Seabed seismic: from reservoir management to full-azimuth exploration

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Summary

This paper considers the high cost and operational inefficiencies traditionally associated with ocean bottom seismic (OBS) acquisition that have deterred wider industry adoption of this compelling technology. A case study is presented on how the main challenges are being overcome in the development of a next generation ocean bottom node (OBN) system focused on lower cost and more efficient, faster operation with scope for exploration projects as well as reservoir characterization and monitoring.

Introduction

There has never been a better opportunity for ocean bottom seismic (OBS) acquisition to cross over to the industry E&P mainstream. In the persistent low oil price environment, oil companies are focused on cost-effective management of their existing and easy to exploit potential reserves. This requirement will be best served by optimal imaging of the subsurface for which OBS has proved over at least two decades to be unarguably the best technical tool, if not the most cost-effective. The need for superior full-azimuth imaging in areas with complex geology/overburden seems likely to force a further move towards the seabed.

Oil operator adoption of cable and node-based seabed seismic data acquisition systems has in the past been hampered by prohibitive cost, operational complexity, slow rates of production and cheaper competition from towed streamer solutions.

A new generation of ocean bottom node (OBN) technology is now emerging. It aims to provide all the benefits of seabed multi-component acquisition at a cost and productivity that should make OBN the system of choice for many reservoir characterization and monitoring projects, as well as near-field exploration targets. In this paper the current operational limitations, and challenges of developing a new generation OBN system from concept to commercial reality, are discussed. The process was guided by the need for a high degree of automation and integration. It involved the rethinking of node design, the deployment/retrieval system, deck storage/handling and data management. The result is a cost-effective game-changing, seabed seismic acquisition system, now ready for the market. It is capable of operating at speeds of up to 6 knots with commensurate increased coverage in the order of 20 square kilometers per day, all at a significantly lower cost than current offerings. OBN systems such as this, we suggest, will provide oil companies with the capability they need to produce more oil with the least investment.

The challenge

When the Venator project was first contemplated in 2012, the value proposition of OBS acquisition systems despite their technical success was still limited. Few oil companies outside the major operators with large budgets ever considered the option. It was clear that any improvement in cost or efficiency would come from node-based methods where all the research by existing OBS companies was being directed (Lewis et al, 2016) The consensus was that some of the shortcomings experienced with deploying seabed cable were never going to be susceptible to resolution, e.g., cable damage and repair issues during operation, in-sea electronic vulnerability, lack of flexibility around existing infrastructure or other subsea obstacles, limited geometry of cable arrays, weight of the equipment, etc. (Mitchell, 2011).

The benefits of OBN seismic surveys were well established in theory (Ronen et al., 2009). In acquisition (Olofsson, 2012) some of the practical advantages cited were 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. However, some efficiency restraints still applied to OBN systems, especially the slow operational speed, cumbersome back-deck handling, limitations on the number of nodes, difficulties with battery management, and poor control of rope movement and node positioning.

Getting from A to B

A theoretical survey example is presented in Figure 1. The survey design assumes a setup with two source vessels (blended dual source), and that enough nodes are available to avoid overlaps. Careful consideration should be given when designing an OBN survey in order to minimize idle time for the vessels involved in the operation. It should also be noted that current trends in seismic data acquisition techniques, such as triple source and better algorithms for handling simultaneous shooting, have the potential to increase efficiencies (and reduce node counts) further. Figure 2 shows the relationship between deployment/recovery speeds and theoretical spatial coverage (km² per day). The example clearly illustrates that speed is paramount for achieving higher production rates in OBN surveys. Streamer operators have been pushing for production gains for decades, resulting in the efficient spreads that we see today. We believe that it’s time for the OBN operators to take a similar approach.

