Transforming ocean bottom seismic technology into an exploration tool

Vidar Hovland[1*] **explains how a new generation of ocean bottom node technology could transform oil company demand for seabed seismic solutions to both reservoir and exploration projects.**

It has been one of the enduring features of the oil and gas E&P industry that ocean bottom seismic (OBS) survey technology has yet to fulfil its potential. Ten years ago a similar observation was made (Berg, 2007). It was suggested then that towed-streamer surveys dominated the offshore survey market because the technology was well-established and inexpensive compared to ocean bottom techniques. The message was that an ocean bottom node (OBN) seismic acquisition could be 'well worth the additional expense'. This was perhaps an unfortunate turn of phrase reinforcing an industry perception that seabed seismic was indeed a costly operation.

In the intervening period, according to our best estimate, OBS surveys have in fact been slowly eroding the previous dollar value market share held by towed streamers, rising from around 4% in 2006 to approximately 15% in 2015 (see Table 1). It is also clear that the application of ocean bottom node systems rather than ocean bottom cable (OBC) is becoming the technology of choice for oil companies. More than 50% of OBS surveys now use some form of seabed node receivers (see Table 2). These have been developed over the years by a number of suppliers. Those OBC surveys that are being carried out are largely dependent on legacy systems with no similar record of recent innovation.

We contend in this article that the technical case for node-based seabed seismic has been made in theory (See Ronen et al., 2009) and, in practice, judging by the increasing number of OBN surveys worldwide. It is also the case that in the current oil price crisis that oil companies for the foreseeable future are likely to concentrate their investment dollars on optimizing output from existing reservoirs in order to replenish reserves. This implies an increased role for OBS if the technology is offered at the right price point. We also believe that in a number of future exploration scenarios, e.g., complex geological settings in known oil provinces, OBN can be a more than viable alternative to towed-streamer solutions.

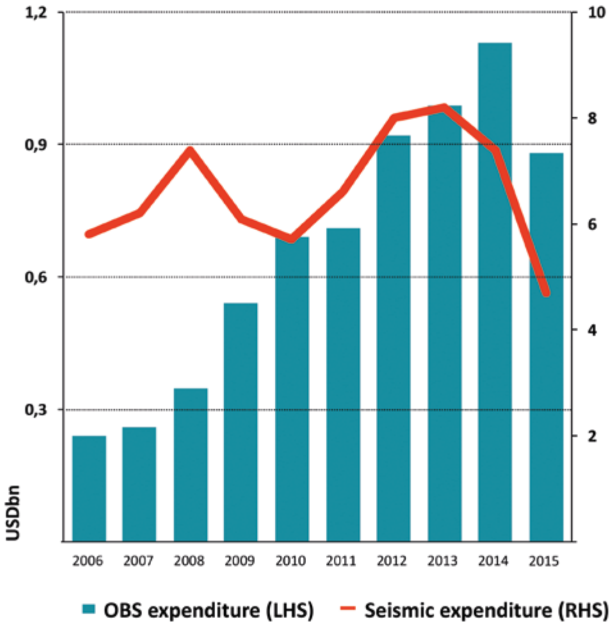

Table 1 *OBS market share of marine seismic streamer market.*

Challenges ahead

The benefits of OBN seismic surveys are well established (Olofsson, 2012). They include operational efficiency in the presence of surface and seafloor obstructions, full azimuth coverage, vector fidelity, high-resolution imaging naturally rich in low frequencies, low ambient noise, 4D repeatability, full elastic wavefield recording and continuous recording. These have far outweighed the initial perceived downsides such as clock drift correction, node reliability and, on occasion, sparse receivers, all of which are being resolved.

More generally, there has been a lingering concern over the blind shooting aspect of OBN acquisition, i.e., you cannot be sure of the data recording quality until the nodes have been recovered from the seabed and interrogated. With OBC recording, data is available to the crew in real time. However, these days, node reliability is typically as high 98%, and there is built-in redundancy in a network of nodes should one or two fail. With OBC, on the other hand, cable damage is always a risk. The vulnerability of in-sea electronics and

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cable connectors is an issue where failures can have a serious impact on the survey operation and costs. An advantage of OBN operations is that no connectors are involved, nor do the nodes have to be attached to a recording vessel or buoy. Both of these can be an obstruction for the source vessel, in addition to being a challenge in deep water.

