SUBOPTIC 2007 UNIQUE MARINE OPERATIONS; OIL AND GAS AND SCIENTIFIC APPLICATIONS

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Abstract: The traditional, time tested, installation techniques for deploying commercial undersea telecommunications systems apply directly to an emerging new market of oil platform connectively and also to scientific sensor systems and observatories. Traditional cable designs, branching units, repeaters, and cable burial and protection methods apply equally well in these new applications.

The new systems also have unique hardware requiring new installation techniques that are being developed and tested for these applications. Deployment pallets, cable termination modules, fusible links and wet mate connectors are used in the oil and gas sectors at the connection point to offshore platforms. Trawl resistant science nodes, wet mate connectors, sensor instrumentation and cabling are being used in undersea science observatories. This hardware requires special shipboard storage, handling, over boarding and deployment methods and a means to accurately positioning the equipment on the seabed. Also, unique to oil and gas are the safety requirements for working around oil platforms and its adjoining infrastructure. Health, Safety and Environment (HSE) procedures are standard requirements in this industry.

There is significant synergy between the oil and gas applications and the scientific systems both in hardware designs and deployment systems and methods. In this paper, the areas of commonality between commercial systems, oil and gas systems, and scientific systems are compared and reviewed with a view to how this synergy may benefit the purchasers.

1 INTRODUCTION

The planning, installation, and maintenance methods used for commercial submarine telecommunications systems have advanced over the last several decades driven by new route planning technologies, greater availability of planning data, short project cycle schedules and the need to drive down costs. Many of these advances in practices and methods directly benefit the planning of scientific submarine cable systems whether they be large regional cabled observatories such as Neptune [1,2,3], Arena [2], and ESONET or near shore science nodes at the end of a 20 km cable that provides HDTV to a public aquarium and its web site. In addition, there have been a number of projects connecting offshore oil and gas platforms and seabed infrastructure with optical telecommunications cables to improve the reliability of communications to these platforms.

However, oil and gas platform and scientific submarine cable systems and sensors have unique requirements that impose different, (i) methods for planning, (ii) requirements for route survey data which necessitate different survey instruments, (iii) requirements for cable armor, and (iv)other protection methods such as burial. Some of the most interesting experiments are in the most rugged and challenging seabed often beyond allowable armor cable depths, (places where planners of commercial cable routes try to avoid). Specialized riser cables, seabed connection manifolds, and fusible links are required around platforms. This hardware requires unique deployment methods, driven by node weight, jointing and connector technologies, sensor configuration and placement accuracy requirements. Also important is the manner by which individual sensors are connected to the node and how the sensor field is configured around the site of interest. The hardware design life, reliability and maintenance philosophy, and how often recovery is envisioned in order to upgrade technologies or change experiments or sensors will also drive the hardware configuration, the deployment method, and recovery and deployment approach.

Although the focus of this paper is on new systems, many of the aspects also pertain to re-use of de commissioned commercial cable systems for scientific use. The cable may be recovered and relayed in a different location or may be used in place. [4,5]

The principal investigator designing an experiment or measurement of the seabed will be primarily focused on the physical science, the sensors, and the sampling regime and less on the cable infrastructure that provides the data, control, and power to the sensors. However, knowledge and insight into the design, placement and constraints of undersea cable systems can only assist with trade-off and decision making by the scientific community. Likewise for oil and gas systems, routing must consider existing and future seabed hardware infrastructure. Consideration of oil and gas lease block holders must be accommodated as well.

The objective of this paper is to review several of the unique marine planning and deployment practices and methods that apply to oil and gas platforms and to scientific cable systems since there is significant similarity in these sectors. This paper will also provide the oil and gas and scientific communities with an insight into the main elements of a marine project and the requirements that drive the costs of these systems.

2 ARCHITECTURES

For the present discussion, we have grouped commercial telecommunications configurations as follows:

- Optically Amplified
- Regenerative Systems
- Branched Systems
- Repeater less Systems
- Festoons

Modern commercial telecommunication submarine cable systems generally comprise a point to point transport of optical data from one land mass to another. Data is transported at several optical wavelengths within a relatively small set of fibers**.** Present day systems employ optical amplifiers, spaced every 50 to 70 km along the cable, where the signal on the fiber data is amplified optically. The primary advantage of this technology is that all optical wavelengths transmitted on a fiber are amplified together. There is no optical-to-electrical conversion needed. Additional wavelengths can be added to the system from shore with no change to the undersea hardware. Certainly this technology has direct application to scientific systems and to oil and gas sensor fields in cases where data collected at a node must be sent long distances to reach other nodes, platforms or a shore station. The amplifiers require constant current power that is provided on the cable power conductor.

