REPEATERLESS FIBER OPTIC TELECOMMUNICATION SOLUTIONS AS A POWERFUL TOOL TO OVERCOME THE CHALLENGES IN THE OFFSHORE OIL AND GAS BUSINESS

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Abstract: New oil patches are more remote with simultaneously escalating external hazards. Challenging technologies such as subsea exploration are being pursued. Concurrently, pressure continues to keep a tight rein on costs. Remote control, automation and other bandwidth demanding applications are obvious trends in the industries. Therefore, highly reliable and flexible telecommunication systems are becoming a key function for ongoing success. Repeaterless fiber-optic submarine networks can easily be adjusted to continuous changing business environments and can be incorporated into future engineering concepts.

1 INTRODUCTION

Communication plays an increasingly important role for oil and gas companies. New oil and gas fields are being developed at ever-greater distances from shore. As a result, these new oil and gas fields are located deeper than 2000 m with a clear tendency to 3000 m (and more). Such depths necessitate “free-floating” platforms. Until now, the preferred means of communications used microwave and satellite technology. Microwave links are limited to distances of about 80 km. These links have additional problems in that the platforms move slightly out of the focus of the microwave radio beam. On the other hand, satellites do not provide the bandwidth required by today’s applications at such a low cost level.

The engineer's new toys are data hungry applications like 4C (four component) / 4D (four dimensional) seismic surveying with real-time data delivery. Remotely supervised and controlled operations require huge data pipes and guaranteed “Quality of Services.”

Last year's (2005) category five hurricanes Katrina, Rita and Wilma caused large-scale evacuations of facilities (more than 500 platforms and rigs) and tremendous production downtimes. Many platforms were either heavily damaged, lost (more than 20 after Katrina), or even sank. Wireless communication systems like microwave and satellite rely on precisely aligned antenna systems placed on top of the platforms where they are directly exposed to the power of nature. Unlike these fragile structures, submarine cables enter the platforms well protected from below the water through steel I or J tubes.

Fiber optic submarine cable systems with this improved protection philosophy not only significantly improve the communication system uptime; they also provide the necessary bandwidth for tomorrow’s applications and services. Business-critical processes can be handled over a fiber optic submarine system due to the superior availability and reliability. Furthermore, huge OPEX savings are possible.

If a platform evacuation becomes necessary, the status (“health”) of the rig can still be monitored when wireless communication systems are already destroyed. Of course, a fiber optic submarine cable cannot hold a rig in position, but the loss of this data connection will indicate that something very serious has happed and emergency actions can be initiated. Direct service calls to onshore specialists or subcontractors with real-time video and audio can help solve problems faster so that escalation can be minimized.

In addition to the described data and voice communication services, which can nowadays be combined via “Voice over IP,” a fiber optic submarine cable system can handle extra “added value” services like:

- Security and surveillance applications
- Cable TV
- Backbone network for 2nd and 3rd generation mobile telecommunication services
- Backbone network for “last mile” techniques like wireless networks using the upcoming WIMAX standard (Worldwide Interoperability for Microwave Access)

Bigger networks can connect different regions of a country, remote islands or even different countries. In this case, the potential of extra income from leasing dark fibers to telecom carriers might increase the attractiveness in the eyes of decision makers.

In this context, it is easy to understand why oil and gas companies are paying more and more attention to all communication-related aspects with special emphasis on fiber optic submarine cable systems and all their advantages.

As stated above, the topic “communication” is an ever more critical business aspect. However, since it is not part of the core business of oil and gas companies, these companies are not interested in worrying about the technical details and other related problems. They require precisely tailored, i.e., engineered, turnkey solutions. One recent trend is that oil and gas companies are outsourcing all communications-related tasks to independent service providers who are building, operating and maintaining those networks. As a result, the engineering quality of complex telecommunication services for the oil and gas business has received top ranking, in terms of value, for both the customer and the supplier. For the customer, it is the basis for gaining confidence in the solution. For the supplier, it serves as a shining example of his capabilities.

2 NETWORK DESIGN CONSIDERATIONS

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 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. In addition, separate networks for independent customers or different applications are simple to realize. This will lead to complex fiber routing plans that can be implemented straightforwardly using high fiber count repeaterless submarine cables and accessories like branching units or junction boxes.

With repeaterless technology, distances between terminal stations of more than 400 km can be easily bridged. This technology needs neither submerged electrical power nor active elements and is therefore more reliable and cost effective.

