Next Generation Digital Connectivity in Pacific Basin Offshore Oil and Gas Production Facilities

Wayne Nielsen, Managing Director
WFN Strategies
21495 Ridgetop Circle, Suite 201, Sterling, VA 20166
wnielsen@wfnstrategies.com

Proposals Objectives: This paper explains how increased demand in digital systems and subsequent demand for high performance connectivity is leading the Pacific oil/gas industry to standardize on fiber optic based connectivity including subsea fiber for offshore platforms. The paper explores various technical considerations in designing a fiberoptic system for these special applications, as well as the commercial, operational and maintenance considerations involved for the enterprise. The paper concludes with a summary of how the telecoms cable industry can address the unique requirements of the offshore market, wherein communication services are an ancillary function rather than a primary objective of the customer's business.

Abstract:

With a desire to operate Pacific Basin oil and gas fields more efficiently and increase operational safety, it is becoming a necessity to implement an increasing number of digital systems. These digital systems, including, real-time monitoring, collaboration, video surveillance, work management systems and other applications are requiring connectivity with more and more capacity, reliability and security. Looking at these requirements from the productivity, it is easy to understand why current solutions, particularly offshore, are struggling to meet the emerging requirements. Limits on size, capacity, reliability, distances and cost often need a custom solution for individual hydrocarbon basins. The capacity, reliability, low latency and security provided by offshore fiber optic systems are identified as key by the industry for improving production operations. Based on the multi-decade lifecycle and production rates, hydrocarbon basins are now able to justify the implementation of and ongoing operations of fiber systems.

The implementation of digital connectivity for offshore production facilities using fiber optics is increasingly becoming a strategic initiative within the oil industry. A successful implementation is defined by extended reliability and sustained access to the high capacity digital infrastructure. This paper will elaborate on how subsea fiber solutions play a vital role, including consideration with the desire for high bandwidth submarine fiber solutions against the imposing realities of economics, permitting and the legacy of "traditional" microwave and tropo-scatter, radio, satellite or cellular technologies. Drawing upon extensive oil and gas telecoms development and engineering experience, the paper will explain how the telecoms industry could better serve this growing market in its infancy and beyond.

Case for High Bandwidth, Low Latency and Reliable Connectivity

To safely and efficiently operate assets, the oil and gas industry is implementing a growing number of digital systems on hydrocarbon producing assets, including, real-time monitoring, collaboration, video surveillance and work management systems. Focusing on the productivity angle of this case, current connectivity solutions are struggling to meet the emerging requirements.

Figure 1- Distributed assets collaborating with cross discipline teams

The demand for high bandwidth, low latency and highly reliable digital connectivity is growing as more and more digital systems are further deployed and new ways of using them evolve. Accordingly, the "digital oilfield" is being driven as follows:

1. Back-office applications, such as email, file sharing, etc., benefit in cost of operating and time to repair with centralized servers and data storage being located onshore. Yet performance to large facilities can only be achieved with high end connectivity.
2. Operations applications, such as work management systems, document storage/management, personnel logistics, scheduling and others, need to be accessed from distributed workforces and require highly responsive performance to meet the heavily iterative workflows. This responsiveness is driven by both high bandwidth to allow multiple sessions, as well as low latency to minimize the protocol/latency sensitivity. Furthermore, through the introduction of handheld devices and wireless LAN on the facilities, digital systems are used more continuously instead of a single downloading at the end of a shift.
3. Real-time data is used to support both field optimization, as well as monitor the health of the facility in order to initiate necessary interventions. Data is shared real-time with suppliers as well as used internally. Data collection has evolved over the past ten years to not only collect 10-20 times the data points on facilities, but also collect some data points multiple times a second; whereas previously this was done on a per minute basis. For example, a facility 10 years ago might have monitored 2,500 tags across 5-10% of the topsides; today they are monitoring 50,000 tags across topsides, rotating equipment, vessel management and risers at a frequency of up to 25 Hz. While each tag is small (2 bytes), the quantity and the need to synchronize the data within seconds of acquisition requires high bandwidth.
4. Collaboration between distributed and inter-discipline subject matter experts is becoming a normal way of working. The use of 24x7 high resolution video conference systems to "extend the control room" as well as the use of smaller systems for workgroups is becoming a normal operating condition. In doing this, the demand for video bandwidth is moving from sub-megabit per second to 10's of megabits to deliver the quality and quantity required.
5. Video surveillance, whether using fixed cameras or wearable computers, is beginning to grow as the capacity and the work force is distributed between onshore and offshore. This provides the ability to bring the work area closer to a limited set of subject matter experts, such as when working a procedure on a piece of rotating equipment in the field.

