Autonomous Nodes – The Future of Marine Seismic Data Acquisition?

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Abstract

Whilst autonomous or "cable free" seismic recording is not a new technology, having been originally developed by Amoco in the 1970s with the Seismic Group Recorder, its application offshore has been relatively recent.

A number of surveys have been undertaken in the Gulf of Mexico, UKCS and offshore West Africa in deep water where the nodes, as the autonomous recording units are now referred to, are deployed and recovered using Remotely Operated Vehicles (ROVs).

Recently FairfieldNodal have introduced a node based marine system which does not require the use of ROVs for node deployment and recovery.

In this paper we will review both deep water and this new "shallow" water technology and show the improved productivity and enhanced operational performance that autonomous nodes can provide.

Introduction

The initial driving force behind the development of the Seismic Group Recorder (SGR) by Amoco in the 1970s was that the geophysical desirability of increasing the number of channels on the ground was being constrained by the available bandwidth of the telemetry systems then available. By eliminating the telemetry cables between the receiver stations this limitation was overcome and it became quickly apparent that the lower weight of this cable free system allowed it to be deployed with far fewer personnel. It could also be operated in mountainous areas and areas with poor road access with much greater operational efficiency than conventional cable systems.

Operational reliability was a challenge, however, with the electronics of the day and the availability of increasing channel count cable systems soon rendered the system obsolete.

In early 2002 Fairfield Industries, whose primary business activities were multi-client data acquisition and sales in the Gulf of Mexico and equipment manufacture, decided to re-examine the issues which were limiting the performance of the cable-based shallow water acquisition system they were employing to acquire 2C data in the GoM. These were electrical leakage, termination failure and cable breakage especially as the data acquisition moved into water depths greater than 100m.

The outcome of these investigations was a decision to eliminate these causes of equipment failure and move to stand-alone or autonomous data recording. Prototype shallow water units, or nodes as they have become to be called, were developed and tested. Much work was undertaken to investigate the packaging of the system – what was the best shape for consistency of coupling across a wide variety of sea bed conditions - as well as the best way to ensure system reliability.

The development of this autonomous marine system was recognized as having potential deep water applications, too and in response to input from BP, a deep water – capable of operating down to 3000m water depths - was developed and successfully tested leading to the first commercial deep water Ocean Bottom Node (OBN) survey over the Atlantis field in the GoM. In these water depths it was decided to deploy and recover the nodes using an ROV.

Subsequently a "shallow" water system – capable of operating down to 700m water depths – which does not require an ROV for deployment or recovery has been brought into commercial operation. The first crew has been operating in water depths from 10m to more than 700m in the Red Sea offshore Saudi Arabia for more than 18 months and a second crew commenced work in the UK sector of the North Sea in the spring of 2011.

Deep Water Application

The basic principle of operation for the deep water nodes is shown in Figure 1, below:-

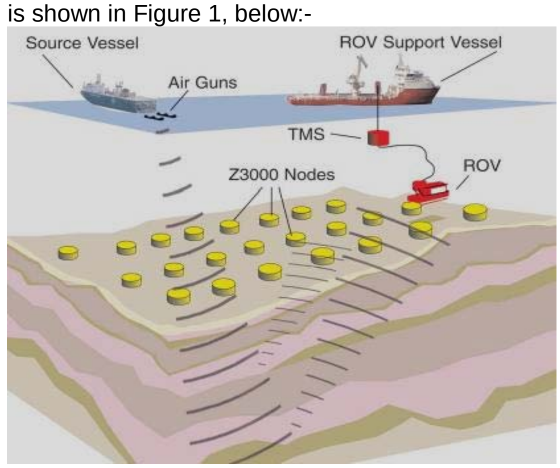

Figure1: Deep water node operation

The crew comprises two vessels – a conventional dual source shooting boat and an ROV equipped node handling vessel. The latter has to have DP2 – Dynamic Positioning Type 2 – capability since it is working in close proximity to oilfield installations, whilst the source arrays employed are generally radially symmetric since the shooting geometries are full azimuth.

The nodes themselves are not small devices – they weigh almost 100kg in air/47kg submerged – and are capable of continuous recording for more than 60 days.

Figure 2: Z3000 Autonomous Seismic Recording Unit

Equipped with a fixed-axis 3C 10Hz geophone and a spectrally matched hydrophone the nodes are 57cm in diameter and 25cm high. The 4C data are recorded on 32Gbyte flash memory and the timing of the unit is maintained using a double oven crystal oscillator. The whole system is powered using Lithium-Ion batteries which are recharged between deployments. The system has been designed for maximum physical integrity and in more than 12,000 node deployments in water depths up to 2,400m the node failure rate has been less than 2%.

The nodes are moved around onboard the vessel using "baskets", as shown in Figure 3.

