IBP2046_12

SUBSEA DATA TO DESKTOP; SEAFLOOR DATA ACQUISITION AND CONTROLS USING FIBER OPTIC TELECOMMUNICATION TECHNOLOGY

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Abstract

This paper describes subsea data acquisition and power systems that are based on fiber optic cable technologies developed for trans-oceanic telecommunication systems. This paper reviews submarine telecommunication cables, the technologies used within the systems, and recent applications of these technologies for oceanographic observatories, tsunami warning systems, and oil & gas platform-to-shore communication systems. Several potential applications of this technology for subsea controls and data acquisition system are presented.

Innovative subsea architectures for long step-outs, based on telecommunication cable technologies, for oceanographic permanent subsea observatories have been deployed offshore of North America, Japan, and Europe. These systems provide bi-directional communication and power to retrievable science instrumentation. Instruments for oceanographic research, tsunami warning systems, and neutrino astronomy have been successfully deployed. Researchers can access and control experiments directly from their desktop computers.

For platform-to-shore communications, BP has installed a network in the U.S. Gulf of Mexico. The 1,216-km system of backbone and spurs reaches a depth of 2,000 meters. The system, which was designed for flexibility and future expansion, has a redundant "ring architecture" with shore landings in Mississippi and Texas. It includes multiple subsea distribution points to individual platforms using optical wet-mate connectors. This system provides data transmissions up to 10 Gbps and reliable communication even during severe weather conditions. Similar offshore systems are planned for Brazil and Angola.

The paper discusses a system that will provide both platform-to-shore communication and subsea control functions. This will include direct connection to SIIS (Subsea Instrumentation Interface Standardization-), compliant subsea sensors and traditional FSK control systems. The system also includes adequate power for direct electrical actuation of subsea valves or indirect actuation through electrically powered seabed hydraulic systems. The major benefits of the system are increased bandwidth, more subsea data, and enhanced reliability via a direct link to shore independent of the platform.

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1. Introduction

The first trans-oceanic fiber optic cable (TAT-8) was installed in 1988 and spanned the Atlantic Ocean. Since then more than 400,000 km of submarine fiber optic cable have been installed worldwide (Figure 1). Today, subsea fiber optic cables reliably carry 95 percent of the global voice and data communication; the remaining 5 percent is transmitted via satellite.

