High-density seismic with nodes for a minimal environmental footprint

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Summary

The latest changes in the energy industry have put a lot of constraints on seismic acquisition, especially onshore, where more nimble systems are required to respond to the continuous need for better seismic images at lower cost, lower environmental impact, and lower HSSE exposure. Cabled high count channel systems have become the state of the art in seismic acquisition, however, cable management and equipment volume have been a real burden on crews, sometimes restricting access to a specific area (difficult terrain, urban areas) or at best slowing them down and increasing chances of downtime. The increased HSSE risk of line cutting added to the environmental impact and associated cost when using cable systems are also significant and have made it prohibitive to acquire dense surveys, especially for non-Oil and Gas industries. In this paper, we will discuss how the new generation of very compact nodal systems can allow the acquisition of high-density seismic in practically any terrain with minimal environmental footprint on the receiver side.

Theory / Method / Workflow

Since the beginning of last century, there has been a progressive shift towards high trace density surveys as an enabler for a higher quality seismic and attributes (Ourabah et al, 2015). Trace density being the number of pair source-receiver per unit of surface, it can be increase by either increasing the source density or the receiver density. If we look at how conventional surveys have evolved to high density on the source side in the last few decades, we see that conventional source fleets have been dispatched to form much denser single point sources, often shooting simultaneously in an autonomous way, delivering an unprecedented efficiency to vibroseis fleets (Howe et al, 2008). The receiver side however have lagged behind, waiting for the arrays to be spread and become independent single point receivers, but to do so, new sensors needed to be autonomous and nimble enough to allow this explosion of receiver count to reach its full potential.

Figure 1 - The STRYDE node, 150gr, 13x4cm

Nodal systems were the natural solution to this idea, and although early nodes were too bulky to achieve this vision, some of the latest systems have reached a new level of miniaturization (Manning et al, SEG 2018) (Figure 1), approaching the size of a geophone, they can replace arrays with dense autonomous single point receivers without the burden of the cables and associated problems.

Results, Observations, Conclusions

To explore the benefits of using compact nodes for denser seismic surveys we will review three surveys acquired with the STRYDE nodes in three very distinct environments: Desert, Taiga forest, and urban environment.

The 1st survey example, which took place in a desert environment, was a comparative study of a nodal system against three cable systems (arrays and single sensor) (Ourabah et al, 2019). Several layouts were tested including a 12Km 2D line and a super dense cross-spread. This test revealed the operational benefits of an autonomous nodal system compared to cable system cables showing : reduced equipment's volume and weight (up to 20 time lighter), faster deployment/retrieval (4 times faster) and reduced HSE risk (5 times less vehicles). The data recorded showed identical seismic quality sensor to sensor and the benefit of single sensor recording compared to arrays systems for linear noise attenuation and dispersion curves, (Figure 2).

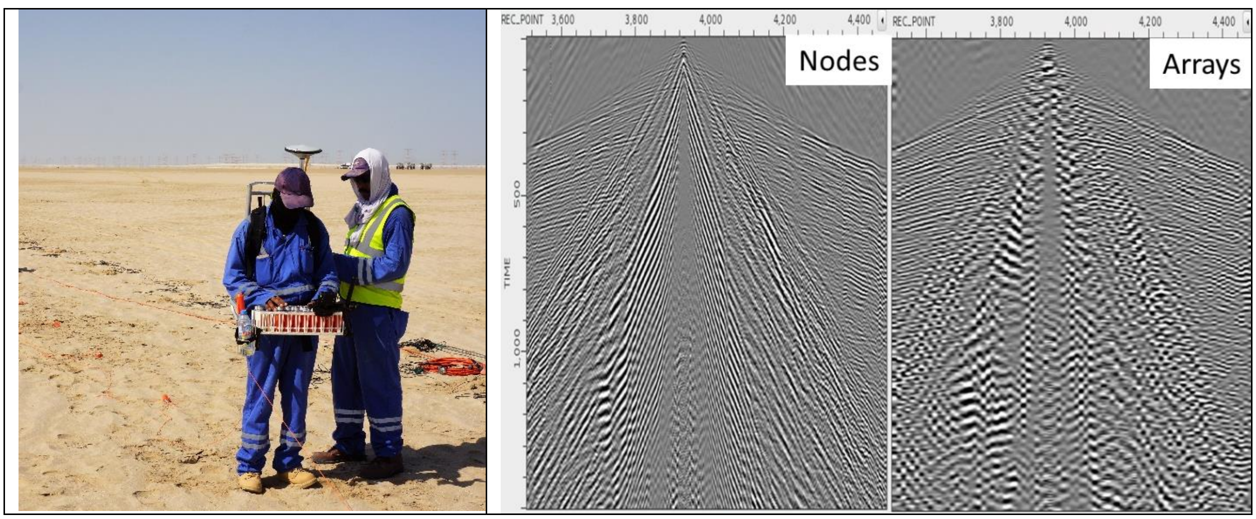

Figure 2 - 2D comparative field trial in desert environment (Ourabah et al, 2019). Left, deployment crew. Right, nodal system versus cable system shot gather.

