IMPLEMENTING A SUBMARINE FIBER OPTIC SYSTEM TO OFFSHORE OIL & GAS FACILITIES

Wayne Nielsen, Managing Director (WFN Strategies)
Email: wnielsen@wfnstrategies.com

WFN Strategies, 21495 Ridgetop Circle, Suite 201, Sterling, Virginia 20166 USA

Abstract: Today's Oil & Gas operations require massive amounts of data connectivity. Offshore platforms and wells require real-time voice and data connectivity to the onshore facilities and onwards to the rest of the world. They must reach local company offices, corporate headquarters, the Internet, the public telephone network, etc. If the Oil & Gas operations are offshore and beyond the microwave radio frequency horizon, communications are a significant consideration. There are presently two viable options for offshore connectivity beyond the microwave RF horizon: satellite and submarine fiber optics. Satellite provides less voice and data throughput at lower cost. Submarine fiber optics provides "infinite" bandwidth, but at a higher cost.

This paper explores the connectivity, risk, design, permitting, and O&M considerations of implementing a submarine fiber optic cable system to connect offshore hydrocarbon facilities. This paper is based upon experiences in the Oil & Gas sector in the Gulf of Mexico, Australia, Persian Gulf, and West Africa.

1. INTRODUCTION

The implementation of digital connectivity for offshore production facilities using fiber optics is increasingly becoming a strategic initiative within the Oil & Gas industry. A successful implementation is defined by extended reliability and sustained access to the high capacity digital infrastructure, and subsea fiber solutions play a vital role against the legacy of "traditional" microwave and tropo-scatter, radio, satellite, or cellular technologies.

System growth remains strong for the foreseeable future and should maintain this level as oil exploration around the world continues to see renewed interest. The continued move to remote monitoring and automation combined with the need to process large data sets in onshore data centers cements the necessity of fiber for future offshore projects.

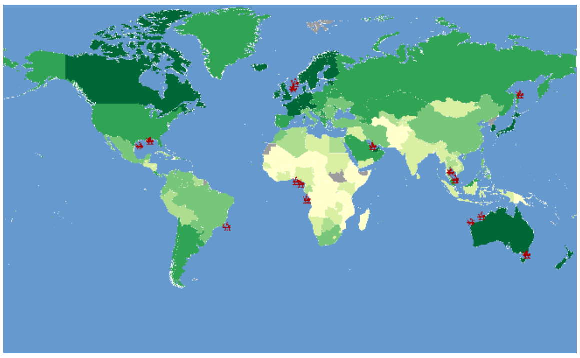

Figure 1: Possible Oil & Gas Fiber Regions

According to the recent Offshore Oil & Gas Submarine Telecoms Market Sector Report:

> *There is expected to be over $2.6 billion worth of investment in submarine fiber systems through 2022 – nearly doubling existing investment amounts. The Gulf of Mexico and AustralAsia regions will account for more than half of all new system activity through 2022. Renewed*

> *exploration efforts from the United States, Australia and other Pacific nations contribute towards this growth trend. The Gulf of Mexico and AustralAsia regions will account for $346 million and $675 million-dollar investments, respectively.* (Clark, 2018)

Connectivity, risk, design, permitting, and O&M considerations of implementing a submarine fiber optic cable system to connect offshore hydrocarbon facilities need to be addressed by Oil & Gas companies.

2. CONNECTIVITY CONSIDERATIONS

The ownership and operating model for a subsea fiber serving the Oil & Gas sector needs to be considered. While there are multitude of models and variations to any option provided, there are three primary options available to the Oil & Gas company:

- Dedicated Oil & Gas company system – typically employed when a user requires accessing fiber in a timely and long-term manner, which is critical to their business and more ideal alternative models are not readily available.
- Multi-company agreement or consortium – useful when a basin is developing, and future assets locations are questionable, or when there is a desire for a level of guaranteed ownership and access rights. Cross company, indefeasible rights to use (IRU) would be used to complete the network to improve resiliency and flexibility.
- Managed service – in order to be successful, the company selling the fiber access needs to be established with previously guaranteed funding.

For any of the direct company ownership models, the owner(s) can consider selling extra connections and excess bandwidth to third parties, which can be accomplished by direct sell or through external third parties. Ownership models are analyzed on a case-by-case basis, as they can evolve over time into joint ownership consortiums, managed services or others as economics and risk management allow. (Nielsen, 2008)

The amount of Oil & Gas company involvement depends upon the chosen ownership option. It could be that the Oil & Gas company is responsible for everything or it might only lease services, and the provider is responsible for everything between the service interface points. Subsequently, any model other than 100% ownership by the Oil & Gas operating company poses long term risks. As such, choosing an alternate solution can only be done when the risks are properly mitigated – both contractually and technically.

