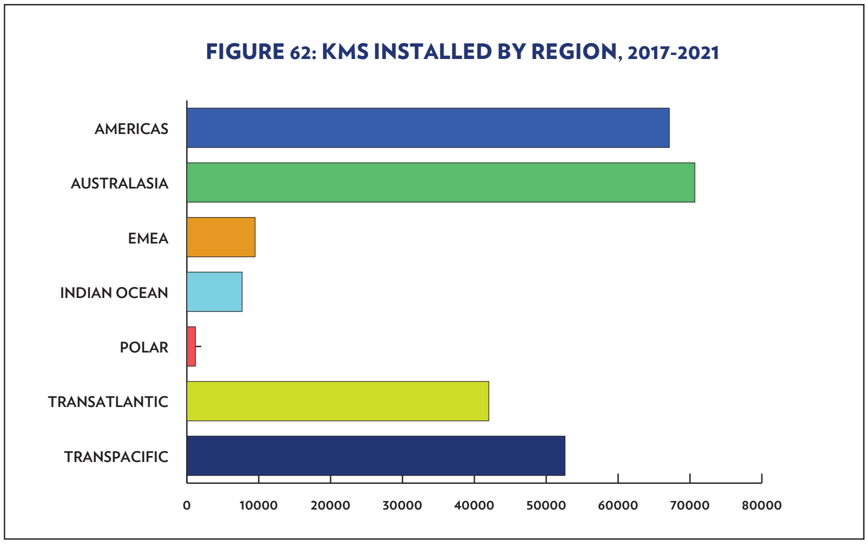


Figure 62: KMs Installed by Region, 2017-2021

3.2.3 REGIONAL ACTIVITY

As several systems took longer to install in 2020 due to Covid delays, the number of kilometers installed in the last five years has seen a slight decrease compared to previous years. The amount of cable installed by region for the period of 2017 to 2021 shows the AustralAsia region as the busiest by a small margin over the Americas, though overall saw the largest decrease globally. The Americas, Transpacific, and Transatlantic all saw small decreases but will benefit from emerging markets in South America in the coming years. The increase in transoceanic routes on either side of the Americas will likely continue over the next several years as systems such as the Humboldt Cable come to fruition.

The Indian Ocean region experienced the most drastic decrease having laid a 50 percent less in the last 5 years than prior analysis showed.

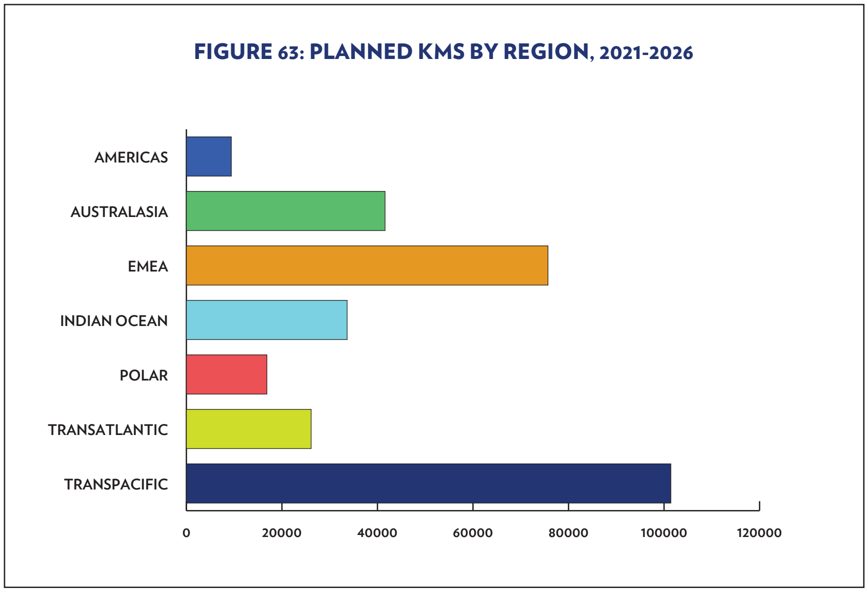


Figure 63: Planned KMs by Region, 2021-2026

The EMEA region did experience a downward trend in recent years which continued in 2020. This trend can be seen in the overall of kilometers installed in the region but will likely change direction in the coming year. Systems like NO-UK and N0R5KE VIKING will be completed by the end of 2021 among others, adding to the EMEA total. (Figure 62)

Projections for the next three years indicate a new trend differing from that of the previous five. The Transpacific region is expected to see the most activity by far, as several large systems are set to be installed throughout the region to connect major economic and data center hubs in the United States, East Asia, and Southeast Asia. The Transatlantic, Indian Ocean, EMEA, and AustralAsia regions will see moderate growth, as Hyperscalers and private companies continue to add infrastructure to these regions. The Americas region is expected to see a marked decrease in activity as it has been one of the busiest over the last couple years and has already received numerous new cable systems that likely meet the region's need for the foreseeable future. There are early plans for new Polar systems, but they are the most uncertain – owing to the technical challenges and expenses incurred from dealing with ice. (Figure 63) ■

3.3

Surveyors

3.3.1 CURRENT SURVEYS

Based on announced activity, EGS has accomplished by a large majority and has completed 46 percent of the surveys in the last five years. EGS and Elettra both have survey experience in nearly every region of the world, though performs more over Fugro's 24 percent. Fugro and IT International Telecom are also quite diverse with nine and seven percent of the announced surveys performed.

When looking at the big picture, many of these companies overlap – providing comprehensive global survey capability for the industry at large. While completing a survey is generally the first crucial step for an upcoming system, a surveyor should always be available regardless of the system's timeline. This allows a cable owner a great deal of flexibility when planning their new system. (Figure 64)

Video 10: René D'Avezac de Moran, Service Line Manager - Hydrography - Fugro

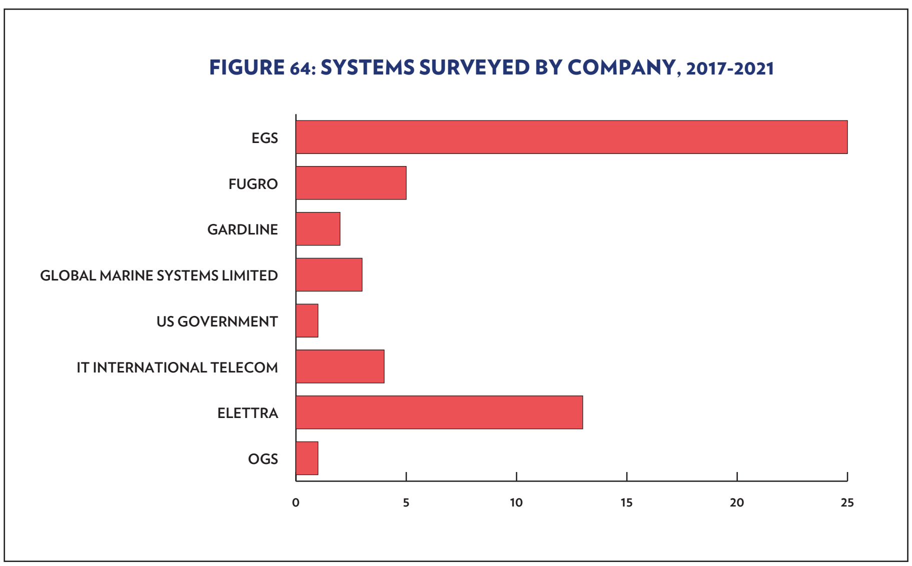


Figure 64: Systems Surveyed by Company, 2017-2021

3.3.2 PLANNED SURVEYS

Completing a survey is one of the first real hurdles on the way to system implementation and 45 percent of planned systems for the period 2021 to 2026 have performed this task. Additionally, 74 percent of all systems planned for 2021 have completed a survey, and 46 percent of all systems set to be RFS in 2022 have completed a survey. As it can take an average of about 18 months for a system to go from survey to completion, there are quite a few systems that will likely be pushed into 2022 and beyond. This time last year, only 25 percent of systems planned for the following year had completed their survey. (Figure 65) ■

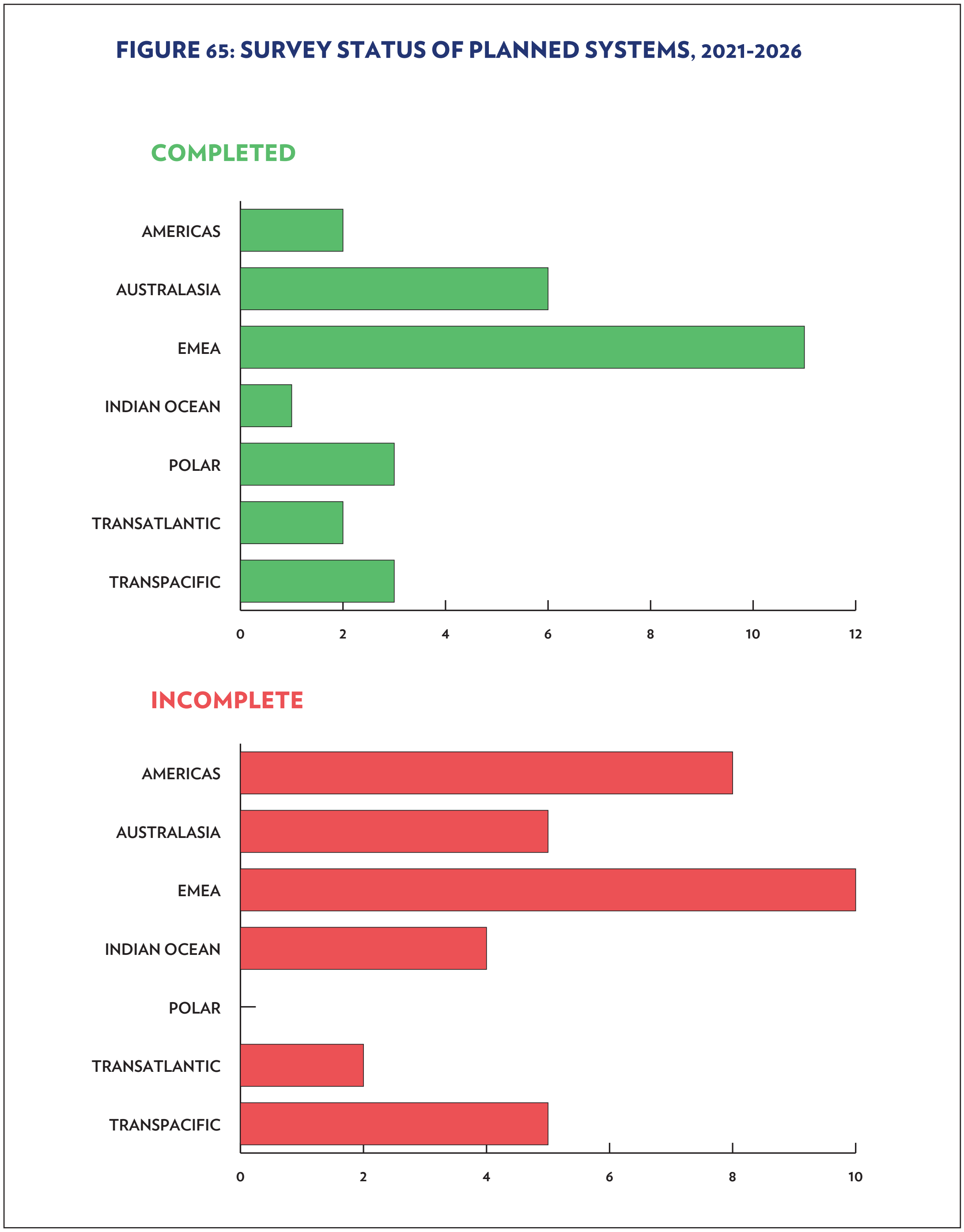


Figure 65: Survey Status of Planned Systems, 2021-2026

3.4

Recent Mergers, Acquisitions, and Industry Activities

Business Development Agency Bermuda

Video 11: Andrew Lipman, Partner - Morgan, Lewis & Bockius LLP

3.4.1 AQUA COMMS

In April 2021, Aqua Comms announced its acquisition by Triple Point's Digital 9 Infrastructure PLC, the externally managed trust which is focused on digital infrastructure assets that deliver a "reliable, functioning internet". *(https://subtelforum.com/aqua-comms-announces-acquisition-by-triple-points-digital-9-infrastructure-plc/)*

3.4.2 ASN

In April 2021, ASN announced joining forces with iXblue and SeaOwl to develop partnerships around innovative technologies dedicated to environmental protection underwater. *(https://subtelforum.com/asn-joining-forces-with-ixblue-and-seaowl/)*

3.4.3 BULK FIBER NETWORKS

In October 2021, Bulk Fiber Networks and WFN Strategies announced the commencement of the Leif Erikson cable project, the first trans-Atlantic cable powered with 100% renewable energy. Leif Erikson Cable System will consist of a direct link between southern Norway and Atlantic-Canada connecting into Goose Bay, including plans to extend the system terrestrially back to Montreal. *(https://subtelforum.com/bulk-wfn-strategies-announce-leif-erikson-cable/)*

3.4.4 FACEBOOK

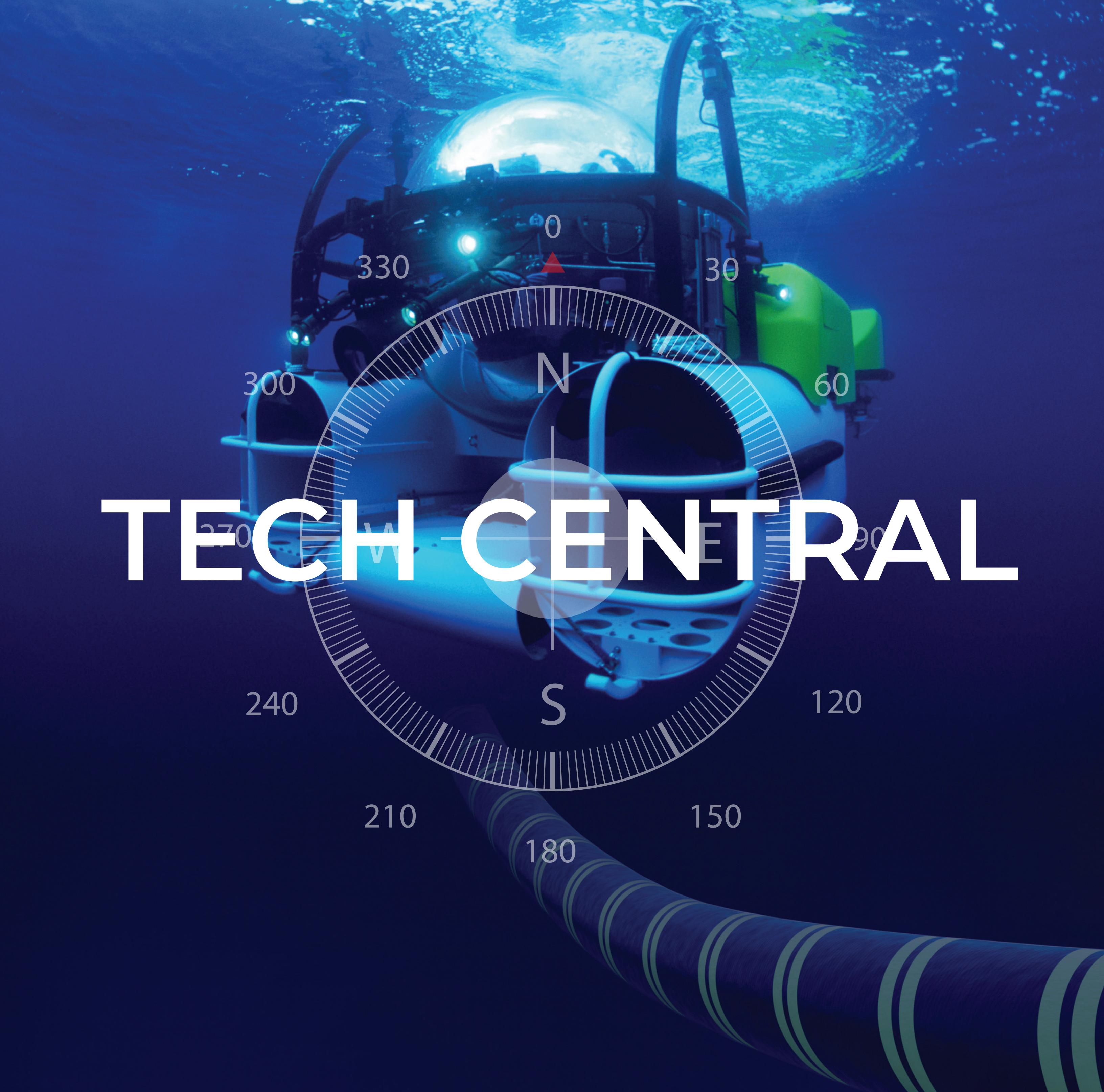
In March 2021, Facebook withdrew from the Hong Kong Americas cable consortium. *(https://subtelforum.com/facebook-withdraws-from-hong-kong-to-us-cable/)*

3.4.5 GTT COMMUNICATIONS

In September 2021, GTT Communications filed for Chapter 11 bankruptcy after it sells infrastructure business to I Squared. *(https://subtelforum.com/gtt-communications-to-file-for-bankruptcy/)*

3.4.6 ICPC

In July 2021, International Cable Protection Committee (ICPC) released cable protection recommendations, "Best Practices for Cable Protection and Resilience as Resource for Governments" to assist governments in


TECH CENTRAL

developing laws, policies, and practices. *(https://subtelforum.com/icpc-releases-cable-protection-recommendations/)*

3.4.7 NEC

In Jun 2021, NEC joined the RE100 and adjusted its emissions targets, aiming to reduce CO2 emissions from its direct business operations to become carbon neutral by 2050, in order to accelerate climate change measures to become carbon neutral by 2050. *(https://subtelforum.com/nec-joins-re100-and-adjusts-emissions-targets/)*

In October 2021, NEC announced that it had been contracted by Facebook to build an ultra-high performance transatlantic subsea fiber-optic cable connecting the USA and Europe. Using NEC's newly developed 24 fiber pair cable and repeaters (*1), the system can deliver a maximum transmission capacity of a half Petabit per second, the highest to date for a long distance repeatered optical subsea cable system (*2). *(https://subtelforum.com/nec-to-build-a-transatlantic-cable/)*

Also in October 2021, NEC, its subsidiary OCC Corporation and Sumitomo Electric Industries announced that they had completed the first trial of submarine cable with multicore fiber - uncoupled (*1) 4-core submarine fiber cable (*2) — verified its transmission performance to meet the exacting demands of global telecommunications networks. *(https://subtelforum.com/first-trial-of-submarine-cable-with-multicore-fiber-complete-by-nec-occ-sumitomo/)*

3.4.8 PRYSMIAN GROUP

In May 2021, the Prysmian Group announced working for sustainability with its ECO CABLE, a business strategy consistent with the UN Sustainable Development Goals. ECO CABLE is the first green label in the cable industry and vouches for the greenness of their cables. *(https://subtelforum.com/prysmian-working-for-sustainability-with-eco-cable/)*

In July 2021, the Prysmian Group commented on the importance of energy efficient fiber solutions, highlighting the need for operators to prioritize green solutions for the post Covid-19 era, with optical fibre significantly outperforming its rivals in terms of consumption. By deploying optical fibre networks that use eco-friendly materials, Prysmian believe operators will reduce energy consumption and cut out unnecessary emissions across the supply chain, according to their official press release. As countries across the continent prepare for the post Covid-19 era, quality passive optical networks will be essential to enable their digital transformation. *(https://subtelforum.com/prysmian-group-on-the-importance-of-energy-efficient-fiber-solutions/)*

3.4.9 SUBOPTIC

In September 2021, SubOptic announced that due to the ongoing uncertainty around COVID-19, the Executive Committee had postponed SubOptic 2022, moving the date of the conference from April 2022, as originally planned, to a new date in the first half of 2023. SubOptic intended to re-schedule the event as a live event in Asia with HMN Tech as the host sponsor, and the committee said that they would brief all sponsors and delegates as soon as possible on the revised plan. *(https://subtelforum.com/suboptic-2022-postponed/)*

In October, SubOptic 2023 was announced to be held on 13-16 March 2023 in Bangkok, Thailand.

3.4.10 WFN STRATEGIES

In April 2021, WFN Strategies joined The Climate Pledge alongside Amazon, Verizon, and over 100 other companies from across dozens of industries. *(https://subtelforum.com/wfn-strategies-joins-the-climate-pledge/)* ■

4

System Maintenance

4.1

Publicity

Unsurprisingly, three of the largest regions in the world generate the most media stories about cable faults. The Americas, AustralAsia and EMEA regions are not only expansive, but several of the landing stations contained within each region are also in high traffic shipping areas; and in the case of AustralAsia, there are multiple cables within geologically active areas. Historically, the AustralAsia and EMEA regions have had poor reporting, but they have experienced increased coverage since 2017. (Figure 66)

The Transpacific and Indian Ocean regions have had a handful of stories with the Indian Ocean region, seeing an increase from 2 percent of the overall stories through 2020 to 5 percent this past year. The remaining Transatlantic region has had no reported cable faults within the period 2014 to 2021. While the former two regions simply have fewer cables to manage compared to the more problematic zones— in relatively cable-safe regions — the latter is one of the most established regions in the world. It is again likely that many faults in these regions go unreported. Specifically, in the case of the Transatlantic region, there is almost always a cable repair ship nearby to quickly restore any damage within days or hours – likely preventing many faults from even being noticed.

Video 12: Ryan Wopschall, General Manager - International Cable Protection Committee

FIGURE 66: CABLE FAULT STORIES PER REGION, 2014-2021

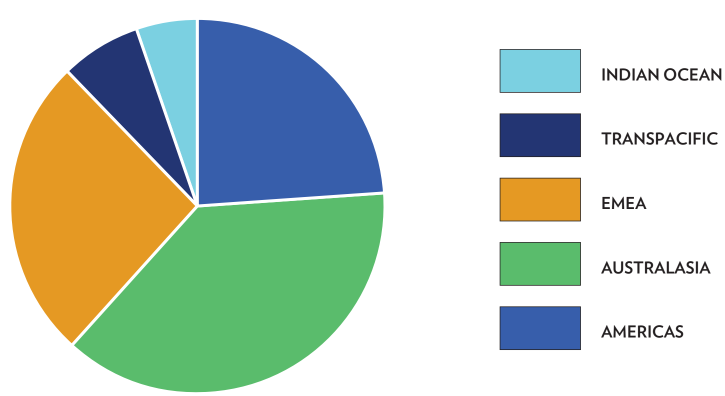


Figure 66: Cable Fault Stories Per Region, 2014-2021

A sharp rise in the volume of media coverage for cable faults has been observed since 2014. This is likely due to an increase in reporting, rather than an increase in cable faults, and almost certainly tied to the rapid rise of internet media reporting. Our global society is more interconnected than ever, with people sharing news faster than at any point in history. In 2021 there were less faults reported in globally popular publications and several of the stories seen were for the same two systems, AAG and AAE-1. These two systems had several issues this past year, one of which isn't slated to be resolved until at least November. (Figure 67)

As the average customer is becoming more technically proficient – and quicker to complain to service providers – this has contributed to an increase in media coverage for cable faults. As more people are connected to the global submarine fiber network every year, the rise in reported faults by the media is expected to continue. This provides much needed transparency and accountability for the submarine fiber industry. ■

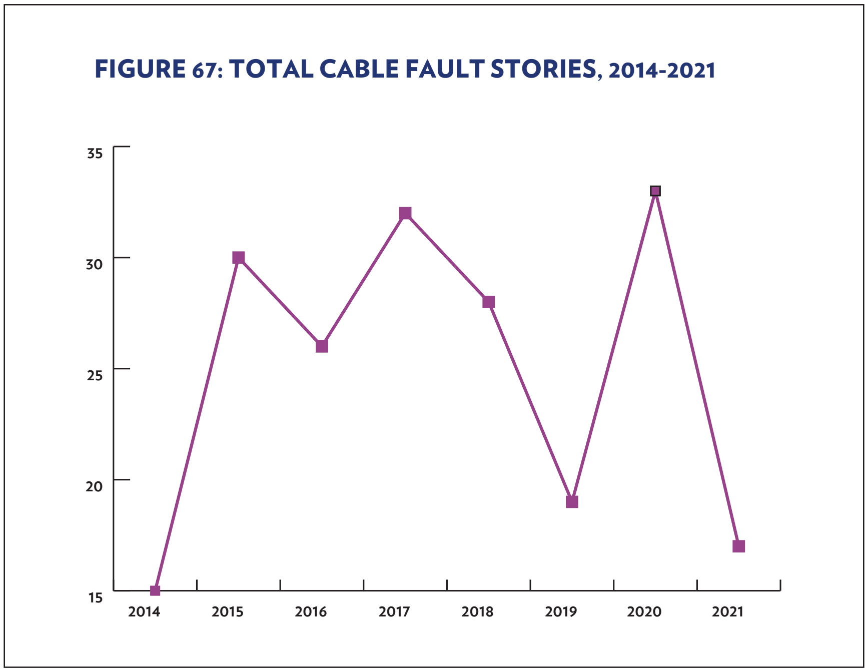


Figure 67: Total Cable Fault Stories, 2014-2021

4.2

Reporting Trends and Repair Times

With progressively faster reporting time, it is very likely that announcement times will average under a week in the near future. This not only helps to hold cable owners and operators more accountable but also provides reassurance to customers that cable faults are being addressed in a timely fashion. More accurate and transparent reporting of cable faults also helps maintenance agreement zones and private contractors to more reliably predict where to distribute assets

The average time to repair was trending downwards for a time in the last seven years, averaging around 24 days in that time. The 2021 average has more than doubled compared to previous years. With repeated breaks on the same cables came costly repairs, and those repairs are reliant on the availability the contracted repair vessel, which are not always free to drop everything to rush to fix a fault. But the downward trend in cable fault repair time seen in previous years could still lead to a lower average time as the world continues to recover from the effects of the Covid-19 Pandemic and more importantly, the global cable fleet is growing to allow more work to be done in less time. (Figure 68)

Raising awareness of cable faults puts pressure on government agencies in charge of issuing permits for cable repair work. For instance, when the Sulawesi Maluku Papua Cable System was cut during Military action earlier in 2021, (Internet cut in Papua as Military Operatiosn Intensify, n.d.) word of the disruption spread like wildfire and Telkom Indonesia began working immediately trying to get the necessary support. (Pebrianto, n.d.). ■

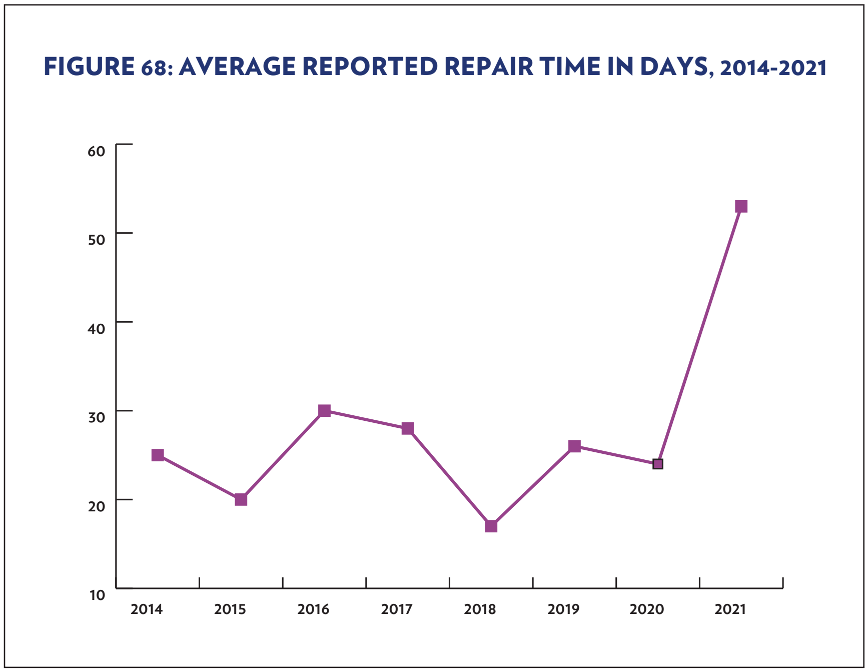


Figure 68: Average Reported Repair Time in Days, 2014-2021

4.3

Club Versus Private Agreements

Marine maintenance is a shared service where several cable owners share the benefit of resources within a defined operational area. There are two forms an agreement can take – private, wherein the contractor and cable owner agree prices and conditions on a bilateral basis, and club, wherein the agreement conditions and prices are linked with all the participating cable owners.

