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Suppliers of Undersea Telecommunications Systems

A Technology & Market Assessment Report: Executive Summary

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Executive Summary

With the support of 99% intercontinental traffic and $10 trillion of transactions daily, it is no wonder that submarine fiber optic cable systems have been viewed in recent years as essential network infrastructure for consumers, businesses, and governments. The critical nature of subsea telecommunications cable systems is truer than ever with the outbreak of the COVID-19 pandemic that has led to a range of physical distancing measures and lockdowns. In turn this has resulted in many millions of people being required to work from home and forced to severely limit their social interactions and activities. As a result, there has been a sharp spike in internet traffic since mid-February 2020 to support social, business, educational, cultural, gaming, and entertainment activities in many places around the world. Submarine cable systems are a key element to respond to this surge in demand for content, cloud, and streaming services and to maintain the cohesion of the entire society.

Commercial and Technical Trends

The majority of new submarine capacity upgrades, new cables announced, and deployed are to address insatiable growth in data flowing between large data centers via this submerged information superhighway infrastructure. This insatiable need for more capacity is illustrated by the advent of OTTs operating on a scale completely unseen or unimagined by the telcos and carriers 10 years ago. These new, hungry capacity users have profoundly shaped the way long-haul cable systems are developed, designed, and built. Today there is no plan B for submarine networks as there is simply no viable alternative networking technology that comes close to optical networks in terms of capacity, scalability, latency, reliability, and economies of scale. This means, as an industry, the supplier community must continue to innovate submarine optical networking technology. For their part, buyers must ensure that they maintain a minimum number of sellers for the sake of a robust, competitive, and innovative supply chain.

Although invisible to the vast majority of bandwidth users, subsea infrastructure is a unique engineering marvel combining optical communication, information science, high-end photonics, nonlinear optics, electrical engineering, material science, engineering practices, multi-dimensional project management, high reliability standard, marine expertise, and complex, long-time proven, slowly changing operations in an adverse sea environment (such as cable installation). In addition, the subsea industry is also unique because it has to care about integrity and safety of data, safety of cables, geopolitical constraints, and environmental impacts.

Subsea cable infrastructure transports an order of magnitude more bits than just five years ago. Subsea cable infrastructure encodes information into amplitude, phase, and polarization of high-frequency (in

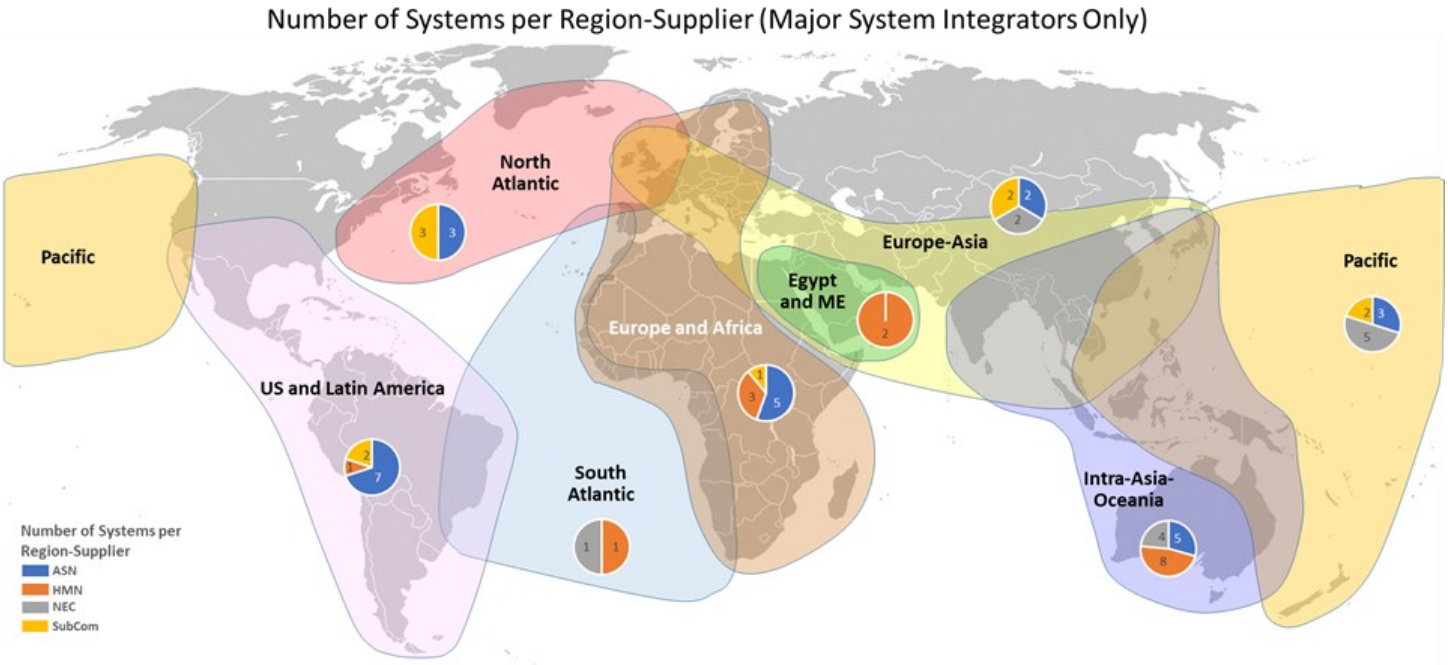
the range of 200 THz) electro-magnetic waves. Subsea cable infrastructure can send over 25,000,000,000,000 bits (25 Tbit/s) every second across the Atlantic Ocean in a single strand of fiber. To achieve this, today's submarine cable systems rely on a unique technical ecosystem for optical communications, based on three pillars invented and developed in the past 60 years: the semiconductor laser in 1962, the optical fiber concept in the mid-1960s, and the fiber-based optical amplifier design in 1986-87. Optical fiber offers high-end, cost-effective transmission medium with low attenuation over a large bandwidth and reasonable tolerance against micro and macro bending, allowing the cabling of fibers and installation of cables on the seabed by cable ships. Erbium-doped fiber amplifier design achieves gain in the spectral region where fiber attenuation is minimal (around 1,550 nm), offers broad gain bandwidth enabling land-based equipment to pack multiple closely-spaced carriers with no inter-carrier crosstalk, exhibits attractive gain dynamics (the optical gain is not impacted by signals modulated at high speed, while the amplifier gain can be modulated at low frequency to enable communication between the dry and wet plants for system monitoring and control), and can be operated in gain saturation mode (offering self-healing behavior to recover increase in the loss of the preceding spans and decrease in pump power in the preceding repeaters).