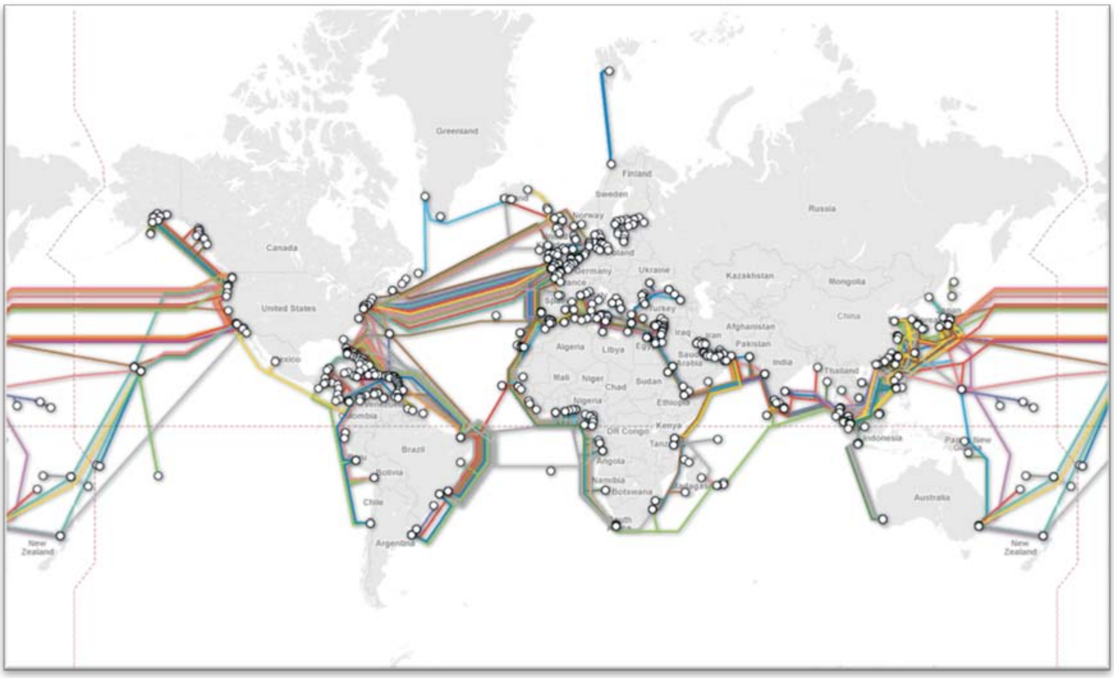

Figure 1. Global submarine cable network.

For trans-oceanic systems, segments of cable up to 400 km are joined by optical repeaters that boost the optical signal. The repeaters are powered by direct current power supplies located onshore. A conductor element in the cable provides the current path to the repeater and a return path is provided from a cathode located at the repeater through open seawater to an anode located near shore. A cable/riser connects the anode to the power supply to complete the circuit. The conductive element also provides an atmospheric conduit for the fiber (Figure 2).

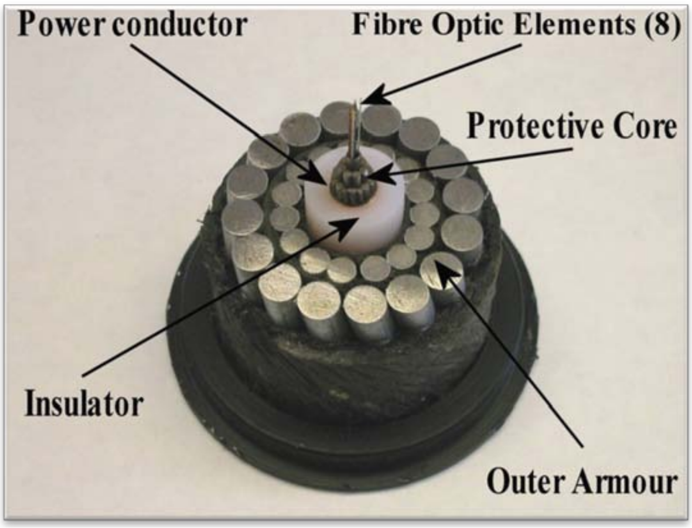

Figure 2. Typical telecommunication cable.

2. Cabled Seabed Observatories

A seabed observatory uses telecommunication cable technology to provide a communication backbone with science nodes positioned along the trunk cable. Instruments are connected to the retrievable nodes while the telecommunication cables are joined to the node base. The communication backbone can be connected directly to shore or to a buoy that houses satellite communication equipment (Figure 3).

Figure 3. Science observatory network architecture with backbone cable, nodes, sensors, and electrical power.

The optical signal and high voltage DC power from the node base are connected to the retrievable science nodes by wet-mate connectors (Figures 4 and 5). Communication is handled by the optical modems located topside and on the seafloor. Power for the subsea node is provided by a DC-to-DC step-down power converter. The power of the cables is also used to power repeaters within the node. The nodes instrumentation ports provide 100BASE-T Ethernet communication and low voltage DC power to the individual science experiments through standard electrical wet-mate connectors (see Figure 5), enabling scientists to directly access the instruments from anywhere in the world via an internet connection.

