WET PLANT CONSIDERATIONS FOR HIGH CAPACITY / LONG HAUL SYSTEM APPLICATIONS WITH PASSIVE AMPLIFICATION METHODS

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Abstract: Submarine Fiber Optic Systems are highly dependent on reliable technological advances. They still continue to push the limits of fiber-optic transmission, both in terms of system length as well as bit rate.

Improved TR equipment, e.g. with forward error correction, newly developed fiber types and/or additional optical amplification (EDFA and Raman) can be used as modern instruments to provide solutions for high bandwidth telecommunication approaches as well as special systems such as ultra long haul systems with low data rates for the oil & gas industry in deep water and/or far away from shore.

By means of two actual projects, the JANNA and the SHEFA-2 project, the possibilities / limitations of repeaterless systems will be described.

Newly gained experience, increased performance, sophisticated manufacturing technology, significant quality measures, alternative approaches and future trends in the design of typical systems for repeaterless fiber optic systems will be discussed.

1 MAIN PAPER

Since the first fiber optic submarine cables were installed in the mid-eighties, fiber and cable developments have allowed the link lengths for repeaterless systems to be increased dramatically. Increasing the bandwidth of the system by adding wavelengths or by upgrading the data rates constitute the new objective instead of increasing the number of fibers.

The following projects should explain how the market takes advantage of this highly developed technology for repeaterless cable systems.

2 THE JANNA PROJECT

The JANNA submarine cable network links the Italian mainland with Sardinia and Sicily (Figure 1). The link lengths are 249 km (Link 1 from Civitavecchia - Olbia, Sardinia) and 380 km (Link 2 from Cagliari, Sardinia to Mazara del Vallo, Sicily). To offer a transparent media to different transmission equipment providers using Remote Optical Pumped Amplifiers (ROPAs) was not a viable option. The use of transmission equipment incorporating Raman amplification dictated an extremely tough maximum attenuation of 65 dB for the 380 km link from Sardinia to Sicily. Achieving this result required the utilization of fibers with a cabled attenuation of 0.172 dB/km or less.

Figure 1: The JANNA Project

Therefore, the submarine cables are designed around a very tough and rigid seam welded central copper tube which contains 48 fibers with a specific longitudinal excess length and a high radial clearance. Hence the fibers are neither squeezed nor strained whenever the outer cable structure is stressed within the design limits of the cable. The central copper tube has been pressure tested to more than 600 bar (equivalent to water depth of 6000 meters). The central copper tube is filled with a thixotropic filling compound which limits water ingress into the tube in the event of cable damage. It is mandatory that a hermetically sealed copper barrier against hydrogen is designed into the submarine cables due to the increased loss mechanisms in the fibers in the presence of hydrogen. Every effect that increases the bare attenuation figures of each individual fiber must be prevented. The cable armoring of all cable types consists of high tensile strength steel wires which are carefully preformed prior to the stranding process, thereby reducing the residual torque in the unloaded cable to a negligible minimum. With this measure, the twisting, throwing loops and kinks are not an issue in any of the laying operations performed. It should be noted that it is mandatory for the armoring wires of the submarine cables to be stranded in a unilay manner in order to make the cable lie flat in cable tanks or cable cribs during storage and lay. [1]

After manufacturing, all of the fibers in link 2 have a point-to-point attenuation of 65 dB or less. This is now one of the longest repeaterless systems that can operate at n x 10 Gbit/s without ROPA technology.

3 SHEFA-2 – THE FAROE ISLAND PROJECT:

The SHEFA-2 network will be separated into three main links that will connect the Faroe, Shetland and Orkney Islands and the mainland of Scotland. The direct link between the islands of Faroe and Shetland (approx. 400 km) is the core challenge of the system design. The link, presently the world’s longest high capacity repeaterless link, will have a data rate of up to 190 Gbit/s (19x10 Gbit/s) per fiber pair over 389 km without the use of submerged repeaters or remote optically pumped amplifiers. The cable will also be used along with existing submarine cables to insure highly reliable access to the rest of the world and international traffic. The high-capacity, ultra-long repeaterless SHEFA-2 network will be deployed using Raman technology which has been used by a number of worldwide service providers over the past year to provide significant capacity upgrades on existing repeaterless submarine systems.

The use of the brand new Corning® Vascade® EX1000 optical fiber makes such long distances possible. The fact that it is possible to minimize the number of splices and minimize attenuation increase by the design of the cable (described above) is the key to realizing high capacity repeaterless cable systems over very long distances.

The Corning® Vascade® EX1000 fiber is an ultra-low-attenuation fiber designed to maximize the cost efficiency of repeaterless submarine networks. Similar to all fibers in the Vascade® product family, Vascade EX1000 is manufactured with the most rigorous quality architecture in the industry to provide the robustness required by the harsh submarine environment. Standard grade Vascade® EX1000 fiber features typical attenuation lower than 0.174 dB/km at 1550 nm and improved Raman performance, providing extended reach and flexibility for network designers.