The major recent technology breakthrough in the past decade happened with the terminal equipment with the advent of coherent technology (an old concept in radio communications, which made its way into optical communications at the end of the 2000s and in subsea cable systems at the beginning of the 2010s). Coherent technology, together with digital signal processing for compensating some of the fiber impairments, high-gain soft-decision forward error correction, and spectral shaping, provides capacity performance close to the upper boundary set by the fundamental Shannon limit. Additional impacts from coherent technology include the convergence between optical network and equipment designs, the blurring of the demarcation between subsea cable systems and terrestrial networks (with some cable systems terminating inside inland data centers, and no longer in cable landing stations), and the subsequent leadership of terrestrial equipment vendors in the submarine line terminal equipment market segment.

While most of today's sophisticated (and most expensive) system designs allow operators to maximize the per fiber capacity and minimize the gap between their operation and the Shannon-limited capacity, system designers are now facing another limit set by the electrical powering of the cable systems. In consideration of cable capacity, it is now clear that a better use can be made of the limited electrical power fed to the wet plant by increasing the number of fiber pairs and operating them at a lower capacity (typically in the range of 16 to 20 Tbit/s per fiber pair). This high fiber count (HFC) – sometimes called spatial division multiplexing (SDM) - approach offers lower cost per transported bit and now enables the development of 320 Tbit/s transatlantic cable systems (that will enter commercial service in 2022), while

keeping the same electrical design of the cable and submerged equipment. The electrical limit faced by system designers has triggered the qualification of subsea cable structure using an aluminum conductor. This option is claimed by its proponents to economically allow for a lower cable voltage drop, which allows for a higher number of fiber pairs per cable. That makes aluminum a realistic option to increase the number of fiber pairs per cable — aluminum is also significantly less expensive than copper. Lastly, the last three years saw the deployment of the first reconfigurable wavelength management units based on subsea-qualified wavelength selective switches.

All these technical matters are analyzed and discussed in this comprehensive report *Suppliers of Undersea Telecommunications Systems* published by Pioneer Consulting, together with the recent commercial trends in the subsea capacity supply and demand market, as both aspects are thoroughly interleaved. This latest report includes a 230-page, 163-figure tutorial section on submarine cable system design and technology. This section is written in plain English accessible to non-technical readers, begins with an introduction to basic technologies like optical fiber and optical amplification, describes the structure of submarine cables, covers the optical, electrical and mechanical designs of submerged equipment such as repeater, branching units and wavelength management units, details the building blocks of modern coherent submarine line terminal equipment, and addresses power feed equipment and operations software topics.



Suppliers Review

The second half of this report reviews the major suppliers for subsea fiber optic cable systems, both the major system integrators capable to design, manufacture and deploy subsea cable systems of any type worldwide and the smaller, more focused suppliers providing cable, submarine line terminal equipment, and specific components (including fiber, wavelength selective switches and pump sources) for submarine applications. These reviews include overall company information, historical background, financial data (when publicly available), capabilities/services, list of recent projects, as well as detailed product offering.