Video 13: Stewart Ash, Marine Design & Installation Manager - WFN Strategies, LLC

4.3.1 TRADITIONAL CLUB AGREEMENTS

The way that the Maintenance Zone operates is that each owner nominates a representative to act as the main point of contact between itself and the marine service provider and the depot operator. This representative is called the Maintenance Authority for the system and will provide instructions to the ship during the repair and the depot operator before and after the repair. The Maintenance Authority will also retain the detailed as-laid records for the system and update them after each repair.

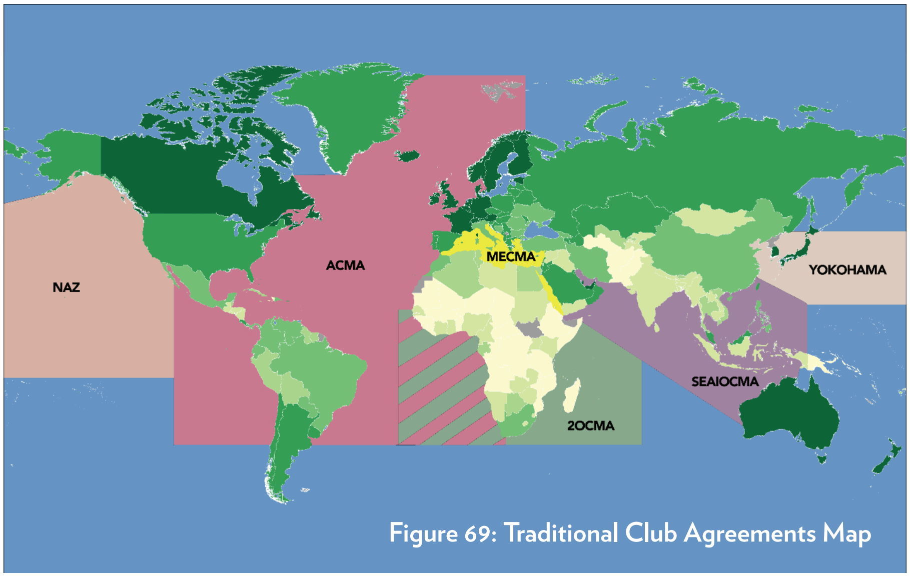


Figure 69: Traditional Club Agreements Map

4.3.1.1 2 OCEANS CABLE MAINTENANCE AGREEMENT

2 Oceans Cable Maintenance Agreement (2OCMA) operates in the South of Atlantic and Indian oceans from Cape Town (South Africa) using the facilities of Telkom SA depot. 2OCMA is supported by vessels and facilities from Orange Marine, and possesses base ports in Cape Town, South Africa.

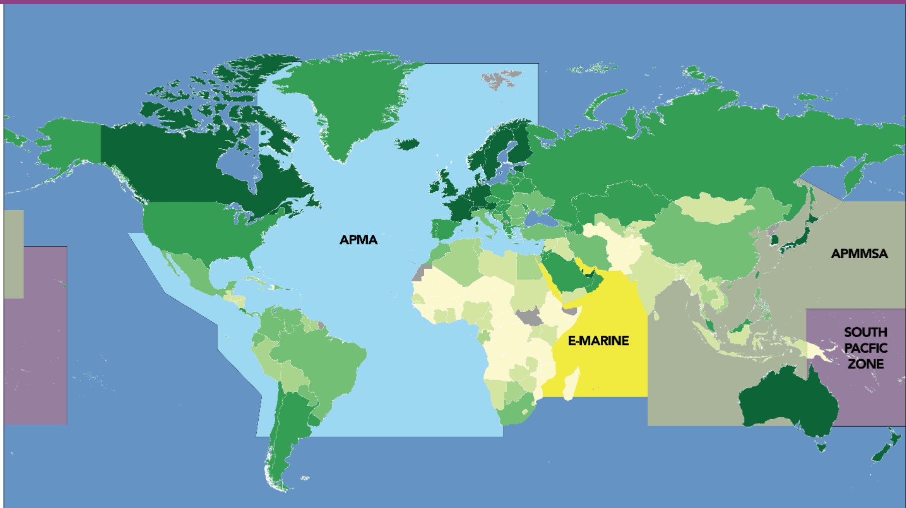


Figure 70: Private Maintenance Agreements Map

4.3.1.2 ATLANTIC CABLE MAINTENANCE AGREEMENT

The benchmark for all maintenance services and the most popular worldwide is the Maintenance Zone. The first Maintenance Zone was set up in the North Atlantic in 1965 and is called Atlantic Cable Maintenance Agreement (ACMA). ACMA defined and continues to set the standards for structure and operating procedures that all other Maintenance Zones around the world now follow.

ACMA operates in the Atlantic, Southeast Pacific and Northern Europe zones. The agreement utilizes Global Marine depot facilities in Portland, UK, and Bermuda; Orange Marine's facilities in Brest (Northern France); and SubCom facilities in Curacao (Dutch Antilles). Global Marine vessels are nominally based in Curacao and Portland whilst the Orange Marine vessel is based in Brest.

4.3.1.3 MEDITERRANEAN CABLE MAINTENANCE AGREEMENT

Mediterranean Cable Maintenance Agreement (MECMA) operates from the Mediterranean Marine Base of La Seyne-sur-Mer (Southern France) on 71,000 km of cables in the Mediterranean zone including the Black and Red Seas. MECMA is supported by vessels and facilities from Orange Marine and Elettra and possesses base ports in Le Seyne Sur Mer, France and Catania, Italy.

4.3.1.4 NORTH AMERICAN ZONE CABLE MAINTENANCE AGREEMENT

North American Zone Cable Maintenance Agreement (NAZ) covers an area from the Bering Sea and Alaska in the North to the Equator in the South and from the Americas to approximately 167° West Longitude. NAZ is supported by vessels and facilities from Global Marine Systems Limited, and possesses a base port in Victoria, Canada.

4.3.1.5 SOUTHEAST ASIA/INDIA OCEAN CABLE MAINTENANCE AGREEMENT

Southeast Asia / Indian Ocean Cable Maintenance Agreement (SEAIOCMA) stretches from Djibouti to Guam and from Taiwan to Australia and covers an area of approximately one-third of the earth's oceans. SEAIOCMA is supported by vessels and facilities from ACPL, IOCPL and Global Marine Systems Limited and possesses base ports in Singapore; Colombo, Sri Lanka; and Manila, Philippines.

4.3.1.6 YOKOHAMA ZONE CABLE MAINTENANCE AGREEMENT

The Yokohama Zone has been one of the major cable maintenance zones in the Asia-Pacific region, covering cables in Northern Asia and Northwest region of the Pacific, and adjacent to the NAZ and SEAIOCMA zones. Yokohama Zone is supported by vessels and facilities from KCS, KTS and SBSS and possesses base ports in Yokohama, Japan; Keoje, Korea; and Wujing, China.

4.3.2 PRIVATE MAINTENANCE AGREEMENTS

There are several types of contracts in place for providing private marine maintenance services globally. Private agreements are typically offered by the ship operators and are usually tailored (within the limits of the overall economic model) to the needs of the individual system owner.

4.3.2.1 ATLANTIC PRIVATE MAINTENANCE AGREEMENT

The Atlantic Private Maintenance Agreement (APMA) covers an area encompassing the Atlantic and Mediterranean. APMA is supported by vessels and facilities from ASN and SubCom and possesses base ports in Calais, France; Curacao; and Cape Verde.

4.3.2.2 ASIA PACIFIC MARINE MAINTENANCE SERVICE AGREEMENT

APMMSA is supported by vessels and facilities from SubCom and possesses a base port in Taichung, Taiwan.

4.3.2.3 E-MARINE

E-marine covers the maintenance of cables primarily in the Arabian Gulf, Red Sea, Indian Ocean, and Arabian Sea. E-marine possesses base ports in Hamriya, UAE and Salalah, Oman.

4.3.2.4 SOUTH PACIFIC MAINTENANCE AGREEMENT

The South Pacific Maintenance Agreement (SPMA) covers the southern Pacific region eastward to the Hawaiian Islands. SPMA is supported by vessels and facilities from SubCom and possesses a base port in Samoa. ■

5

Cable Ships

5.1

Current Cable Ships

5.1.1 FLEET DISTRIBUTION

Cable ship ownership has become much more diverse in the past several years. Looking at the fleet of 51 cable laying vessels, SubCom is the front runner in sheer numbers with eight vessels. Launching the Leonardo da Vinci this past year put Orange Marine and ASN in a tie for second where they each own six vessels. And this will change again in early 2023 when Orange Marine finishes building their next state of the art vessel the Sophie Germain (Orange Marine, 2021). (Figure 71)

As the Atlantic and Pacific Oceans are the busiest and highest traffic maritime regions in the world, most of the global cableship fleet is stationed in these two regions. (Figure 72) Many of the world's most important telecommunications routes cross these two oceans, requiring multiple maintenance vessels to be on hand and installation vessels available for new routes. The Indian Ocean and Mediterranean regions are slightly-less busy and have a smaller coverage footprint. Therefore, fewer ships are necessary to handle the workload required by these regions, resulting in a significantly smaller portion of the fleet stationed there.

The overall distribution of cable ships dedicated to maintenance agreements versus those available for installation jobs is almost even. Of the global fleet, 21 are dedicated to club and private maintenance zones, 26 are dedicated towards installation work. The remaining four are not dedicated to a sole purpose. (Figure 73)

Cable ships are stationed around the world in strategic locations reflecting established fault profiles to be able to cover all parts of the world easily.

5.1.2 GROWTH AND AGE OF CABLE SHIP FLEET

The large spike visible in additional cable ships from 2001 to 2003 was in anticipation of explosive market growth that failed to materialize. Because of a far less busy industry, no cable ships were added to the global fleet from 2004 to 2010. While an average of one cable ship has been added per year since 2011, this is not enough to keep up with future demand as older ships begin to reach the end of their usable years. (Figure 74)

Most of the cableships in the fleet are between 20 and 30 years old, with the average age being 25. All but eight cable ships are 18 years or older, and one is as old

FIGURE 71: CABLE SHIP FLEET DISTRIBUTION BY COMPANY

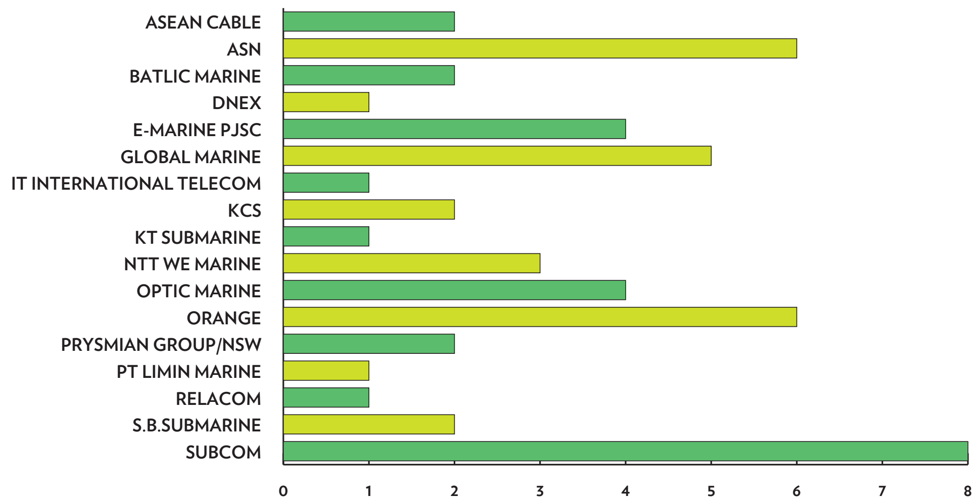


Figure 71: Cable Ship Fleet Distribution by Company

as 52 years. This indicates that there is still room for modernization that companies such as Orange Marine and ASN are actively trying to fill with new vessels and redesigned new acquisitions; though there are still a large quantity of vessels that are over 30 years old – 19 to be exact. And there are not enough planned cable ships to replace them as they age out, which will impact installation and maintenance availability in the coming decade. (Figure 75)

5.1.3 CABLE SHIP ACTIVITY

In early 2020, SubTel Forum began collecting daily cable ship tracking data based on information publicly available through AIS tracking; data which has been invaluable in analyzing the activity of the global fleet on a macroscopic level. This past year, a total of 32 regions have been reported as vessel locations across the globe, with 13 regions seeing less than 2 percent of all activity listed as "Other". (Figure 76)

Three of the most active locations over the past year were East Asia, Southeast Asia, and China Coast, showing that the Pacific Ocean has maintained its status as one of the busiest maritime zones in the world. In 2020 the North Sea followed strongly behind as the fourth busiest region but has been replaced by the Northeast Atlantic Ocean and West Africa regions, which each had 9 and 7 percent of the overall activity. This increase in activity off the coasts of North America and Africa are expected, as systems like Dunant, EllaLink, and Malbec were finished and became ready for service. Together, those six regions comprise of 54 percent of the overall activity reported this year.

Most of the remaining vessel activity is spread out regularly across 13 other regions with the remaining minority listed as "Other" accounting for less than 1 percent of activity. This minority often results from a ship passing through, though shorter unrepeatered systems like NO-UK or maintenance projects can also be the reason and therefore would not result in long periods of activity. Covid has still been a factor that project managers must work into their system's projected work schedules as every port and vessel can have a different set of quarantine requirements to plan for.

5.1.4 NEW CABLE SHIPS

As of this report, there are several new vessels to look forward to over the next few years. Orange

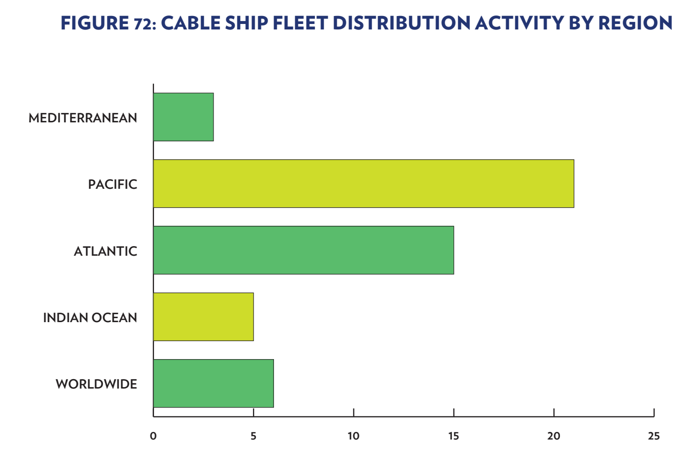


Figure 72: Cable Ship Fleet Activity by Region

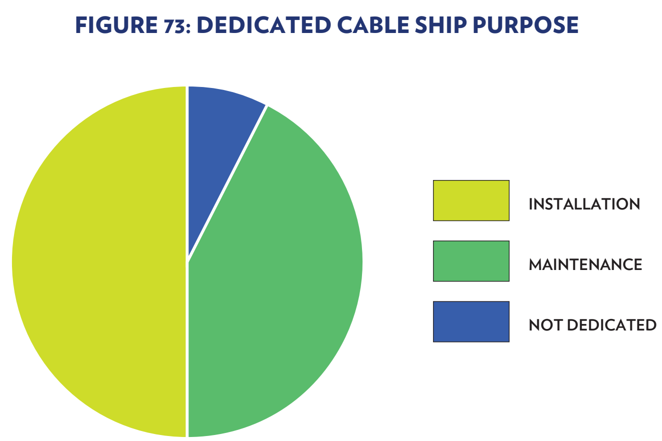


Figure 73: Dedicated Cable Ship Purpose

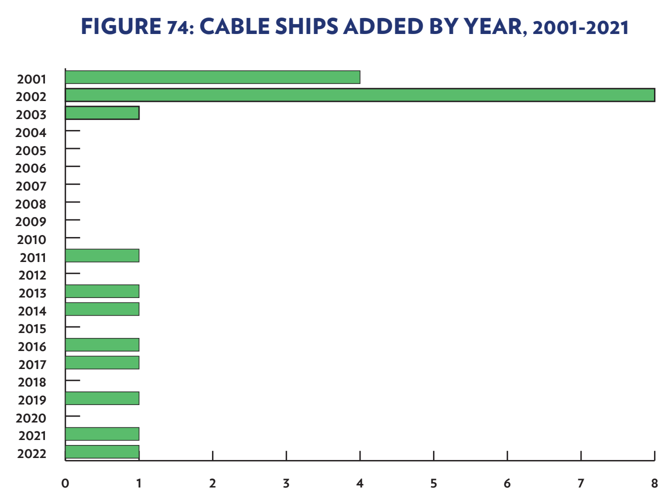


Figure 74: Cable Ships Added by Year, 2001-2021

Marine is currently building their newest addition: the Sophie Germain. "It will be cutting-edge and equipped with modern and efficient equipment, and it has been designed to reduce its environmental footprint by 20% for CO_2 emissions and 80% for nitrogen oxide emissions compared to the Raymond Croze, the cable ship which it will replace in the Orange Marine fleet." (Orange Marine, 2021) ASN is also adding to the global fleet with the Ile de Molène and the Ile d'Yeu. Both vessels are now going through, "a heavy engineering and upgrade program to meet the expectations of ASN's customers and the missions that they will be carrying out." (ASN, 2021) Though the addition of these three vessels is excellent news, more companies need to take a look at their existing capabilities and find ways to modernize the fleet before the older vessels are too outdated to continue laying cable.

FIGURE 75: AGE DISTRIBUTION OF CABLE SHIP FLEET

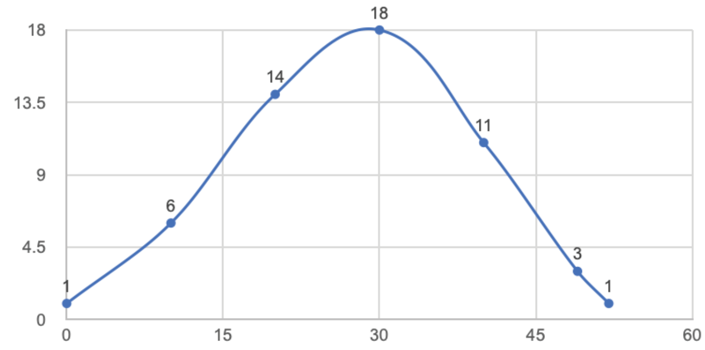


Figure 75: Age Distribution of Cable Ship Fleet

FIGURE 76: CABLE SHIP ACTIVITY

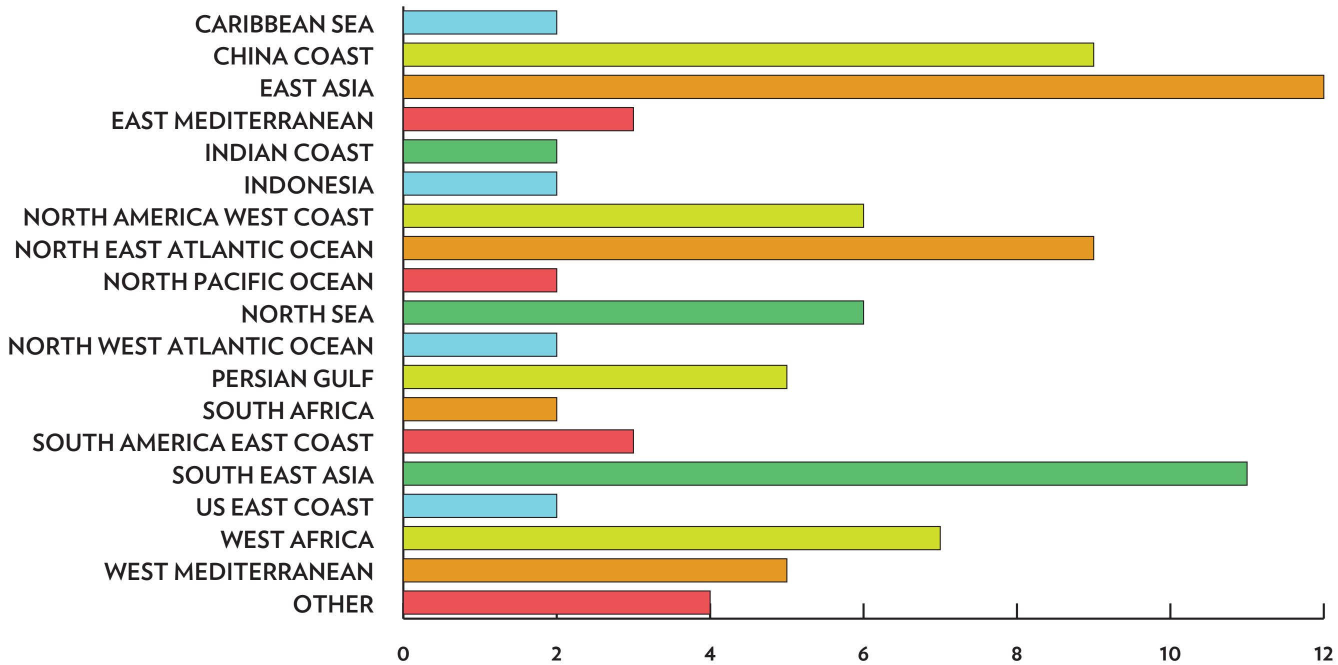


Figure 76: Cable Ship Activity

5.2

Shore-End Activity

5.2.1 CURRENT SHORE-END ACTIVITY

The number of shore-end installations by region for the period 2017 to 2021 correlates closely to the number of systems per region over the period. The EMEA, AustralAsia and Americas regions are characterized by numerous systems that connect three or more landing points. The Indian Ocean, Transatlantic, and Transpacific are typically characterized by systems taking more direct routes between fewer landing points. (Figure 77)

5.2.2 FUTURE SHORE-END ACTIVITY

The number of shore-end installations by region for the period 2021 to 2026 diverges compared to the number of systems per region over the period. Systems in AustralAsia will continue with historical trends, providing numerous shore-end installation opportunities. New Transpacific systems will, on average, connect more landing points than normally observed. New systems in the Americas will, on average, connect fewer. The overall distribution stays relatively the same except for an increase in EMEA activity compared to AustralAsia. (Figure 78)

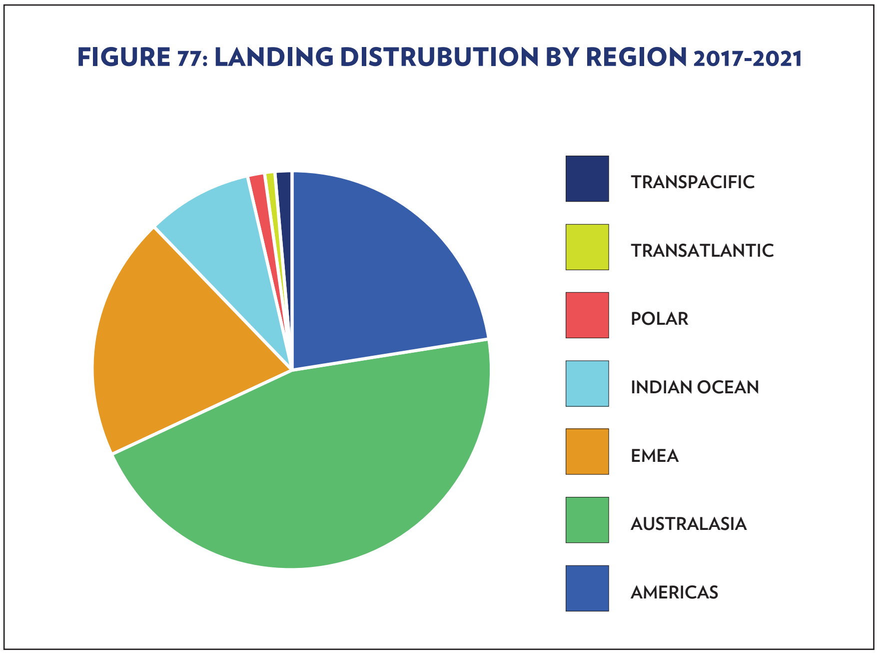


Figure 77: Landing Distribution by Region, 2017-2021

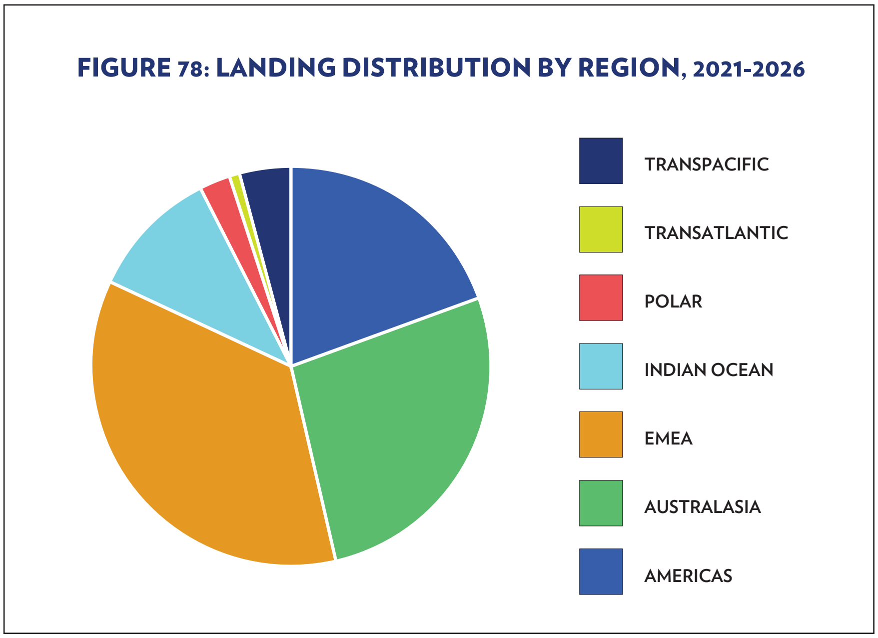


Figure 78: Landing Distribution by Region, 2021-2026

6

Market Drivers and Influencers

6.1 *Hyperscalers*

Hyperscalers are an increasingly integral part of the submarine cable system development process. Facebook, Google, Microsoft – and now Amazon – are moving from capacity purchasers to cable owners. Not only are these new players now driving where cables are going, they are helping to push along new innovations inside of the cable systems themselves. New transmission technology to handle higher capacity wavelengths, increased fiber counts for more overall system capacity and streamlined network management, and the push for open systems leading to shared system architecture are just a small sampling of new technologies and ideas these providers are backing.