Ironically, older generation regenerative repeater technology has found application in sensor systems. In these systems, the optical signal is converted to an electrical signal, amplified, regenerated in a clean digital waveform and converted back to optical for transport to the next repeater. This conversion facilitates the insertion of new sensor data (which is predominantly electrical) into the undersea data stream. Sensor systems are based on similar multiplexing architectures.

In many systems, where more than two land masses are connected, it is economical to configure the cable system with branches off the main trunk to connect additional landing sites. Branching Units can be passive, where only fibers or wavelengths are branched, or power switched which have highly reliable switching circuitry so that power can be switched to or from the branch leg (Figure 1). Branching Units (BU) are an important element in many designs of oil and gas and scientific sensor systems as will be described later in this paper.

Figure 1. Branching Unit

Repeaterless systems are, as the name implies, point to point systems where the signal does not require undersea powered amplifiers anywhere along its length. Distances of 200-300 km are possible with this technology. The industry also employs remotely pumped lengths of erbium doped fiber placed along the cable to amplify the signal. The fiber is optically "pumped" from the shore station. This allows greater distance to be achieved without electrical power applied to the cable. The advantages of a repeater less system is that the cable is smaller and less expensive since a power conductor is not required. In cases where a node is powered by other means (battery, wave energy device, or by another cable), this technology may be applicable to the science community.

Festoon systems are a special class of the systems that have already been described, where the cable connects a number of landing sites along a continent. These can be repeater less, or if the distances between landings are great, amplified systems**.** Festoons have application as science systems where there are configured along a coastline on seismic fault lines for example. Instead of an undersea ring configuration, the ring may be more economically closed via a terrestrial route connecting the two landing points.

We now look at how these commercial configurations can be adapted for oil and gas and scientific systems. Cabled observatories, connecting undersea sites of science experiments or seabed oil and gas sensors fields have been envisioned in the following principle configurations:

- Single line of Sensors or Nodes
- Sensor Rings
- Sensor Meshes

Scientific systems deployed to date have been predominantly a single cable routed from the landing point to the sea where one or several sensors are connected to the cable. Many sensor systems employ a single node, sensor or hydrophone at the end of a cable; while newer systems employ 10-20 sensors multiplexed onto a single cable. Power is applied to the cable from the shore station; the return path is either a second conductor in the cable or via a seawater return that employs a sea water ground anode at the end of the cable and a ground bed on the beach. The fundamental draw back of a single cable is its susceptibility to a fault (electrical or cable cut). Due to budgets constraints, single cable sensor systems will continue to be an important configuration used by the science community and there are many ways to reduce the risk of faults to these systems. Several examples of existing and planned systems based on single line architectures include: Guam-Ninomiya [6], H20 [7], Leo-15 [8], Martha's Vineyard [9], Memorial University Bonne Bay, Mars, and Venus.

Neptune Canada (University of Victoria) is planning one of the first sensor systems configured in a ring. The system is envisioned with two cables routed to the same landing point on physically diverse routes, so that if one leg is accidentally faulted, by say a fishing trawler, the other leg can continue to supply power around the ring and transmits data to and from the science experiments. This enhanced reliability comes at the cost of a second landing, shore end cable, and plow burial all elements that are considered in the cost, performance, reliability trade-off on the system. A typical ring configuration is shown in Figure 2 (see Section 8).

Figure 3 (see Section 8) shows a typical trunk and branch architecture connecting many offshore platforms and two landing points. Each platform is assigned a unique optical wavelength that is dropped and added at each BU.