The possibility of connecting any hydrocarbon facility system to other systems in a region to provide mutual restoration and overall increased resilience needs to be considered. There is a growing desire by both the traditional commercial cable owners and Oil & Gas companies to connect offshore hydrocarbon facilities to existing or planned commercial systems. Existing systems with pre-existing Branching Units (BUs) in the vicinity of a hydrocarbon facility and available capacity can be easily and cost effectively connected.

Related projects, such as other Oil & Gas submarine systems in the vicinity, need to be identified as possible connection partners. Potential BUs need to be identified for future production facilities. If the facilities require the same capacity and are closer to the plant, similar submarine systems could be installed to the future facilities, e.g., 400Gbps per facility.

Synergistic submarine cable systems, such as existing or planned commercial systems with available or potential adjacent BUs, should also be identified. As such, we are seeing an increase in connectivity activity between commercial systems and hydrocarbon facilities. The Australia-Singapore Cable, for instance, has a planned spur to Port Hedland, Australia and will likely service the Oil & Gas community there; the North West Cable System connects Port Hedland to Darwin, and from Darwin the Nextgen the terrestrial network connects all the way back to Perth and Sydney.

Planned commercial system developers should be approached early in their implementation cycle with a view to negotiating the addition of a BU supporting an offshore hydrocarbon facility.

Existing systems without a pre-existing BU will necessitate available system bandwidth and/or fiber pairs, as well as require an extensive and potentially risky marine operation for the addition of the BU. Because of this inherent risk, there is typically little desire for an existing cable owner to add an Oil & Gas specific BU to its system unless such a system's economic or technical throughput are greatly enhanced by such an effort.

3. RISK CONSIDERATIONS

Risks associated with an Oil & Gas fiber optic cable need to be evaluated and described in detail, including ranking the options according to risk. This detailed Risk Matrix should include all potential issues related to commercial, social, operability, local impact and socioeconomic considerations, Health, Safety, and Environmental (HSE). This is in addition to any other risks deemed applicable, including the following:

- All Physical risks identified, including suggested mitigation
- All Political/Legal risks identified, including suggested mitigation
- All cultural risks identified, including suggested mitigation.

Further, the Equator Principles, which are a set of voluntary standards designed to help banks identify and manage the social and environmental risks associated with the direct financing of large infrastructure projects, cover over 70% of international project finance debt in emerging markets. Equator Principles 2: Social and Environmental Assessment and 3: Applicable Social and Environmental Standards are potentially applicable when discussing social and political aspects of an Oil & Gas fiber optic cable and need to be addressed accordingly.

Project risks and potential mitigation need to be thoroughly addressed by the Oil & Gas company, the key aspects of which need to be included in the project schedule as the recommended approach for progressing a project, such as:

- Commercial Risk where the results of marine survey and Route Working Group differ from estimates – mitigated by applying a per-cent "factor" during the budgeting exercise to allow for additional cable lengths.
- Legal and Regulatory Risk where environmental permitting stalls the implementation effort – mitigated by starting the permitting effort early and engaging interested parties throughout the project schedule.
- Operability Risk where existing buildings may not be suitable in size for use by the system – mitigated by locating another location nearby that has adequate space and power or building outright a new shelter.
- Service Impacting Risks include Availability of Service where timely completion of the system impacts project service delivery expectations – mitigated by the effective interaction between the marine installation and commissioning and the plan of work.
- Socio-Economic Risks, such as Compensation Claims where various local industries require compensation

claims for the fiber optic cable effort – mitigated by the Oil & Gas company initiating the same procedures/policies as with the product pipeline.

- System Failure/O&M Risk where the cost and efficacy of O&M may be impacted by the time of year (e.g., hurricane season) and the speed and cost of repair may be significantly impacted – mitigated by negotiating beforehand marine maintenance coverage and/or utilizing backup VSAT service for the duration of any outage.
- Timely Project Completion in line with project service delivery expectations – mitigated by the effective interaction between the construction, installation, and commissioning and the plan of work.

4. DESIGN CONSIDERATIONS

A high-level fiber optic cable system design needs to be developed in collaboration with the Oil & Gas company which outlines expected performance, fibre count, bandwidth availability, facility requirements (space and power), possible synergies with other parties, and potential mechanisms for expanding the system.

