Permanent Reservoir Monitoring (PRM) System Installation: The Installers Perspective

Introduction

Global Marine Systems Limited (Global Marine) has a vast wealth of knowledge in designing planning and installing all types of fibre optic cable (FOC) systems, including lightweight cable systems in water depths ranging from the very shallow (<10m) to the very deep (>6000m). This article shares Global Marine's main considerations when designing and delivering long lasting **Permanent Reservoir Monitoring (**PRM) installation solutions that reap rewards for those oil majors globally carefully assessing the opportunity cost of same.

Permanent Reservoir Monitoring, or PRM, is a relatively new method for enhancing oil extraction from certain existing offshore fields, as well as new ones. These systems generally offer improved operational costs, optimised drilling and are well placed to deliver Enhanced Oil Recovery (EOR).

The capital investment in PRM is significant, and experience with the handling and deployment of the small-diameter cable types that are used in PRM is crucial to the success of these system installations. Teamed with this is the need to have comprehensive cable route engineering to identify seabed obstacles, detailed analysis looking at cable and sensor deployment issues and a thorough evaluation of all installation risk considerations.

Planning and Pre Engineering Considerations

Field design

What is the best field design herringbone or ring backbone?

This will be dictated by the oil reservoir shape and existing field infrastructure. Anchor wires, pipelines, umbilicals, power cables and communication cables as well as the prevailing environmental conditions, all of which impact the path that the PRM cables can take. Compromises may well need to be made between the ideal sensor location and actual viable locations from the point of view of cable deployment and installation. The field design must take into account the existing infrastructure, in conjunction with the installation process, as each has an impact upon the other driving a successful outcome. Nonetheless, it is undeniably true that it is essential to achieve full coverage of the sensor packages.

Route Engineering

It is of paramount importance to work with a subsea cable installer with extensive experience in undertaking detailed pre-system deployment planning, providing a detailed risk assessment to aid critical decision making that will impact system cost and security.

Working with knowledgeable route and cable engineers is essential as they are able to offer assessments for the suitability of potential terrestrial landing sites and the subsequent engineering design including providing engineering solutions for cable connectivity to various offshore platforms or FPSO's. Moving this on further they will be able to provide sound routes, evaluate cable risks, and present solutions that promote sound return on investment decisions against a backdrop of long-term system security. However, it doesn't stop there; having cable installation and maintenance experience ensures that a complete lifetime solution is

offered, one that protects the significant investment being made even further.

This end-to-end approach holds great advantages and should comprise of: desktop studies, top level cable routing and engineering, realistic cable quantity estimates, site and route evaluations, hazard risk assessments, solution design, survey management, offshore and post survey route engineering, burial assessment, planning and design.

Desktop Study

A cable route desktop study is a key part of the initial phase of any cable related plan. For Hydrocarbon developments it often forms part of the FEED process. Properly executed, it should accurately determine core information about the route, such as an overall risk assessment, submarine project plant quantities, handling characteristics and potential issues and precise detail regarding the system's security through its lifetime.

The desktop study provides a technical reference for the entire project, from the outset of the survey through to cable installation, and then throughout its maintenance lifecycle. It ultimately supports the design life of the cable system, detailing key influencing factors and subsequent issues that are likely to impact the installation and maintenance as planned if not addressed from the outset.

A good desk top study will focus on risk factors along the proposed cable route. Looking closely at effects on system integrity, constraints, influencing cable operations, and control costs. Based on perceived risk, the report will provide decision makers with the information required to identify the most suitable system solution.

A summary of the typical scope of a cable route desk top study follows:

- Visit potential landing sites; meet with representatives of relevant Marine Authorities local to the systems, and visit representatives of industry whose action may affect the integrity of the cable (e.g. fishing, shipping, planning, and port authorities).
- Research bathymetry, seafloor and shallow seabed lithology, currents, weather, seismology, tides, permits, other seabed users, fishing, shipping.
- Identify areas of potential difficulty for survey, installation and subsequent maintenance.
- Investigate and detail environmental and cultural aspects relating to the cable route highlighting relevant statutes and regulations of the various authoritative bodies.
- Identify possible sources of risk to the cable and the extent of which identified hazards pose a risk to the cable.
- Identify permits, licences and other regulatory requirements necessary to install the cable and for the cable to remain in situ along the proposed route.
- Recommend routes that do not conflict with existing subsea infrastructure.

Burial Assessment

The burial assessment process takes into account soil types in the area of installation and proposes the best type of burial methodology; whether it be water jet trenching, ploughing or other burial techniques to suit the client’s requirement for burial depth, whilst not putting the cable itself at risk during handling.