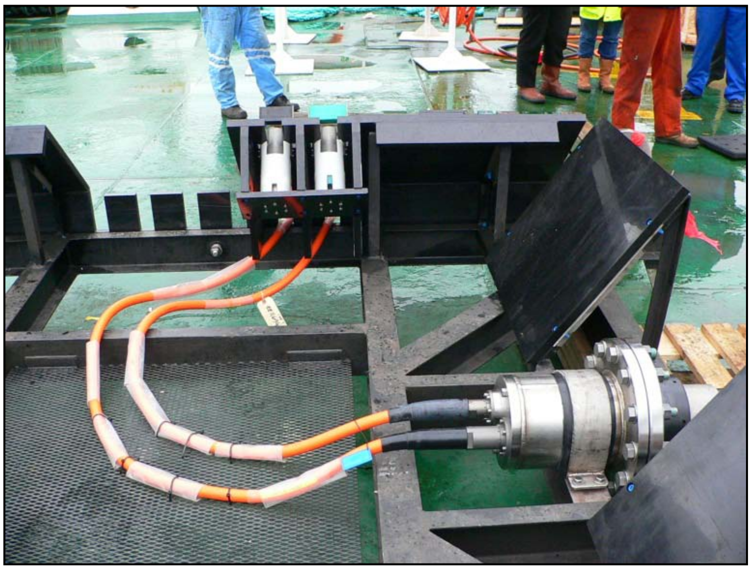

Figure 4. Node base with telecommunication cable termination and wet-mate connectors.

Figure 5. Node base with retrievable node installed, input power, input optical signal connected and 1 of 4 instrument connected.

The evolution of Submarine Cabled Observatories using wet-mate connectivity is rooted in the JAMSTEC cabled observatory. JAMSTEC was deployed in the early 1990s as an all-electrical system and used the existing, previously retired TPC-2 telecom cable for long-term, continuous data collection. The wet-mate connectivity added the benefit of re-configurability and maintainability on the seafloor with the use of Remotely Operated Vehicles (ROVs). Prior to this time, cabled systems were hardwired and required the system to be harvested from the seafloor for maintenance or re-configuration.

The first operational fiber optic cabled observatory was the VENUS (Victoria Experimental Network Under the Sea) in 2006. A summary of cabled observatories is provided in table 1.

Table 1. Summary of Cabled Seabed Observatories

Project Name	Description	Max. Water Depth (Meters)	Backbone Cable Length (km)
ANTARES (Astronomy with a Neutrino Telescope and Abyss environmental RESearch project)	A neutrino telescope residing in the Mediterranean Sea off the coast of Toulon, France. http://antares.in2p3.fr/	2,475	40
DONET (Dense Oceanfloor Network System for Earthquakes and Tsunamis)	This system is designed for real-time seafloor research and surveillance infrastructure for earthquake, geodetic, and tsunami observation and analysis off the coast of Japan. http://www.jamstec.go.jp/jamstec-e/maritec/donet/	4,000	>2,500
MARS (Monterey Accelerated Research System)	Developed as a test bed for cabled observatory technology and instrumentation. Located off the coast of Monterey, California. http://www.mbari.org/mars/	891	52
NEPTUNE (North-East Pacific Time-Series Underwater Networked)	An extensive network providing tsunami detection and measuringvolcanic activity and oceanographic data. Located off the northwest coast of Canada. http://www.neptunecanada.ca	3,500	800
RSN (Regional Scale Node)	A large scaled system planned offshore of the northwest US. http://rsn.apl.washington.edu/	TBD	TBD
OCB (Offshore Communications Backbone)	A buoy-powered ocean observatory that operates off the southern coast of Cyprus. The system provides tsunami and oceanographic data. Future expansion of the system will include oil & gas applications. http://www.touchoilandgas.com/csnet-offshore-communications-backbone-a8854-1.html	2,400	255
VENUS (Victoria Experimental Network Under the Sea)	The first operational optical cabled observatory "on-line" February 25, 2006. Located of Victoria, Canada. http://venus.uvic.ca/	<300	<10

3. Platform-to-Shore Communication Network

Platform-to-shore communications are typically provided by satellite or microwave links. These systems have limited bandwidth, do not function during severe weather, and in the case of microwave links are often dependent on adjacent platforms. To address these limitations, direct platform-to-platform and platform-to-shore fiber optical systems have been used. The primary disadvantages of direct connection approach are the riser installation costs to individual platforms, limited distance/bandwidth, and a lack of future expansion capabilities. To address these limitations, a system using repeaters, branching units, and wet-mate connectors was developed by BP in the Gulf of Mexico (Figure 6).

The 1216-km system of backbone and spurs reaches a depth of almost 2,000 meters. The system has a redundant “ring architecture” with shore landings in Mississippi and Texas. The project initially includes 19 platform connections for subsea distribution points and is capable of expanding to 31 platforms. The use of wet-mate connectors and branching units allows for the expansion and reduces the installation costs associated with riser installation. To increase bandwidth and the distance between platforms, a total of 21 subsea repeaters were used.