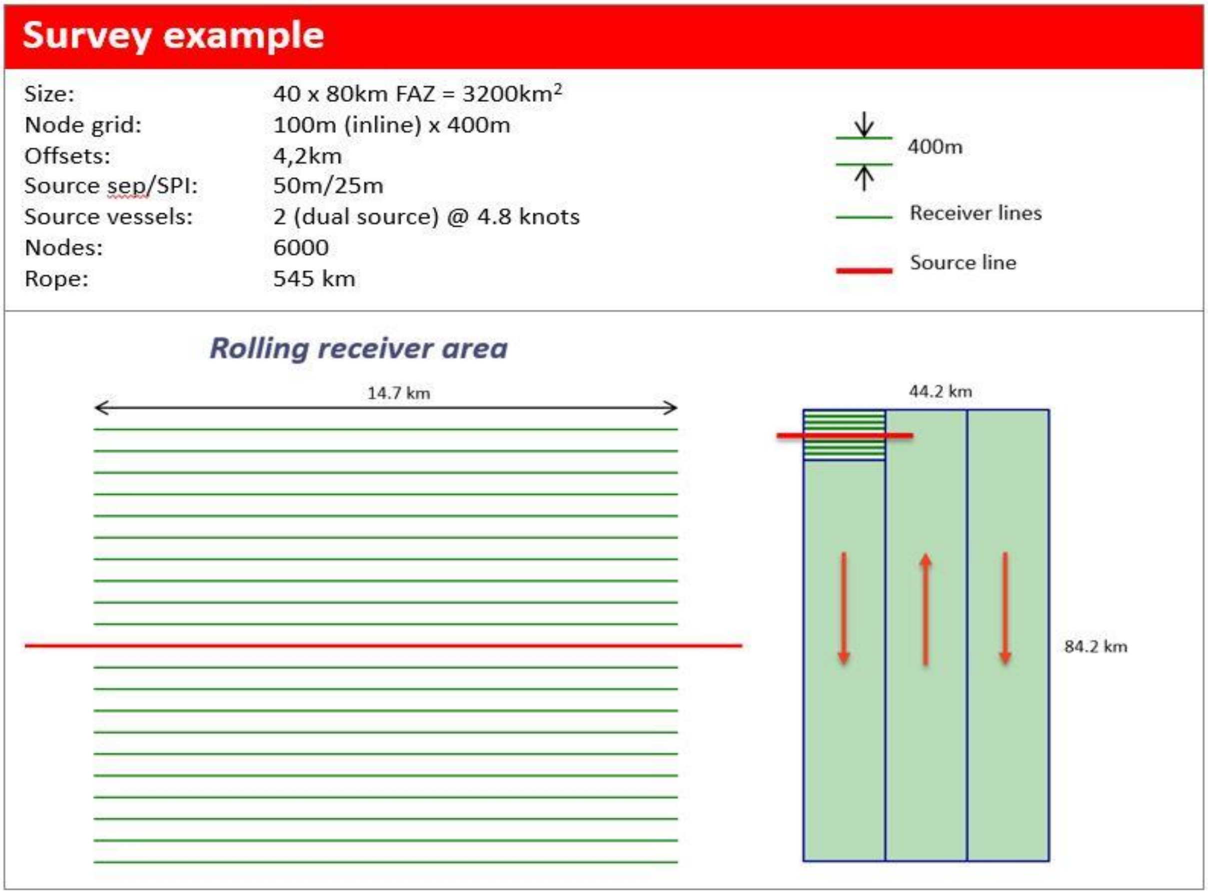

Figure 1: Example OBN survey parameters and design

Development strategy

In designing the new system, overcoming the known problems was essential. The key priority was to produce a system that could operate at significantly faster rates than existing ocean bottom node systems. This would extend the scope of the technology to include near-field exploration and, as a result, increase the market opportunities for OBN solutions.

Venator was developed in conjunction with leading automation, electronics, manufacturing and data management companies to offer a highly automated node-on-a-rope system deploying the same 'all-in-one' node for depths down to 3000 meters (ROV assisted in deep waters). It was designed to operate a large number of nodes (10,000+) from vessels of opportunity (typically supply or under-utilized seismic vessels), thus potentially removing the need for expensive, long-term vessel charters.

Furthermore, a containerized version was essential in order to facilitate easy transport and inventory management.

A combination of robust technologies was integrated into the final product with the emphasis on automated, hands-free, safe and efficient operation. These include:

Basic node design. The new A3000 node allows four channel recording with one hydrophone and three orthogonal mounted geophones, has a tilt sensor, three-axis compass, enhanced clock stability and takes advantage of the latest battery technology to give 100 days operating life.

Transponder. Unique to the A3000 node is the built-in 26 kHz USBL transponder. This enables the operator to know the exact position of every node at all times. But more importantly there is no delay in deployment to attach the unit to the node, or removal on retrieval.