3 COMMON ELEMENTS: COMMERCIAL, OIL AND GAS AND SCIENTIFIC SYSTEMS

The commonality between commercial telecommunication systems and those employed in oil and gas and scientific systems, in general terms, has been described in the preceding discussion. Specific elements of commonality that can be exploited to take advantage of existing assets, hardware, and trained personnel that will lower cost and lower risk include:

- Cable Station, Terrestrial Route, Landing Point
- Shore End and Near Shore Cable Protection
- Wet Plant: Cables, Armor Types, and Branching Units
- Cable and BU deployment
- Jointing and Splicing
- Documentation Standards
- Maintenance Organizations
- Cable Ships

4 UNIQUE ASPECTS OF OIL AND GAS AND SCIENTIFIC SYSTEMS

Sites of Interest (Shelf, slopes, ridges). The most scientifically interesting sites on the seabed tend to be those sites that pose the most difficulty to the cable route engineer for ensuring the long term integrity of the cable routed there. The location of oil and gas exploration sites, sensors, and production platforms are dictated by where reserves are most likely to be found. Shallow water sites on the continental shelf, where the study of fish stocks and water column mixing may be interesting, pose risks from external aggression due to anchoring and fishing. The cable, the science node, and the science sensors and its cabling can be at increased risk. Cable burial and trawler resistant housings provide protection to these elements. Perhaps the most effective mitigation measure is to route the cable in no fishing areas or establish a program of cable awareness with seabed users. This approach has been very successful in the commercial sector.

Slopes and seismically active ridges, also the sites of hot vents, are of special interest to both geologists and biologists. These areas, which tend to comprise rocky and abrasive seabed, require Special Purpose Application (SPA) cable or a Light Wire Armor (LWA) cable to reduce the risk of abrasion faults to the cable. Consideration must be given to the depth of the site to ensure that it is not beyond the recommended deployment depth of armored cable.

Cable Armor Deployment Depths. Cable suppliers and installers specify the maximum deployment depth of armored cables in their handling guidelines. The depth is based on the ability to recover the cable in the event of a repair. In many cases the armored cable must be recovered with the adjoining Lightweight (LW) or SPA cable; and it is the strength of the LW cable that will determine the recovery depth of the armored cable. The depth is also a function of recovery speed, lead angle, and sea state. Exceptions can be made to these depth limits if the design allows for the recovery of the armored cable with like cable (LWA with LWA) or from the "strong side". Use of SPA or LWA cable for several water depths at nodes will also ensure the cable will survive multiple recovery and deployment cycles over its life.

Survey Requirements. Typical survey requirements for telecommunication cable routes require sub bottom data and side scan sonar (SSS) to depths of approximately 800 to 1500m depending of the depth of cable burial. Surveys for the routing of scientific cables and placement of nodes will often require such data to depths of 2500 or 3500 m where many science node and platform have been sited. SSS imaging to higher resolution at these sites along with geophysical seabed information are required for to determine the node stability once deployed and for routing of sensors and sensor cables. Survey must also confirm the location of existing pipelines and other seabed infrastructure. These requirements must be considered when planning marine surveys.

Node Deployment and Recovery. Although cable and BU deployments, as envisioned for these systems, can be identical with practices used on commercial systems, the deployment of the node have some unique aspects. Using the ring configuration in Figure 2 as an example, the sequence of installation may go as follows: 1) direct land the cable and plow in the cable on the continental shelf from shore to sea, 2) as a node site is approached, buoy the trunk cable, 3) transit to beyond the node site and deploy an anchor and ground rope, 4) deploy the node against the ground rope to align it and lay the branch cable toward the BU location, 5) recover the buoyed end of the trunk and splice in the BU leg, 6) deploy the BU legs and then the BU from the trunk cable toward the next node in the ring and repeat the process. System testing is conducted during installation to ensure that there are no faults. If node placement is critical, acoustic positioning transducers can be used in a number of configurations to assist in placing the anchor and node.

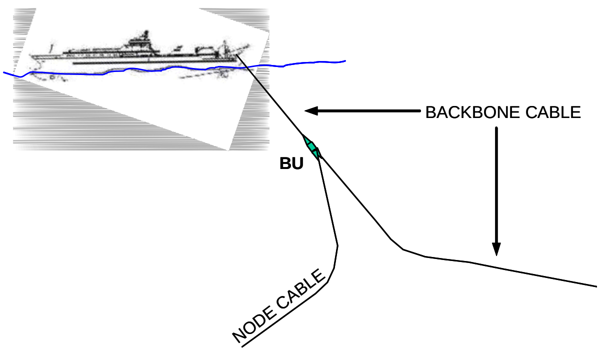

Figure 4. Branching Unit Deployment. The BU is an important element of a oil and gas and scientific sensor systems with a proven track record and well established deployment methods.