Figure 2 - Onshore & offshore teams using video conferencing

As a result of the increased usage and the critical demand for high performance, large production assets are no longer capable of extending their digital capability with high latency (>200ms) or low bandwidth links (<10Mbps). Instead, it is now understood, large facilities will use in excess of 45 Mbps and as high as 1 Gbps in the near future as the digital systems continue to evolve naturally and through step change programs. Table 1 demonstrates the difference in capabilities and acceptable performance level a typical operating manager might see between high and low bandwidth.

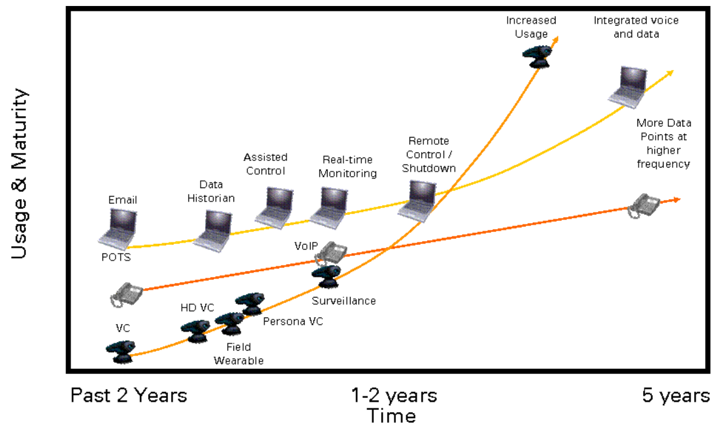

Figure 3 - Relative growth of voice, video and data technologies in an asset, the largest of which is video based

Activity	Maximum Capability at Low Speed	Minimum Capability with High Speed
Data Rate	2 Mbps	155 Mbps
Daily Throughput	20 Gigabytes/day	1.5 Terabytes/day
Telephone Calls	20-30 medium quality	200 high quality
Video Conferences	1 or 2 medium quality	25 high quality
Personal Webcams	Not Possible	50 active sessions
Video Surveillance	1-2 low quality feeds	50 medium-high quality
Work Management System	5-10 users	100 users
Document Management System - 5 Mbyte drawing in 1-2 min	1-2 users	50 users
Internet/Intranet Users - 100 Kbyte in 3-4 seconds	1-2 users	100 users
Real-time data collection	200,000 tag/30 seconds	600,000 tags/1 second
Life of Field Seismic	Tapes used to transport	Same day transfer
Petrotechnical Workstation	Local Data	Shared Data 1-2 users

Table 1 – Impact of Bandwidth on Performance and User Capability

Basis for Fiber

The primary telecom technologies available for evaluation are satellite, microwave (including "broadband WiMAX") and fiber. As shown in Figure 4, fiber is clearly the lead technology as a result of its ability to reach nearly unlimited distances using subsea repeaters; near unlimited bandwidth using 10 Gbps dense wave division multiplexing (DWDM); and tolerance to poor weather conditions including rain fade and wind damage. While microwave is capable of delivering bandwidth, the primary drawback is its limitation of 40 km's between hops. Many new assets are hundreds of kilometers from the beach. In deep water, they are floating and their movement makes the RF alignment difficult to maintain. In addition finding and maintaining suitable repeater stations for the life of the asset is nearly impossible.

Microwave and other RF based technologies, however, play a role in helping to extend the high bandwidth from a primary asset to support and drilling vessels located within close proximity. Because they move often, it is cost prohibitive to build subsea fiber risers to connect them.

Satellite is not capable of meeting long term bandwidth needs nor can it achieve the necessary latency targets. Satellite requires a large footprint for medium bandwidths, which is difficult to reserve on platform topsides where space is at a premium. Satellite is appropriate, as a backup for catastrophic failure of the primary communications system.