3 NETWORK EXTENSIONS AND SCALABILITY

Fiber optic submarine cable networks for oil and gas applications have to be as flexible as the business using them. New oil and gas fields will be developed, old platforms might be scrapped, new customers or applications might show up. Fiber optic submarine networks can easily be adjusted to these situations and can already be incorporated into future engineering concepts. Submersible fiber optic junction boxes with wet-mate connectors, which can be handled by “Remotely Operated Vehicles” (ROVs), can be preinstalled into branches of the network. New platforms or complete new network segments can be simply plugged into these underwater manifolds. No additional riser cables need be installed on platforms which are already connected to the network and no additional slots in the limited J or I tubes are required. The transmission equipment can be preconfigured. In the best case, new links can be configured and managed completely remotely from the network management center. Another possibility to address future network extensions is the use of branching units with short jumper cables and Lay-down Heads with looped fibers. The Lay-down Heads can be recovered later and a new cable can be spliced onto the preinstalled cable tail. Both options are only a small advance investment and provide the network operator great flexibility for further extensions with considerable CAPEX and time savings when implementing these extensions in the future.

4 BUSINESS CASE

Anyone planning to provide communication services to oil and gas platforms is usually very interested to know all the pros and cons of the available solutions in order to balance their requirements with performance and costs:

Satellite

Pros:

- Huge coverage, the user is not fixed to any infrastructure
- Very fast setup, there are solutions available which are up and running in less than one hour
- Low initial cost (CAPEX)
- Cons:
- Limited bandwidth
- Delays / echoes / distortion
- Increasing operational costs (OPEX) if more and more bandwidth needed
- Antenna exposed to harsh environment

Microwave

Pros:

- More bandwidth than satellite
- Moderate initial cost (CAPEX)
- Cons:
- Bandwidth still limited
- Distance limitation (approx. 80 km)
- Possible antenna alignment problems with free-floating platforms
- Antenna exposed to harsh environment

Submarine Cable

Pros:

- Virtually no bandwidth limitation
- Distances up to 500 km
- System well protected on the ocean floor
- Only passive components used in the wet plant
- Different customers or applications can use separate fibers

Cons:

- Most costly solution
- Longest time to implement

The three existing solutions do not necessarily compete with each other; usually they complement one another and are providing a very reasonable upgrade path to the customer.

A satellite connection can be used to cover initial communication needs. A microwave link (if technically feasible) can handle increased bandwidth needs, and finally a submarine cable can meet the highest reliability and performance demands.

In addition, the business case becomes more and more attractive with the number of platforms connected using a single cable system. Even multiple operators can share one single system without the need to share the communication media (i.e., the fibers). Once a platform is connected to a cable system, it can be used as a base station to connect surrounding platforms with wireless technologies like WIMAX which will multiply the accessible users.

5 DRY PLANT EQUIPMENT, TRANSMISSION EQUIPMENT

The transmission (TR) equipment is the interface to the customer. Therefore, it has to support all the required services and interfaces. In the past, this has been exclusively done with SONET/SDH technology but in the last few years we have seen an obvious trend towards unified Ethernet structures carrying "Everything over Internet Protocol" where everything means voice, data, real-time video, TV, remote control and whatever else is required by the end user. "Quality of Service" features ensure that huge low-priority file transfers do not interfere with voice steams or applications requiring real-time response.

Network protection schemes will compensate for equipment malfunctions or cable cuts by automatically switching to alternative network paths or redundant equipment.

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 TR equipment also provides plenty of the margin 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.

Finally, a powerful network management system (NMS) 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 headquarter.

6 WET PLANT COMPONENTS, SUBMARINE CABLES

Of course, the most import part of the network is the submarine cable itself. Especially for oil and gas networks, the design requirements are both diverse and demanding. Therefore, the selection, design and engineering of the appropriate cable types require very close coordination with the customer. A typical fiber optic submarine cable network consists of several cable portions:

- Trunk cables for the main "backbone" cable
- Jumper cables connecting the platforms to the branching units
- Static riser cables for fixed platforms
- Dynamic riser cables for floating platforms for the last section from the seabed to the platform itself

Figure 1 Dynamic riser cables installed at a platform

The dynamic riser cables in particular will be engineered with tools for the design and analysis of flexible risers. These tools consider the ambient conditions like platform movements or other fixed or flexible elements in its environment.

Submarine cables which are specifically designed for repeaterless broadband signal transmission, can easily bridge distances over 400 km. Even 500 km at a 10 Gb/s bandwidth are possible with today's low-loss optical fibers and advanced repeaterless technology.

Typical repeaterless submarine cables are available in lightweight (LW), single-armored light (SAL), single-armored (SA), double-armored light (DAL) and double-armored (DA) versions that have been qualified and proven to meet all the requirements of cable-laying and recovery environments.

Figure 2LW, SA and DA repeaterless submarine cables.

To prevent a loss in transmission signal quality resulting from physical contact of hydrogen molecules with the optical fibers, the design of submarine cables needs to consider a hermetically sealed copper barrier against hydrogen ingress.