Similar systems are planned for installation offshore of Brazil (Malha Optica) and Angola (Sonangol Offshore Optical Cable).

Figure 6. BP Gulf of Mexico fiber optic network.

4. Integration of Communication Networks and Subsea Controls

Telecommunication cable-based subsea observatories have proven to be an economical, reliable, and efficient means of providing high bandwidth communication and power to seafloor instrumentation, power, and communication systems. At the same time, the oil and gas industry has combined the use of telecommunication cable technology and wet-mate connectivity to design scalable high bandwidth platform-to-shore communication systems. In addition, emerging subsea production control technology is designed to eliminate the use of hydraulic lines in platform-to-seafloor umbilical.

The authors would propose an integrated system that utilizes proven observatory technology while considering the platform communication requirements as well as subsea data acquisition and controls system. Such a system would provide a direct link to shore independent of the platform, increased subsea bandwidth, and enhanced reliability (Figure 7).

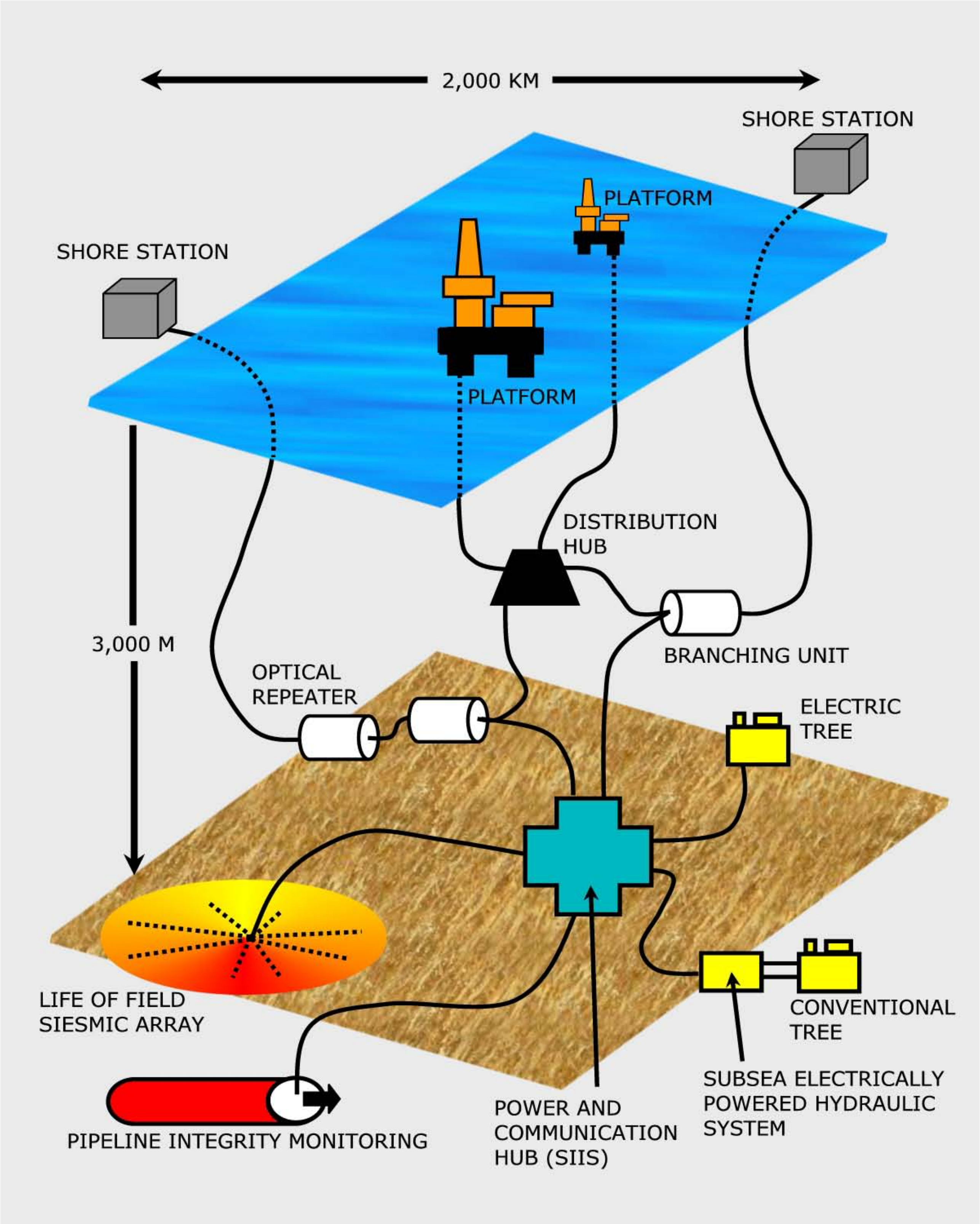

Figure 7. Shows the subsea distribution architecture for an integrated communication and power network.

The key element of the system is the power and communication hub based on field-proven observatory node technology (Figure 8). The design basis requirements for the power and communication hub for an oil and gas applications are given in Table 1.