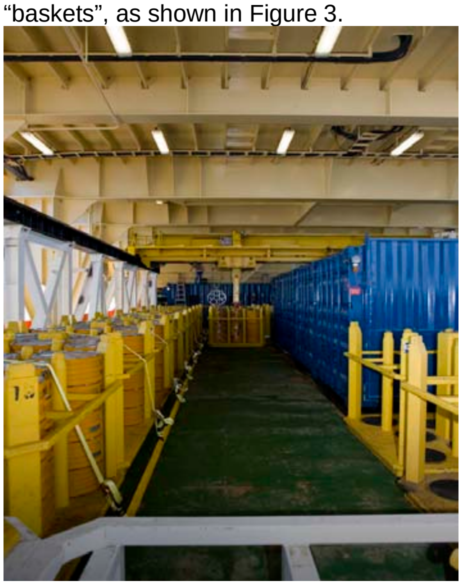
Figure 3: Z3000 Node "Baskets" on the back deck

Data are downloaded from the nodes once they are brought onboard via high speed USB and the same cable is used to charge the unit and synchronise the double oven crystal oscillator clock with GPS time both immediately before deployment and after recovery.


Figure 4: Z3000 nodes – Data unloading/charging

Whilst the performance of the nodes themselves is critically important the speed with which they can be deployed and recovered has a major impact on number of nodes required for a survey. By employing dual ROVs and a High Speed Loader (HSL) as many as 100 nodes can be deployed and recovered per day thus allowing a "rolling" spread geometry to be adopted rather than the static spread which is dictated when only 20 or 30 nodes can be deployed/recovered per day.

The dual ROV launch and recovery systems (LARS), mounted port and starboard and the HSL high speed winch crane, aft, can be seen in the picture below of the node handling vessel, currently operated by FairfieldNodal in the GoM:-


Figure 5: Node Handling Vessel – Carolyn Chouest

The ROVs are 200 HP working class ROVs which are operated via a sub-surface tether management system (TMS) on, currently 650m tethers:-

Figure 6: Schilling ROV, with under-slung node skid and Tether Management System (TMS)

Each ROV is deployed with up to 12 nodes in the node skid mounted beneath the ROV and the 24 node capacity HSL is then used to supply additional nodes to both ROVs to avoid bringing them back up to the surface.

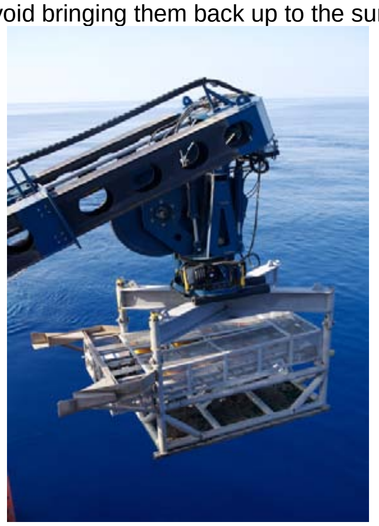

Figure 7: 24 Node Capacity High Speed Loader

Typical acquisition geometries are "sparse" spread – i.e. the receiver spacing is very large by modern day marine seismic standards – 300m or 400m node "grids" are typical.

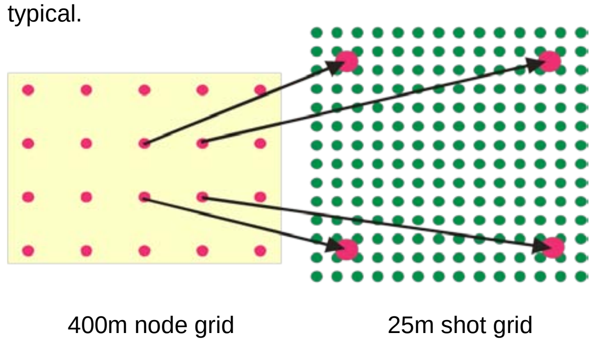

Figure 8: Sparse Receiver/High Density Shot Geometry

By having TMS systems on both ROVs multiple receiver "lines" can be deployed simultaneously, as illustrated below:-

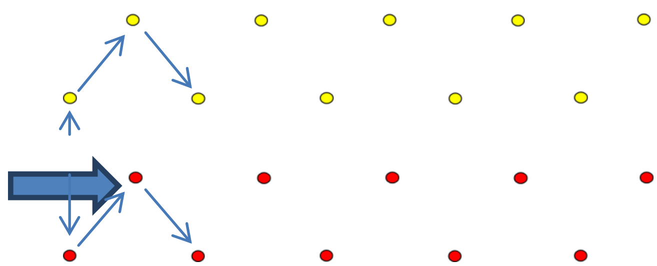

Figure 9: 4 Line Deployment – 650 metre tether

It is critically important to plan these deep water node surveys with a clear understanding of the precise nature of the surface and sub-surface facilities that are present in the survey area. The importance of good communication with the OIM and full awareness of SIM OPS – the other oilfield service activity that will be taking place during the execution of the survey - cannot be underestimated.