System Development

Once fiber is deemed to be a strategic solution for a specific hydrocarbon basin, a high level implementation and system design need to be developed for the area. While the global needs of the organization need to be considered, the majority of the constraints are of a local basin nature. The issues can be broken into the five primary categories. Even though they are broken out, there are cross dependencies in these issues. For example, if an expensive technology is selected such as subsea repeatered, it may have an impact on your procurement or commercial model feasibilities.

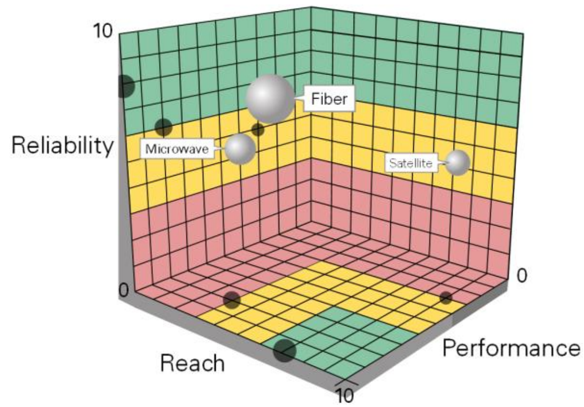

Figure 4 - Relative comparison of technologies

Basin System Map

The first area to consider is the overall *system map*. At the highest level, this is a line drawing of the basin showing immediate and future service areas and how best to connect while avoiding as much subsea congestion (e.g. pipelines) as possible. In addition, the landing points are identified based on their survivability to weather, availability of terrestrial backhaul and ease of marine approach, including environmental and pipeline congestion. For example, in the Gulf of Mexico, the landing stations were selected to be over 400 miles apart to minimize the potential impact of a single hurricane knocking out both beach landings and causing a catastrophic outage. Given the unique nature of partnership on fields and potential transfer of assets between organizations, as well as potential desire to sell "excess" bandwidth when looking at asset locations, one must be concerned with several factors such as those listed below.

- Where are the assets, including company operated, partner operated, others?
- Which assets are dependent on other assets, such as pipeline gathering stations?
- How will the basin map evolve during the coming 25 or more years?
- What is the distribution and grouping of assets across the basin?

In selecting the final system route, consideration needs to be given to using sub tended fiber and RF connectivity through "backbone" platforms. While this does not provide ideal reliability, it does offer lower cost and extended flexibility and range as backbone branching units provide 100km range; whereas subtended fiber connectivity provides 300-400km range off of a backbone connected platform. Often, these will be connected through wetmate connectors to maximize flexibility and minimize disruption to service during hook up and commissioning.

Technology Plan

Once the base route is selected, a *technology plan* is developed. The offshore Oil &Gas sector is moving towards the preference for IP over "LAN extensions." To achieve the transmission distances required, the two solutions in use are subsea repeatered systems and signal re-transmission at each platform in the chain. The drivers for a subsea-based system are for platform independence when power or longevity of the "repeater stations" cannot be guaranteed, for capacity, security and future flexibility; the desire is to drop a lambda for each facility providing in excess of 10 Gbps of dedicated capacity. Ideally, if retransmission is done on each platform, platforms are within 100 km of each other, allowing additional optical pairs to be lit thereby creating mini-rings and bypasses to minimize the effect of one or two platform outages.

A significant concern is over what access layer protocol to use. One can either choose to go with a SDH/Sonet-based solution, or with a packet-based solution, such as Ethernet protocols. The drivers here are to consider how the end users, including third parties working on the facility, build and operate the network, the security requirements, space requirements and cost for network hardware gear. The move to start building internal MPLS core networks or equivalent to provide segregation of process control networks from enterprise from third parties traffic is growing. This promotes packet based solutions versus standard TDMA.

Engineering and Procurement

Engineering and Procurement of a system is also critical. Together they are the key as to how to properly front-end load the engineering to ensure competitive procurement and effective contracting strategy.

While a perfect model will vary by country and complexity of the environment, the goal is to balance the risk on the system builder versus the system buyer. There are many types of engineering risks for an offshore platform, each having potentially noticeable effects on the cost of the system, including

- Riser design, which is based on the movement of vessels, weather, water depth, vessel design and slot availability, and may cost $1-3M per riser depending upon the design.
- Pipeline crossings, which can be quite numerous and owners may have additional protection requirements. The system in the Gulf of Mexico, for example, has more than 60 pipeline crossings in the 1200 km main trunk.
- Preferred oil & gas engineering companies and procedures are often required due to the proprietary nature of each vessel where fit for purpose designs using previous history and information are critical to timely and trusted success. This has a time, logistics/workload and cost impact on a project.
- Final route, which is dependent upon the survey, seabed clutter including mooring patterns and field developments throughout the system. These changes can create significant (10's of km's in length) and multiple re-routes during the detailed engineering process, which can impact the overall project.

