

Mars rewired

Adding the world's deepest permanent seismic monitoring system to an existing field required considerable engineering expertise.

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The end of the hurricane season may not seem the most ideal time during which to install the world's deepest permanent seismic monitoring system offshore the Louisiana coast, but during October last year Shell did exactly that.

The company chosen to perform the installation and acquire the repeat seismic surveys was Multiwave Geophysical, which mobilized the crew to undertake this ground-breaking project at the end of September.

The project entailed burying a 3.7-mile (6-km) four-component (4-C) seismic cable into the sea floor almost directly beneath the tension-leg platform (TLP) at Shell's Mars field. The cable was then connected to a recording unit on the platform itself via a fiber-optic riser or umbilical. Beyond that the project calls for several repeat 4-D seismic surveys using the cable sensors over the next year or so. The first of these was acquired immediately after the cable had been installed.

Shell scientists have already recognized the use of 4-D seismic data for managing the Mars field and have acquired 4-D data using towed seismic streamers. However, they have also recognized that the best way to acquire 4-D data in this situation is with a permanently installed sensor system.

However, the investment required to install a large permanent monitoring system over a large field such as Mars is significant, as is the technical risk. Therefore, in order to de-risk such a project, Shell has gone ahead with this pilot project over Mars with a single buried cable to evaluate not just the technical benefits of 4-C/4-D data, but also the basic issues of design and implementation in deep water close to field infrastructure. To help in these evaluations, the project included burying the cable to different depths along its length, simultaneous acquisition with 4-C seafloor

nodes that were placed next to some of the 4-C cable sensors and a calibrated hydrophone placed near the seafloor to record the far-field airgun source signature.

The main challenges during the installation were the surface and near-surface environment, which was dominated by the weather and currents, and the subsea environment, which included production risers and other infrastructure around the TLP.

This particular period in October last year saw hurricane Ivan wreak havoc in the Gulf of Mexico and its coastal regions, which delayed some of the pre-installation preparation work on the TLP itself. The prevailing loop currents also caused some delays. These are ocean currents that can be likened to rivers of fast flowing water that meander across sections of the Gulf. The strength of some of these loop currents cause structures such as the Mars TLP to move tens of meters when the currents are at their highest and give the platforms the appearance of being towed through the water with a very distinct wake. Such currents, of course, made the necessary surface and near-surface activities of the cable deploying vessel, some of which were very close to the TLP, even more of a challenge.

At the seafloor, the main problem faced was that of placing the cable between the tension legs and a group of five production risers. Multiwave developed a technique to do this dubbed "keel hauling," which used a strategically placed weight on the seafloor, a winch on the platform with an acoustically positioned winch wire and a remotely operated vehicle (ROV). This technique involved creating a large loop in the 4-C cable in order for it to be passed safely underneath the risers and taken up by a winch on the TLP at the same time as it was paid out from the dynamically positioned (DP) cable deploying vessel.



Figure 1. The remotely operated vehicle is brought onboard the cable-deploying vessel after laying cable on the seafloor. (Photo courtesy of Multiwave Geophysical)

Multiwave then placed the cable in a straight line on the seafloor to within 15 ft (5 m) of the planned position using its Near-Seabed Deployment System (NSDS). Given the water depth of between 2,950 ft and 3,280 ft (900 m and 1,000 m) at the Mars location, this deployment accuracy itself is a major feat and unprecedented in the industry. A fiber-optic umbilical, barely 1 in. in diameter, was then passed up to the platform and connected to the recording system.

There is common understanding of the very basic requirement to bury a permanent cable in order to prevent it from being disturbed by future activity at the field. But the depth of burial and its impact on the quality of the seismic data, and in particular the 4-D data, is largely untested and much