Positional Accuracy

Seabed positioning of the product is paramount to give the optimum separation for all sensors within the array; the water depth is a key factor to the selection of subsea positioning system used to monitor position. Many factors can affect the intended target location for the PRM sensors, the most influential of these would be sub surface water currents due to the very lightweight nature of the cable being used. Vessel speed and location must be closely controlled to achieve the correct sensor location using active feedback of the touchdown location. The touchdown location can be ascertained by several means

a. Touchdown monitoring by ROV during installation.
b. Spot checks by acoustic beacons attached to the cable during laying.
c. Touchdown monitoring by AUV.
d. Touchdown monitoring by assistant vessel using multi beam sonar.
e. Computer modelling using input of vessel position, speed, cable speed, subsea current and cable hydrodynamic characteristics using the Makai system.

Options 'a' and 'b' are susceptible to positioning errors arising from sound velocity changes, interference from vessel noise or field noise arising from construction activity within the area of operations, so the operator must be mindful of these factors and their possible affects during installation. It has been the experience of Global Marine not to rely on one method alone for tracking the cable location at the time of installation and that a more holistic approach to gauging the subsea cable position combining two or more of the list above will be beneficial when working to tight tolerances, especially in the deeper water installations now being considered for PRM systems. The position of the cable takes on great importance at the end of the sensor line when the vessel needs to turn through 180° this is where pre-installation planning comes to the fore in designing the vessel track to achieve the desired vessel route but the ability to deal with changing circumstances on site in real time is also most important.

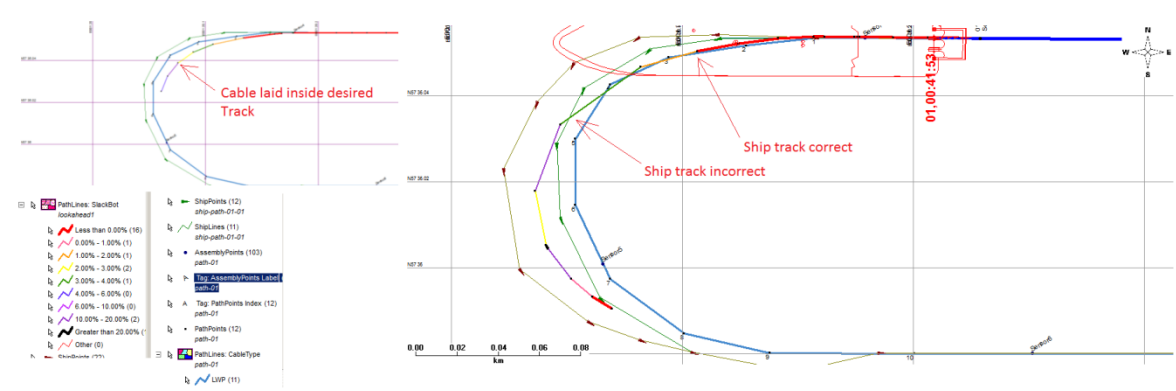

Figure 1 Using pre-lay planning to design the correct path for the vessel

In the illustration above, the cable has ended up inside of the desired track as the vessel did not go outside of the cable path enough. This expensive mistake which would have affected the position of Sensor 6 and those thereafter is avoided through the use of pre-lay planning to avoid such an occurrence.

Simultaneous lay and burial

It was mentioned above that ROV touchdown monitoring can be used to good effect during installation for monitoring the cable position, a more effective approach would be to use the same ROV to bury the cable at the time of laying as it is more efficient on two counts.

- The vessel does not need to make another pass over the whole area for burial operation.
- If the cable starts to move off track it can be rectified immediately prior to burial whilst the installation vessel still has the cable in suspension.