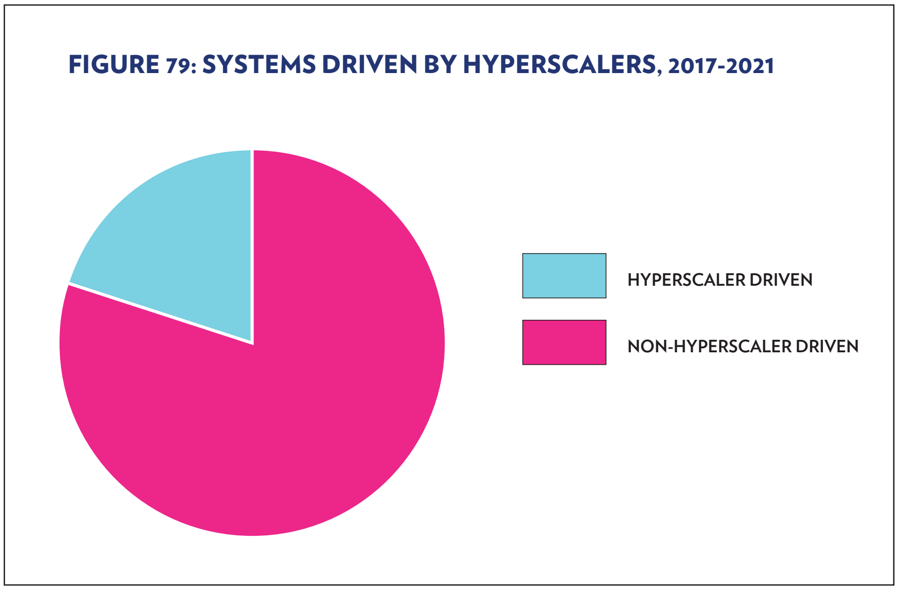


Figure 79: Systems Driven by Hyperscalers, 2017-2021

During the pandemic, the amount of cloud adoption across a variety of industries skyrocketed as companies were forced to find ways for their employees to continue being productive in their homes and other unconventional working conditions. Companies found themselves spending more than ever before on Software as a Service (SaaS) products like Microsoft 365, DocuSign, and Dropbox as well as private cloud options. (Flexera, 2021)

Another major change Hyperscalers have brought to global networks is shifting the focus from city-to-city connections to data center-to-data center connections. Unlike traditional cable owners, companies like Facebook, Google, and Microsoft do not necessarily need to build infrastructure in locations with a variety of interconnect options. Instead, they favor locations that provide economic and cost saving benefits to reduce the operational expenditure impact of their data center facilities. The arrival of a major Hyperscaler provider not only brings new telecoms infrastructure to a region but also the cloud services that the company provides.

6.1.1 CURRENT SYSTEMS IMPACTED

A new paradigm emerged in 2016, with Hyperscalers stepping into the world of submarine cable ownership. Many of these companies have such large and complex infrastructure requirements that it has become more valuable for them to own their own cable systems rather than buy capacity from a carrier.

The dramatic growth in demand is creating significant challenges for telecommunications companies, Internet Service Providers (ISPs), and Hyperscalers. The top segment of many markets is becoming dominated by large Hyperscaler players, such as Google, Amazon, Microsoft, and Facebook – who have become key stakeholders and require large amounts of bandwidth between their data centers on various continents.

Hyperscalers were the driving force behind 20 percent of systems that went into service for the period 2017 to

FIGURE 80 SYSTEMS IMPACTED BY CONTENT PROVIDERS, 2017 - 2021

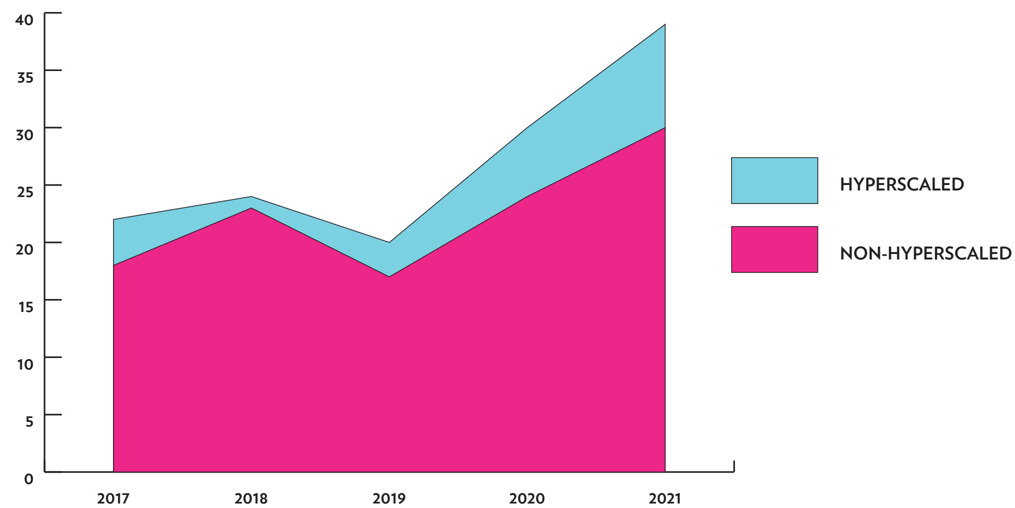


Figure 80: Systems Impacted by Hyperscalers, 2017-2021

2021 – which is down only slightly from 26 percent a year ago. (Figure 79)

Several factors led to these companies making the decision to build their own infrastructure. One of the biggest eye-openers was Hurricane Sandy hitting New Jersey, USA – a major cable landing hub – in 2012. This storm wiped out critical infrastructure, flooded cable ducts and caused a huge loss of connectivity to Europe for several days – ultimately resulting in millions of dollars in lost business. The aftermath of this storm highlighted the need for increased route diversity and more direct control over critical infrastructure. This help to spur on the surge of Hyperscaler backed submarine cable systems. (Figure 80)

Additionally, major Hyperscalers had been growing at such a rapid pace that their need for additional bandwidth was beginning to outpace their ability to purchase it in a timely manner. Building their own infrastructure provided both greater control over assets and removed the need to "compete" against other carriers and businesses also trying to buy capacity circuits. As a result of owning and operating their own critical infrastructure, Hyperscalers can now turn on additional capacity in a matter of days instead of weeks or months when buying circuits from a traditional carrier.

While transoceanic cable systems are expensive – well over $100 million just to get across the Atlantic – these assets represent business potential in the billions of dollars for major Hyperscalers. Even the annual operations expenditure to manage and maintain the cable is a fraction of potential revenue.

6.1.2 FUTURE SYSTEMS IMPACTED

For the period 2022 to 2024, 23 percent of planned systems are being driven by Hyperscalers, an increase of 5 percent from our previous estimate of 2021 - 2023. (Figure 81) This indicates that currently observed levels of Hyperscaler driven systems have potential to continue rising. However, as systems driven by major Hyperscalers have a much greater chance of being implemented – due to the high financing threshold of these companies – expect this percentage to continue to increase as new cables are announced, and other projects die off. Without these kinds of backers, future systems will have a much harder time proving their business case and securing funding.

While the top tier Hyperscalers are continuing to develop new systems, there are numerous other companies in this part of the Information Technology sector. A second wave of these companies – such as Zoom – may decide they need similar infrastructure plans and follow in the footsteps of their respective market leaders. This could trigger a second wave of Hyperscaler driven systems and allow the submarine fiber market to continue enjoying its current level of activity even after the top tier providers begin to reach the end of their infrastructure buildout plans. However, no new Hyperscalers have officially or publicly expressed interest in building submarine cable infrastructure.

Of the nearly $8.3 billion investment for planned systems over the next several years, one-third that amount is tied up in Hyperscaler backed systems. Again, while these companies are not sole owners on every cable system, they are a part of, this still represents a significant dollar value that would very likely not exist without their involvement. (Figure 82)

While only 52 percent of announced cable systems end up entering service (Clark, 2019), Hyperscaler backed systems have thus far proven largely immune to this trend as they generally do not announce a system until it is already CIF. It is therefore probable that up to half of non- Hyperscaler driven systems will not achieve the CIF milestone and further highlight the dominance of the Hyperscalers on the submarine fiber industry. ■

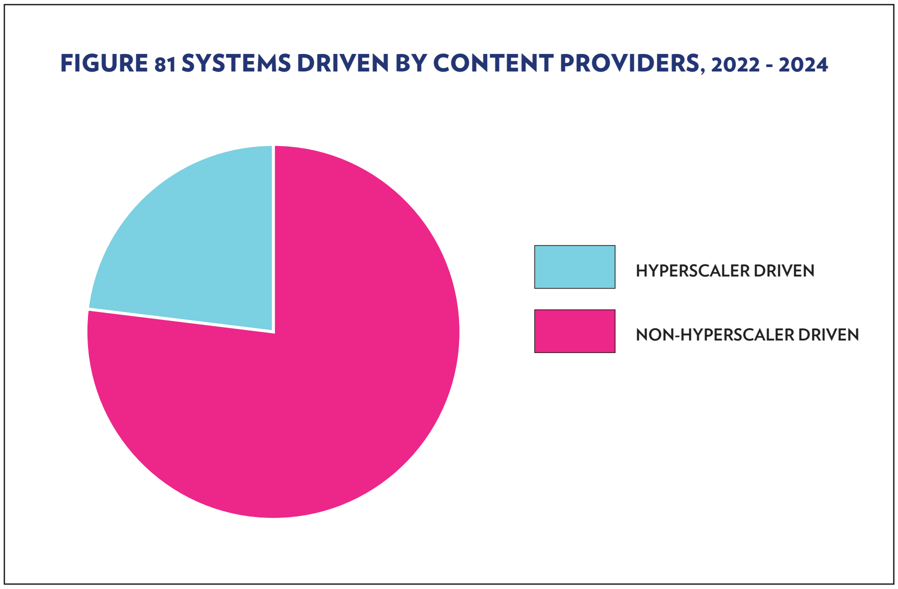


Figure 81: Systems Driven by Hyperscalers, 2022-2024

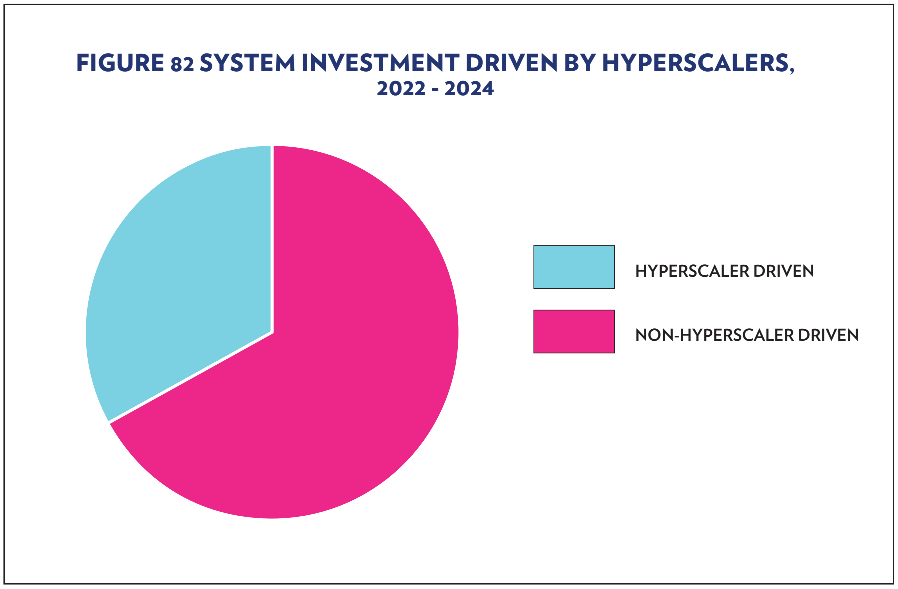


Figure 82: System Investment Driven by Hyperscalers, 2022-2024

6.2

Data Centers

Data center providers have become an increasingly integral part of the submarine telecommunications ecosystem over the last several years. As a result, one of the biggest dynamic changes has been to place data center and colocation facilities closer to cable landing stations in order to maximize interconnection and network services. Building these facilities next to – or even as part of – the cable landing station reduces network latency and streamlines infrastructure.

Video 14: Buddy Rizer, Executive Director of Economic Development - Loudoun County

This type of configuration is especially attractive for cable landing stations that house multiple cable systems as they provide access to a much wider away of customers and interconnection opportunities. For instance, the cable landing facilities in Marseille, France, house thirteen international submarine cables and provide access to dozens of potential customers needing both interconnection and onward backhaul connectivity. (SubTel Forum Analytics Division of Submarine Telecoms Forum, Inc., 2020)

6.2.1 CLOUD ADOPTION

Cloud adoption is at an all-time high as companies continue to shift towards both cloud storage and cloud computing to drive their business. Amazon Web Services and Microsoft Azure lead the way in enterprise adoption with no sign of

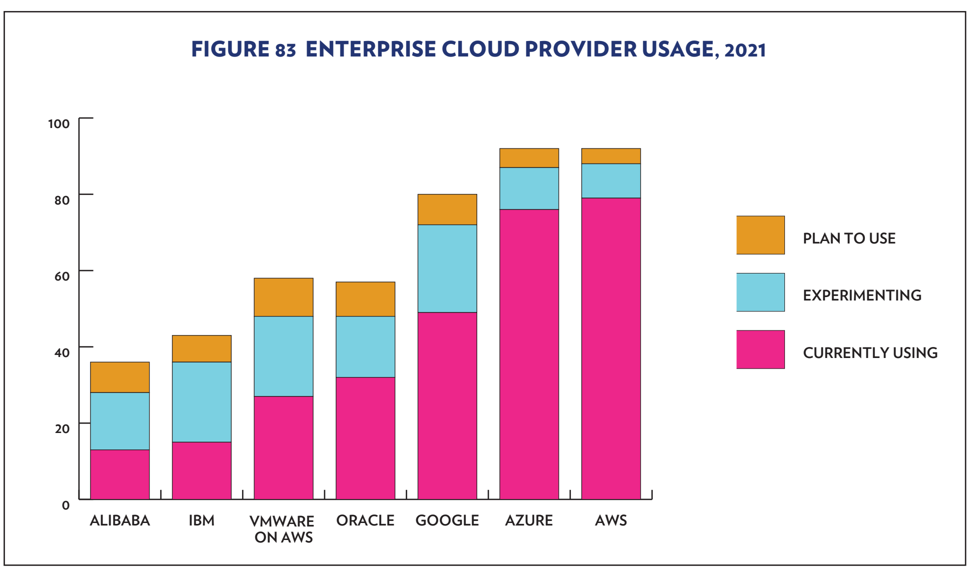


Figure 83: Enterprise Public Cloud Provider Usage, 2021 (Flexera, 2021)

slowing down. (Figure 81) These cloud services are global in nature and inevitably their traffic will end up traveling over submarine telecommunications cables. As a result, data center providers have become more involved with the submarine fiber industry, especially around cable landing stations where they can capitalize on interconnection and colocation opportunities – especially in those areas where multiple cables come ashore to a single location. (Figure 83)

In January 2020, Flexera surveyed 750 enterprise technical professionals about their cloud computing adoption. Of these respondents, 94 percent have adopted the use of cloud computing in some fashion with organizations leveraging five different cloud services on average. Spending on enterprise cloud is growing significantly with companies planning to spend 47 percent more on public cloud in 2021 vs 2020. In all, 36 percent of respondents spend more than $12 million on public cloud services on an annual basis while 83 percent spend more than $1.2 million annually. (Flexera, 2021)

These numbers show that the cloud computing market continues to accelerate overall. As this market grows, so will data center providers and the need to provide robust telecommunications networks that allow enterprise customers to efficiently manage their traffic anywhere in the world. A key part of this will be the integration of data centers with cable landing stations to efficiently provide more backhaul and interconnection opportunities on international telecommunications routes. (Figure 84)

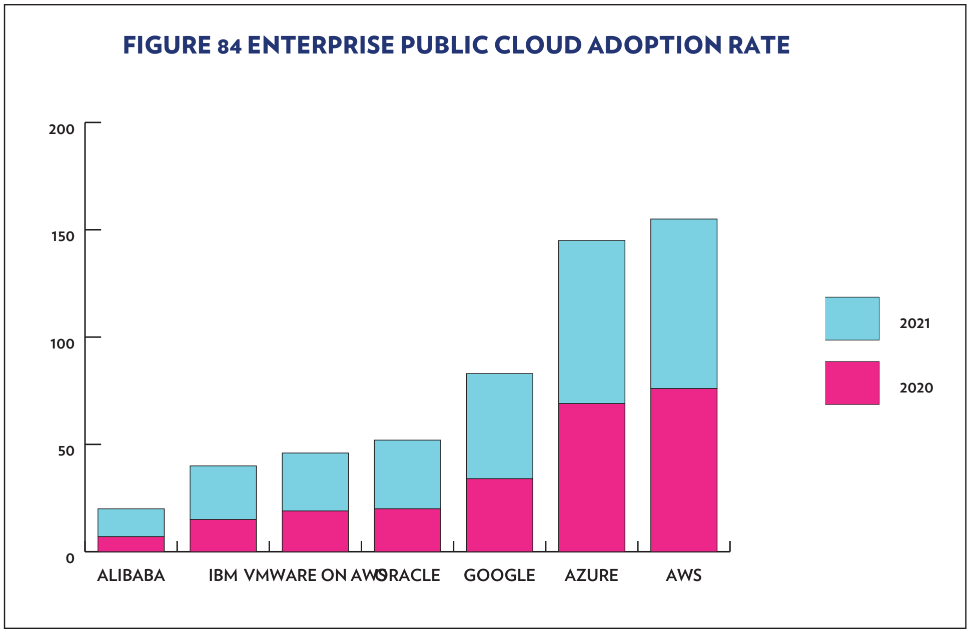


Figure 84: Enterprise Public Cloud Provider Adoption Rate, 2020-2021 (Flexera, 2021)

6.2.2 DATA CENTER MARKET EXPANSION AND INTEGRATION

The cost for implementing a new data center can be steep. Depending on overall size and location, building a new data center can cost anywhere from $6.5 to $10 million per megawatt (MW). (Diaz, 2019) In 2019 alone, data center provider Equinix planned to spend nearly $2 billion to open 12 new International Business Exchange (IBX) and expand 23 existing IBX facilities. (Lima, 2019) Non-Hyperscaler data centers, Equinix, Digital Realty Trust and Interxion, will continue to benefit from submarine cable construction activity as proximity to a cable landing station can provide numerous interconnection opportunities that can help make the high cost of a new data center build worth it.

While non-Hyperscaler data centers do benefit from submarine cable infrastructure, they are not driving new builds and are strictly interested in the interconnection opportunities that being involved with cable landing stations provides. For Equinix and other carrier-neutral providers, locations with only a single cable system are not attractive growth options.

In the future, expect data center providers to continue integrating more closely with submarine cables. Bridging the gap between terrestrial and submarine traffic is one of the most critical components of international connectivity. Traditionally, submarine fiber systems would come ashore at a cable landing station, negotiate deals for backhaul connectivity to a data center – which was not always close by – and from there negotiate interconnection services to other carriers and providers. This would add network latency and complexity – both of which are greatly reduced when data center and cable landing station facilities are integrated more closely. As new ideas and technologies are developed towards this effort, network efficiency and reliability will increase. ■

7

Special Markets

7.1

Offshore Energy

This year has been challenging for many industries around the world due to the continued COVID-19 pandemic. As important as offshore energy is to the global economy, the energy industry has not been immune its impact.

Compared to previous years, demand for hydrocarbons has shrunk but its growth is expected, and the price of crude has heavily recovered from its 2020 lows. While production capability has been met with difficulties imposed by quarantines and social distancing requirements. The Oil & Gas industry has also started to redesign itself with multiple oil companies looking to shift to renewable energy sources such as wind and in doing so are divesting of their lower margin hydrocarbon assets. As a result, submarine fiber activity in this market has been brought almost to a standstill.

Video 15: Greg Otto, Technical Director - WFN Strategies, LLC

However, while the immediate impacts are disheartening, the long-term effects of the global pandemic could result in a boon for the submarine fiber industry. COVID-19 has forced many industries to expand their remote work and automation capabilities – all of which need the capacity and reliability that only fiber can provide. As the demand for more capacity to offshore facilities grows, so will the demand for submarine fiber systems as the more traditional geosynchronous satellite and midearth orbit satellite such as O3b telecoms solutions have multiple challenges to meet the increased data and demands.

Before 2019, there were several new systems added around the world, as various offshore energy companies began to realize the benefits of fiber systems for their offshore facilities. However, a dip in oil prices in late 2018 through early 2019 and an overall global economic downturn slowed, or flat out halted, progress on systems for 2019. As prices and the economy began to pick back up through the latter half of the year, several systems were announced for 2020 and beyond – making it seem like things were back on track.

Of course, COVID-19 hit the world towards the end of Q1 2020 and brought the entire world to a standstill, with quarantine procedures effectively keeping people at home. In addition, most Oil & Gas companies went into a downsizing or even a business transition such as BP's re-invent which included reassignment of capital to align with longer term strategies. With less commuting and travel, demand for Oil & Gas was brought down significantly in 2020 resulting in constrained capital conditions and fiber and communications related projects were often set aside. Due to these circumstances, four systems that had been planned for 2020 did not enter service on time.

Offshore energy fields are dynamic and evolve over the years - new production platforms come on station, old platforms are decommissioned, new turbines are installed, and older ones are decommissioned. In addition, facilities have ongoing projects and minor expansion. As energy companies look to become more efficient and address climate change, new digital technologies and applications are introduced, and new communication solutions become available, most notably wireless technologies such as 5G.

> *When most of the early offshore Oil & Gas submarine cable networks were built, the business case was measured in terms of production gain (e.g., boe/day) that could be attributed to improved connectivity and new applications. Focus on fewer offshore personnel did not drive value as those beds would inevitably be replaced with other workers, such as maintenance and project personnel who would work to improve production efficiency (boe/day). (Nielsen & Otto, 2021)*

However, as the industry focuses on utilizing new technologies to increase efficiency and automation as a key strategy to reduce cost and maintain margins – especially considering the new reality brought on by pandemic quarantine and social distancing procedures – demand for new offshore fiber systems should increase through 2024. One aspect to this is with the use of robotics and AI; some platforms which did not "qualify or justify" the capital investment for fiber may now meet the business conditions. However, this will be accomplished through a combination of new fiber, expansion of existing and the use of hybrid solutions whereby wireless 4G/5G is used to manage capital exposure.

Granted, due to the ongoing global impact of COVID-19 and redesign of offshore Oil & Gas, it has become apparent that our initial estimates for length of cable added in 2023 has drastically changed. Substantial delays and cancellations have greatly altered the landscape of our data. The growth we were expecting to see in 2023 has shifted to the following year in 2024 and maybe into 2025, however the amount of growth is much lower. As a result, 2023 is now expected to see very little length added. (Figure 85)

The same can be said about the number of systems that will be active in the coming years. With the previous expectation of 15 systems planned for 2023, that number has been brought to its knees as only one system is currently planned. We don't expect to see too many more systems coming online the following year, in 2024, due to ongoing delays due to COVID-19 and changing focus of Oil & Gas companies. (Figure 86)

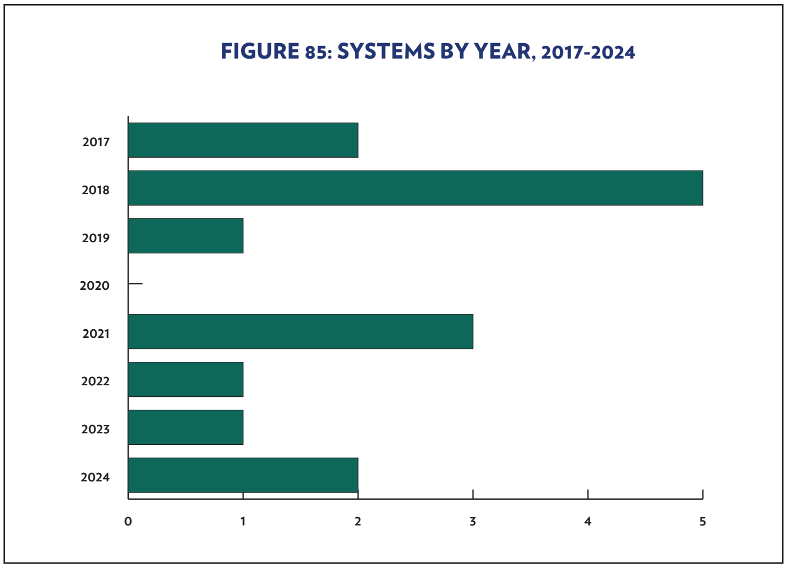


Figure 85: Systems by Year, 2017-2024

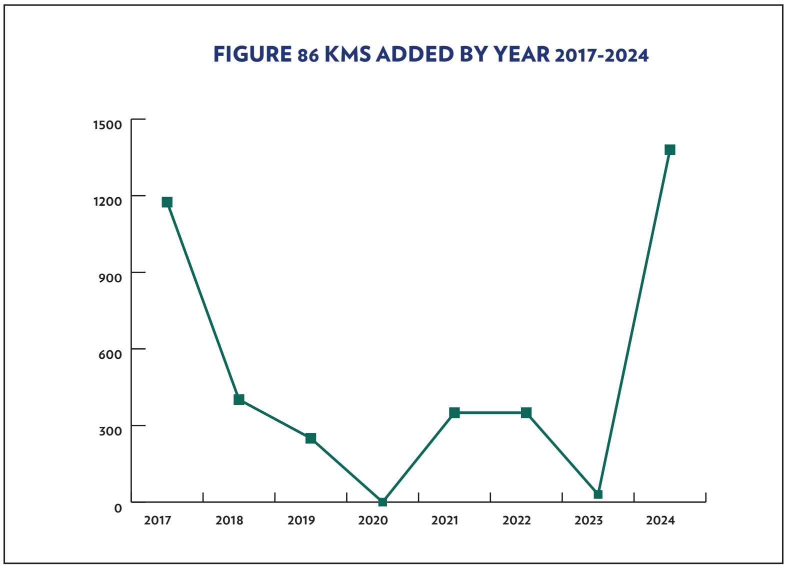


Figure 86: KMs Added by Year, 2017-2024

7.1.1 OIL PRICE HISTORY

Looking at the average quarterly price of a barrel of oil over the last five years via the Brent Crude oil price history, oil prices reached their peak in October of 2018. Prices reached $86 per barrel at the start of the month. After that, prices began to decline to an average of just over $55 per barrel and remained relatively steady at this range throughout 2019. Eventually, however, as initial COVID-19 lockdowns were put in place around the world, a sharp drop in prices was witnessed and quickly the prices bottomed out at just over $9 per barrel on April 21, 2020, as oil was being moved into storage waiting for higher prices to return, and as a result, storage facilities were no longer available driving the price lower. This gradual-to-steep price decline was a heavy contributor to why the market saw such a sharp decline in new systems implemented in 2019 and no new systems in 2020. Many systems either died outright or were pushed back to 2021 and beyond.