The second survey example took place in the Taiga forest of east Siberia (Brooks et al, 2018). This was a 3D production survey acquired with an array cabled system where 8800 nodes were placed along 8 receiver lines covering an area of 36km^2. The use of nodes in this type of environment demonstrated an outstanding ability at deploying receivers faster, with less people and with nearly zero environmental footprint. The nodes were rolled twice as fast over the ground as the cable system which had 12 geophones arrays at 50m interval (1 geophone every 4m) while the nodes were deployed every 5m. Node crews were formed of 2 persons only, while the cable crews were formed of 5 persons. The test showed that same line kms as the cable system can be deployed with these nodes using less than half the people, and that is excluding the additional cable staff required for troubleshooting before the spread is ready for acquisition. An activity that is obsolete with nodal systems. Extra tests have also proven that, although the nodes were deployed along cut lines, the same efficiency could have been achieved if the crews were walking along uncut lines (Figure 3), which should have huge benefits on cost, time, environmental footprint and HSE exposure as line cutting is by far the most expensive and risky activity in these time of environments. Data quality here again showed superior quality with a much-improved resolution over the cable system (Figure 3).

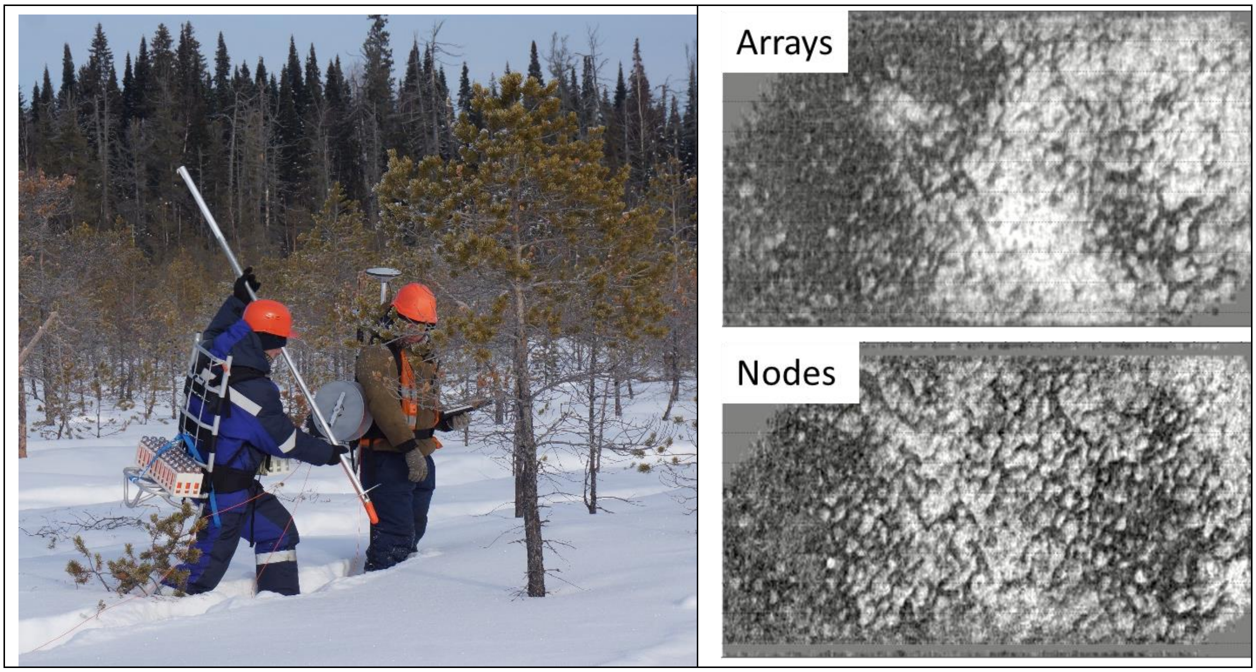

Figure 3 - 3D trial in Siberia with 8800 nodes (Brooks et al, 2018). Left, deployment crew. Right, time-slice comparison of PSTM fast-track processing of the nodal system and the cable system used in this survey.

The 3rd survey example was a series of 2D lines acquire in European cities for geothermal applications. Urban environments – which are very common in this industry – although providing some logistical advantages compared to remote locations, do present some painful challenges such as complex permitting, rigid or limited time windows for shooting, costly compensation schemes, making the use of cable systems very costly or sometimes impossible.