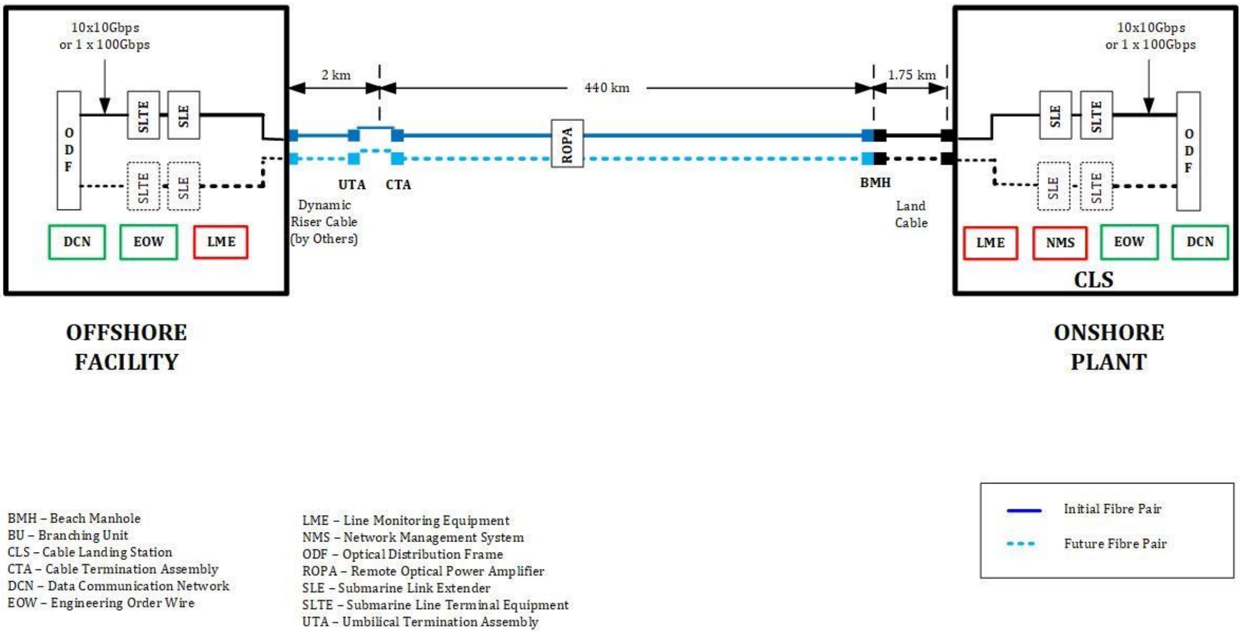

Figure 2: Typical Oil & Gas Offshore Unrepeatered Fiber Optic Cable System Design

The submarine fiber optic cable system can be a point-to-point system (festoon) or an add/drop system that supports multiple offshore facilities. The system interface points are in the communications room on the offshore facility and in the onshore Cable Landing Station. Voice and data distribution on the offshore platform is standard other than the distribution wiring is in a marine and hydrocarbon environment. The onshore interface might be local but will probably require interfaces to forward the voice and data to national or international corporate offices. (Foreman, 2018)

The following principles are typical design guidelines for an Oil & Gas fiber optic cable system:

- Ensure capability to support Oil & Gas company network communication needs for at least 30 years starting from RFS, a requirement that is 5 years longer than typical commercial systems.

- Ensure Oil & Gas company receives a minimum of 10 Gbps of fiber optic bandwidth capacity between each Oil & Gas company office facility.
- Consider options that provide cost optimization for future offshore facilities tie-in to the fiber optic network.
- Ensure SLA guaranteed availability of 99.995%.
- Ensure end-to-end QoS over the entirety of the carrier network

The expected design life of a system is 25 years with normal submarine system maintenance; however, the increased life of hydrocarbon facilities of up to 30 or more years will need to be addressed by the system suppliers. After the landing site surveys and marine surveys are completed, the fiber optic cable will be engineered to minimize all identified hazards and risks. This could include such features as additional backup power for the Cable Landing Station, additional armoring, and/or increased burial for the submarine cable.

Design options will need to typically consider the following:

- Offshore facilities connecting to onshore with onward international connections via local telecommunication service providers
- Offshore facilities connecting to existing fiber optic cable systems with onward connection via Tier 1 network service provider
- Offshore connecting to “in progress” fiber optic cable systems with onward connection to Tier 1 network service provider.