FIGURE 87: BRENT CRUDE OIL QUARTERLY PRICE HISTORY

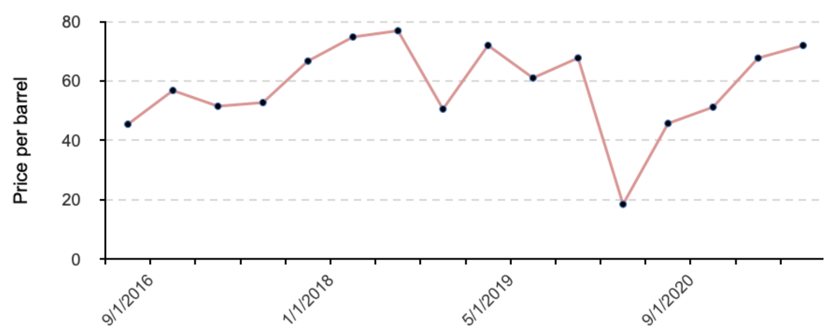


Figure 87: Brent Crude Oil Quarterly Price History, 2016-2021

While 2021-2024 are currently predicted to have a respectable increase in system activity, it is unclear whether oil prices and energy demand have recovered enough to support such an optimistic outlook. However, with the need for additional automation and remote capabilities brought on by the global pandemic, this may balance out demand for additional telecommunications capacity with a reduction in Oil & Gas demand. (Figure 87)

7.1.2 DEDICATED VS. MANAGED SYSTEMS

Dedicated systems are those built primarily by one or more Oil & Gas companies to serve their specific offshore facility's needs. Managed systems are those operated by a third-party telecoms service provider to one or more Oil & Gas companies' offshore facilities.

As end users of fiber systems to support core business, Oil & Gas companies evaluate a multitude of factors when deciding whether to own systems or buy connectivity services. For many companies, there will be a bias to buying a service in order to manage constrained capital (a $100M is the cost of a new well which is core business) and many Oil & Gas companies don't have the skillsets to build and operate a system. Therefore, one can expect there to be a decent split between managed and dedicated systems as engaging a willing and financially capable telecom provider will be an ongoing challenge.

As of now, 56 percent of all planned systems through to 2024 will be Dedicated, and 44 percent will be Managed systems.

However, with Tampnet's landmark acquisition of the BP GoM offshore cable system in August of 2020, a new trend is proving out as noted above where commercial telecoms companies own and operate multiple systems specifically for offshore Oil & Gas clients. (Tampnet Press Release, 2020)

Historically, systems like BP GoM had been owned by one or more oil companies that then have to manage the network for any additional third parties that connect to the system as funded telecom providers were not available. This has the potential to create some conflict as companies essentially must trust their data in the hands of a competitor. Tampnet has already established itself as an independent operator in the North Sea, and as they are looking to replicate that model in the Gulf of Mexico, this opens the doors for other telecoms companies to do the same. The next step would be for a third-party telecoms company like Tampnet to build a brand-new system to service offshore facilities instead of acquiring existing assets – as has been done up to this point.

If this model catches on, companies will have to decide for themselves which is the better option for their purposes, but more options are almost always a net positive.

7.1.3 OUTLOOK

This time last year told a very different story. There was a lot of uncertainty in which direction the price of oil would go. From the second half of 2020 and the first half of 2021, we witnessed an incredible rebound in oil prices. As of the beginning of Q2 2021, the price of oil is back up to just under $65 per barrel; $21 per barrel less than the peak we saw in 2018.

While the price of oil appears to be in an upward trend the submarine cable industry remains to have an uncertain future due to offshore energy industry noticeable transition to sources other than fossil fuels. We remain hopeful that the needs for increased digital presence in large and now smaller and later life production assets along with the use of hybrid solutions will result in an expanded needs and thus growth in offshore fiber demand for this industry. Ultimately, however, outlook for this aspect of the submarine fiber industry is entirely up in the air. ■

7.1

Unrepeated Systems

HEXATRONIC

Unrepeatered systems are an important part of the submarine cable industry. Historically unrepeatered links have been used to connect transoceanic systems from one landing point to its neighbor, creating short point-to-point systems across harbors, rivers, and lakes among other shorter distances. They also remove the need for power feeding equipment, repeaters, and line monitoring. (Ljung & Spence, Unrepeatered Systems: A View of the Sea, 2021)

These systems are also often a wise choice for owners looking simply to sell dark fiber pairs and not get involved in equipping and managing a network and selling capacity. In addition to repeater placement and proximity, the Oil & Gas industry also has genuine concerns about bringing powered cables up onto the platforms and hence unrepeatered festoon designs are typically adopted. (Ljung, Frisch, & Thomas, When Should You Consider an Unrepeatered Solution?, 2019)

Unrepeatered cables have always been distance limited, with links up to 250 kilometers topping out at about 18-24 Tbps per fiber pair, with the amount of 100G wavelengths that can be carried over an unrepeatered line exponentially dropping over 350 kilometers. However, unrepeatered submarine cables can make use of extremely high fiber counts to offset the reduction of capacity on an individual fiber pair. Their design flexibility, low CAPEX and OPEX are the

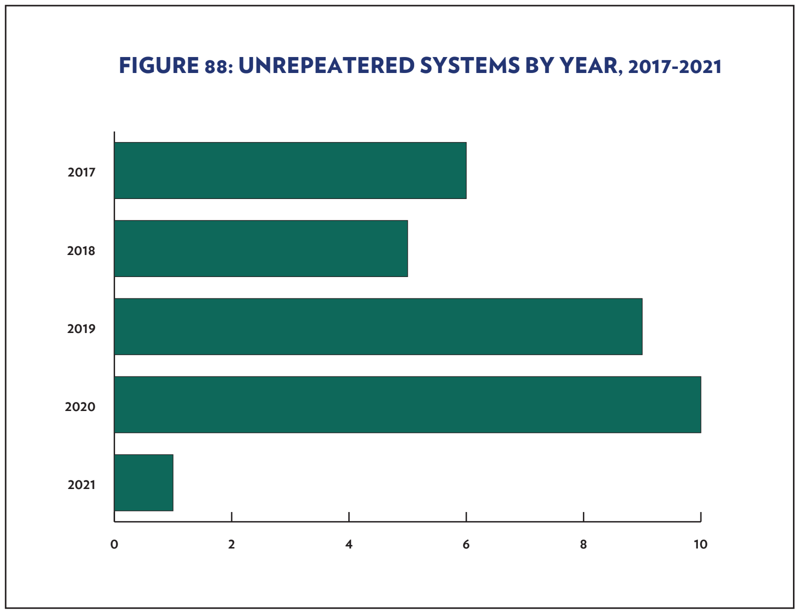


Figure 88: Unrepeatered Systems by Year, 2017-2021

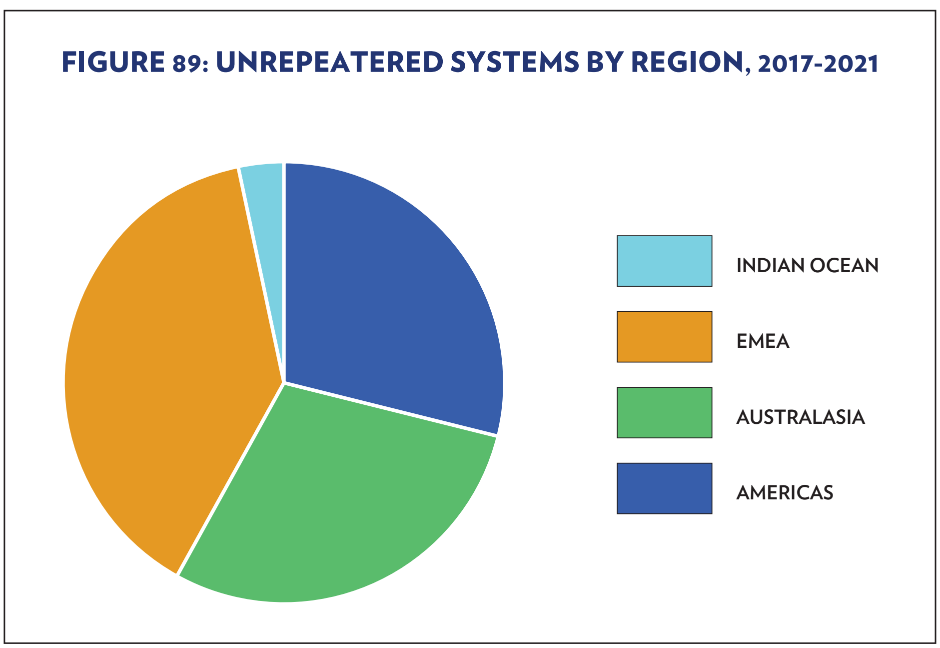


Figure 89: Unrepeatered Systems by Region, 2017-201

major advantages of such systems. (Ottersberg & Bhargava, 2020)

Based on publicly announced projects for the period 2017 to 2021, there have been a total of 31 unrepeatered systems put into service. Last year there were seven systems that went into service after the 2020 Industry Report was finalized, shown in a big jump from three to ten. So far this year, Scylla cable is the only unrepeatered system to be ready for service in 2021. There are a handful of systems that have made great strides this year that will likely reach the in-service milestone shortly, including Cross Channel, Zeus, and HAVSIL cable system by Bulk Infrastructure all of which are expected to complete their marine installation towards the end of 2021. (Figure 88)

Though this seems like a small number of systems, it is very common for smaller more local systems to not reach the same level of notoriety as their longer distance counterparts. In an article published by SubTel Forum Magazine in July 2021, Anders Ljung and Rebecca Spence detailed how common it is for unrepeatered systems to go unannounced and therefore untracked. They speculate that only 1 in 5 are made public. (Ljung & Spence, Unrepeatered Systems: A View of the Sea, 2021)

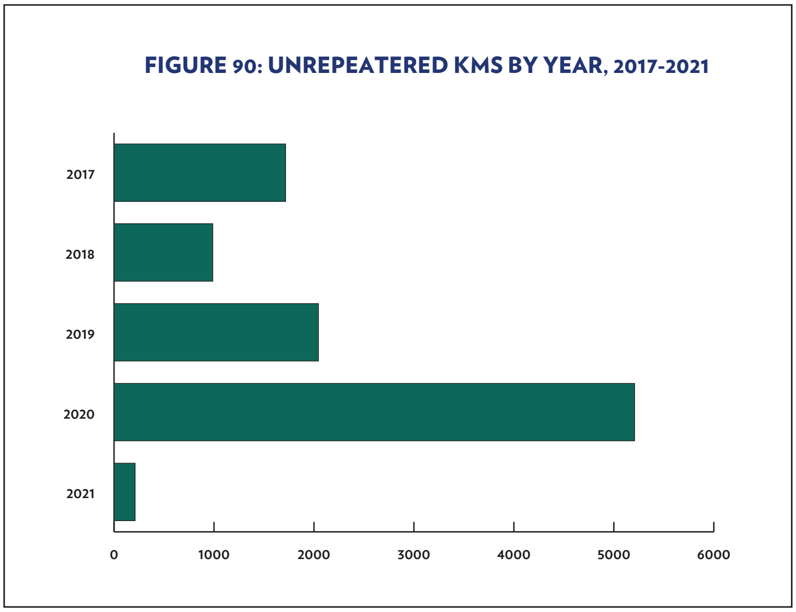


Figure 90: Unrepeatered KMs by Year, 2017-2021

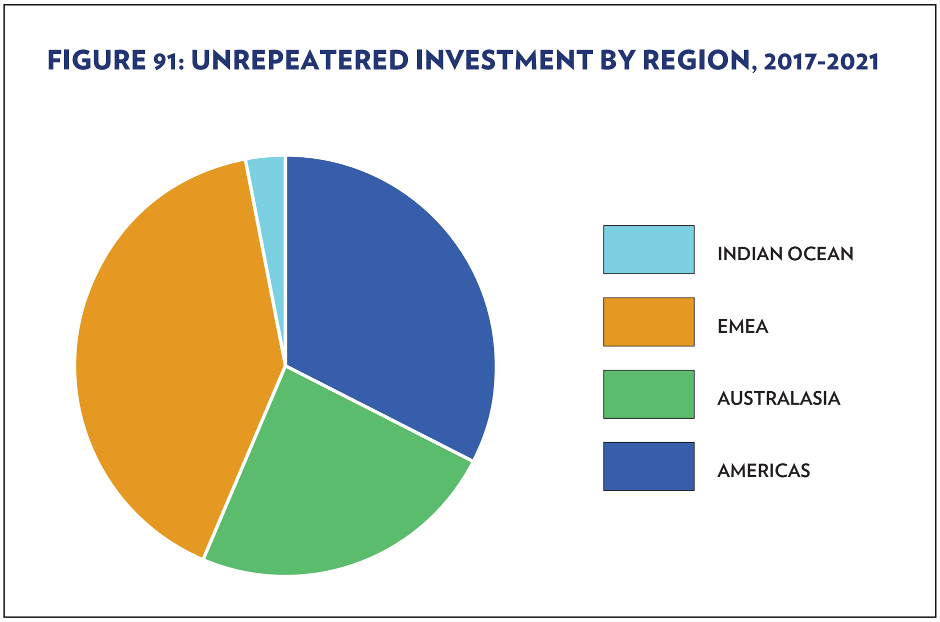


Figure 91: Unrepeatered Investment by Region, 2016-2020

With a maximum distance of 250 kilometers between links, there are distance limitations presented by unrepeatered cable technology. As such, there are no Transatlantic or Transpacific unrepeatered systems for example. For the period 2017 to 2021, the EMEA region contained the most unrepeatered cable systems with 39 percent of the overall number. This abundance of unrepeatered systems is unsurprising as there are many lakes and rivers that can utilize shorter systems more effectively. AustralAsia and the Americas were responsible for 29 percent each, while the Indian Ocean region observed 3 percent of the unrepeatered market. (Figure 89)

Previously the amount of unrepeatered cable added per year aligned closely with the number of new systems. But the addition of the 3,550 kilometers PRAT festoon system on the western coast of South America, the number of kilometers added in 2020 was almost tripled. Over the past five years, a total of 10,167 kilometers have been added, averaging 2,033.4 kilometers per year. As demand for new telecoms infrastructure around the world continues to increase, we are likely to also see an increase in demand for unrepeatered cable systems as well. Their unique ability to connect to longer systems and reach otherwise unreachable geographically diverse areas will allow new regions to be touched by connectivity than ever before. (Figure 90)

Unrepeatered cables have been responsible for over $388 million total investment, averaging $78 million per year. The EMEA region is responsible for 41 percent of this investment, the Americas increased from 13 percent to 33 percent, AustralAsia is 24 percent, and the Indian Ocean was responsible for 2 percent. (Figure 91)

There is a total of 13 unrepeatered systems currently planned for the period 2021 to 2024. Two of these systems will be implemented in the Americas, three in the AustralAsia region, and seven new systems will be added in the EMEA region. (Figure 92) ■

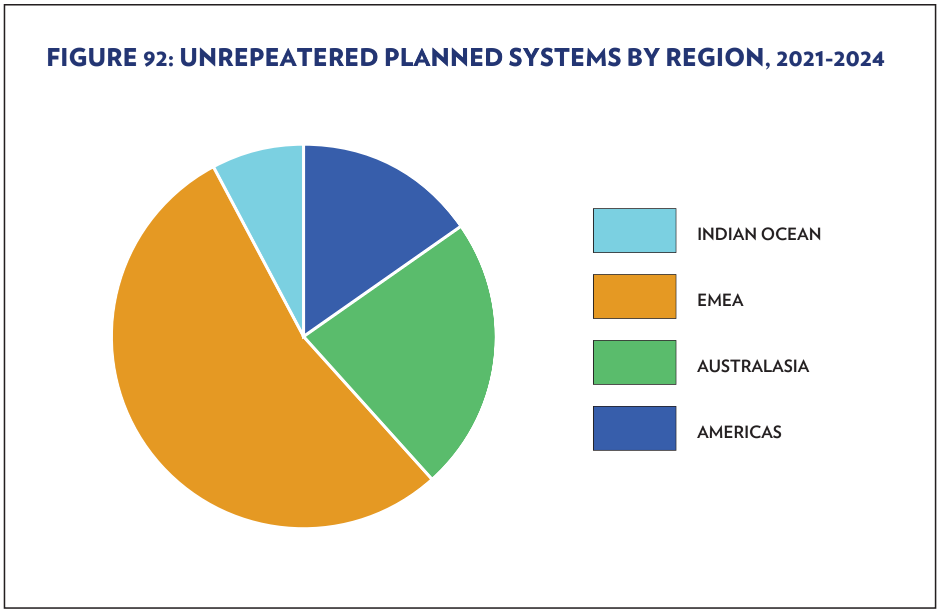


Figure 92: Unrepeatered Planned Systems by Region, 2021-2024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into the future
Hexatronic is a reliable partner specializing in submarine fiber optic cables ranging from just a few kilometers up to thousands.
We focus on providing customized logistics solutions according to the specific requirements for each project and help you every step of the way.
Time and cost efficient solutions
Hexatronic offers complete submarine cable solutions and passive fiber infrastructure based on scalable and future proof technology.
• Flexible approach for each and every project
• High fiber count cables
• Fast response, turnaround and delivery times
• No project is too big or small
• Swedish quality and technical proficiency
• Easy to do business with!
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8

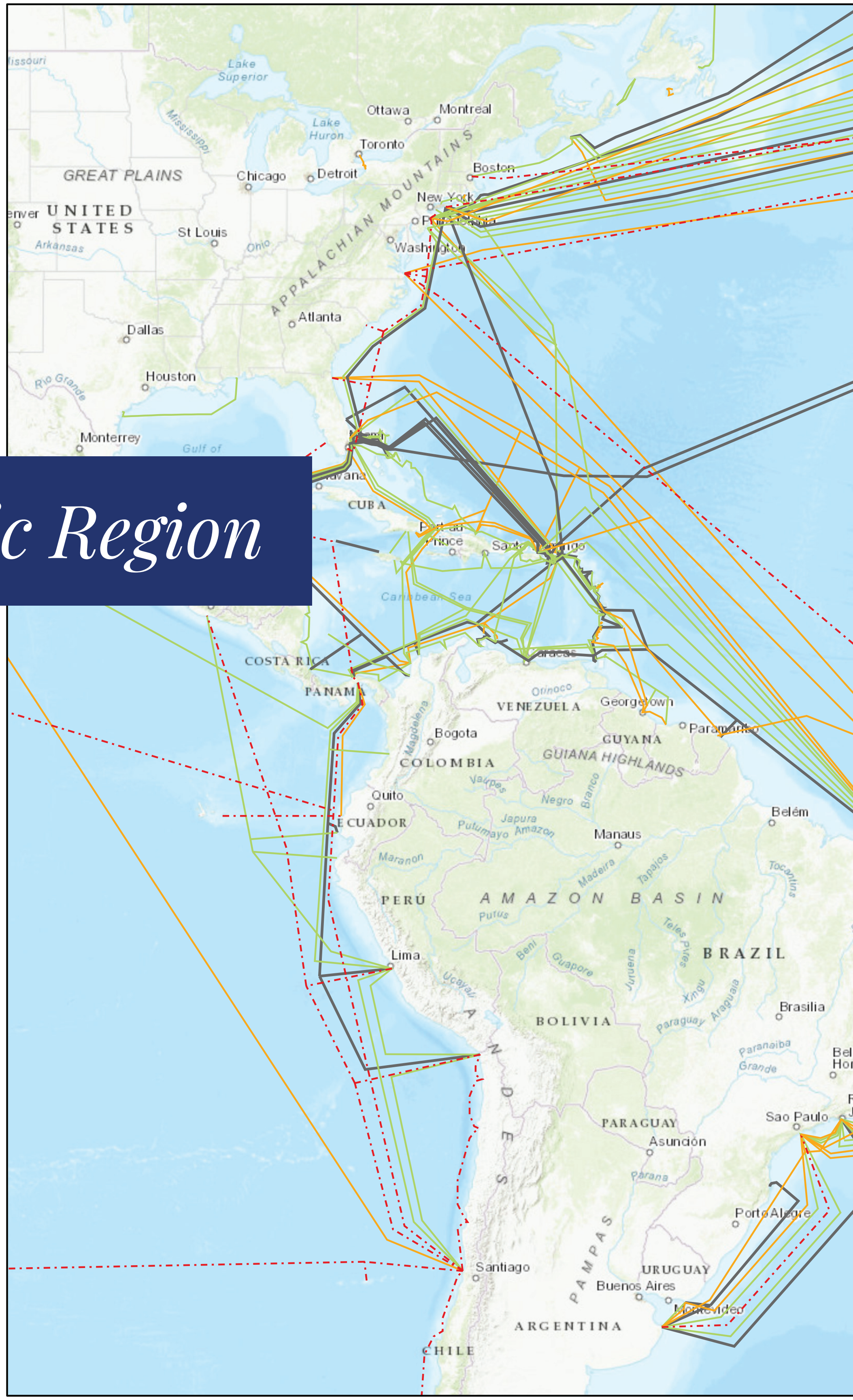
Regional Analysis and Capacity Outlook

Video 16: Michael Thornton, Data Analyst - Submarine Telecoms Forum, Inc.

The submarine fiber market continues to grow through 2021 at a similar rate to that observed since 2016. Some regions have begun to slow their pace with fewer systems planned beyond 2021, while other regions are seeing a substantial increase to their overall system count through to 2024. There are some overbuild concerns considering the rapid pace of system development over the last few years, but many cable systems that are reaching the end of their economic and technological lifespans and will need replacing.

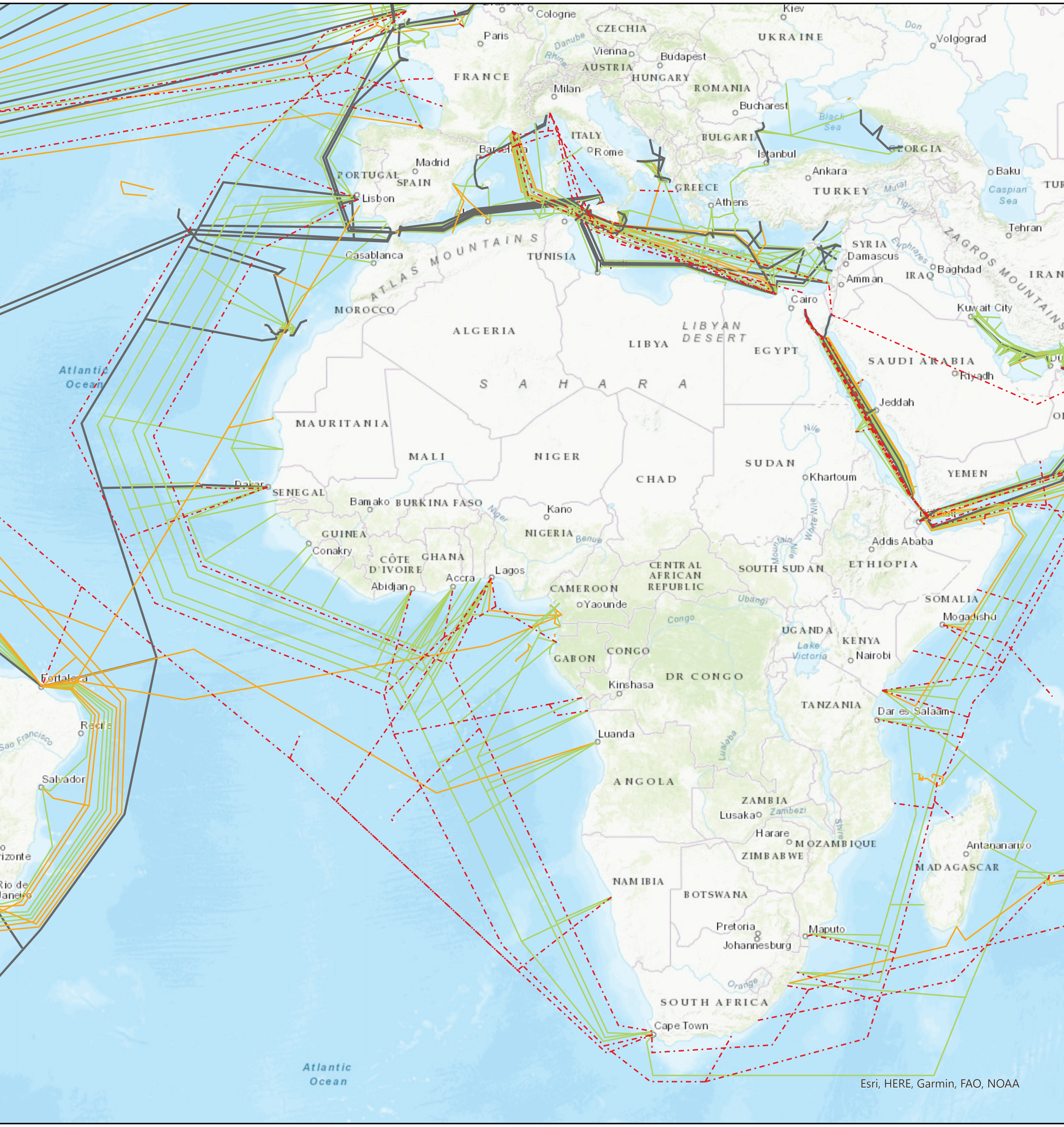
Business models around the world are changing, as more of the submarine fiber industry is driven by Hyperscaler infrastructure needs and the desire to connect data centers rather than population centers. The bulk of Hyperscaler infrastructure and major data center clusters are currently located in the United States, Europe, East Asia, and South America. As a result, the regions most affected by this trend are the Transatlantic, Transpacific, and Americas regions. (SubTel Forum Analytics Division of Submarine Telecoms Forum, Inc., 2020)

Transatlantic Region



REGIONAL SNAPSHOT:

Current Systems: 19
Capacity: 1609 Tbps
Planned Systems: 4
Planned Capacity: 131 Tbps


Cologne
Kiev
CZECHIA
UKRAINE
Paris
Volgograd
Danube
Rhine
Don
Vienna
Budapest
AUSTRIA
FRANCE
HUNGARY
Milan
ROMANIA
Bucharest
Black Sea
ITALY
BULGARIA
Rome
Barcelona
Istanbul
GEORGIA
Madrid
Ankara
Baku
PORTUGAL
SPAIN
GREECE
Lisbon
Caspian Sea
TURKEY
Athens
Tigris
Euphrates
Tehran
ATLAS MOUNTAINS
SYRIA
Damascus
Casablanca
TUNISIA
ZAGROS MOUNTAINS
Baghdad
IRAQ
IRAN
Amman
MOROCCO
Cairo
Kuwait City
ALGERIA
LIBYAN DESERT
LIBYA
EGYPT
Atlantic Ocean
SAUDI ARABIA
Riyadh
S A H A R A
Jeddah
MAURITANIA
Nile
MALI
NIGER
SUDAN
YEMEN
CHAD
Khartoum
Dakar
SENEGAL
Bamako
BURKINA FASO
Kano
Niger
White Nile
GUINEA
NIGERIA
Benue
Addis Ababa
Conakry
CÔTE D'IVOIRE
GHANA
CENTRAL AFRICAN REPUBLIC
SOUTH SUDAN
ETHIOPIA
Accra
Lagos
Abidjan
CAMEROON
Yaounde
Ubangi
SOMALIA
Mogadishu
Congo
UGANDA
KENYA
Lake Victoria
Nairobi
GABON
CONGO
Fortaleza
DR CONGO
Kinshasa
TANZANIA
Recife
Dar es Salaam
Sao Francisco
Luanda
Salvador
ANGOLA
ZAMBIA
Lusaka
Zambezi
Harare
MOZAMBIQUE
ZIMBABWE
Antananarivo
MADAGASCAR
NAMIBIA
BOTSWANA
Pretoria
Maputo
Johannesburg
Orange
SOUTH AFRICA
Cape Town
Atlantic Ocean
Esri, HERE, Garmin, FAO, NOAA

8.1.1 CURRENT SYSTEMS

Growth on the Transatlantic route skyrocketed from the late 1990s through 2003. After a 12-year drought, the Transatlantic region added a new cable every year from 2015 to 2018. After a brief respite in 2019, the Transatlantic region is back to pushing forward with strong momentum. (Figure 93)

Two major causes of the development slowdown were a glut of capacity and the financial crash of the early 2000s which was brought on by overinvestment in the submarine cable industry. With investment on the rise again, and systems aging out in the Transatlantic route, new systems are beginning to come online. The MAREA system installed in 2017 tapped into the exploding demand from Hyperscalers, with one of the key selling points being massive bandwidth available — 200 Tbps potential — on a modern submarine fiber system on a route full of aging cables. Additionally, this cable — along with the newly-created Dunant cable — provide an alternative path to increase route diversity, and more directly connect Europe to important data centers in Ashburn, Virginia. The SACS and SAIL cables installed in 2018 continue this push for alternative routes and connect South America and Africa directly. Finally, to further connect South America with other areas of the world, 2021 saw the addition of the EllaLink system that branches across other areas of the continent before traveling north to Europe.