Maintenance actions on the node (planned upgrades or unplanned repairs) that require recovery can be made by recovering the node using a lifting line attached by a Remotely Operated Vehicle (ROV), and recovering cable toward the BU. A design with 4 x water depth of cable between the node and BU ensures that the BU is not disturbed in the recovery. Re deployment is done in the reverse direction, with the fixed branch cable length helping to ensure the node is placed at its original position. Improved placement accuracy can be achieved by use of a Long Baseline (LBL), Short Baseline (SBL) or Ultra Short Baseline (USBL) positioning transducers.

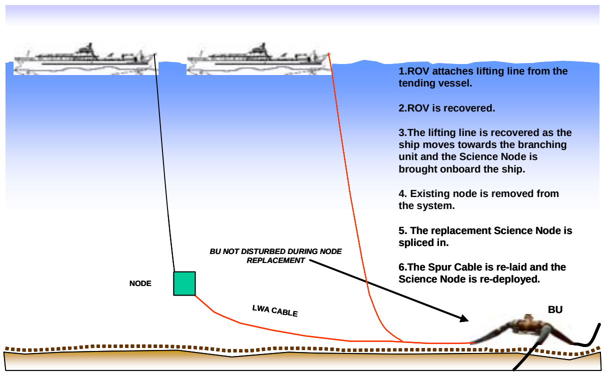

Figure 5. Node Recovery and Redeployment

Sensor fields. The placement of sensors and sensor cables in and around a node are constrained by the length of the sensor cables and the need to establish a keep out area equal to the accuracy of node placement. The keep out area is established so that the redeployed node does not land on sensors or sensor cables. This keep out area becomes smaller at shallower water depths since the node placement accuracy is a function of water depth.

System Availability. The components used in commercial undersea telecommunications have very high reliability and a 25 year design life which provide high system availability requiring relatively few repairs over its life. High system availability can also be met with less reliable, shorter life components if repair and upgrades are planned in the lifecycle of the system. However, repair ship time is expensive. The balance between reliability and refurbishment must be struck that considers: technology insertion, levels of redundancy, component reliability, sensor change out cycles, ship type and cost.

From this, the number of times the node will planned to be recovered over its life can be estimated. This then will drive the node design and how it is placed on the seabed. Central to this is the decision on the type of connection (spliced joint or WMC) between the backbone cable and the node. The spliced joint provides higher reliability at the expense of having to recover and deploy the branch cable during a node repair. If the strategy is to recover and redeploy the node a few times over its life then a spliced joint may be the preferred approach. On the other hand, if it is envisioned that the node must be recovered often, then a WMC may be the preferred. It allows the branch cable to be disconnected from the node and leaves the sensor connections in a fixed frame on the seabed. The trade-off is more complex than described here and one better made once a track record is established on the high power WMC and on the ability of the ROV to move the connecting cable and make these connections reliably.

Repair Vessels. The system engineering for oil an gas and scientific systems also considers the requirements for maintenance vessels to recover and redeploy the node, associated cable and make the required cable splices. Cable drums, linear cable engines, cable tanks, splicing and jointing facilities, cable test equipment, dynamic positioning capability and personal and crews trained in testing, jointing and deploying cable are all part of modern cable ships (Figure 6) that ensure the reliability of the system repair. Consideration of vessels of opportunity as repair ships must allow for the added cost to add this capability.

Figure 6. Purpose Built Cable Ship Tyco Reliance

5 SUMMARY

There is much in common between commercial undersea cable systems and the requirements for systems used in the oil and gas sector and in scientific undersea observatories that can be exploited to shorten schedules, reduce cost, and lower risk to the program. Several of these common elements include: shore end and near shore cable protection; submarine cables, and Branching Units; cable and BU deployment methods; jointing and splicing tools and crews; documentation standards; maintenance approaches; and cable ships

Several of the aspects that are more unique to the planning and implementation of oil and gas and scientific systems have been reviewed in this paper with the objective of providing the customers with an insight into the elements of a marine project and the requirements that drive the cost of planning and installing these systems so that informed decisions can be made in the design of scientific experiments on the seabed and in the configuration of offshore platform and oil and gas sensor fields.