The various components of a submarine fiber optic cable system when implementing a submarine fiber optic cable system to an offshore facility are as follows:

- Budget – the capital and expense budgets for the life of the system
- System availability – Service Level Agreements
- System capacity — number of fiber pairs and traffic bandwidth
- System interfaces – SDH, Ethernet, other
- Plan of Work and Schedule – scope and timeframe of the project
- Regulatory and Permitting – permitting matrix and expected timing
- Desktop Study – the basic route, pipeline and cable crossings, cable armoring types and cable protection (burial requirements)
- Marine Survey –Desktop Study verification and cable types confirmation
- Cable Route Engineering – the physical security of the submarine system from natural and man-made hazards
- Offshore facilities – method of cable interface, i.e., seabed equipment, J-tube/I-tube/over-hang head/rotary joint, topside routing, floor space, HVAC, electrical power/backup and security/alarms
- Simultaneous Operations – special considerations when installing around offshore hydrocarbon facilities
- Onshore facilities – beach manhole, outside plant, ocean ground bed (if required), Cable Landing Station space, HVAC, electrical power/backup and security/alarms
- Training – high-level system design training and technician training

- Documentation – system manuals, as-builts, test results and software
- Network Operations and Maintenance – Network Management System, spares, test equipment and technical assistance
- Marine Maintenance – maintenance contract and wet plant spares
- Warrantee – dry plant and wet plant warrantee support

A detailed set of Technical Requirements is typically prepared based on the data collected and analyzed with inputs from the Oil & Gas company. The design includes network architecture and proposed technologies to implement that architecture and meet Oil & Gas company's capacity and functional requirements. The high-level design is reviewed with the Oil & Gas company and appropriate revisions made before the commencement of the effort. A detailed set of Service Requirements is prepared and reviewed with the Oil & Gas company before the effort commencement. The technical study assist the Oil & Gas company by:

- Reviewing existing and future submarine cable system/projects in the region and their main characteristics
- Evaluating options/feasibility to connect to such systems (at-sea branching, dedicated system towards common landing point, etc.)
- Evaluating onward connection solutions and estimated speeds (i.e. to reach network operating center)
- Evaluating reliability and availability characteristics of local connection (e.g. branch to existing system, dedicated local system, etc.) and onward connection, and possible redundancy
- Evaluating general site requirements to land submarine cables on platforms/vessels
- Considering damages or reliability issues related to existing submarine cable systems.

The overall goal of the design is to ensure that the fiber optic network, which includes the subsea fiber cable, termination assemblies, and optical termination equipment, and transport nodes meet or exceed the performance metrics (e.g., 99.995%) availability per year.

5. PERMITTING CONSIDERATIONS

Installation of a fiber optic cable system typically requires a significant and expansive permit process. For submarine fiber optic telecommunication cables installations to hydrocarbon facilities, four types of permissions are typically required:

1. Operator's License – the license to operate a submarine cable system
2. Permits in Principle – the permissions or approvals to install a cable system within a country's territorial waters, possibly its EEZ, and along a terrestrial route to the Terminal Station
3. Operational Permits – those permits necessary for survey, installation, and maintenance operations by the installer/contractor who is employed onsite (whether marine or terrestrial) to accomplish day-to-day operations
4. Permission from other Marine Users – includes crossing permissions from other cable and pipeline owners.

A high-level review of the regulatory and permitting requirements for each area of interest needs to be accomplished, summarized with:

- Regulatory requirements for each area of interest - The Australia Telecommunications Act 1997, for instance, is the principle statute that lays out requirements for installation of submarine cables.

- Permitting requirements for each area of interest
- Estimated timeframes to complete regulatory and permitting requirements for each area of interest – typically 18 to 24 months duration
- Estimated costs to complete regulatory and permitting requirements for each area of interest.

Working in or around a national park, both marine and terrestrial, for instance, may require a license. Cost and timing are dependent on the type of project and the required assessments. A pre-application meeting may be desired before an environmental assessment application is made.

The resulting Permitting Matrix needs to consider applicable legislation and permitting requirements, including:

1. The actual authorisation and permits needed to install telecommunications infrastructure in territorial waters;
2. Environmental concerns expressly related to the development of the system and;
3. Any Native Land Authorizations.

Many of the permitting and approvals are based on assumptions and are subject to change based on the approved cable route. Environmental concerns may not only affect the route of the cable, but also the scheduling. Permitting is typically the long pole in the tent of fiber optic cable implementation and may require up to 24 months duration to complete.

Permitting requirements may have changed since the last project's permits were issued. The permitting process requires astute and adaptive personnel to successfully acquire the necessary permits in a timely manner.