Due to increasing capacity demands along the north Transatlantic between New York and Europe and the desire for new connections to the Mid-Atlantic of the United States and across the South Atlantic, the Transatlantic route has enjoyed steady growth.

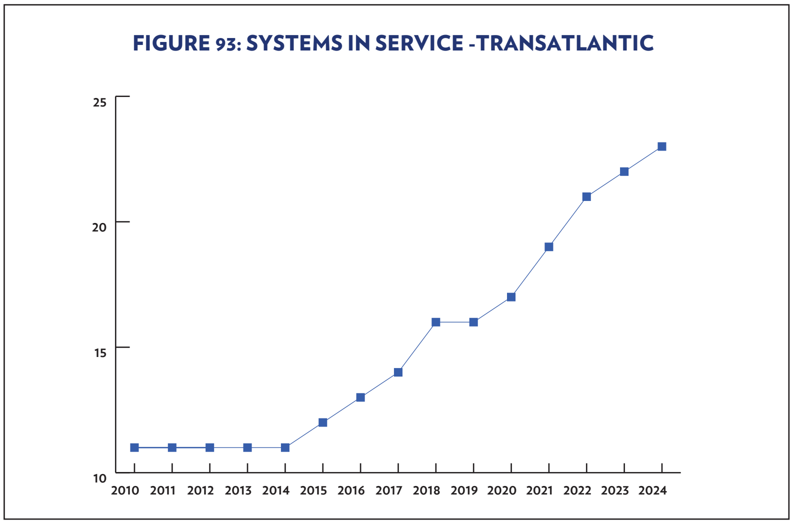


Figure 93: Systems in Service -Transatlantic

8.1.2 FUTURE SYSTEMS

During the initial boom of Transatlantic system development, the average system length was roughly 12,000 kilometers with most systems taking similar routes between Europe and the US.

While there was a notable rise in demand for routes away from the traditional New York-London, the announced Amitie and Grace Hopper cables will create an additional connection to this route. (Figure 94) The change in customer requirements from purely bandwidth to bandwidth and low latency has driven developers to plan routes averaging 18 percent shorter than previous systems from the early 2000s. Proposed systems claim to drop up

TABLE 2: TRANSATLANTIC SYSTEMS, 2010-PRESENT

RFS YEAR	SYSTEM	CAPACITY (TBPS)	LENGTH (KMS)
2015	GTT Express	53	4,600
2016	AEC-1	78	5,536
2017	MAREA	200	6,600
2018	SACS	40	6,209
2018	SAIL	32	6,000
2019	HAVFRUE/AEC-2	108	8,179
2021	Dunant	250	6,600
2021	EllaLink	72	9,300

to 20ms latency due to being shorter by an average of 2,000 kilometers in addition to providing much needed infrastructure. However, some of the proposed South Atlantic systems are considerably larger than the more traditional Transatlantic systems and will address different needs than the region is used to.

There are currently four planned systems set to be ready for service for the period 2022 to 2024 in the Transatlantic region. Two of these planned systems are along the northern route between Europe and the United States, further illustrating the desire to move away from traditional Transatlantic routes. The third planned system stretches from Virginia Beach, Virginia in the United States all the way to South Africa. Tech giants such as Facebook, Google, and Microsoft want connections between Europe and the Ashburn, Virginia, data centers, while other providers are looking to blaze entirely new trails. Lastly, the fourth cable's route remains unknown at this time.

Half of the four planned Transatlantic systems have achieved the all-important CIF milestone. (Figure 95) This indicates a certain unknown to the region's future in cable development; likely due to delays caused by the COVID-19 pandemic. ■

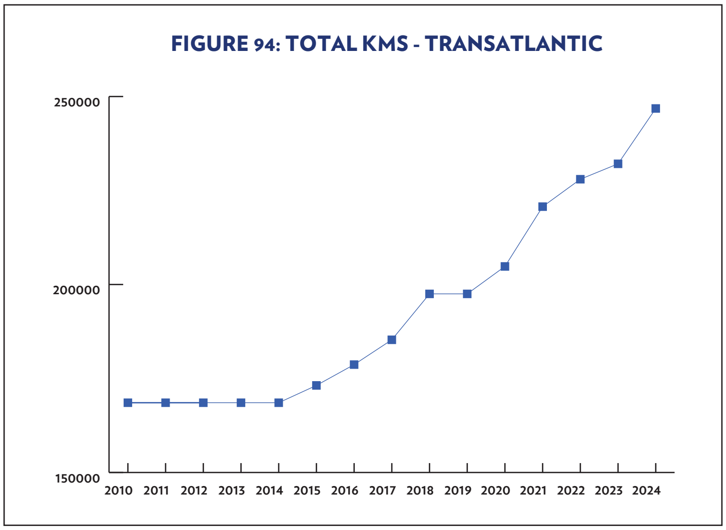


Figure 94: Total KMs - Transatlantic

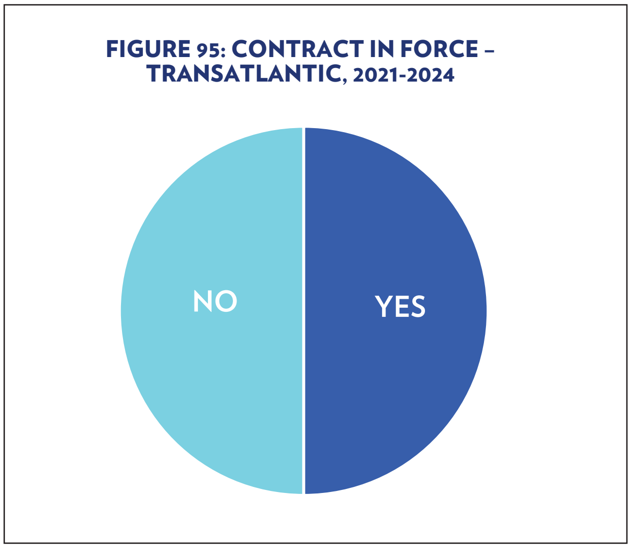


Figure 95: Contract in Force – Transatlantic, 2021-2024

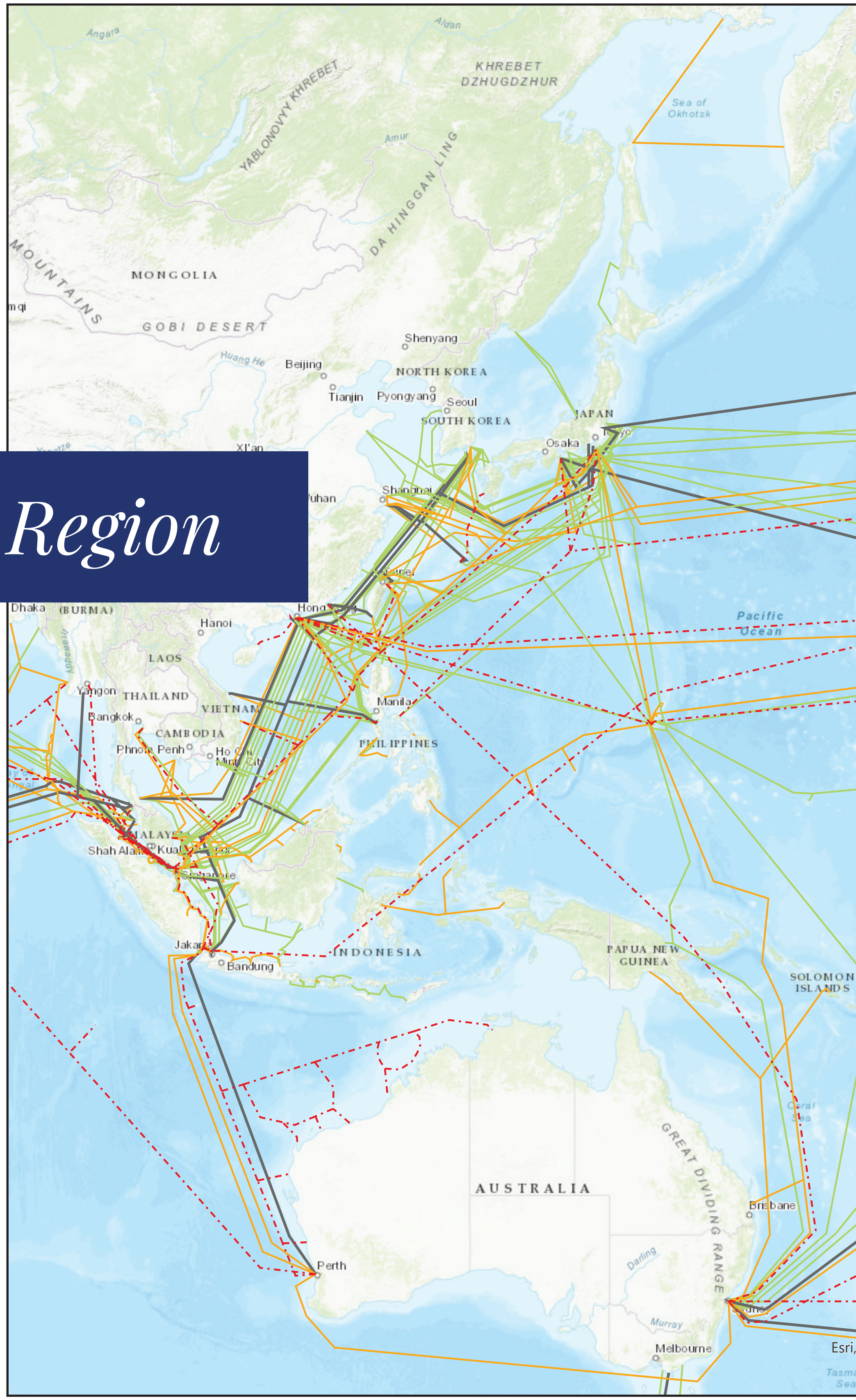
TABLE 3: TRANSATLANTIC PLANNED SYSTEMS

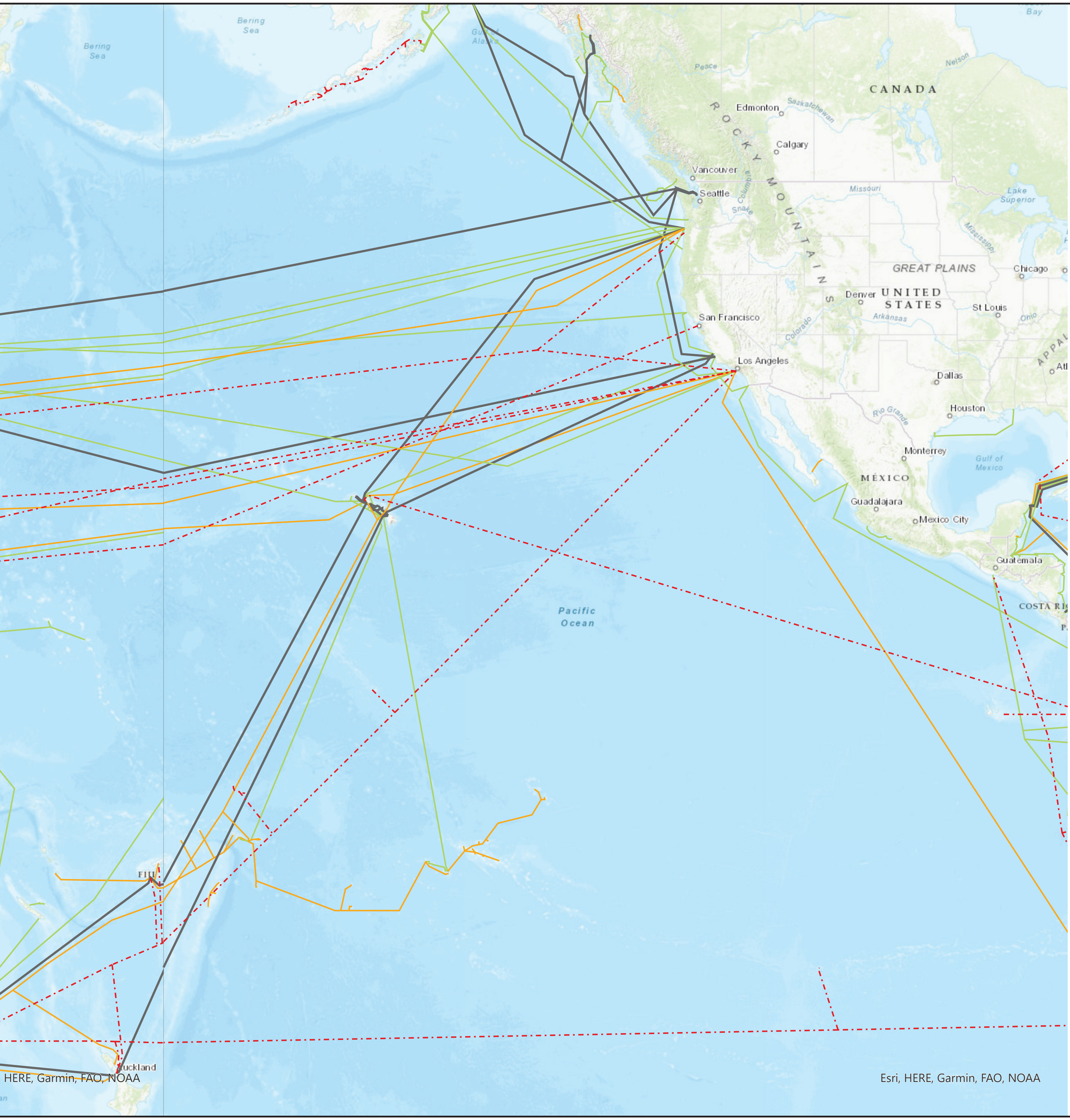
RFS YEAR	SYSTEM	CAPACITY (TBPS)	LENGTH (KMS)
2022	Amitie	23	7,292
2022	Grace Hopper	-	-
2023	Leif Erikson	-	4,100
2024	SAEx1	108	14,720

Transpacific Region

REGIONAL SNAPSHOT:

Current Systems: 13
Capacity: 657 Tbps
Planned Systems: 8
Planned Capacity: 392 Tbps




Bering Sea
Bering Sea
CANADA
Edmonton
Calgary
Vancouver
Seattle
ROCKY MOUNTAINS
GREAT PLAINS
UNITED STATES
Chicago
Denver
St Louis
San Francisco
Los Angeles
Dallas
Houston
Monterrey
MÉXICO
Guadalajara
Mexico City
Guatemala
Gulf of Mexico
Pacific Ocean
FIJI
Auckland
Esri, HERE, Garmin, FAO, NOAA
HERE, Garmin, FAO, NOAA

8.2.1 CURRENT SYSTEMS

The Transpacific market has been like that of the Transatlantic in recent years, showing relatively little growth year-upon-year. New systems have been added sporadically, however most of the capacity increases have been from upgrades. Lately, Hyperscalers and those seeking route diversity have been driving new system growth.

From 2002 to 2016, only four systems were added to the region. (Figure 96) The industry crash of the early 2000s certainly played a large part in this limited growth, but the fact that there had been no new systems on the Transpacific routes from 2010 to 2016 is largely due to existing systems being able to upgrade their capacity for relatively little cost and push potential competitors out of the market.

As with the Transatlantic market, until very recently the Transpacific has been almost fully saturated, with little room for growth other than route diversity and cutting down on existing latency. Lately, however, new systems are being explored in a similar manner to the Transatlantic with the region seeing at least one new cable every year since 2016, with a similar respite in 2019. Demand from Hyperscalers and desire for route diversity are the primary drivers behind these newer Transpacific systems. As a result, several new systems are planned through to 2024.

Video 17: Laurie Miller, President and Chief Executive Officer - Southern Cross Cable Network

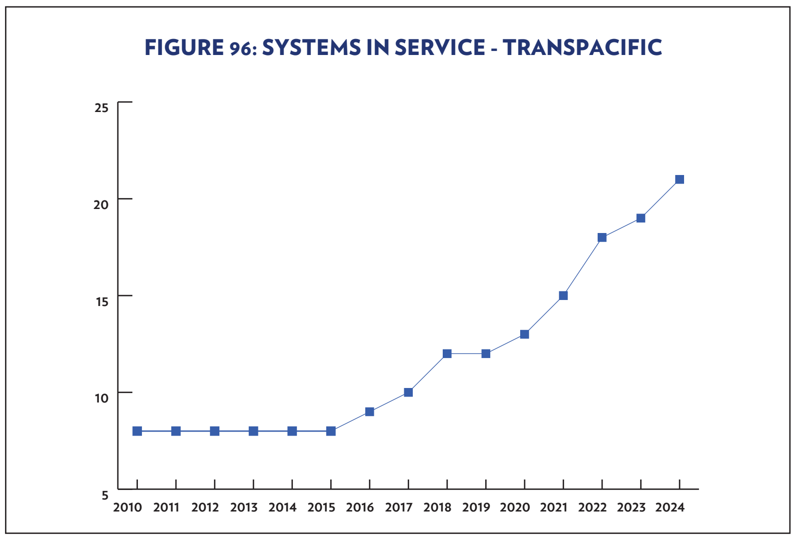


Figure 96: Systems in Service - Transpacific

TABLE 4: TRANSPACIFIC SYSTEMS, 2010-PRESENT

RFS YEAR	SYSTEM	CAPACITY (TBPS)	LENGTH (KMS)
2010	Unity	76.8	9,486
2016	Faster	60	9,000
2017	SEA-US	20	15,400
2018	Hawaiki	67	15,000
2018	NCP	80	13,618
2020	PLCN	144	12,900

8.2.2 FUTURE SYSTEMS

No systems were added at all to this region from 2010 to 2016. Since then, the region has experienced steady growth with at least one system added each year for the period 2016 to 2020 and eight systems planned through 2024.

The amount of cable in the region increased by 31 percent during this period of growth - adding over 60,000 kilometers of cable. (Figure 97) Average system length in the region is just over 16,400 kilometers, owing to the Transpacific region having some of the longest routes in the world. Between the massive systems required to span the region, and the easy availability of cheap capacity upgrades, the historically static nature of the region comes as no surprise. Recently, however, there has been a noticeable uptick in system activity.

There are currently eight planned systems set to be ready for service for the period 2021 to 2024 and 50 percent of them have achieved the CIF milestone – up significantly from last year's 27 percent. (Figure 98) Nearly all these systems are trying to bring large capacity increases along their respective routes, but many of them are directly competing along the same or similar routes. With the average system length of all planned systems for the Transpacific market remaining around 12,700 kilometers.

These new systems provide a bonus of increased route diversity – especially along the southern part of the region. A few of the systems that are not yet CIF are backed by Hyperscalers. This takes them out of direct competition with other planned systems and removes some of the financial risk from having to sign on outside investors. ■

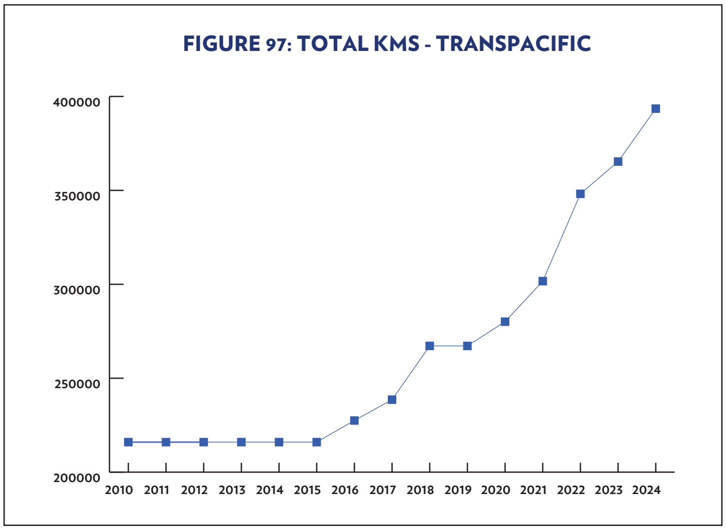


Figure 97: Total KMs - Transpacific

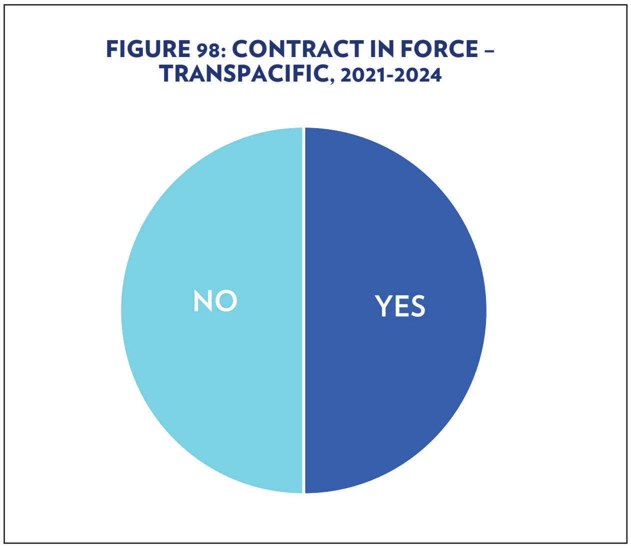


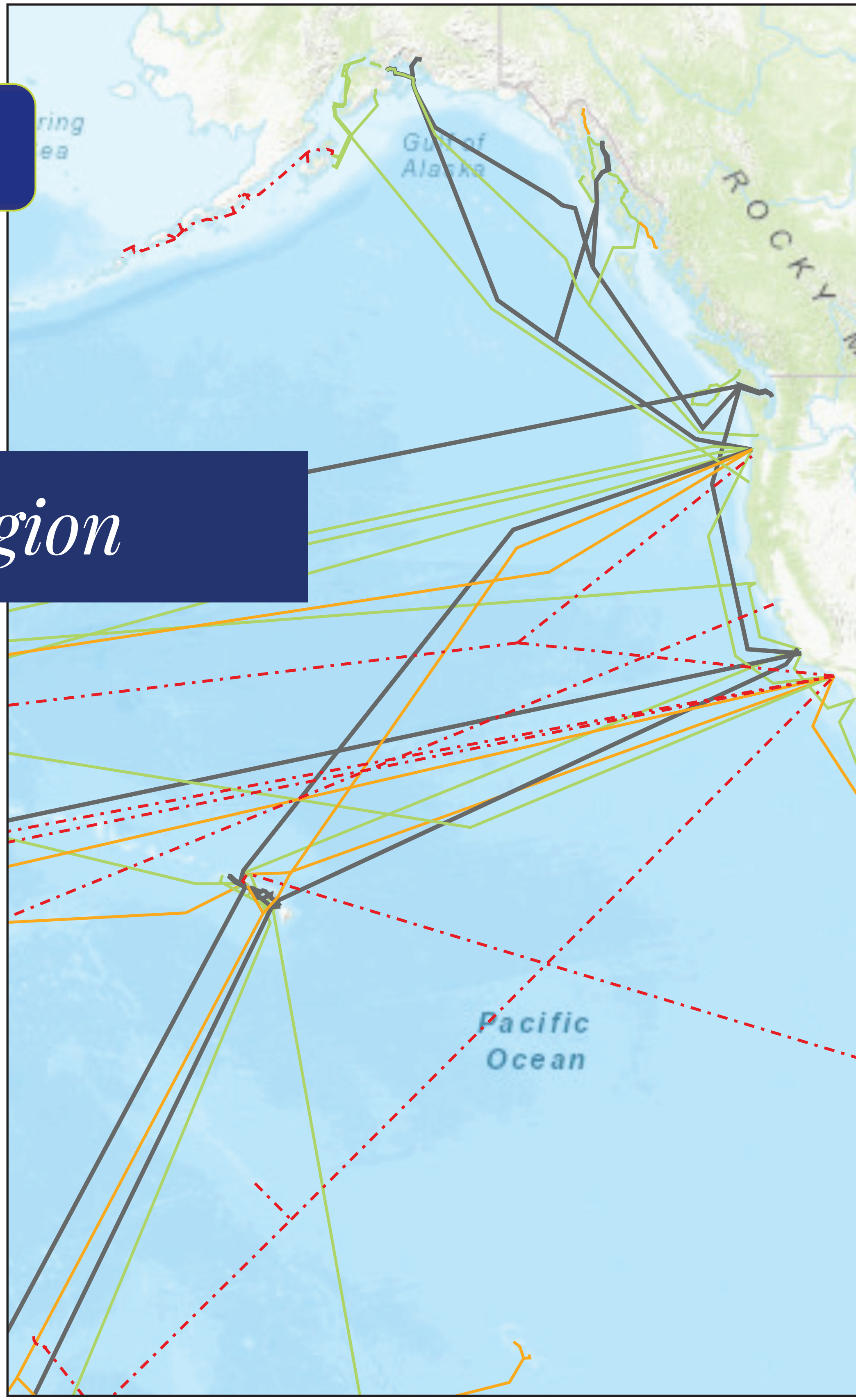
Figure 98: Contract in Force – Transpacific, 2021-2024