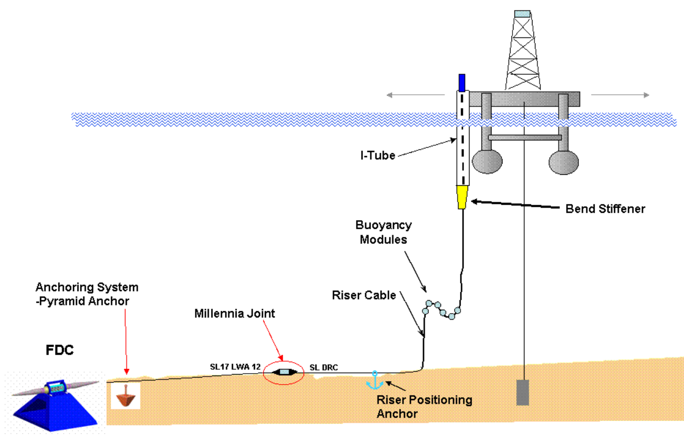

Figure 5 - Gulf of Mexico System Lazy S riser with float and ballast

Given there is a need to balance the project lifecycle including engineering, construct versus the cost and risk management, it is typically not possible to do 100% of the engineering prior to construction contract issue. However, experience does indicate a significant level of information on topics, such as those identified above need to be included in the specification to make it biddable and reduce risk for both parties. A buyer then needs to decide if the builder will carry the risk or share it amongst the parties. Where possible, it is recommended to have clear and relevant unit prices and to allow proper contingency in the buyer's project allowance to cover any unknowns.

Ownership Model

There is a need to give careful consideration to the ownership and operating model for a subsea fiber serving the oil and gas sector. Due to the nature of the oil and gas industry where there are limited hydrocarbon basins, various forms of ownership and operating partnerships including government partners need to be considered due to the significant build and maintenance costs of subsea fiber.

While there are multitude of models and variations to any option provided, there are three primary options available:

First, is a dedicated system owned and operated by the dominant end user E&P company. This model would be 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.

A second option becomes useful when there are multiple company consumers desiring fiber connectivity, but there is limited time to build a multi-company agreement or consortium. This option is also useful when a basin is still developing and future assets locations are questionable, or when there is a desire for a level of guaranteed ownership and access rights. In this model, each of the dominant E&P companies a cable with a shore landing connected to their facilities. Cross company, indefeasible rights to use (IRU) would be used to complete the network to improve resiliency and flexibility. Spurs could also be negotiated at a later date. For this to be successful there must be either initial agreement on the supplier, or a high level of interoperability to tie the systems together. Options to consolidate cable maintenance also become available but time is less critical.

The third option is to acquire a managed service. This model poses several concerns about the ability to gain the required access. Experience would indicate in order to be successful the company selling the fiber access needs to be established with previously guaranteed funding. Given the unique nature of this business, the time to acquire customers and guaranteed income can vary drastically and thus the anchor "buyers" run the risk of not achieving their desired connectivity.

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 can be analyzed on a case-by-case basis, as it can evolve over time into joint ownership consortiums, managed services or others as economics and risk management allow.

Subsequently, any model other then 100% ownership by the E&P 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.

Maintenance Options

A few years ago, an extended outage of the connectivity to a platform may have been tolerated for a week or two; this is no longer the case.

While offshore assets may or may not be remotely controlled, the telecommunications is critical to effectively and safely operate platforms. As a result, it is imperative the telecom system be built to withstand failure through construction methods and redundancy in design including the use of satellite. It is also imperative a system restoration plan, as well as other preventative maintenance be put into place. Given the offshore environment, logistics and training, maintenance and repair is best sub-divided into the wet plant and dry plant including system monitoring.

Through minor additions to existing skills and toolsets, many of the existing offshore telecom companies are capable of operating the dry plant. This includes activities such as licenses, satellite backup, terrestrial backhaul, system monitoring & fault isolation, hardware replacement, re-provisioning, security and testing.