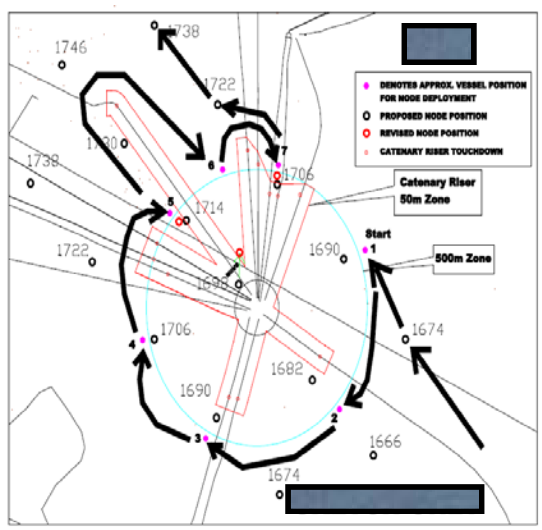

Figure 10: Node Handling Vessel Traverse Plan

"Shallow" Water Application

The basic operational principle for the non-ROV deployed node system is illustrated in Figure 11:-

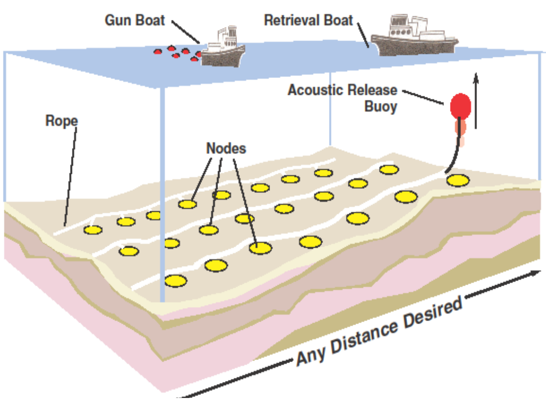

Figure 11: Z700 Deployment Schematic

The shallow water nodes are functionally identical to the deep water nodes described but as they are designed to operate to 700m rather than 3000m the physical packaging and battery life are smaller.

Figure 12: Z700 Nodes on conveyor belts used for onboard handling

Weighing 30kg in air/18kg in water, the Z700 nodes are 43cm in diameter and 14 cm high with 8GB flash memory and 15 day battery life. Three orthogonal 15Hz Omni-phones are used to avoid the node having to have an "up" side and the hydrophone is again spectrally matched to the geophone.

The purple "rope" shown in the above figure is the lanyard used to attach the node to the Vectran™ deployment/ recovery rope which has a breaking strain of 30,000 lbs.

This Vectran™ rope is stored loose in a bin rather than spooled and node coupling units - mechanical "take outs" - are placed at the required receiver station spacing interval to which each node is manually attached immediately prior to deployment.

Figure 13: Node Rope Storage Bin – 70 km

Figure 14: Custom design pinch sheave for node rope deployment and recovery

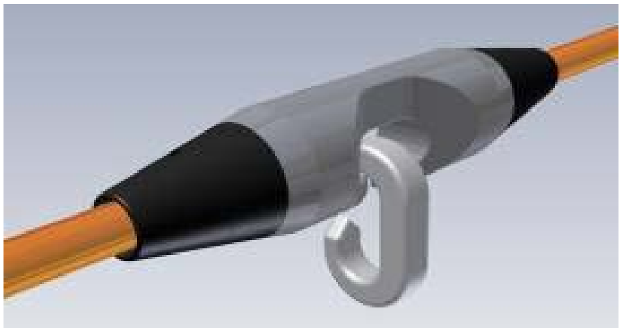

Figure 15: Node Coupling Unit – 10,000 lb breaking strain

Since the nodes are autonomous any receiver spacing can be employed and any length of receiver line can be accommodated. This eliminates the need for duplicate or "zipper" shots thus improving overall operational performance.

All movement of the nodes onboard the vessel is accomplished using conveyor belts - at no time is any node manually picked up.

Figure 16: Node Handling Conveyor Belts Onboard

Each node is charged/synchronized/data unloaded via a single cable as for the deep water system

Figure 17: Node Charging/Synchronising/Data Unloading

As illustrated earlier the operation is executed as a dual vessel crew – conventional dual source shooting vessel and a DP2 node handling vessel.

Figure 18: Z700 Node handling Vessel – C-Pacer

Figure 19: Z700 Shooting Vessel – Fairfield New Venture

By eliminating the traditional sources of Ocean Bottom Cable (OBC) equipment downtime – leakage, termination failure, cable repair, telemetry errors – the operational performance of the Z700 system is substantially higher than that historically achieved by OBC systems. Operational reliability of the nodes todate has been in excess of 98%.

With no minimum bend radius or termination overstressing concerns node deployment and recovery can be undertaken at much higher rates thus further improving the performance of the system.

Conclusions

Autonomous seismic recording technology is creating a paradigm shift in the way that land seismic data are being acquired. With the advent of both deep and shallow water Ocean Bottom Nodes the authors believe that a similar move will occur offshore. By providing a complete range of azimuths/offsets the deep water sparse receiver geometries have achieved unprecedented sub-salt imaging for both 3D and 4D applications. The increase in operational performance that autonomous nodes offer for OBC type applications makes shallow water OBN solutions more commercially attractive than traditional OBC. Recent contract awards in both the GoM and the North Sea bear out these premises and we are optimistic that the technology will become the standard methodology for ocean bottom seismic surveys worldwide in the future.

Acknowledgements

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