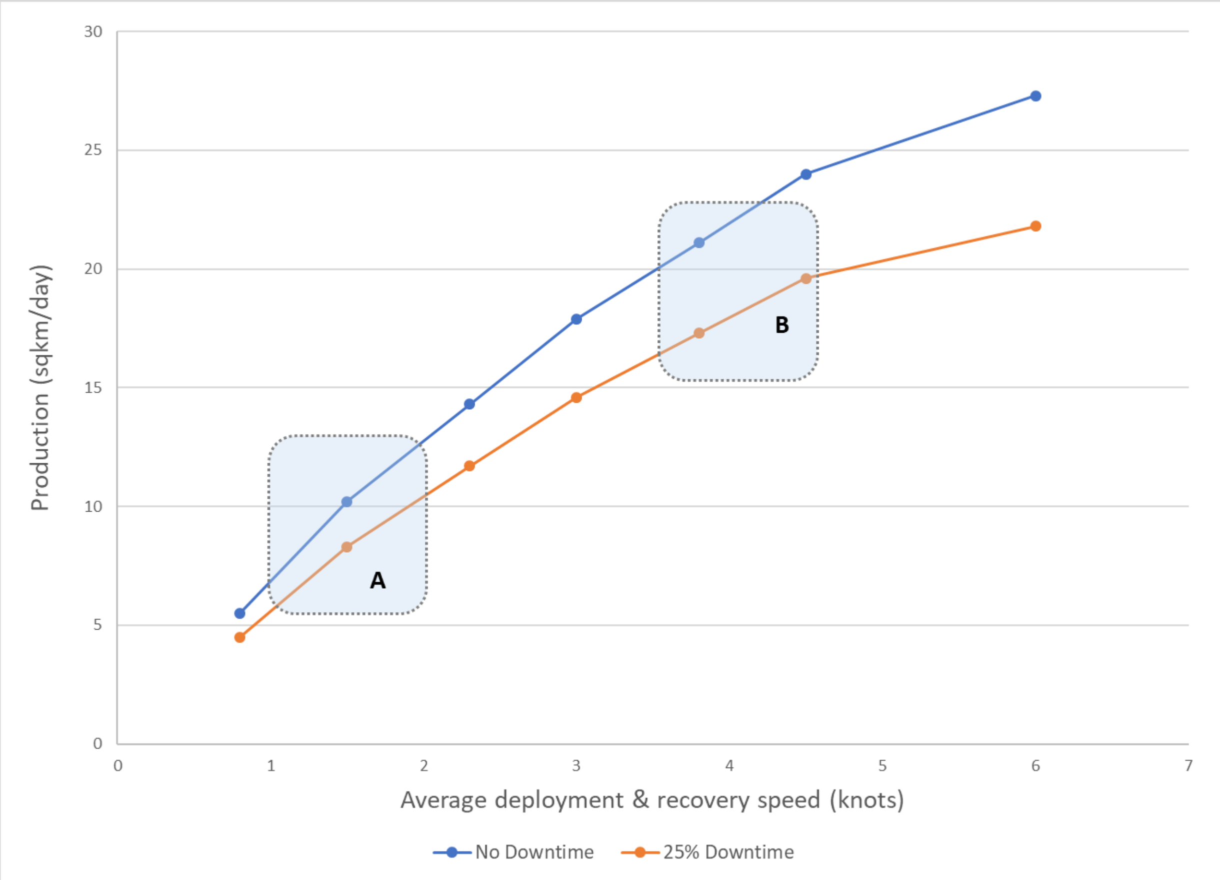

Figure 2: Theoretical production as a function of average deployment & recovery speed. Typical operational window today (**"A"**) versus potential operational window with Venator (**"B"**). Source: inApril AS

In operation, the rope tension profile can be monitored and adjusted according to varying water depth, vessel speed, currents and seabed conditions. This is achieved by real-time modelling[1] of the rope profile in the water column, which guides the vessel movement and controls rope speed.

Battery. The node battery management strategy benefits firstly from the 100 days life available with latest technology. Secondly, the battery charger is incorporated into the node. This makes rack storage on deck more compact with robotics able to plug each node into power and data management without human intervention. Having nodes racked and continuously connected allows real-time battery monitoring, which gives safety benefits, and keeps the clock oscillators powered at all times, which enhances clock stability.

Launch and recovery system. Nodes can be attached to and detached from the rope at speeds of up to 6 knots (hands-free), which equates to sending a node off every 16 seconds at 50m node intervals. It should be noted that in an operational environment, the achievable speed will depend on water depth and other environmental conditions. If necessary the rope can be stopped from full speed and restarted in less than a second, a key safety feature. The positioning of nodes on the rope is fully flexible, controlled by a customized computer program, i.e., nodes do not have to be deployed at fixed intervals and can be tailored to meet specific survey needs.

Data management system (DMS). Web interface to data acquisition communications, including the latest Gator II command and control navigation/positioning module, provides a hands-off system all the way to SEG-Y.

[1] Makai Ocean Engineering' MakaiLay modelling system interfaces to Venator

Commercialisation

The Venator automated handling system and all acquisition components have undergone extensive factory testing. In addition, several successful pilot surveys have been carried out in different offshore locations and environments around the world with a view to entering the market in the latter half of 2017.

Conclusion

The reasons for oil industry hesitation over OBS have been identified, and addressed in the development of the Venator next generation fully automated, node-based acquisition system. The lower cost and improved efficiency, in particular the much faster node deployment/retrieval and the option of using flexible & containerized solutions, enables OBN to become more than a reservoir management tool but also a cost-effective alternative for near field exploration, including wide-azimuth, providing imaging quality unachievable using conventional towed-streamer acquisition.

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