To date OBN seismic surveys have mainly been deployed as a reservoir tool because of the cost. The industry has yet to be convinced that OBN can be a cost-effective option for exploration. For this to happen, a step change in the technology offering is still needed. It requires a significant reduction in the acquisition cost relative to current offerings. For OBN to really become a competitive exploration tool, it needs to be able to match, for example, the acquisition costs of multi-azimuth and wide-azimuth towed streamer operations while providing superior imaging. This view is endorsed by a recent BP study (Lewis et al., 2016). It found that high-density ocean bottom seismic is becoming significantly more cost-efficient with the cost per trace reducing by approximately 50% every two years. The conclusion was that 'through the combination of new efficient node deployment methods, simultaneous source techniques, larger node inventories, and "split-spread, single-line-roll" geometries, more routine application of higher-density OBS surveys, not only for reservoir management purposes but potentially in exploration settings, is expected.'

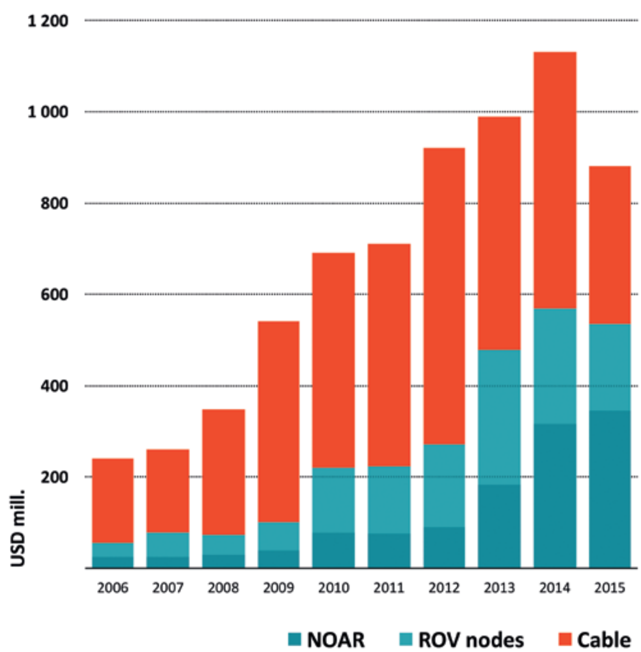

Table 2 OBS market by acquisition technology.

Back to the drawing board

To accelerate the development of a more technically optimal and commercially viable solution, we have focused principally on the operational side of OBN systems where most of the cost and efficiency issues seemed to reside. Our analysis suggested that the available deployment and retrieval solutions for ocean bottom nodes needed to be revisited. Speed, reliability and safety of operations seemed to be mainly affected by the degree of crew involvement in the prepping of nodes before deployment, the positioning of nodes on the seabed and then the recovery and storage of the nodes on deck for data collection. The logic of this thinking led to some reconsideration of node design with regard to aspects such as shape, battery life, position tracking during deployment as well as storage before and after deployment to ensure efficient battery recharging and node maintenance. Commercially, our system would be independently manufactured and available to any seismic survey operator for a fixed vessel installation or a containerized option. The idea was to enable an expansion in the overall market for OBN technology including exploration.

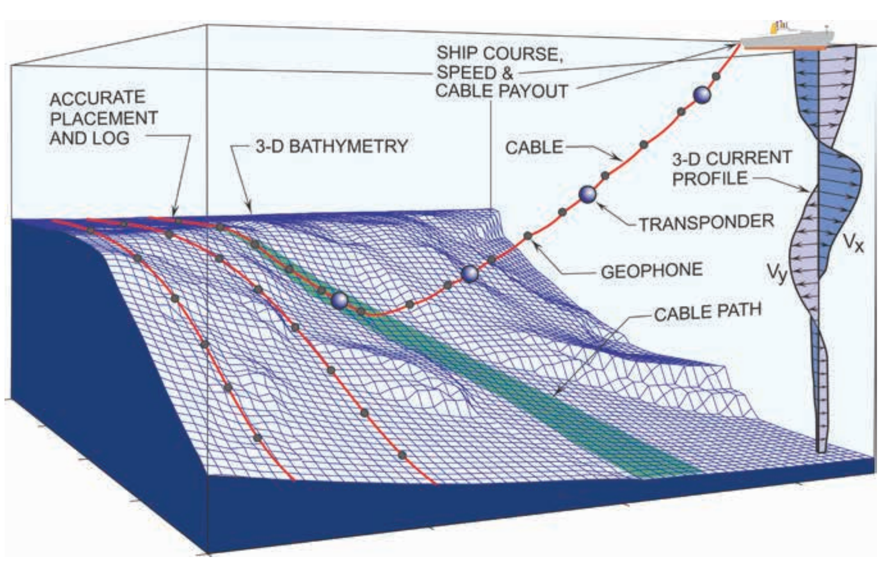

Figure 1 Controlled node deployment using MakaiLay software (image courtesy of Makai Ocean Engineering).