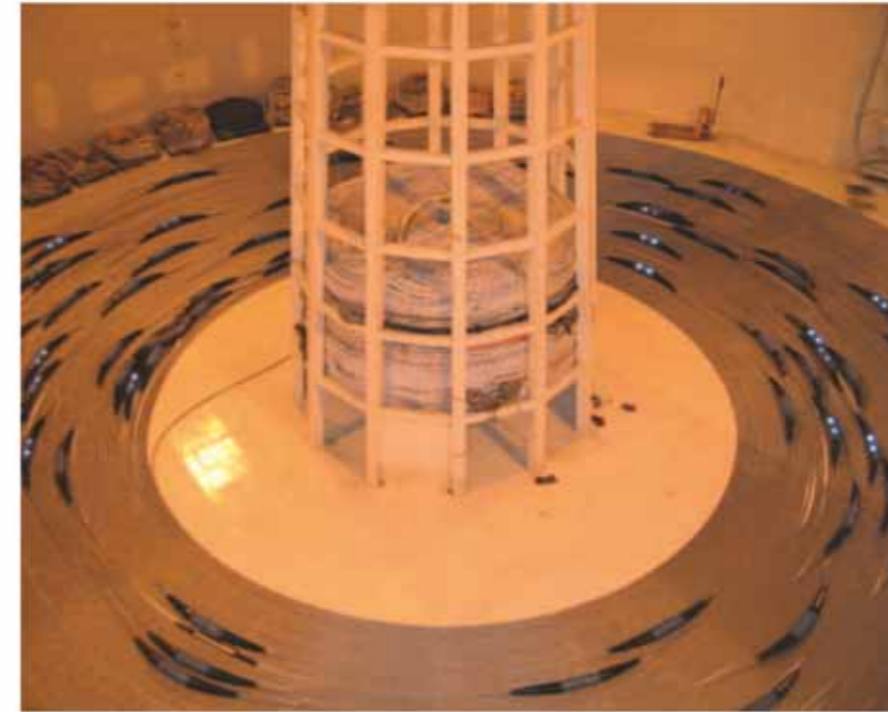


Figure 2. The four-component cable awaits deployment in the cable tank. (Photo courtesy of Multiwave Geophysical)

less understood. Shell therefore included this aspect of permanent installations within the pilot study by having a portion of the cable unburied and the remainder buried at two different depths.

Intuitively it is appreciated that the data from any buried portion of the cable will be susceptible to less ambient noise than the portion that is unburied. However, from the data that has already been collected at Mars with this system, it is possible that a good case could be made for burying sensors for normal ocean bottom cable (OBC) acquisition.

In many ways, however, the actual installation phase of the project was just the tip of the iceberg when looking at the project as a whole. For months, before a single piece of equipment was mobilized for the project, a design team at Multiwave in collaboration with Shell were hard at work. After all, this was a project that involved installing equipment on the TLP at Shell's largest oil and gas producer in the Gulf of Mexico, close-pass activity with a DP vessel, ROV and trenching equipment, and of course the sensitive 4-C seismic cable installed within meters of the TLP itself and the production risers. Extremely detailed design and planning was required. The first phase of the project included a design study for the installation itself, part of which addressed

the engineering design of the equipment. This had to take into account the various environmental conditions that might prevail at the offshore site. Major weather systems, including hurricanes, and the infamous Gulf of Mexico loop currents are high-potential events that required modeling. Finite Element Model (FEM) catenary analyses of the existing 3,940-ft (1,200-m) production risers, together with the new 4,265-ft (1,300-m) fiber-optic umbilical to the buried multicomponent seismic cable, were undertaken using 10-year statistical environmental data for sea states, winds (hurricanes) and loop currents. Position shifts of the TLP surface structure due to these same 10-year conditions were also added to the overall dynamic model of the new fiber-optic umbilical.

Analysis of the geotechnical data of the seafloor was carried out in order to design the most appropriate umbilical-anchoring and cable-burying method. Finally, dynamic stresses, tensions and bending moments were calculated for each component of the installed equipment.

Other aspects of the detailed design study included a project safety plan, step-by-step field installation procedures, project and task-based risk assessments, a survey plan, and an offshore communications plan. Combined with an extremely comprehensive



Figure 3. As shot from the remotely operated vehicle, the four-component cable as it looks on the seafloor. (Photo courtesy of Multiwave Geophysical)

set of detailed engineering drawings for every piece of hardware involved, the study represented a proof of concept for the overall project. Regular stakeholder review meetings added to the confidence that the installation project would be a success.

Looking ahead, the intention is that Multiwave will acquire several swathes of 4-D data using the buried 4-C cable over the next 12 to 18 months. Undoubtedly a great deal will be learned to take forward into future permanent monitoring installations. **E&P**