TABLE 5: TRANSPACIFIC PLANNED SYSTEMS

RFS YEAR	SYSTEM	CAPACITY (TBPS)	LENGTH (KMS)
2021	Jupiter	60	14,577
2021	TOPAZ	-	7,000
2022	H2 Cable	20	10,500
2022	Southern Cross NEXT	72	13,483
2022	SxS	96	10,500
2023	Echo	144	17,184
2024	Bifrost	-	15,000
2024	HCS	-	13,180

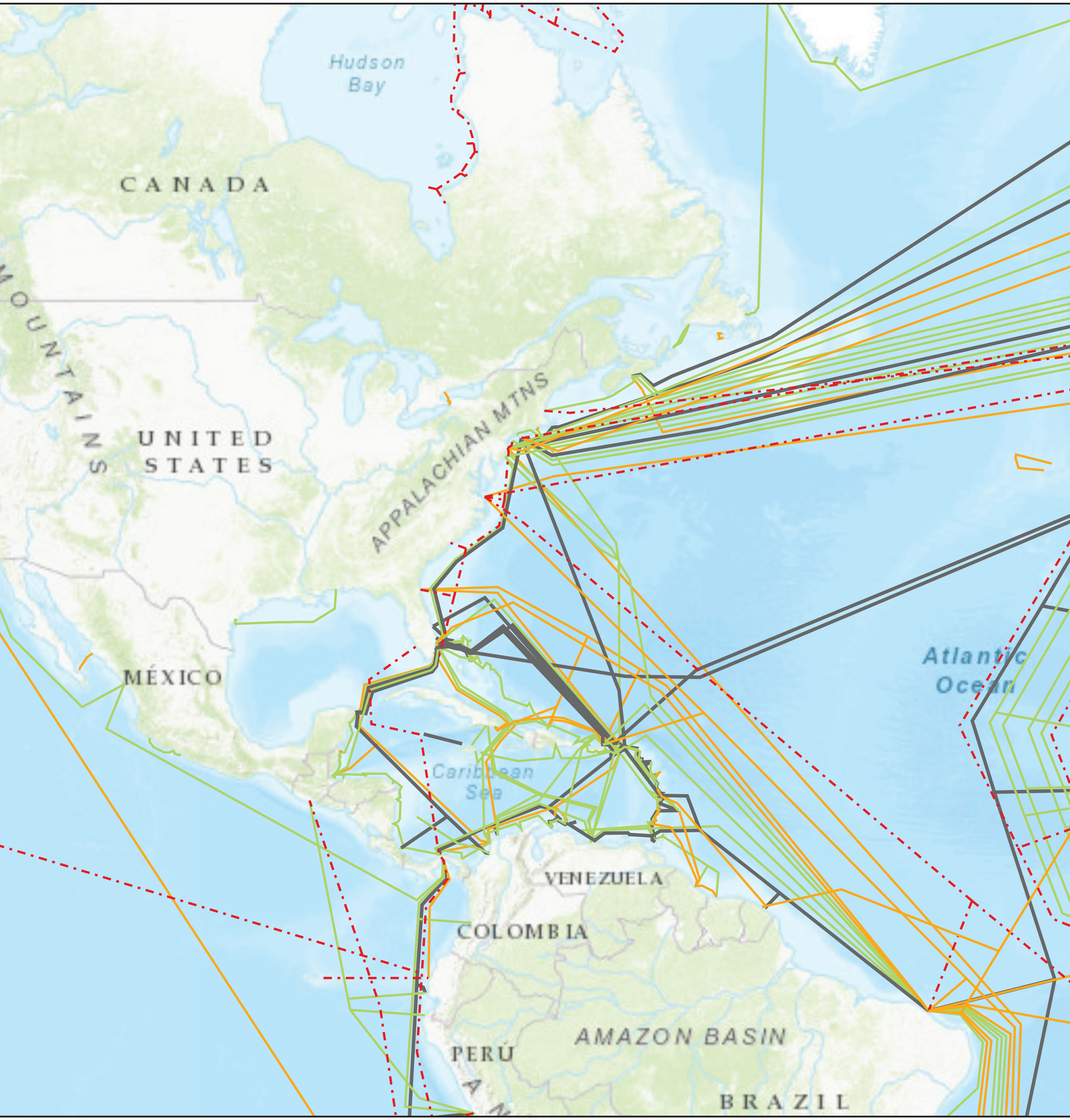
EllaLink

Americas Region



REGIONAL SNAPSHOT:

Current Systems: 84
Capacity: 1,086 Tbps
Planned Systems: 10
Planned Capacity: 588 Tbps


Hudson Bay
CANADA
UNITED STATES
APPALACHIAN MTNS
MÉXICO
Caribbean Sea
Atlantic Ocean
VENEZUELA
COLOMBIA
AMAZON BASIN
PERÚ
BRAZIL

8.3.1 CURRENT SYSTEMS

Characterized by steady growth since the early 1990s, the Americas region has continued to enjoy frequent additions over the last 10 years – going from 40 cables in 2008 to 69 cables in 2018.

After 10 years of steady growth, with an average of about two systems being ready for service per year, the region is currently undergoing another boom in development with five systems implemented in 2017, seven systems in 2019, five more in 2020, and six additional systems planned to be ready for service by the end of 2021. (Figure 99)

Video 18: Patricio Rey, General Manager - Desarrollo Pais

8.3.2 FUTURE SYSTEMS

Unlike most of the other markets, the Americas region has consistently observed medium to high levels of growth.

Since 2005, new cable development has consistently added an average of roughly 5 percent more kilometers per year. Breaking from this average, there was a 7 percent increase in 2009, a 10 percent increase in 2014, an 11.7 percent increase in 2017 and a 6 percent increase in 2019. By and large, the region has seen steady growth until 2017 when an unprecedented 11.7 percent growth rate was observed. Looking forward, this higher-than-average growth rate will not continue through to 2024, with the number of kilometers for 2022 only resulting in a 0.9 percent increase in kilometers added due to several new systems currently planned that are relatively short for 2022 and beyond. (Figure 100)

There are currently ten systems planned through to 2024 and 40 percent of those cables have achieved their CIF milestone. (Figure 101) The last few years have been relatively busy compared to historical trends for the Americas region and may have satisfied infrastructure needs for now. With a development rate that has remained steady since 2001, productivity in 2022 will be on par with historical norms should most of these planned systems come into force. However,

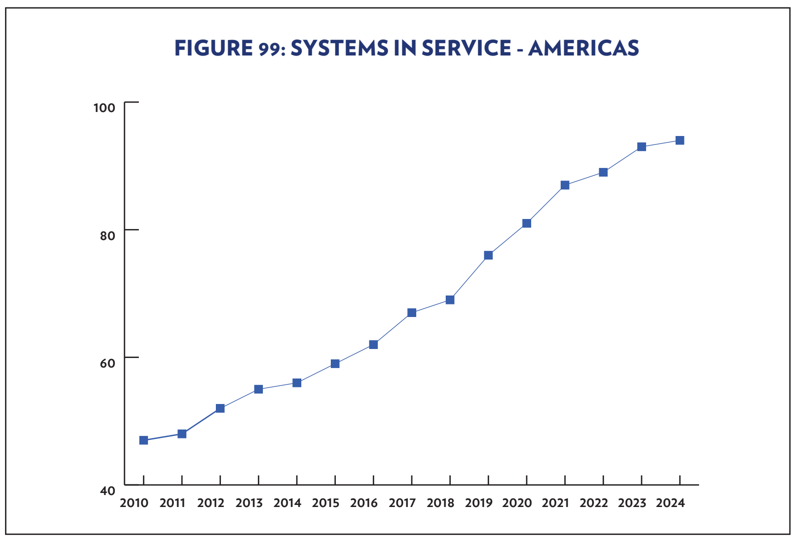


Figure 99: Systems in Service - Americas

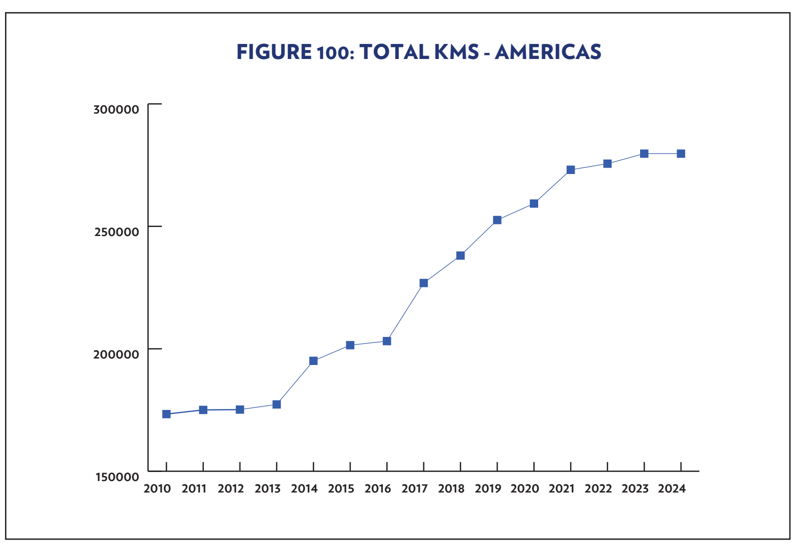


Figure 100: Total KMs - Americas

TABLE 6: AMERICAS SYSTEMS, 2010-PRESENT

RFS YEAR	SYSTEM	CAPACITY (TBPS)	LENGTH (KMS)
2010	Antel	3.84	250
2010	SAIT		826
2010	SG-SCS	1.28	1,249
2011	East-West	2.5	1,700
2012	AUTA		53
2012	Estrecho de Magallanes	1.8	37
2012	TERRA SW		
2012	TT-1		48
2013	ALBA-1	5.12	1,600
2013	LCMSSCS		322
2013	Saint Thomas - Saint Croix System		183
2014	AMX-1	50	17,800
2015	FOS Quellon-Chacabuco		350
2015	PCCS	45	6,000
2015	Segunda FOS Canal de Chacao		40
2016	Guantanamo Bay Cable		1,500
2016	Lynn Canal Fiber		138
2016	Sea2Shore		32
2017	Junior		390
2017	Monet	60	10,556
2017	Seabras-1	72	10,750
2017	SEUL		24
2017	Tannat	90	2,000
2018	BRUSA	160	11,000
2018	Saint Pierre and Miquelon Cable		200
2019	CARCIP		225
2019	Crosslake Fibre		62
2019	Curie	72	10,500
2019	Guantanamo Bay Cable 2		1,200
2019	Kanawa	10	1,746
2019	Redellhabela-1		3
2019	X-Link Submarine Cable		775
2020	FOA	16	2,900
2020	GCIS		118
2020	KetchCan1		160
2020	Prat	9.6	3,550
2020	Tannat Extension	90	
2021	Curie Panama Extension	72	1,073
2021	Malbec		2,600
2021	SPSC/Mistral	132	7,300

the next 12 to 18 months are busy for the industry at large as suppliers work to catch up from the impact of COVID-19. With a finite number of cable ships to accomplish so many projects, several systems for this region could end up being delayed a year or more.■

FIGURE 101: CONTRACT IN FORCE – AMERICAS, 2021-2024

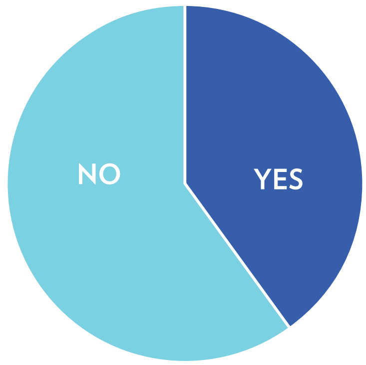


Figure 101: Contract in Force – Americas, 2021-2024

TABLE 7: AMERICAS PLANNED SYSTEMS

RFS YEAR	SYSTEM	CAPACITY (TBPS)	LENGTH (KMS)
2021	ARBR	48	2,700
2021	Connected Coast	-	-
2021	WALL-LI	-	125
2022	Ecuador - Galapagos Islands	20	1,280
2022	GigNet-1	-	1,200
2023	AU-Aleutian Cable System	-	860
2023	Boriken Submarine Cable System	-	670
2023	Confluence-1	500	2,571
2023	Firmina	-	-
2024	Caribbean Express	20	-

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Latency combined with Diversity

Low latency - Diverse - High Availability

100 TBPS
25 Tbps capacity direct from Europe to Latin America per Fibre Pair

Winner
Best project of the year subsea networks Global Carrier Awards 2019 & 2020

10 POPs
Presence in 6 data centers and 4 cable landing stations

<60 ms RTD
To cross the Atlantic connecting Portugal and Brazil

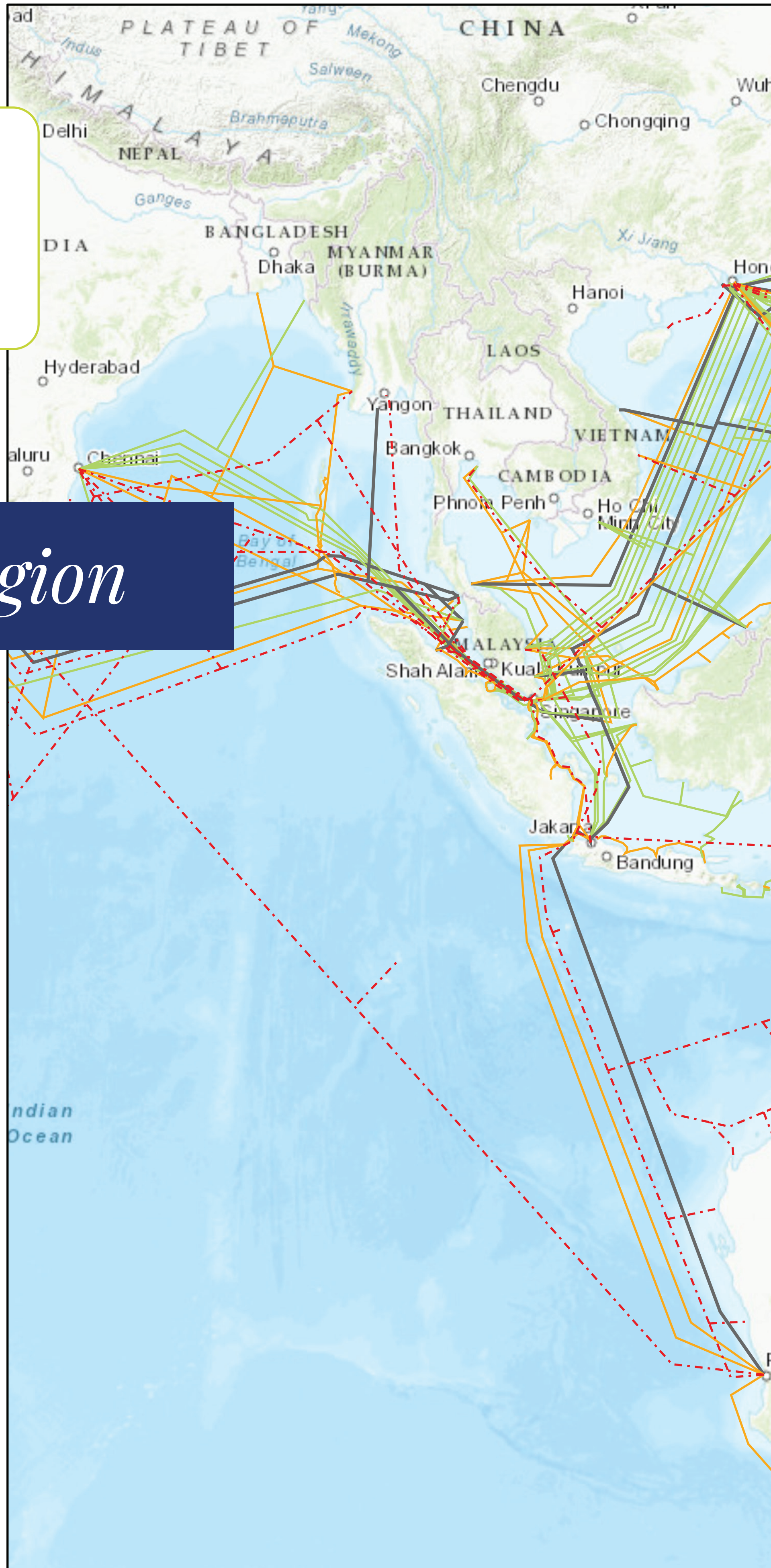
<135ms RTD
Between Marseille and São Paulo

Seamless Pop to Pop Connectivity
10G/100G low latency Capacity & scalable Spectrum services

190 TBPS
Landing in Sines, Portugal

EllaLink GeoLab
Open scientific project leading the SMART cables innovation revolution

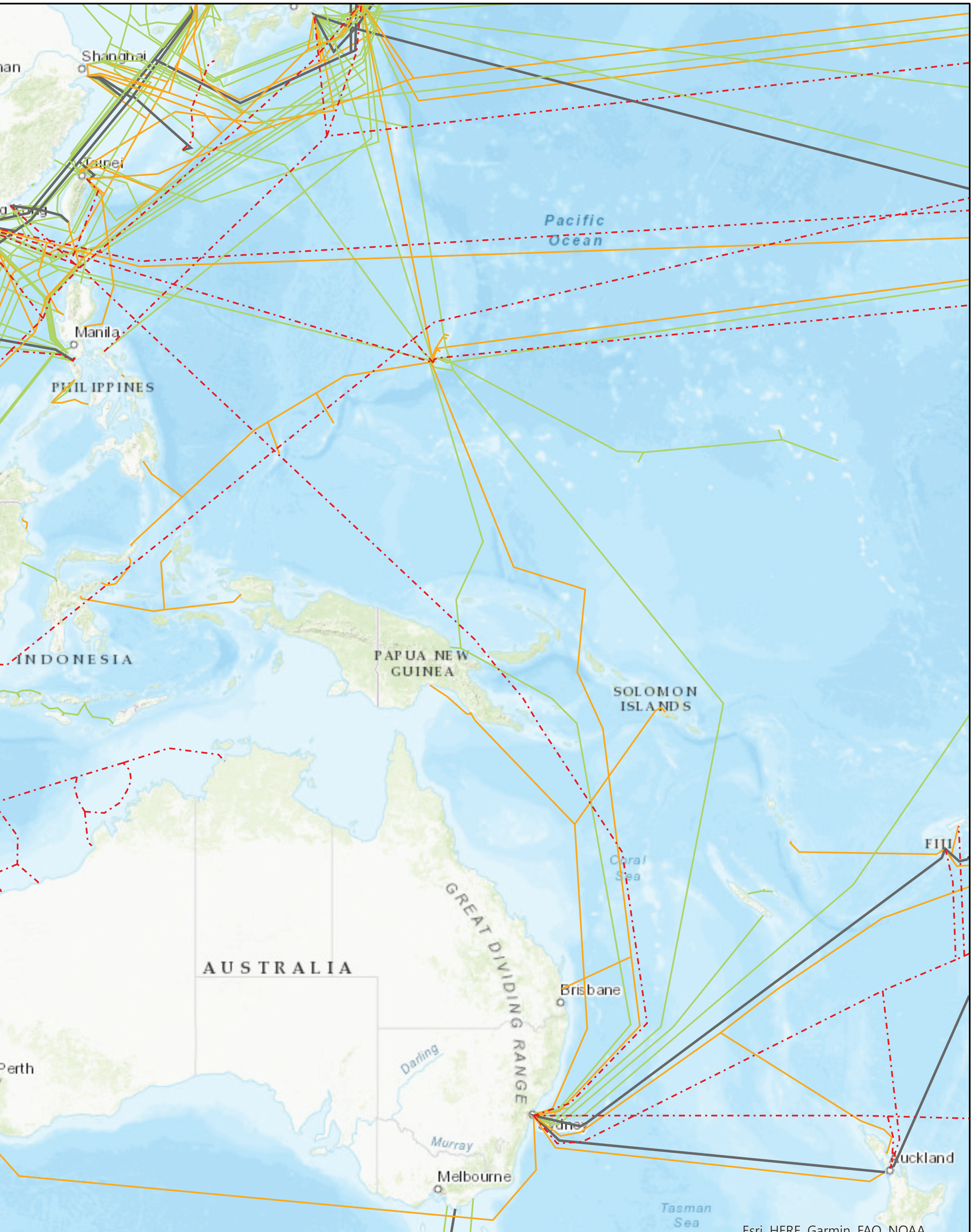
Proven Diversity
Totally diverse transatlantic route, beach landings, and terrestrial routes



AustralAsia Region

REGIONAL SNAPSHOT:

Current Systems: 100
Capacity: 833 Tbps
Planned Systems: 12
Planned Capacity: 431 Tbps



Shanghai
Taipei
Manila
PHILIPPINES
Pacific
Ocean
INDONESIA
PAPUA NEW
GUINEA
SOLOMON
ISLANDS
Coral
Sea
FIJI
AUSTRALIA
GREAT DIVIDING RANGE
Brisbane
Perth
Darling
Murray
Melbourne
Auckland
Tasman
Sea
Esri, HERE, Garmin, FAO, NOAA

8.4.2 CURRENT SYSTEMS

The AustralAsia market has been characterized by a massive amount of growth in a relatively short amount of time. Since 2008, it has been one of the busiest regions in the entire world – only seeing three years with reduced expansion, from 2010 to 2012.

Growth from 2001 to 2005 was negligible, and while there was a moderate amount of activity in 2006, the real growth spurt occurred from 2008 to 2009. (Figure 102) The biggest factor contributing to growth in the region is emerging markets in Southeast Asia, with countries such as Indonesia, Singapore, and Hong Kong being the recipients of new data center growth as mentioned in section 1.5 of this report.

The industry crash of the early 2000s certainly influenced the later timing of the region's boom, but the rising markets of Southeast Asia and their ardent desire for international connectivity largely overrode such concerns. The widespread adoption of mobile and cloud services throughout the region combined with the recent surge of data center and Hyperscaler driven

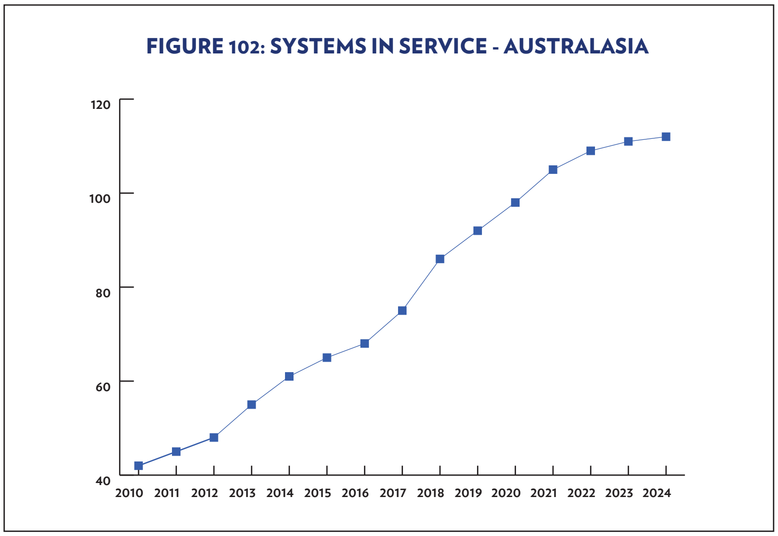


Figure 102: Systems in Service - AustralAsia

TABLE 8: AUSTRALASIA SYSTEMS, 2010-PRESENT

RFS YEAR	SYSTEM	CAPACITY (TBPS)	LENGTH (KMS)
2010	Hantru-1	-	2,908
2010	JaKa2DeLeMa	9.6	1,800
2010	PGASCOM		264
2011	BDM	2.56	400
2011	MKCS	1.8	1,318
2011	SCAN	1.92	4,300
2012	B3JS	-	1,031
2012	Cross Straits Cable Network	-	21
2012	Tonga-Fiji	-	827
2013	ASE	15.36	7,200
2013	Boracay-Palawan	4.8	332
2013	GOKI	0.08	4,200
2013	JBCS	-	40
2013	SJC	28	8,986
2013	TPKM-3	-	-
2013	TSE-1	6.4	270
2014	ICN1	0.32	1,259
2014	JIBA	-	267
2014	Palawa-Iloilo Cable System	-	300
2014	PNG LNG	-	200

2014	TSCS	-	83
2014	Western Visayas-Palawan	-	300
2015	BLAST	-	250
2015	Far East	1.6	1,844
2015	LTCS	-	446
2015	SMPCS	40	2,000
2016	APG	54	10,400
2016	BALOK	-	50
2016	NWCS	12	2,100
2017	ATISA	7.2	280
2017	LBC	9.6	52
2017	MCT	30	1,425
2017	Palapa W	-	1,725
2017	SEA-ME-WE 5	36	20,000
2017	SKR1M	6	3,500
2017	Tasman Global Access	20	2,300
2018	ASC	60	4,600
2018	IGG	-	5,300
2018	JAYABAYA	-	915
2018	NATITUA	10	2,500
2018	Palapa E	-	6,878
2018	Palapa M	-	1,600
2018	SEAX-1	-	250
2018	SSSFOIP	-	21
2018	SUSP	-	127
2018	TDCE	40	390
2018	Tui Samoa	17.6	1,410
2019	Chuuk-Pohnpei Cable	-	1,200
2019	Coral Sea	20	4,700
2019	Indigo Central	36	4,850
2019	Indigo West	36	4,600
2019	PASULI	-	40
2019	Tanjung Pandan-Sungai Kakap Cable	-	348
2020	DAMAI Cable System	-	575
2020	JGA North	24	2,700
2020	JGA South	36	7,000
2020	KSCN	-	5,457
2020	Manatua One	10	3,634
2020	Okinawa Cellular Cable	80	760
2021	H2HE	19.2	700
2021	MSC	0.1	840

systems promises to sustain growth in the region for the foreseeable future.

8.4.3 FUTURE SYSTEMS

After the huge growth spurt from 2008 to 2009, the AustralAsia market has seen a steady amount of growth in the amount of cable added per year.