Figure 2 *A3000 ocean bottom node.*

Figure 3 *Fully automated and space-efficient storage system.*

At the onset, the vision for a new generation of OBN would focus on introducing a fully integrated, hands-free, automated launch and recovery system. The target was to develop a system capable of deployment and recovery speeds of up to three knots (but probably more) at significantly lower cost than available systems. This approach generated some additional innovation, particularly with regard to node and automation design and the rethinking of the data management system. That said, the imperative was to employ standard equipment where appropriate, and not reinvent unnecessarily. The focus was to develop simple and robust solutions that come out as reliable and affordable.

Key to achieving high-speed performance has been the inclusion for the first time of a 26 kHz USBL transponder built into the node providing a number of key advantages. The obvious operational benefit during a survey is that the position of every node is known at all times. In practical terms there is no necessity to pause rope deployment to physically attach, or detach, a transponder to/from a rope as in existing systems. Current systems also typically only attach the transponder to every second, third or even fourth node, to save on cost and deployment time. A crucial difference with transponders in every node is that an operator, or system, will be able to monitor the rope profile in the water column during deployment and thereby have the ability to better control the rope tension or slack along the seabed, which is necessary when deploying at high speed. This becomes particularly important on the seabed at varying water depths. We have incorporated available software systems that have been used for decades in laying power and telecommunication cables to manage these seabed operations (see Figure 1).

Devil is in the detail

Autonomous node

Industry experience strongly pointed towards any OBN solution being based on a node-on-a-rope deployment and retrieval system. Our challenge was to see how this could be improved, looking first at the requirements of the node. It was clear that there was an immediate efficiency in designing a single node capable of operating in all node applications and water depths, in this case 0-3000 m. The challenge was to develop a node small enough for node-on-a-rope and at the same time have the battery capacity for deep-water ROV deployment. This has been implemented in the A3000 node (see Figure 2).

An important element of the design was to push the water depth at which a node-on-rope can operate unaided. From a commercial perspective the deeper the water, the more opportunities in the seabed seismic marketplace there will be for the equipment because of the economies it offers compared with ROV-assisted surveys. The current expectation is that depths greater than 1500 m will be exceeded which is far more than today's available node-on-a rope systems, typically 500-700 m.

The A3000 node itself is standard to the extent that it allows four channel recording with one hydrophone and three orthogonal mounted geophones, has a tilt sensor, three-axis compass, enhanced clock stability (always powered) and takes advantage of the latest battery technology to give 100 days life. All nodes are pressure tested to their full depth before leaving the manufacturing facility and never have to be opened on board the vessel.

As well as the transponder included in each node, another novel feature is the built-in battery charger. This makes a surprising difference to the storage space and logistics needed to rack the nodes and to the speed and convenience with which the batteries can be recharged on board the vessel and then redeployed. As per the original design criteria, the entire node conveyor and racking system on the vessel is automated. Vertical lifts take care of plugging each node into power and data management without human intervention (see Figure 3). Having all the nodes racked and connected at all times is an important safety issue as it gives the system the possibility to continuously monitor the huge amount of batteries and take actions should these be required. It also ensures that the clock oscillators in each node are continuously powered. Over time this provides better stability and avoids time-consuming stabilizing operations if power is allowed to be shut off when not in use.

These are some of the reasons why 10,000 or more nodes can be stacked on board enabling extensive and rapid survey coverage from a single ship.

Data management system

The data management system (DMS) controls all communications with the node, data download and the merging of seismic data with navigation data to produce data deliverables. The configuration module controls the node configurations, clock calibration, a self-test prior to deployment and clock drift during recovery. The result is that the operator is at all times in full control of the battery and data status, node movement and position (see Figure 4). The DMS automatically controls the nodes to be deployed, position and intervals on the rope during deployment. It is set up to work using any navigation software system for merging the seismic data with navigation data, but a dedicated software module in the navigation system is required for an automatic process.

Figure 4 Engineer monitoring a factory test of ocean bottom nodes.