In 2017, when the previous *Suppliers of Undersea Telecommunications Systems* report was published, the submarine cable systems supplier landscape was unchanged compared to the previous 2012 edition except that the repeater products from US-based Xtera and Brazil-based Padtec were announced and deployed. **Since 2017, five significant changes to the system integrators have happened in this landscape:**

- In 2018, TE Connectivity sold TE SubCom to Cerberus. At the same time, the two publicly known attempts of Nokia to sell its Alcatel Submarine Networks (ASN) subsea cable system division failed.
- In 2019, Hengtong Optic-Electric Co Ltd announced that they will acquire the shares of Huawei in Huawei Marine Networks (HMN) (Huawei held 51% of the Huawei Marine joint venture) and those of HC2 Holdings, mother company of Global Marine Group, in HMN (HC2 Holdings hold 49% of the Huawei Marine joint venture).
- In 2019, the repeater activities of Padtec were acquired by IPG Photonics and subsequently disbanded.
- SubCom exited the transmission terminal business and now teams with Ciena to provide this equipment.
- A new China-based supplier, FiberHome Marine, appeared in the market, claiming a system integrator position with a full product range including cable, repeater, and branching unit.

ASN remains the only fully integrated system integrator, designing and manufacturing its cable, submerged equipment, power feed equipment and transmission equipment, and owning a fleet of six cable ships for installation and maintenance.

It is the finding of this report that, while ignoring geopolitical issues surrounding China-based HMN, commercial issues reign supreme in understanding the relative strengths of the suppliers reported

herein. Whilst technical capabilities cannot be ignored, the technical differentiators within a group of similar suppliers are not significant. Buying decisions are generally made based on price, relationships, track record, and ability to deliver on time, on specification, and on budget.

System Integrators: With about 87% of market share for ASN, NEC and SubCom (98% if HMN is considered as well), the cable system market is now mostly supplied by four companies. Following its 2019 acquisition by IPG Photonics, the future of Padtec submarine activities appear very unclear with no more projects after its first and only 390 km Junior cable project for Google in 2018. Following its 2016 bankruptcy, Xtera was awarded an additional publicly-known repeatered, cable supply contract. Also, the past three years have seen the advent of a brand-new supplier, FiberHome Marine based in China with a submerged equipment design very similar to the first HMN generation. Xtera and FiberHome continue with the belief that small suppliers, perhaps more willing to offer bespoke design than the more established suppliers, will manage to find their way in the competitive marketplace where, economies of scale and experience are of the upmost importance. The situation differs for FiberHome Marine as they are likely to benefit from the support of their home country that may want to develop two subsea cable systems suppliers. As in the past, access to a reliable and cost competitive supply of cable is critical to the supply of repeatered systems. This is clearly demonstrated by the development and qualification of submarine cables in China by Hengtong and FiberHome Marine.

ASN had a slow start for new builds with OTTs at the beginning of the past decade but the company has passed NEC in the past few months with about 37,000 km added with 2Africa and Amitie cable projects. SubCom remains a very strong provider to OTTs with a total of 12 projects and a cumulated length of 112,841 km of cable since 2010. The award of US-based OTT projects to HMN is not likely to occur in the short- to midterm. Hence, HMN is mostly active today with telco-led projects and tries to make its way in some large telco consortium projects. Both HMN and NEC are focused on the Asia-Pacific region (with some inroads in the transatlantic market), while ASN and SubCom are truly global suppliers across the world.

Cable Suppliers: The most notable updates when compared with the 2017 issue of this report include the acquisition of General Cable (and its submarine cable manufacturer NSW) by Prysmian Group in 2018, and the acquisition of HMN by Hengtong Optic-Electric (HTDG) in 2019 (ongoing).

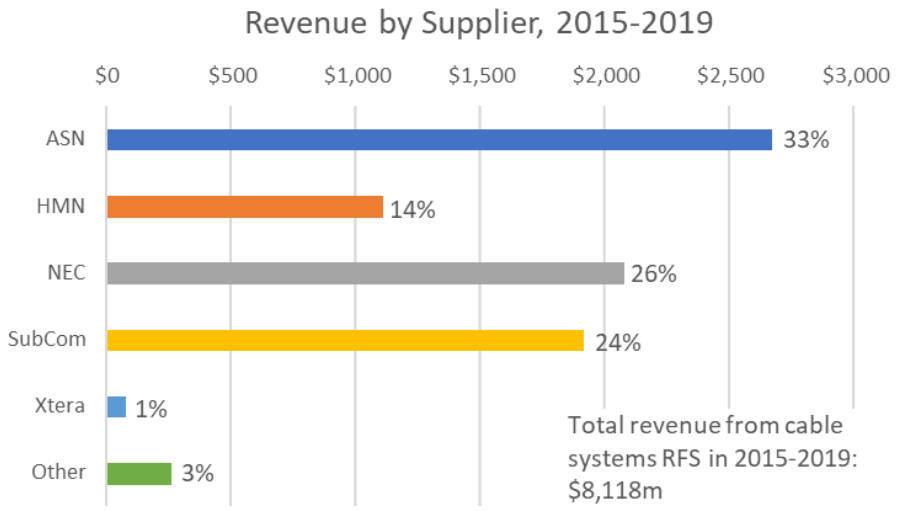
Cable supply for repeaterless systems has a low barrier for entry. Nine companies, all profiled in this report, have a presence in today's market segment for undersea repeaterless cables. The lower cost-base manufacturers are continuing to gain system build experience and are expanding into the international market, where they have an advantage in those markets which are particularly price