The wet plant, including repair, surveying, material depot and system expansion, however, is not within their immediate scope of capability, and needs to be developed. Often these plans will be customized to provide, flexible maintenance capabilities suited to system owners' particular needs. The system owner then needs to balance the major variables in maintenance coverage, including:

- Response time is one of the most critical variables to be determined when identifying a solution. This will drive the option set available as certain basins may be geographically isolated (e.g. Caspian Sea) or remote. The industry will most likely require a typical one week repair window
- Local content, which is developed and sustainable, is often desired as part of the owner's allowance to operate in certain hydrocarbon basins. To achieve this, training and support are required during the early stages of the lifecycle.
- Preventative maintenance, including subsea inspections and failure mode analysis, will have to be scheduled and vessels provided in such a manner as to minimize effort and scheduling.
- Logistics including vessels permits, technicians, depot and material shipments can all have an impact on the ability to manage external resources,
- Cost of both base operations and repair operations will have to be managed against budgets as well as response time. The more responsive and dedicated the system, the higher the base or retaining cost.

As an owner evaluates these variables, they will need to consider the following primary maintenance solutions identified below in Table 2.

Options	**Description**	**Response**	**Costs**
Cable Maintenance	Regional service	Potentially slow due to	Pro-rata based on

Agreement	geared towards large carriers	priority	bandwidth/cable length. T&M Repair
Self Maintenance using Vessel of Opportunity	Contracted vessel(s) and cable repair skills	Medium with ability to reprioritize within owner's work demand	Low retainer costs; requires purchase of spare parts and tools
Contracted Maintenance	Contracted cable vessel owner	Uncertain – depends upon local of boat	High costs
Dedicated Vessel	Dedicated cable vessel and standby personnel	Fast – dedicated	Highest possible costs

Table 2 – Support Options

Once a model is selected, especially if working using standard telecom solutions, a thorough review needs to be accomplished to ensure it will meet the business, safety and procedural demands of the oil & gas industry; e.g., security guidelines about cable grappling near pipelines or other subsea infrastructure.

How Can the Subsea Fiber Industry Help?

Whereas the telecommunications industry sees subsea fiber as a core business, the oil and gas industry needs to make the engineering, procurement, installation and maintenance of these systems more efficient in order to continue minimizing the cost of hydrocarbons to the end consumer. E&P Company operations and technology teams need to be more focused on identifying and deploying the digital systems and applications that will eventually use the connectivity rather than implementing and managing subsea fibre.

In turn, as the oil & gas industry desires relatively low cost and resilient solutions, the subsea fiber industry needs to become familiar with the formers operating model in order to:

- Minimize system cost – The oil industry continues to focus on cost per barrel metrics regardless of whether it is development or lifting costs. Key areas are to have interoperable solutions across vendors, low cost replacement and expansion parts, common solutions suitable to all companies and maximum knowledge of the unique construction areas having an impact.
- Maintenance opportunities - The oil and gas industry possesses fleets of available and potentially suitable vessels; the vessel of opportunity is an available maintenance scheme. Further development to support VOO maintenance, as well as system expansion could benefit future take-up of services. Further evolution and demonstration of the cable maintenance associations to accomplish this type of close-in work is also beneficial.
- Space conscious - Platform space is limited and it is often difficult to get more then two (2) racks of equipment for the transmission system and associated batteries and management systems. Realizing the simplistic needs of the user environment, "tighter" packaging of the optical line terminating equipment (OLTE) and associated components would be beneficial to quick and efficient deployments.
- Future needs - An assumption in today's systems is that there are topsides available to place the OLTE and distributed network equipment. In the near future, topsides may not exist due to the cost and complexity of constructing floating vessels in deep or frozen waters. In such an environment, the OLTE and last meter distribution will need to reside on the seafloor and will require quick and effective connect/disconnect solutions, as well as well tested survivable packaging.

As the oil and gas industry is beginning to realize and accept the value of subsea fiber connectivity, it is difficult to estimate what tomorrow's requirements will be. Thus, any developments that make subsea fiber solutions more cost effective, flexible and readily deployable will add to the industry's embrace of this technology. That being said, gimmick solutions should be minimized as system reliability cannot be scarified as the subsea fiber system dependency grows.