Table 1. Design basis for Oil & Gas Power and Communication Hub

Design Parameter/Attribute	Value/Notes
Water Depth	3,000 Meter
Input Voltage	2,000 VDC
Communication Rate	1 Gbps
Number of Communication Ports	6
Communication Protocols	Ethernet, CANBUS SIIS Level II, 4-20 ma and 485 MODUS
Electronic Architecture	Dual Redundant
Industry Specification	ISO 13823-6 & ISO 13628-8

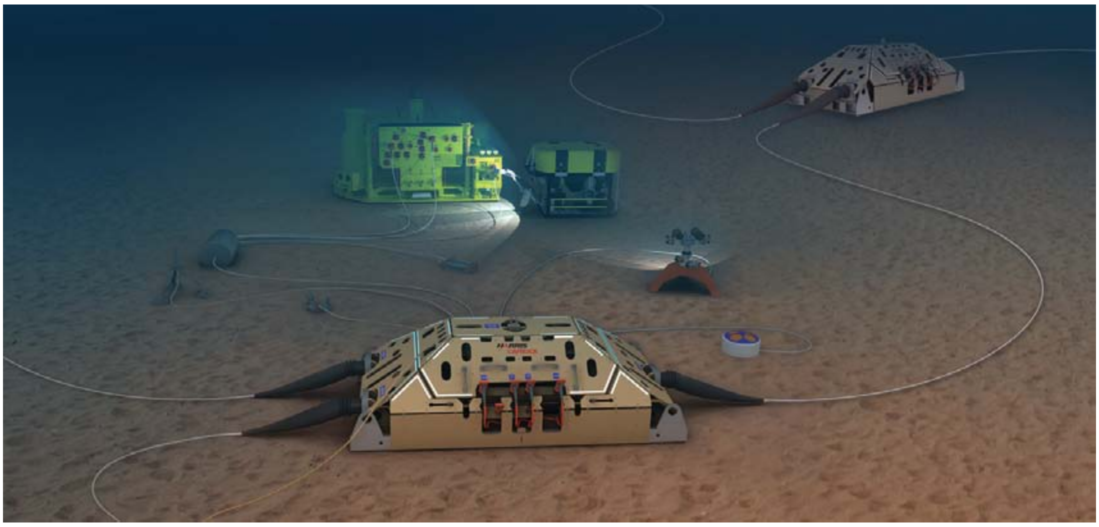

Figure 8. A network power and communication hub connected to a subsea tree and another hub.

In conclusion, an integrated fiber optic network based on well established telecommunication cable technology and proven subsea controls system components does not have any technical barriers to implementation. The major barrier to such a system is the collaboration required between oil companies in a region and, more importantly, the funding models within oil companies. Individual assets typically have the major CAPEX budgets while the corporate information technology groups have limited OPEX-based budgets as well as human resource constraints. The cost of a system will need to be funded by either pooling CAPEX budgets from various assets or entering into a long-term operating contract with a telecommunication company. The problem in not insurmountable and is faced regularly for piping systems that span assets and operators. The best avenue to realize an integrated subsea/platform network is a comprehensive FEEDS study that includes detailed technical as well as commercial analysis.