sensitive. Among the five "pure" cable suppliers profiled in this report, only one is not offering repeatered cable.

Now, with HMN likely to favor cable supply from Hengtong, the future of the other submarine fiber optic cable suppliers may be more challenging since their potential customer base has significantly reduced.

Submarine Line Terminal Equipment (SLTE): The main suppliers for submarine line terminal equipment are the same (ASN, Ciena and Infinera) as in 2017, joined by Cisco and Nokia. Large SLTE suppliers such as Ciena and Infinera benefit from operators who wish to use only one transmission equipment supplier across their global terrestrial and submarine networks. Both Cisco and Nokia want to join Ciena and Infinera in this SLTE market and leverage their terrestrial footprint as well. Nokia has been slow to address the subsea market with its 1830 PSS transmission platform because of the presence of the ASN-designed 1620 SOFTNODE product in this market. Now that no further attempt to sell ASN appears to be part of Nokia's midterm plans, the relative position and definition of Nokia's and ASN's SLTE product is expected to change in the near future.

The key enabling technology in today's terminal equipment are a combination of optics and electronics in a coherent line transceiver module. These modules are incorporated into complete coherent transponders by the eight terminal vendors profiled in this report: ASN, Ciena, Cisco, Huawei, Infinera, Nokia, NEC, and Xtera. Some of these transponder providers purchase OEM coherent line modules, and others have internal capability (notably Nokia, Huawei, and Infinera and Ciena) may be unwilling to sell their own proprietary coherent line transceiver modules to competing transponder vendors (Ciena is an exception that both provided key module technology as well as terminal equipment based on the technology). Today, there are only two companies that supply OEM coherent line transceiver modules



(as opposed to the whole transponder or terminal) with the required capabilities to optimize baud rate, bit rate, modulation code and FEC and meet the demand of the most capacity hungry customers.

The transmission terminal equipment market for unrepeatered applications is more competitive than the repeatered market. There are more suppliers vying for a portion of a smaller cake and the barriers to entry are lower. Not only do the suppliers of repeatered systems also provide repeaterless systems, but any of the world's 20+ manufacturers of terrestrial transport systems are candidates for supplying the terminal transponder for a short undersea span less than 200 km in length.

Specialized Components: Submerged equipment relies on specialized components that are not commonly available, are based on bespoke design and specifications discussed and agreed upon with the customers and are manufactured in small volumes. The most specialized parts are those that are placed undersea in the cable, the repeaters, the branching units, and the wavelength management units. This report focuses on four key components, namely optical fibers, pump lasers, gain flattening filters and reconfigurable optical add drop multiplexers for subsea applications. Two out of these four critical components for submarine cable systems are offered by a very limited number of suppliers.

Supply market figures over the 2015-2019 period are presented and analyzed from different perspectives in the *Suppliers of Undersea Telecommunications Systems* report. These supply market figures relate to the supply and installation of the wet plant (cable, repeaters, branching units, wavelength management units, gain tilt equalizer, and gain shape equalizer) from beach manhole to beach manhole, including power feed equipment (PFE), open cable system interfaces, and marine services for the installation on the seabed. Revenue derived from supply and installation of submarine line terminal equipment (SLTE) and maintenance services are not included in this report.

Suppliers of Undersea Telecommunications Systems provides a comprehensive and multi-faceted analysis of the submarine fiber optic systems supply market. It identifies key market dynamics and technology evolutions, profiles the key market participants, and provides a means of comparing the competitive positions of suppliers in the repeatered and unrepeatered market segments. *Suppliers of Undersea Telecommunications Systems* offers insight and better understanding of the submarine fiber optic systems supply industry to any potential investors, developers, purchasers, or operators of submarine cable infrastructure.

If interested in learning more about "Suppliers of Undersea Telecommunications Systems" or if you would like to purchase this report, please reach out via: sales@pioneerconsulting.com.