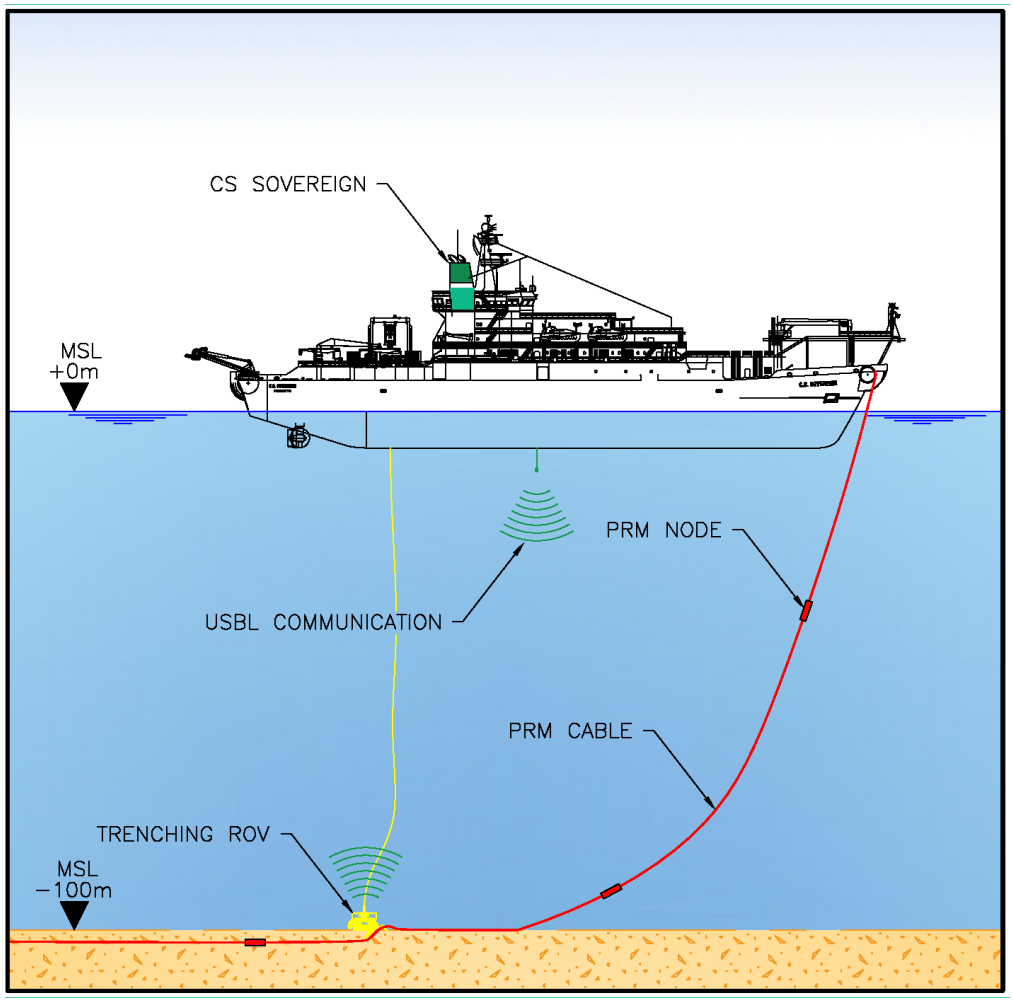

Figure 2 Graphical representation of simultaneous lay and burial of cable

Due to the lightweight design of the cable, positive engagement between the cable and ROV using a system such as the Seismic Cable Bellmouth assembly system designed by OSBIT optimises burial performance. This approach removes the risk of losing track of the cable whilst the burial operation is underway. With the small metallic element in the PRM cable design tracking by conventional means can be problematic.

Node Design

Node design can have a real impact on the ease of which the system can be installed. It should be remembered that the more conventional approach to system design, has a far better chance of installation without having to 'redesign the wheel'. Tried and tested methods stand a better chance of successful installation. The maxim of 'keep it simple' has never been more important.

Cable type

Marine installation is a tough environment for both cable and sensor. Cables and sensors need to stand up to being yanked, rattled across a set of rollers, squished through numerous pairs of wheels and then deployed through the water column to finally come to rest on the seabed. Even then the trauma is not over as a machine passes over to bury it down into the seabed by blasting a water jet over the area to make a trench. With this in mind it is essential that the cable and plant chosen is robust enough to withstand the rigours of cable installation but more importantly if a problem occurs in later life it must be repairable using conventional means.

Vessel Selection

Over and above the DP2 vessel classification as a minimum for work of this nature many more considerations come into play for vessel selection.

- Weather working capability.
- Accuracy of deployment in deeper water depths.
- Storage capability, can the vessel take all cable and plant in one lift? Numerous port calls increase costs.
- Cable working ability, can the vessel support all the operations necessary for the project or will more specialist vessels be required at certain points.
- Is simultaneous lay and burial a possibility with the vessel deck design?
- Vessel endurance, can the vessel stay out of port long enough to complete the project?

Array Burial Options

Trenching is the most widely used burial method for sensor arrays, due to the congested nature of the installation environment (pipelines, communications cables anchor arrays etc.) and the complex seabed configurations of the arrays. The trenching process involves the use of water jetting at various high and low flow rates.

Ploughing is the most efficient and compliant method of cable installation with good burial depths achievable and with minimal environmental impact. However with the small lightweight cable type generally used for PRM systems ploughing can have its challenges, modifications can be made to the cable path which needs to be designed around cable characteristics and mode parameters.

Summary

As highlighted within this article there are numerous influences to consider regarding cable routing, handling and installation methodology when investing in a PRM system, with such a significant investment it is critical that these key factors are not overlooked. The time spent in planning and design will pay dividends to the long term fruition of the project, vessel selection is key to success, in terms of system selection a simple design is vital and importantly a close working relationship between installer and client is paramount.