4 REQUIREMENTS FOR OIL & GAS PROJECTS

Reliability, an exceptionally important key issue for telecommunication systems, e.g. in the oil & gas industry, as well as the selection of robust cable designs and accessories are basics for determining network design, system maintenance, repair provision and traffic restoration philosophy.

In the past, offshore oil and gas platforms have been constructed in distances of a few kilometers relatively close to the shorelines in water depths of a few hundred meters. Most of these are fixed platforms that were built on concrete or steel legs anchored directly onto the seabed. The oil and gas resources in shallow water are nearly exhausted and new oil and gas fields are being developed at ever-greater distances from shore and are located deeper than 2000 m.

Today, repeaterless fiber-optic submarine cable networks are the solution of choice for offshore communications. Any kind of network configuration, such as star, collapsed ring, double ring or any combination can be easily implemented. The basic network design usually contains a ring “trunk” submarine fiber optic cable system with branching units (BU) splitting fibers to the individual platforms. The platforms are connected via designated “jumper” and “riser” cables to the branching units and to the main network. A physical ring system is the best basis for an efficient network protection strategy. If a physical ring system is not feasible, for example, due to economic considerations, a collapsed ring system should be set up in the beginning. This configuration provides basic protection against possible TR equipment failures. Later, the system can be extended to a physical ring system.

By implementing clever engineered fiber routing schemes as the basis for advanced network topologies, the loss of one platform (cut of the jumper cable, TR equipment failure, or loss of the platform itself due to natural disasters) or even multiple platforms will not lead to the loss of the entire network. This is of paramount importance, especially in emergency situations.

Figure 2 shows an example of a full meshed structure realized with a double sided platform bypassing.

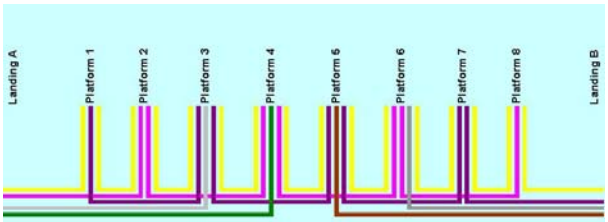

Figure 2: Fully Meshed Structure - Double Sided Platform Bypass

Since repeaterless transmission equipment is closely related to terrestrial equipment, it shares its latest features, ease of use and also its price level which has been introduced for Metro applications and Wide Area Networks (WANs).

The transmission equipment also provides plenty of the margins required for cable repairs, bandwidth upgrades and network extensions. With today's technology, the bandwidth is easily scalable from 2.5 Gbit/s to several times 10 Gbit/s by using industry-proven dense wavelength division multiplexing (DWDM) solutions.

Future offshore oil and gas production facilities will use fewer constructions above the sea level. The trend is going to offshore well heads which are connected via cables and pipes to onshore or offshore facilities located long distances away from the wells. Several projects are currently in the detailed planning or already in the implementation phase.

Finally, a powerful network management system will support the network administrators in handling all supervision, remote configuration and administration tasks. The network management system can be located on any platform, onshore, or even far away at the service provider's headquarters.

The use of amplification technologies such as ROPA (Remote Optical Pumped Amplifier) or Raman Amplifiers and low-loss submarine fibers makes it possible to easily bridge distances between terminal stations of more than 400 km. Low capacity links of up to 600 km are successfully simulated in laboratories by using a combination of ROPA and Raman amplification. These technologies need neither submerged electrical power nor active elements.

Figure 3 compares different transmission systems based on 16 times 10 GBit/s and low loss fibers. The achievable distances of the individual systems vary from 265 to 420 km. By selecting ultra low loss fibers with attenuation figures of < 0.169 dB/km, the stated possible distances are not yet exhausted.

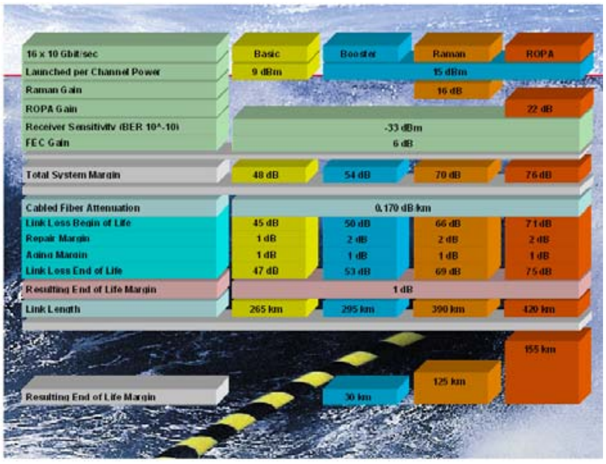

Figure 3: Comparison of different transmission systems related to achievable cable length

5 SUMMARY

Highly reliable telecommunication systems with increased bandwidth performance and ultra long haul systems based on new fiber and component developments are presented.

Proven technology, experience, quality standards and skills from the right partner for engineering and implementing turnkey submarine cable telecommunication systems are available in the industry.

Special achievements, abilities, long-term experience and the possibility to deliver full turnkey solutions is the key for future proof regional submarine networks.

6 REFERENCES:

[1] Unger, C., “High Fiber counts for Aerial and Submarine Optical cables with metal tube design”, IWCS, 1998