The seamless-welded central copper tube provides the best protection and can house high fiber counts up to 144 optical fibers. In addition to its hydrogen-shielding qualities, the central copper tube is filled with a thixotropic compound that limits water ingress into the tube due to cable damage. The cable's optical fiber "floats" in the compound and is sealed into the tube with a precisely controlled amount of excess fiber length that prevents compression or strain when the outer structure of the cable is subjected to stress within the cable's overall design parameters.

The armor consists of high tensile strength steel wires formed in the stranding machine's tooling prior to the actual winding process. This reduces residual torque in the unloaded cable to a negligible minimum. This technique eliminates the problems of cable twist or the formation of kinks or loops during laying operations.

To simplify the customer's repair and maintenance strategy, all submarine cable types should be qualified for the Universal Quick Joint (UQJ) by the Universal Jointing Consortium.

7 WET PLANT COMPONENTS, HARDWARE AND ACCESSORIES

Branching Units (BU)

Branching units are a fundamental part of the submarine cable network concept. Fibers can be routed straight through the branching unit or branched towards a platform (either existing or planned) or any other submersible device. The fibers off the tree cables can be spliced in any possible combination.

Figure 3 Branching unit being deployed in the North Sea

The branching unit's main features are:

- Mechanical and optical continuity
- Protected pressure housing with hydrogen shielded metal seal system
- Secure storage of the fiber splices and fiber termination management
- Bend-limiter system with ball joint technology
- Cable termination with bend stiffener

Cable-to-cable Joints

Cable-to-cable joints are, of course, to provide mechanical and optical continuity. They are usually used for connecting specially designed cable types such as riser cables to jumpers or to the main trunk cable, repair joints and final splices during implementation. With slight modifications, it is possible to adapt the jointing technology to a wide range of third-party submarine cables in order to incorporate existing third-party cables into new network segments.

Lay-down Heads

The Lay-down Heads will be installed on submarine cables as the end seal. In addition, they are designed with some space for fiber management where the fibers can be spliced together to maintain optical continuity for data traffic or optical monitoring.

Pull-in Hang-off Assemblies

The Hang-off assembly is used to secure the submarine cable to the top of the J or I tube or other securing locations. The preinstalled Pull-in device is used to pull the cable through a J or I tube. The Hang-off Head is designed to provide secure mechanical fixation while allowing the cable core to pass through its center. The Pull-in Hang-off assemblies are specially designed for the individual I or J tube configuration and other unique conditions on the platforms.

Miscellaneous Accessories Provided by Third-party Suppliers

Especially for platforms to be connected by dynamic riser cables, additional accessories might be requested:

- Anchor and bend restrictors for dynamic riser cables
- Extra weights and/or buoyancy elements for dynamic riser cables
- J tube sealing, centralizer
- Selected excellent third-party suppliers will provide these accessories

8 QUALIFICATION

Submarine cable design, together with all its accessories, must meet demanding requirements such as protecting single-mode fibers from excessive strain and lateral pressure during laying and recovery operations, from the effects of pressure on the ocean floor and from mechanical damage. Qualification tests are always part

of the submarine cable system development and design program to demonstrate that all requirements including special project needs such as performance, reliability and service life, are fulfilled. All components of a complex telecommunication system for the oil and gas industry must be qualified by means of stringent qualification procedures under consideration of internationally accepted recommendations. Major cable manufacturers, academic experts and leading companies in the submarine telecommunications systems field created these standards to overcome the lack of a specification that accurately reflects harsh marine environments.

Continuous control tests are performed over the entire manufacturing process on incoming materials, semi-finished and finished products in order to assure a consistently high level of quality. Manufacturing control tests may include some or all of the following:

• Process qualification tests

• Manufacturing tools qualification

• Operator qualification tests

• Visual inspections.

This unmatched quality and performance have been confirmed by successfully implemented reference projects in the oil and gas industry in the Caspian Sea and the North Sea.

9 SUMMARY / CONCLUSION

The development of new oil fields is becoming more challenging. The new oil patches are more and more remote with simultaneously escalating external hazards. New technologies such as subsea exploration are already knocking at the door. Although the current price of oil is at a very high level, pressure continues to keep a tight rein on costs. Remote control, collaboration and automation are obvious trends in the industries. In this business, highly reliable telecommunication systems are becoming a key function for continuing success.

Repeaterless submarine cable networks for oil and gas have to be as flexible as the business using them. New oil and gas fields will be developed, old platforms might be scrapped, new customers or applications might show up. Due to the high fiber count, individual fiber pairs can be provided to different customers, user groups or applications. Unified data transport networks utilizing “Everything over Internet Protocol” form the basis for scalability and OPEX savings.