Since 2010, the region has seen an average of 13,400 kilometers added per year, with an average system length of 2,350 kilometers. As submarine cable systems typically require a two-year development cycle from the time they are announced, it is unlikely many systems will be announced for 2023 by the end of this year, and any further system development will occur in 2024 or later. (Figure 103)

There are currently twelve planned systems set to be ready for service for the period 2021 to 2024. Two of these cables are relatively smaller projects, connecting island nations to major hubs while the other cables span large swathes of the region or are backed by Hyperscalers. Of these planned systems, 42 percent are considered CIF – a slight decrease from last year's 55 percent. (Figure 104) This continual decline in CIF rate indicates that the growth rate for the region's immediate future may not be sustainable. However, some of these systems may be delayed due to supplier and installer availability constraints from the impacts of the COVID-19 pandemic. ■

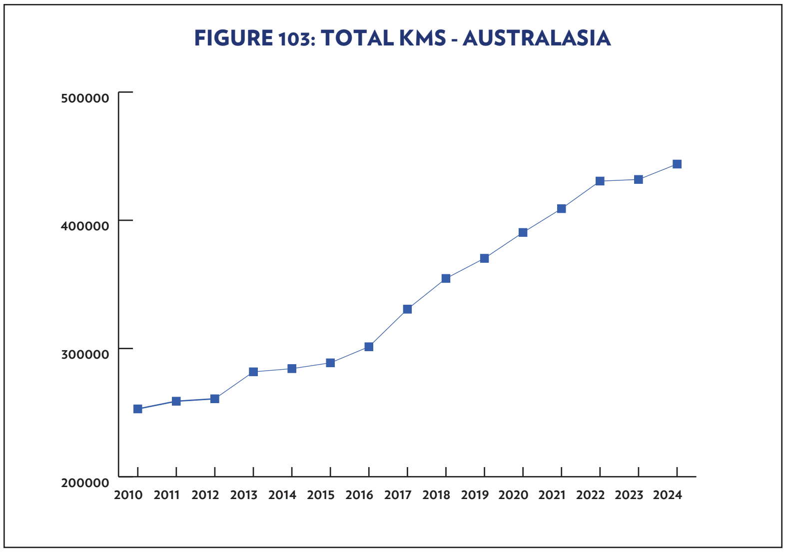


Figure 103: Total KMs - AustralAsia

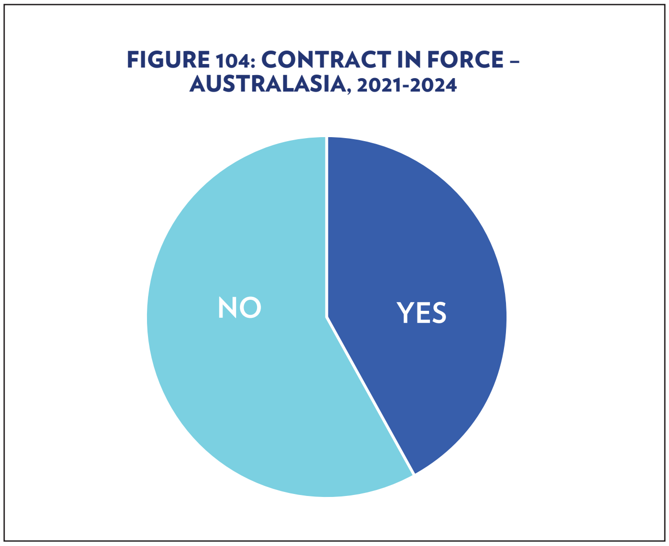


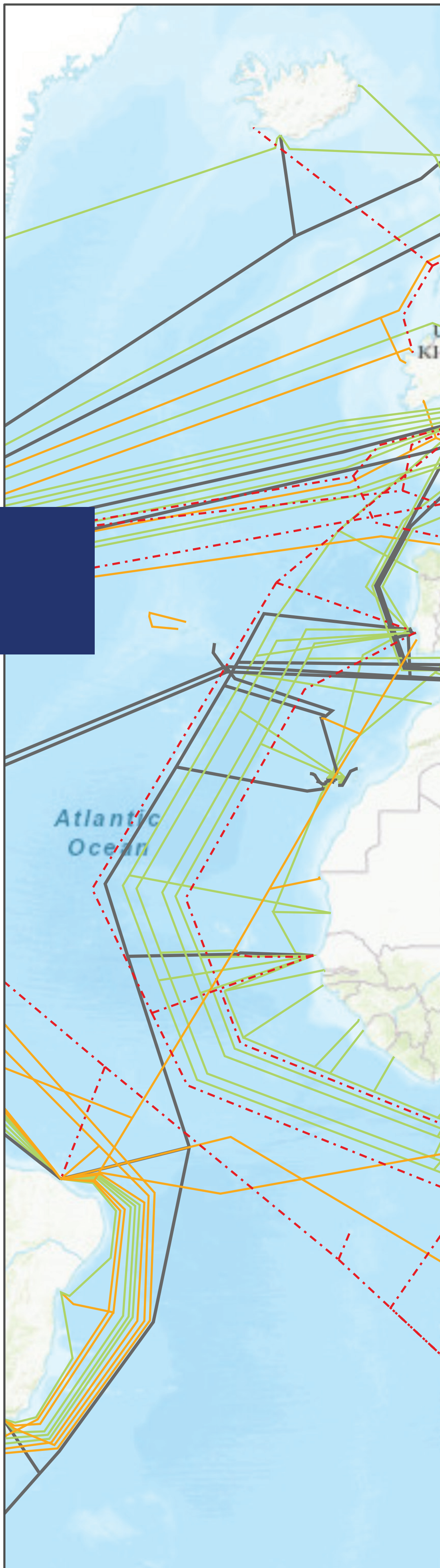
Figure 104: Contract in Force – AustralAsia, 2021-2024

TABLE 9: AUSTRALASIA PLANNED SYSTEMS

RFS YEAR	SYSTEM	CAPACITY (TBPS)	LENGTH (KMS)
2021	BaSICS	-	762
2021	Converge ICT Domestic Submarine Cable	-	1,824
2021	HK-G	48	3,700
2021	SJC2	144	10,500
2021	Tokelau Submarine Cable	-	250
2022	ADC	140	9,400
2022	OAC	39	9,800
2022	SIGMAR	-	2,200
2022	Timor-Leste Australia Cable	-	-
2023	Labuan Bajo-Raba	-	155
2023	Project Koete	60	800
2024	Apricot	-	12,000

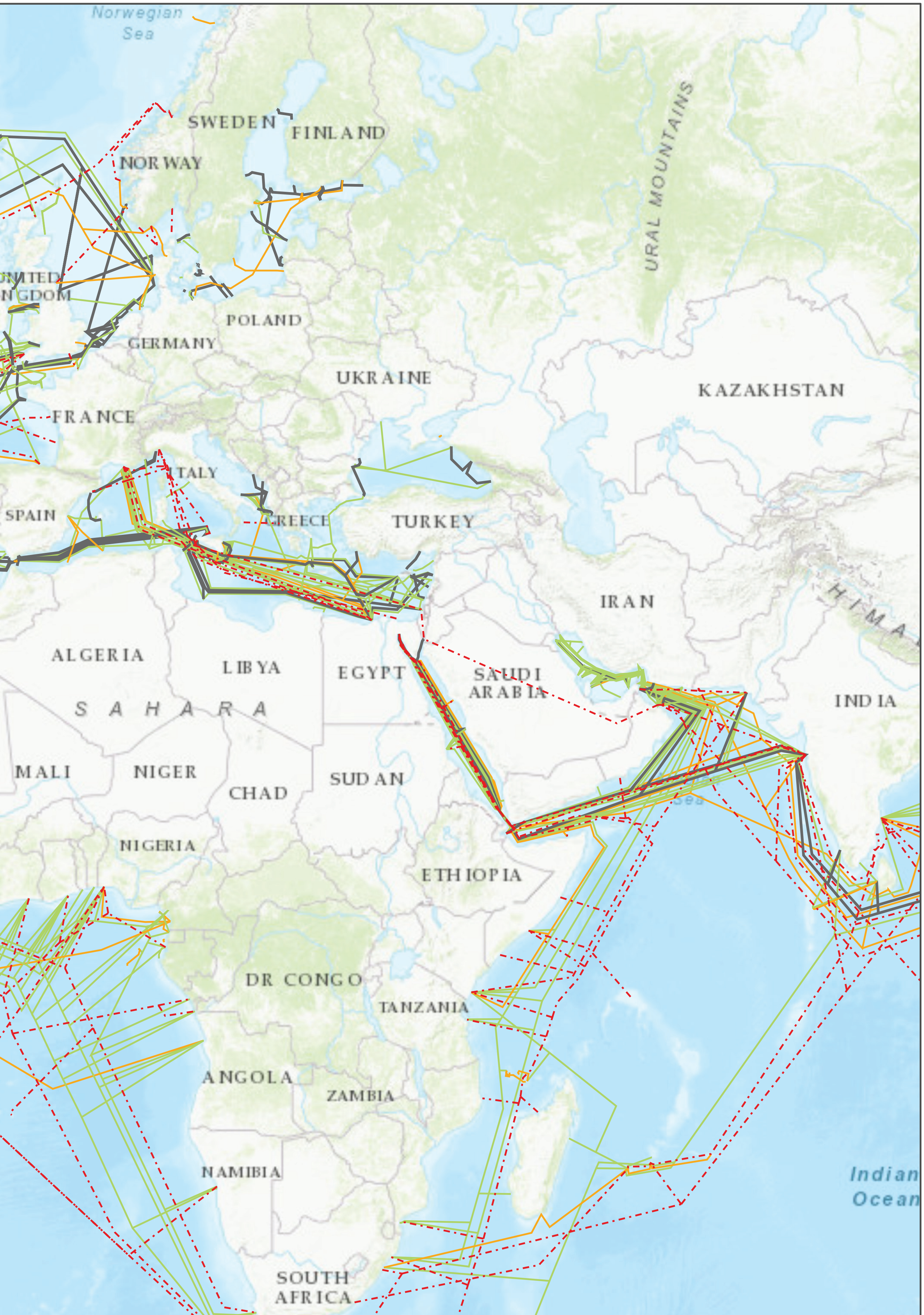

The power of connectivity
begins with us and
continues with you

EMEA Region



REGIONAL SNAPSHOT:

Current Systems: 183
Capacity: 3,256 Tbps
Planned Systems: 24
Planned Capacity: 3,218 Tbps


Norwegian Sea
SWEDEN
FINLAND
NORWAY
URAL MOUNTAINS
UNITED KINGDOM
POLAND
GERMANY
UKRAINE
KAZAKHSTAN
FRANCE
ITALY
SPAIN
GREECE
TURKEY
IRAN
HIMA
ALGERIA
LIBYA
EGYPT
SAUDI ARABIA
SAHARA
INDIA
MALI
NIGER
CHAD
SUDAN
NIGERIA
ETHIOPIA
DR CONGO
TANZANIA
ANGOLA
ZAMBIA
NAMIBIA
SOUTH AFRICA
Indian Ocean

8.5.1 CURRENT SYSTEMS

Characterized by steady growth since the early 1990s, Europe, the Middle East and Africa have all seen an increase in development over recent years. This has been one of the most consistent growth regions in the world, owing to its size as well as the important "crossroads" of the Mediterranean Sea and the Suez Canal.

While system count has remained relatively steady – with an average of five systems ready for service every year since 2002; 2011 seeing the largest surge of 14 new systems – the actual lengths of these systems can vary. (Figure 105) The primary factor behind these growth spurts are the SEA-ME-WE systems, as well as large coastal systems ringing Africa.

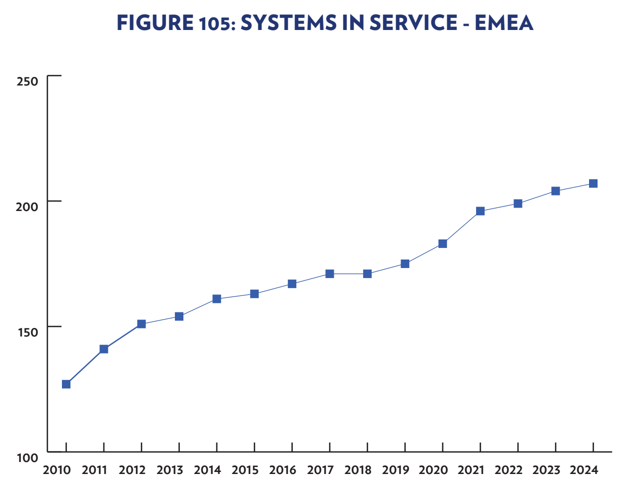


Figure 105: Systems in Service - EMEA

TABLE 10: EMEA SYSTEMS, 2010-PRESENT

RFS YEAR	SYSTEM	CAPACITY (TBPS)	LENGTH (KMS)
2010	Alexandros	10	3,634
2010	EASSy	11.8	9,900
2010	GLO-1	2.5	8,717
2010	I-ME-WE	76.8	12,091
2010	MainOne	10	7,000
2010	Tobruk-Emased	25.6	180
2010	Tverrlinken	-	-
2011	Athena	-	600
2011	BIOS / Jonah	12.8	2,300
2011	Canalink	5.12	2,000
2011	Ceiba-1	-	287
2011	CeltixConnect	0.96	131
2011	Energinet Laeso-Verberg	-	-
2011	Energinet Lyngsa-Laeso	-	-
2011	GBICS	51.2	4,719
2011	Hawk Cable System	2.72	3,181
2011	Pencan-8	-	1,400
2011	SAS-2	-	330
2011	TE North	20	2,938
2011	TGN Gulf	1.28	2,306
2011	Turcyos-2	-	213
2012	ACE	20	17,000
2012	Alasia	25.6	350

2012	Emerald Bridge Fibres	-	120
2012	Geo-Eirgrid	-	187
2012	Libreville-Port Gentil Cable	-	198
2012	POI	-	400
2012	Silphium	1.2	426
2012	Solas	0.005	140
2012	Tamares North	-	345
2012	WACS	14.5	14,350
2013	Europa	-	0
2013	OMRAN/EPEG Cable System	-	600
2013	Scotland-Orkney-Shetland	-	400
2014	BT Highlands and Islands Submarine Cable System		402
2014	Didon	18	173
2014	Flores-Corvo	0.96	685
2014	Isles of Scilly Cable	-	-
2014	Kerch Strait Cable	-	46
2014	MENA	57.6	8,800
2014	Skagerrak 4	-	137
2015	Malta-Italy Interconnector	-	95
2015	NCSCS	12.8	1,100
2016	Avassa	-	260
2016	Bodo-Rost Cable	-	109
2016	C-Lion 1	144	1,172
2016	NordBalt	-	400
2017	AAE-1	80	25,000
2017	Ceiba-2	24	290
2017	Greenland Connect North	4.8	680
2017	SEA-ME-WE 5	36	20,000
2019	COBRACable	-	326
2019	Eastern Light	-	420
2019	MainOne Expansion	-	1,100
2019	Rockabill	-	221
2020	ALVAL/ORVAL	40	800
2020	BKK Digitek	-	195
2020	DARE-1	36	4,854
2020	Dos Continentes	460.8	105
2020	Malta-Gozo Cable	-	21
2020	Mandji Fiber Optic Cable	-	50
2020	SkagenFiber	1920	170
2020	Ultramar GE	-	263

In actual number of systems accomplished, the EMEA region is the most consistent region in the world. It has a growth pattern that is seemingly immune to the industry's boom and bust pattern seen over the past 15 years.

The EMEA region sees a consistent, annual addition of smaller regional systems. These complement the large, multi-region projects like SEA-ME-WE, ACE, EIG, and WACS to name a few. These large projects span multiple regions of the world, rather than smaller, inter-country routes and are the biggest projects the industry tackles. Each system of this kind comes in at well over 10,000 kilometers per route — sometimes beyond 20,000 and 25,000 kilometers. Despite the steady system count, inter-regional projects like this cause a huge surge in kilometers installed with 2010 to 2012 seeing the most recent growth spurt for the region.

8.5.2 FUTURE SYSTEMS

As mentioned previously, the EMEA region is uniquely characterized as a region of steady activity, with bursts of highly ambitious, region-spanning systems every few years.

The rate of kilometers added per year shows an average increase of 6 percent annually. Recent bursts of 23 percent, 14 percent, and 16 percent have been observed in 2010, 2012, and 2017, respectively. However, a significant

TABLE 11: EMEA PLANNED SYSTEMS

RFS YEAR	SYSTEM	CAPACITY (TBPS)	LENGTH (KMS)
2021	BlueMed	240	1,000
2021	CrossChannel Fibre	20	520
2021	Equiano	120	-
2021	Havhingsten	-	940
2021	HAVSIL	-	120
2021	HAVTOR	1440	165
2021	N0R5KE VIKING	-	750
2021	North Sea Connect	-	650
2021	NO-UK	216	700
2021	Orient Express	-	1,300
2021	PEACE	96	15,000
2021	SHARE	16	720
2021	WAF West Africa	-	8,200
2022	Celtic Norse	-	2,100
2022	IONIAN	360	320
2022	IRIS	18	17,50
2023	2Africa	-	32,767
2023	2Africa Canary Islands Extension	-	-
2023	Africa-1	192	10,000
2023	HARP	-	-
2023	TEAS	300	19,000
2024	Blue	-	-
2024	IEX	200	
2024	Raman	-	-

reduction in growth was seen between the years of 2018 and 2020 at a mere 0.8 percent average increase annually. (Figure 106) Unlike the Americas and AustralAsia regions, the EMEA region is not looking at a considerable drop-off in system activity from 2021 through to 2023.

In fact, with a renewed focus from Hyperscalers on countries like Nigeria and South Africa who are booming technologically, large systems like 2Africa from Facebook and Equiano from Google could bring about a new surge in activity to Africa as a whole. As these large Hyperscalers begin to set up hyperscale infrastructure, it will naturally attract other business and more demand for bandwidth between key data center regions like North America and Europe. Both of these new cable systems promise more than 100 Tbps of bandwidth and will be a huge boon to the west coast of Africa which currently has an average of about 8 Tbps per submarine cable.

There are currently twenty-four systems planned to be ready for service for the period 2021-2024. Currently, 50 percent of these systems have achieved the CIF milestone. (Figure 107) With half of these systems being considered viable now, the initial impression is positive. Unfortunately, the EMEA region continues to be rife with economic uncertainty and political instability, casting a cloud over any prospective projects – especially in the wake of COVID-19. ■

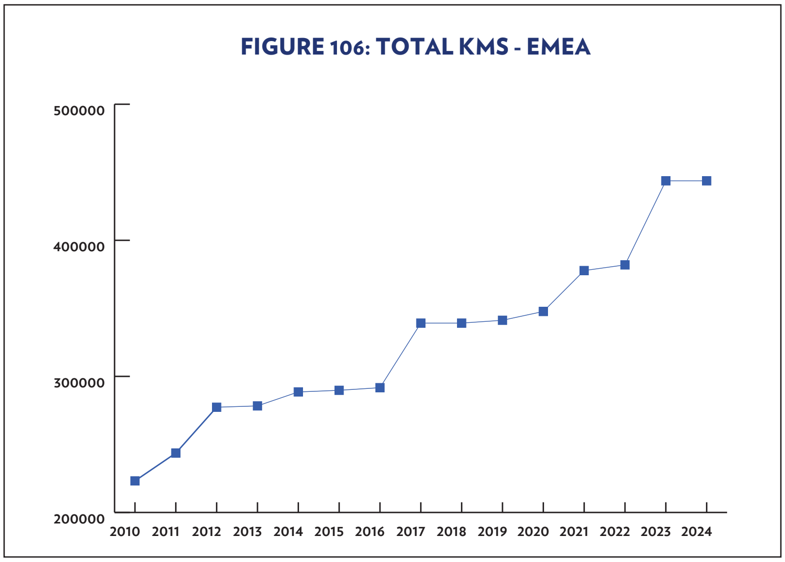


Figure 106: Total KMs - EMEA

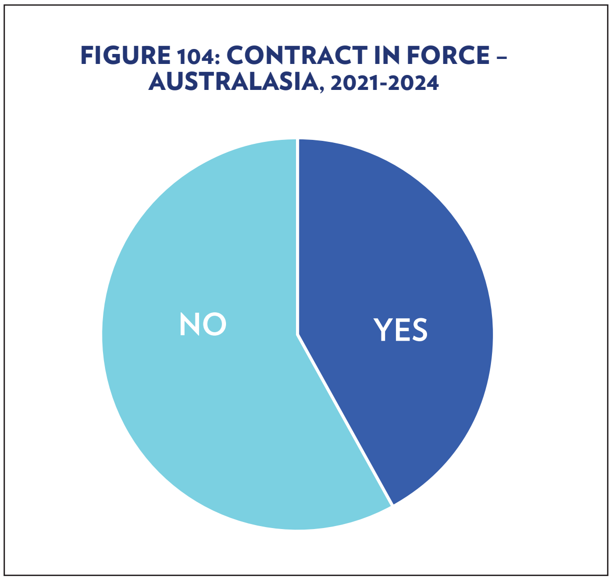
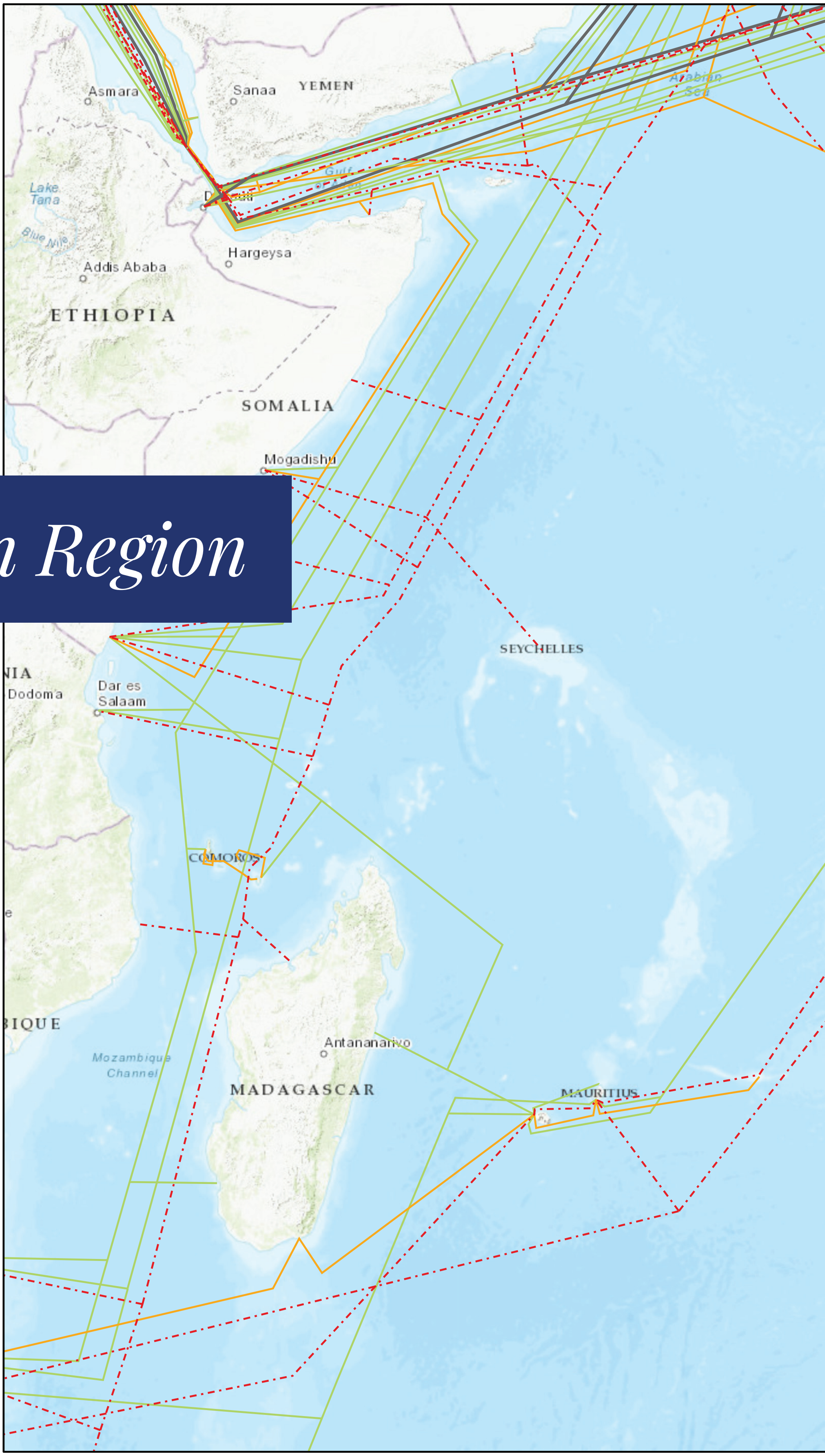


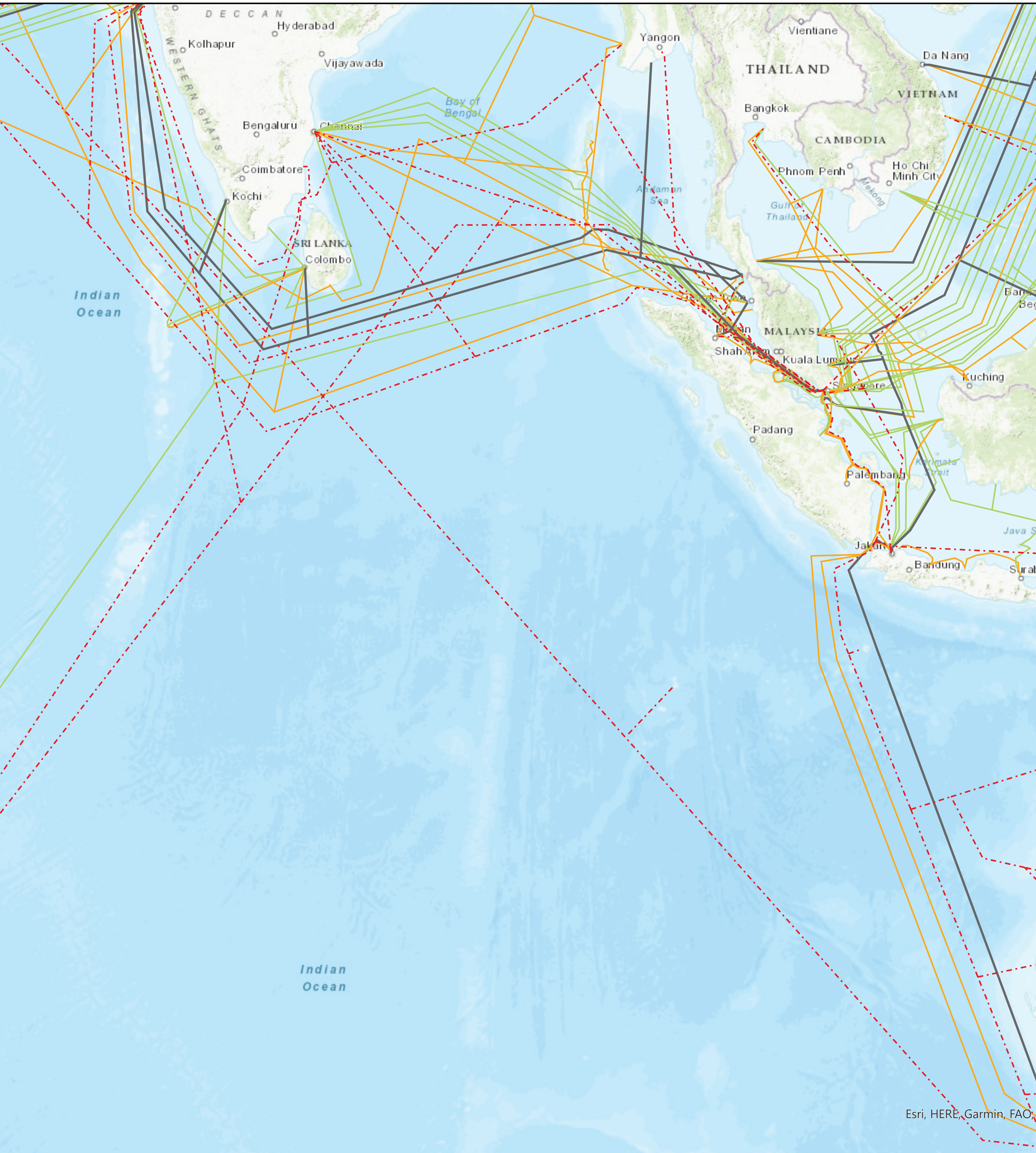
Figure 107: Contract in Force – EMEA, 2021-2024



Indian Ocean Region

REGIONAL SNAPSHOT:

Current Systems: 33
Capacity: 370 Tbps
Planned Systems: 9
Planned Capacity: 1,105 Tbps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Bengaluru
Chennai
Coimbatore
Kochi
SRI LANKA
Colombo
Indian Ocean
Bay of Bengal
Yangon
Vientiane
THAILAND
Da Nang
VIETNAM
Bangkok
CAMBODIA
Phnom Penh
Ho Chi Minh City
Andaman Sea
Gulf of Thailand
MALAYSIA
Medan
Shah Alam
Kuala Lumpur
Kuching
Singapore
Padang
Palembang
Karimata Strait
Java Sea
Jakarta
Bandung
Indian Ocean
Esri, HERE, Garmin, FAO,

8.6.1 CURRENT SYSTEMS

The Indian Ocean region has been on a steady path of development since the boom following the submarine cable industry downturn in the early 2000's. It has enjoyed mostly consistent growth since 2003 despite its small size, largely due to it being an important crossroads region between the busier EMEA and AustralAsia regions.