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8 FIGURES

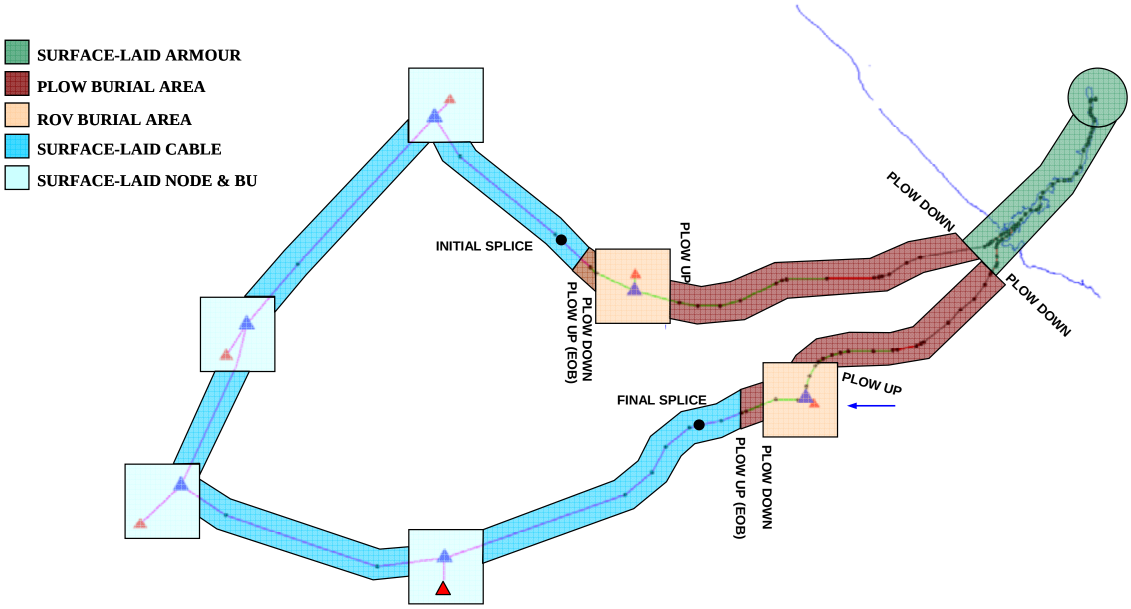

Figure 2. Ring Configuration. One possible implementation with Science Nodes on Branched Legs.

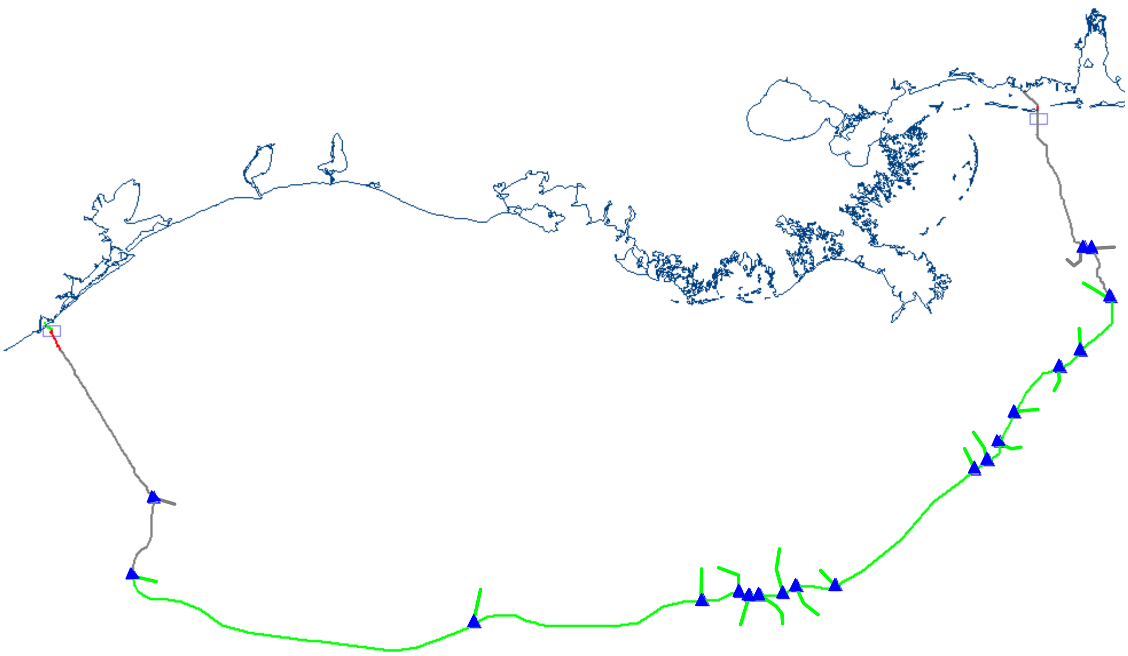

Figure 3. Typical branched configuration connecting offshore oil and gas platforms.