Automation the key

Much of the development effort with regard to reducing the cost and improving the efficiency of OBN seismic operations has gone into rethinking the handling of nodes on board the vessel (see Figure 5). A first step was to turn the problem over to leading automation specialist companies in Norway. That resulted in a more factory-line mindset. A working model of the deployment and recovery systems on/off module (system for attaching and detaching nodes to the rope) was built in a warehouse near Oslo to test all the equipment and make sure it met the prescribed specifications. One special feature is that the system can control the spacing of nodes when being coupled to the rope, i.e., the nodes do not necessarily have to be evenly spread along the line. This allow operators to customize the configuration of the nodes on the seabed should they wish to focus on particular targets.

Reviewing the performance specifications of the rope, including its breaking strength and weight, was all part of the detailed design. The system is expected to allow continuous rope speed without stops during deployment and recovery, but it has the capability to stop the rope in a fraction of a second if required. It was configured so that nodes could be attached and detached at speeds in excess of 3 knots. In addition, a soft receipt of nodes coming in under any weather conditions was essential, with the system able to cope with changing angles of the incoming rope as a result

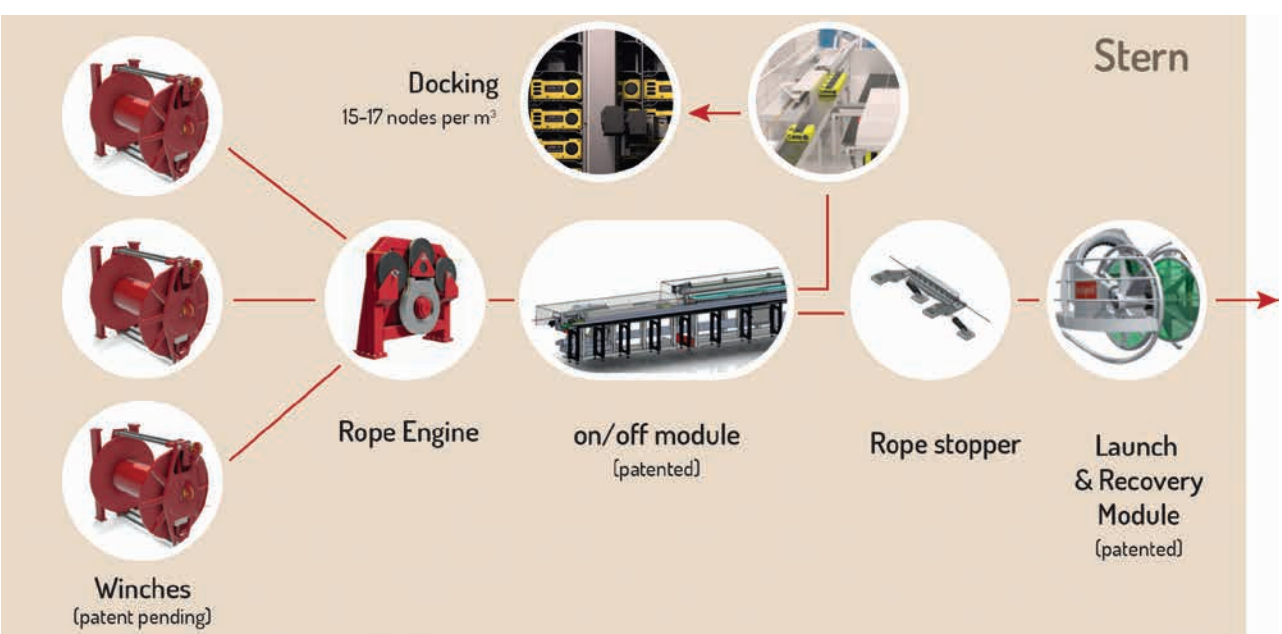

Figure 5 High-speed deployment and recovery system.

Figure 6 *Nodes being assembled for ocean tests.*

of the vessel's movement in the sea. A patented rope launch and recovery system was therefore part of the specification with adequate control and monitoring important priorities.

Commercialization

This autumn a first limited commercial trial of the system was due to be carried out in the Caspian Sea (see Figure 6). A more extensive test of the equipment is to be conducted this winter in the North Sea.

Conclusion

The new OBN challenger in the seabed seismic market is called Venator, the Latin word for hunter. Hopefully, this name is appropriate for a new generation of OBN technology that is designed to be applicable for some complex geology exploration scenarios as well as more conventional reservoir-related projects. Its success will be judged on whether it can meet the industry demand for a cheaper and more effective method of OBS.

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