The region has experienced periods of rapid development, followed by a brief period of dormancy. The years of growth have been largely driven by trans-regional systems such as SEA-ME-WE 3, 4 and 5, FLAG, Falcon, and AAE-1, to name a few. This has resulted in three distinct development spikes in 2006-2007, 2009, and 2015-2017. (Figure 108) Local development is largely small systems linking India east to Indonesia or west to the Middle East and beyond, providing new connections for the countries that ring the Indian Ocean.

Video 19: Mike Last, Director, Marketing and International Business Development - WIOCC

8.6.2 FUTURE SYSTEMS

With three new systems added in 2017, none in 2018, two in 2019, two in 2020, and nine systems planned through 2024, new system development will continue at a sporadic pace. This continues to follow the feast-or-famine style of system development that is the historical norm.

The region enjoyed the addition of two major systems in 2017, and the nine systems planned for the period 2022 to 2024 potentially add over 107,000 kilometers of cable. (Figure 109) With Australia looking for more route diversity from

TABLE 12: INDIAN OCEAN SYSTEMS, 2010-PRESENT

RFS YEAR	SYSTEM	CAPACITY (TBPS)	LENGTH (KMS)
2010	Comoros Domestic Cable System	-	-
2011	EIG	3.84	15,000
2011	MACHO	-	-
2012	Dhiraagu Cable Network	-	1,253
2012	LION-2	1.28	3,000
2012	SEAS	-	2,000
2016	Avassa	-	260
2016	BBG	55	8,040
2017	AAE-1	80	25,000
2017	NaSCOM	3.2	1,086
2017	SEA-ME-WE 5	36	20,000
2019	FLY-LION3	4	400
2019	MARS	8	700
2020	CANI-SMC	25.6	2,300
2020	METISS	24	3,200

its western coast and an increasing desire for connectivity between Asia and Europe, this steady growth could continue beyond 2024. Additionally, Hyperscalers are exploring routes from the United States to India and will potentially bring more system development to the region.

Of the nine systems planned through 2024 in this region, only 22 percent have achieved the CIF milestone. (Figure 110) Three systems are planning to link South Africa to India, while multiple other systems work to connect India to Singapore or India to Europe. Business cases for these systems may be difficult to prove, hampering efforts to secure funding. While these systems would expand route diversity in the region, several are competing with each, and it is very likely at least one of these systems will not hit its target RFS date. ■

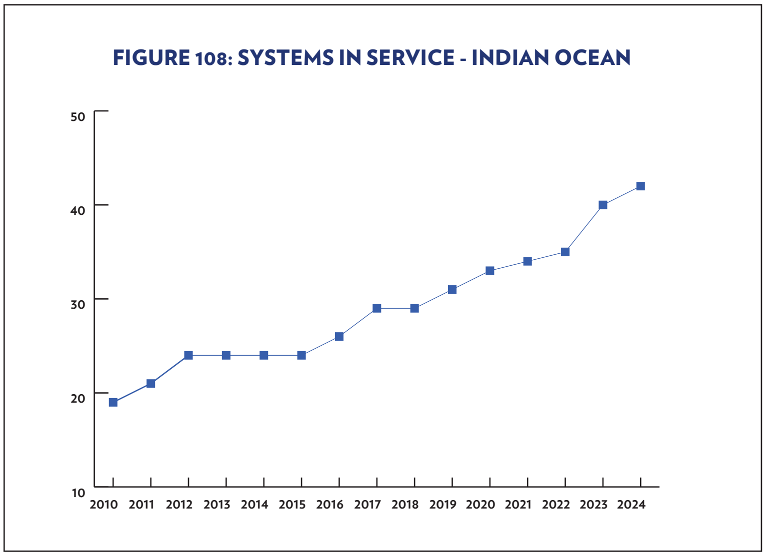


Figure 108: Systems in Service - Indian Ocean

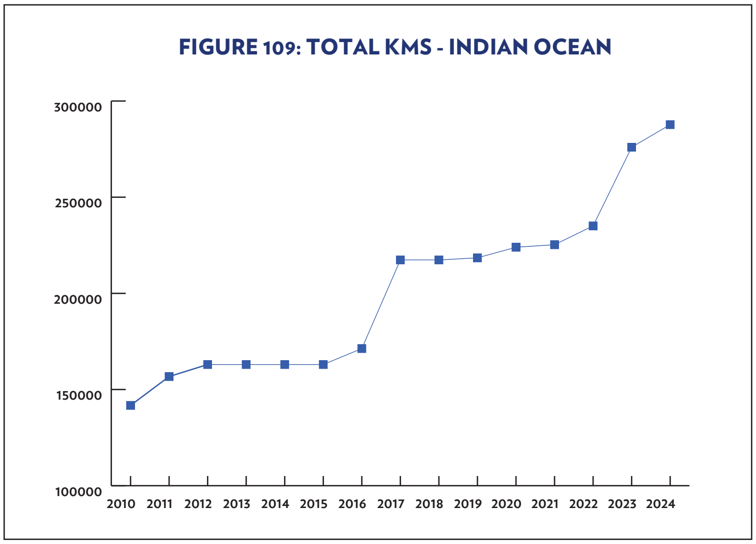


Figure 109: Total KMs - Indian Ocean

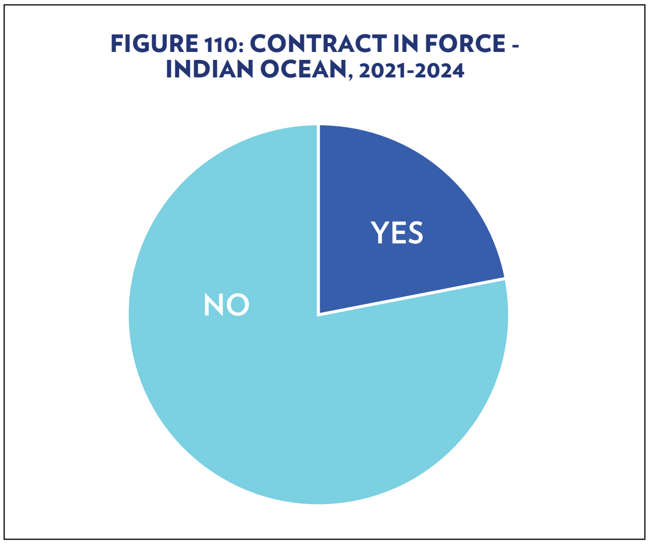


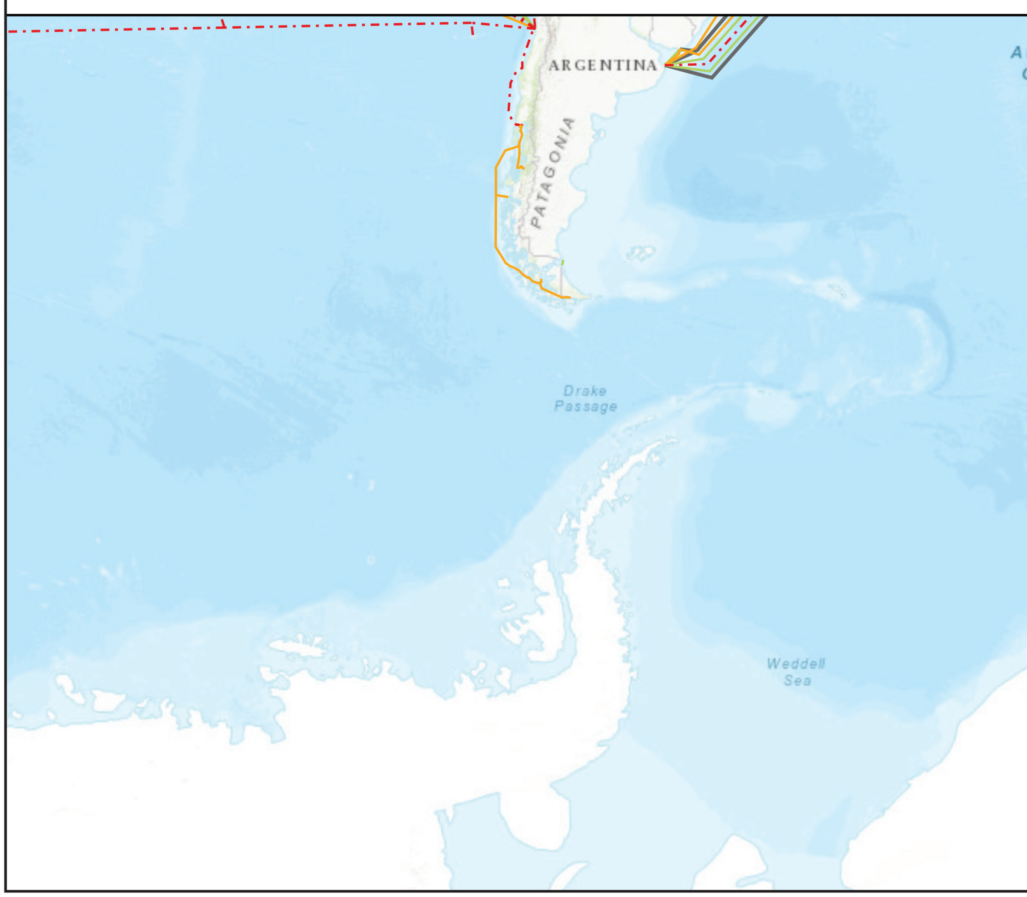
Figure 110: Contract in Force - Indian Ocean, 2021-2024

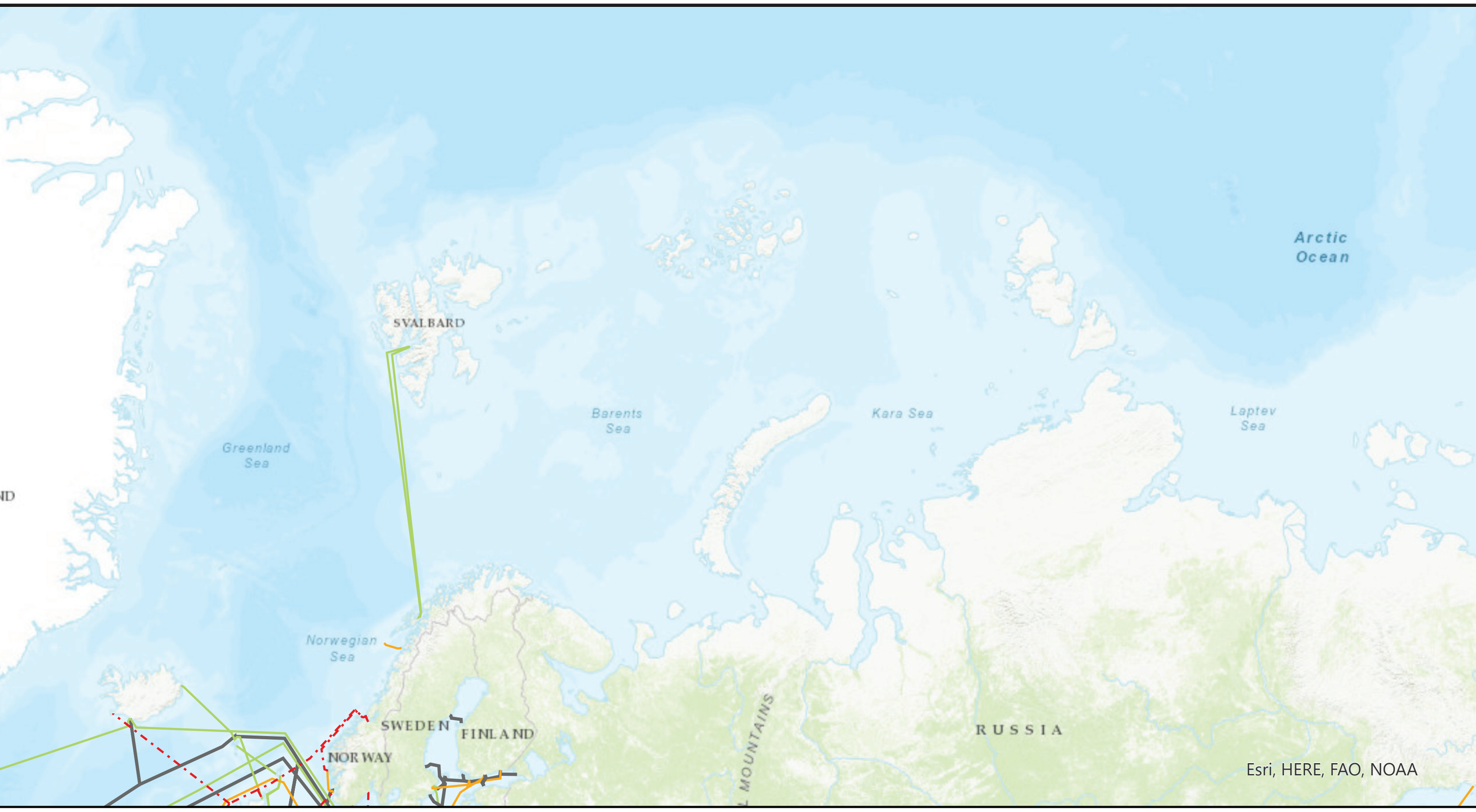
TABLE 13: INDIAN OCEAN PLANNED SYSTEMS

RFS YEAR	SYSTEM	CAPACITY (TBPS)	LENGTH (KMS)
2021	Orient Express	-	1,300
2022	OAC	39	9,800
2023	IAX	200	-
2023	KLI	-	1,900
2023	MIST	240	11,000
2023	SING	18	9,000
2023	TEAS	300	19,000
2024	IEX	200	-
2024	SAEx2	108	11,749

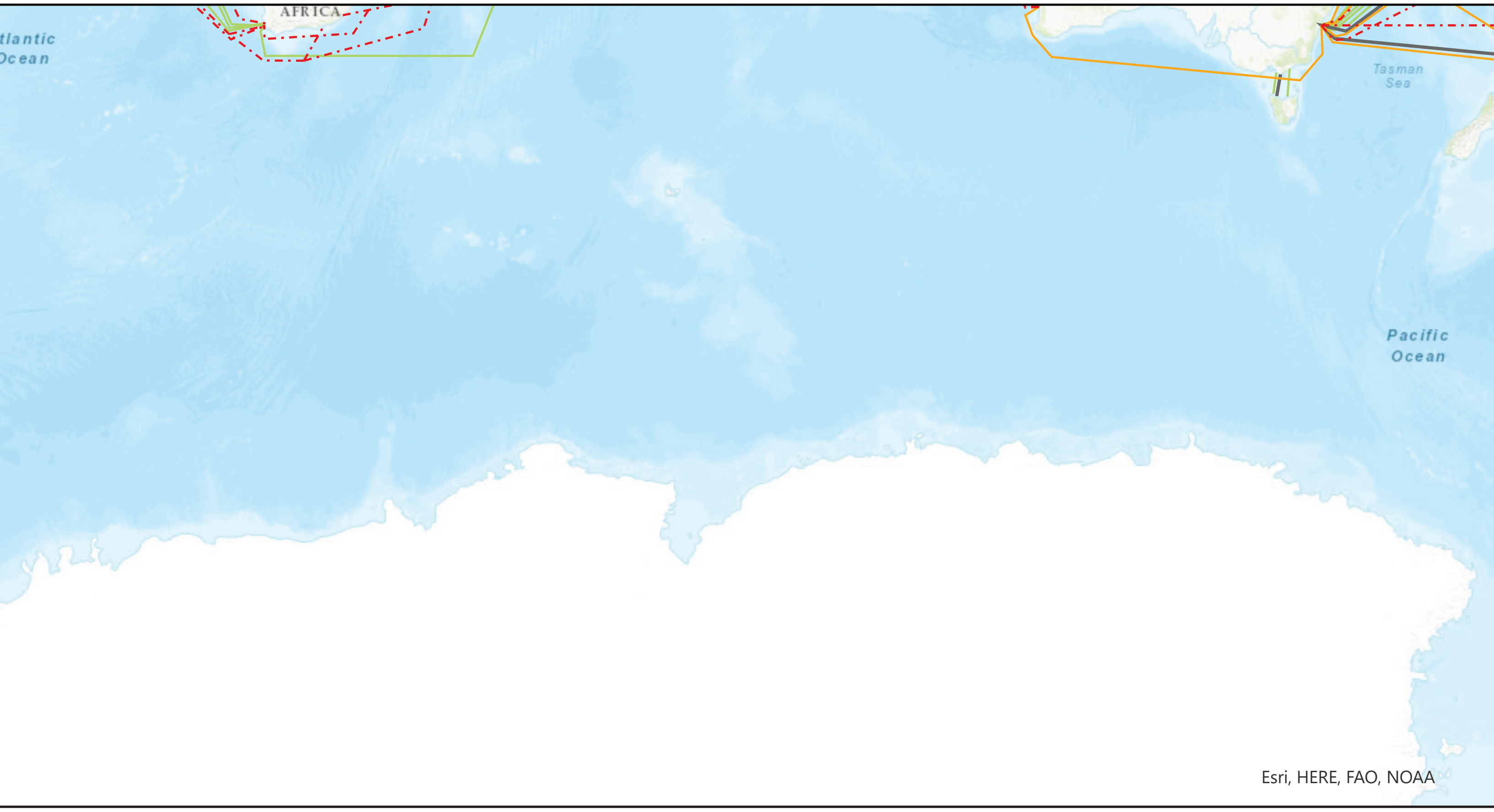
Polar Region

REGIONAL SNAPSHOT:
Current Systems: 2
Capacity: 30 Tbps
Planned Systems: 3
Planned Capacity: 134 Tbps





SVALBARD
Arctic Ocean
Barents Sea
Kara Sea
Laptev Sea
Greenland Sea
Norwegian Sea
SWEDEN
FINLAND
NORWAY
RUSSIA
Esri, HERE, FAO, NOAA



AFRICA
Tasman Sea
Pacific Ocean
Esri, HERE, FAO, NOAA

CURRENT SYSTEMS

The first true Polar submarine fiber system in industry history was installed in 2017. Previous systems, such as Svalbard, had only ever brushed the Polar region. At 1,200 kilometers over six landing points, Quintillion Subsea Phase 1 marked the first successful and fully Polar submarine fiber system in the world.

Interest in Polar projects has been at an all-time high the past few years, as cable developers are looking to take advantage of the dramatically shorter routes that can be achieved through the Polar Circle. The Quintillion Subsea system has proven that a fully Polar system can be done for future systems that look to tackle this particularly difficult region. (Figure 111)

Polar systems have particular challenges to overcome during their development cycle, and only have small windows of time throughout the year during which work can be accomplished. This both extends the development timeline and increases the cost.

Video 20: Hector Hernandez, Projects Director – WFN Strategies, LLC

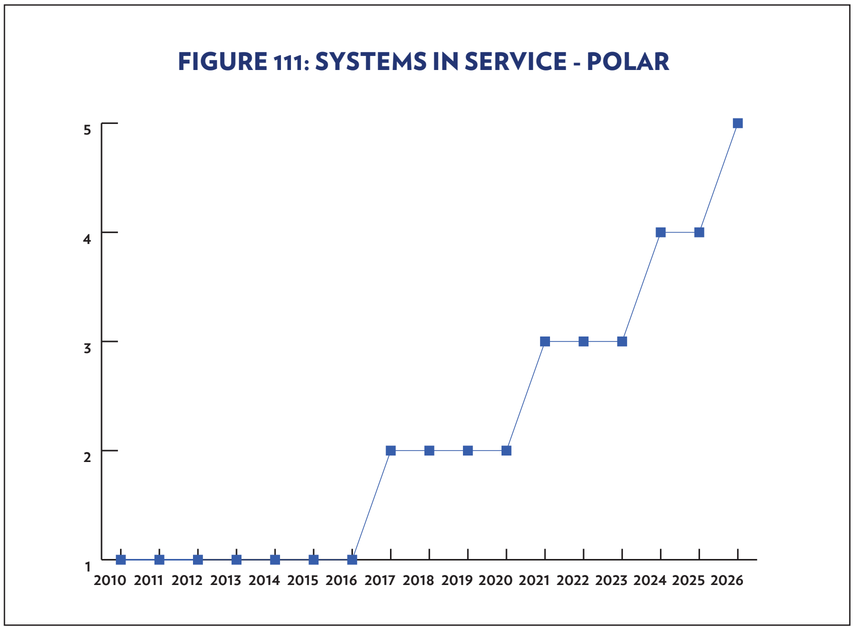


Figure 111: Systems in Service - Polar

FUTURE SYSTEMS

These systems are focused on routes in the far north of Canada, linking up local communities or bridging the gap between Europe and Asia. Arctic Connect was an attempt to link Europe to Japan by going over the top of Russia.

One of the main goals for Polar systems connecting Europe to Asia is to dramatically reduce existing latency. Currently, data must either go through the United States, or through the Suez Canal and Indian Ocean. This has required systems totaling at least 20,000 kilometers in the past. However, future Europe to Asia Polar routes are planned for about 12,600 kilometers — potentially cutting latency in half. Additionally, systems exploring Polar routes avoid the troubled Middle East region and circumvent potential privacy concerns in the United States. (Figure 112) ■

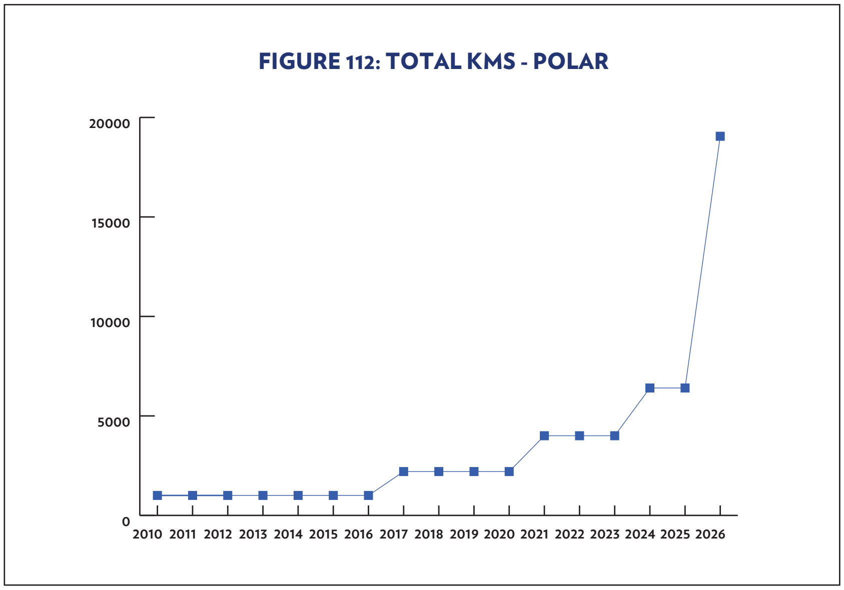


Figure 112: Total KMs - Polar

TABLE 14: POLAR 2010-PRESENT

RFS YEAR	SYSTEM	CAPACITY (TBPS)	LENGTH (KMS)
2017	Quintillion Subsea	30	1,200

TABLE 15: POLAR PLANNED SYSTEMS

RFS YEAR	SYSTEM	CAPACITY (TBPS)	LENGTH (KMS)
2021	EAUFON	30	1,800
2024	Katittuq Nunavut	-	2,400
2026	Polar Express	104	12,650

Afterword

Dear Readers,

Video 21: Kristian Nielsen, Vice President - Submarine Telecoms Forum, Inc.

Here we are, you have officially made it to the end of the Report – you've made it to the place where I get to opine on the industry and make a short thank you to all of those involved in the creation of this terrific document. This piece always feels like the final toast, so if the mood strikes you, do raise a glass.

Firstly, thank you to our special contributors, industry magnates and scholars all, without your astute insights and even more important willingness to throw in and share your minds with us, this report would not have happened.

Thank you to our terrific sponsors! As many know, but maybe not enough, sponsors are all that keep this modest magazine afloat – they are our lifeblood and their trust in our publications never fails to humble me. This year, we have reached a new high-water mark by welcoming a record number of sponsors from across the industry. From surveyors to installers, cable reclaimers to manufacturers, and everything in between, the sponsors of this Report showcase just what a diverse industry we truly have.

I implore you, click their links, check out their companies. They are the reason you hold this document in your hands.

To Rebecca Spence! Our latest hire at SubTel Forum, she's been with us a little over two years and was thrust into the enviable position of Project Manager of this particular effort. Without her relentless effort and sleepless nights, this Report would never have made it out of editorial. I bid you reach out to her on LinkedIn and welcome her to the fold!

And lastly, to our resilient Industry. If there is one truth to be told about the submarine cable industry, now pushing 170 years old, it is that we are resilient, we are adaptive and most importantly, we are more relevant now than almost any time before. The cables that we lay are not only the backbone of the world's businesses, but they also represent the literal shared bonds between peoples. Submarine cables are a tremendous endeavor, one which cannot be accomplished without cooperation between nations and cultures. Our cables are the backbone of the world, the scaffolding enveloping and protecting a world currently under renovation.

For these reasons, we are more necessary than ever before.

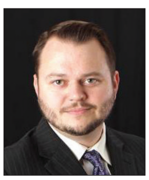
The Pandemic has driven new innovation around the world — new treaties and opportunities for growth between once hostile or indifferent countries, new routes and new investment are being proposed and considered and most importantly new ideas are becoming reality.

With that, I bid one last toast to you, our readers.

Without your continued readership and support over these last 20 years, we simply wouldn't be here. ■

Cheers,

Kristian Nielsen
Vice President



Kristian Nielsen has over 13 years of publishing and management experience and has been working for Submarine Telecoms Forum since 2008 as Business Manager. In 2013, he was promoted to Vice President and is responsible for all SubTel Forum product roll-out, sales strategy, administration and management. Under his direction, Submarine Telecoms Forum's readership has grown from less than 4,000 bi-monthly readers, to over 100,000 every month. He literally grew up in the business since his first 'romp' on a BTM cableship in Southampton at age 5. Professionally, he has supported various international telecoms projects with accounting administration and is the originator of many of SubTel Forum's current products and services.

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