Repeaterless fiber optic submarine networks can easily be adjusted to these situations and can already be incorporated into future engineering concepts.

10 FIGURES

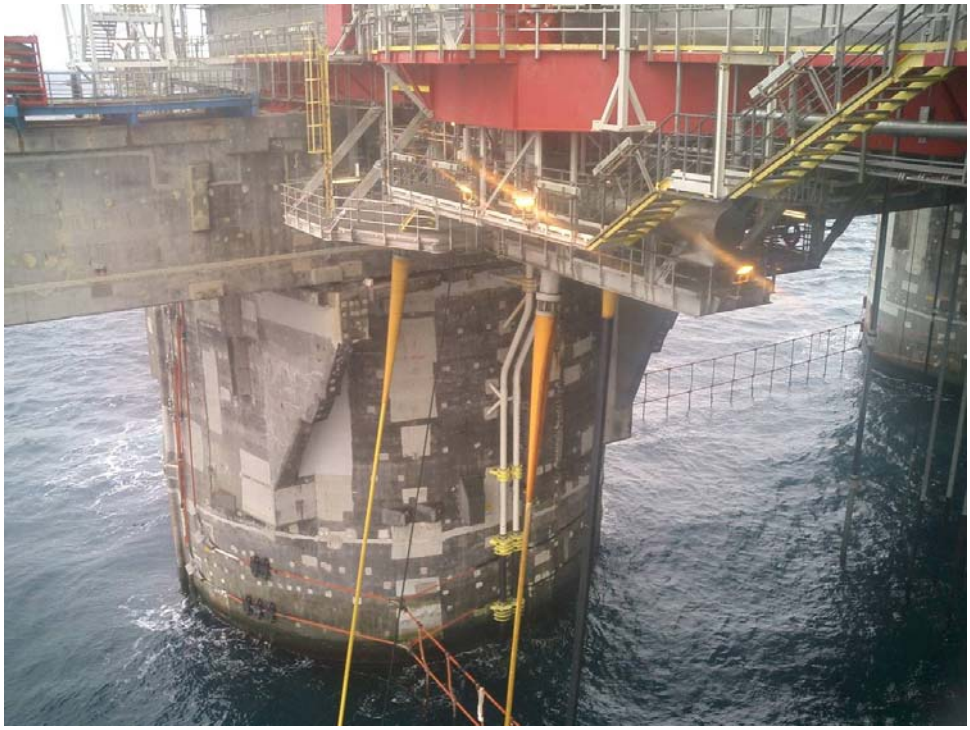

Fig 1 Dynamic riser cables installed at a platform

Fig 2 LW, SA and DA repeaterless submarine cables

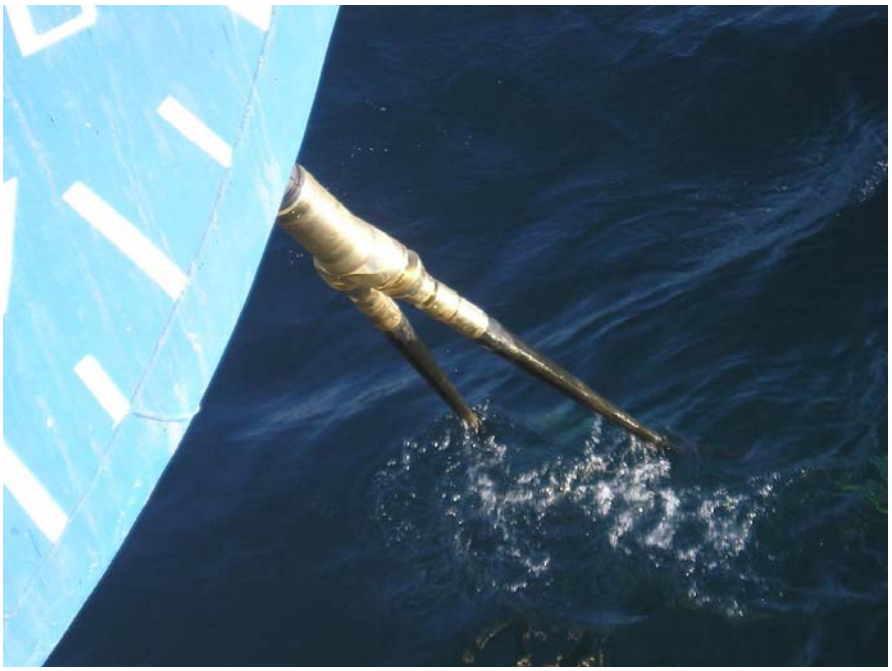

Fig 3 Branching unit being deployed in the North Sea