6. O&M CONSIDERATIONS

Marine Maintenance is the major contributing factor to the annual Operations & Maintenance (O&M) budget. The typical approach to running a submarine system is one of self-insurance, achieved by entering the system into one or more marine maintenance agreements; holding sufficient spare submerged plant in strategic locations; and investing in third party liaison programs. Most system owners enter their systems into a maintenance agreement(s) and then build up reserves from income to cover repair costs, typically based on one repair every two to three years.

The major logistical and cost considerations for an Oil & Gas fiber optic cable are:

1. What services to outsource
2. Distribution of submerged plant spares
3. Choice of Jointing Technology
4. Inventory management of spare submerged plant
5. Management of repair operations
6. Maintenance of charts and system documentation
7. Ongoing liaison with third parties (e.g., fishing communities and sealift companies)
8. Tracking of vessels by Automatic Identification Systems (AIS) monitoring.

Once the system is commissioned, the responsibility for the repair of the system will be passed from the supplier to the Oil & Gas fiber optic cable owner. In the event of a fault, repairs will entail repair or replacement of any of the marine elements of the system from beach manhole to beach manhole. As part of the supply contract, the manufacturer will provide the owner with an agreed quantity of spares to carry out any such work. The work of repairing submarine cables is a specialist service and provided by a very limited number of companies.

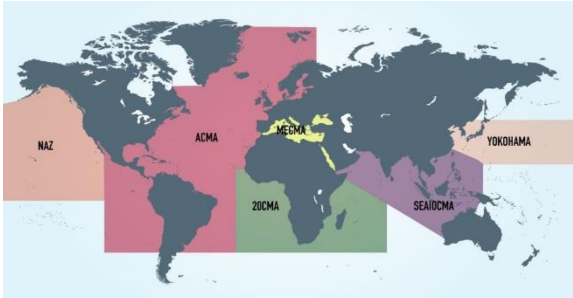

Figure 3: Overview of Club Agreements Worldwide

Marine Maintenance is a shared service where several cable owners share the service of resources within a defined operational area. The agreement can either be Private where the contractor and cable owner agree prices and conditions on a bilateral basis, or Club agreement where conditions and prices are linked with all the other participating cable owners.

Figure 4: Overview of Private Agreements Worldwide

Marine maintenance costs consist of the fixed yearly standby charge plus any at-sea charges (usually day rates for transit and for onsite charges). There also may be yearly storage charges for customer spares kept at the marine contractor's facilities.

7. SUMMARY AND CONCLUSION

Whereas the telecommunications industry sees subsea fiber as a core business, the Oil & Gas industry is making the engineering, procurement, installation, and maintenance of these systems more viable in order to continue minimizing the cost of hydrocarbons to the end consumer. Oil & Gas company operations and technology teams are more focused on identifying and deploying these digital systems because of operational applications that require fiber optic capacity.

Connectivity, risk, design, permitting, and O&M considerations of implementing a submarine fiber optic cable system to connect offshore hydrocarbon facilities by Oil & Gas companies can be summarized as follows:

- The continued move to remote monitoring and automation combined with the need to process large data sets in onshore data centers cements the necessity of fiber for future offshore projects.
- There is a growing desire by both the traditional commercial cable owners and Oil & Gas companies to connect offshore hydrocarbon facilities to existing or planned commercial systems.
- Project risks and potential mitigation need to be thoroughly addressed by the Oil & Gas company, the key aspects of which need to be included in the project schedule as the recommended approach for progressing a project.
- The overall goal of the design is to ensure that the fiber optic network meets or exceeds annual performance availability metrics.
- Permitting of fiber optic cable implementation may require up to 24 months duration to complete.
- Marine Maintenance is the major contributing factor to the annual O&M budget, but extremely necessary.

In conclusion, the Oil & Gas industry has realized and accepted the value of subsea fiber connectivity and numerous implementations have been accomplished and more are underway. Any developments that make subsea fiber solutions more cost effective, flexible, and readily deployable will add to the industry's embrace of this technology.

8. REFERENCES

[1] Clark, K. (2018). Submarine Telecoms Market Sector Report: Offshore Oil & Gas. Sterling: STF Analytics Division of Submarine Telecoms Forum, Inc.

[2] Foreman, C. (2018, November 15). High Speed Telecommunications For Offshore Assets: Implementing a Submarine Fiber Optic System to Connect Oil & Gas Facilities. Submarine Telecoms Forum.

[3] Nielsen, W. (2008). Next Generation Digital Connectivity in Pacific Basin Offshore Oil and Gas Production Facilities. PTC '08. Honolulu: Pacific Telecoms Council.