1600 to 3000 nodes were used to acquire several 2D lines across several European cities, first as comparative tests to existing nodal systems and then as the main production system. Thanks to their size and weight (150gr, 13x4cm), these nodes were not only easier to transport, but also much easier to hide than other bulkier equipment, whether they were cables or nodal systems. An advantage that is not negligeable in such populated environments where theft or voluntary damage can be significant (Figure 4).

The same benefits observed in other environments were replicated here, a particular challenge arose when deploying the nodes on pavements where planting them or using spikes wasn't always possible. After testing several options, the contractor opted for a silicon glue which has delivered excellent coupling. This is demonstrated by the comparison to another nodal system deployed mainly on a baseplate (Figure 4) showing identical seismic data.

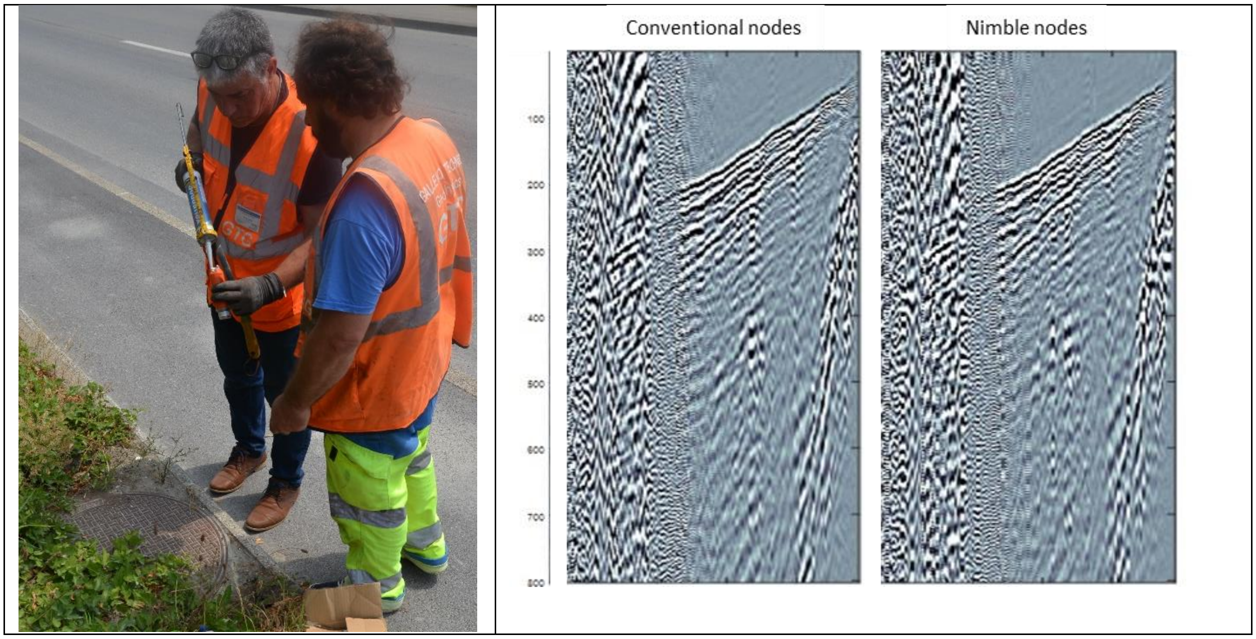

Figure 4 - Example of utilisation of the nodes in urban environment. Left, the crew testing deployment with silicon glue. Right, comparison of shot gathers of the two nodal systems used in this trial.

Novel/Additive Information

Autonomous nodes, especially the ones that reached this new level of miniaturization - making them as small as traditional geophones - have the potential to completely change the way seismic is acquired in any environment. Their complete autonomy, small size, and weight, allow them to be deployed anywhere a person can walk without the need for line preparation, this by itself present significant benefits on the environment and HSE risk. When the terrain is easier to work on, we still see benefits associated to the reduced line crews, the reduced number of vehicles used for transportation, the stake-less operation, the removal of troubleshooting activity and the discretion of the nodes.

These nodal systems, although showing similar seismic quality sensor to sensor to other receiver systems, do allow the acquisition of denser surveys much efficiently, especially in difficult terrains. An example of such capability was demonstrated by a 3D field trial acquired by ADNOC in the UAE in 2019 achieving a staggering 184 million traces/km2 using 50,800 nimble nodes and 36 people, while delivering superior images of the target (Ourabah et al, 2020) (Figure 5). This survey which has seen half a million node's deployment in 53 days, highlighted the importance of a fast charging and harvesting system to keep up with a large number of nodes. It has also demonstrated the added value of merging this new fast moving receiver technology with other existing high efficiency source technologies, like simultaneous shooting, which can increase trace density by another order of magnitude.

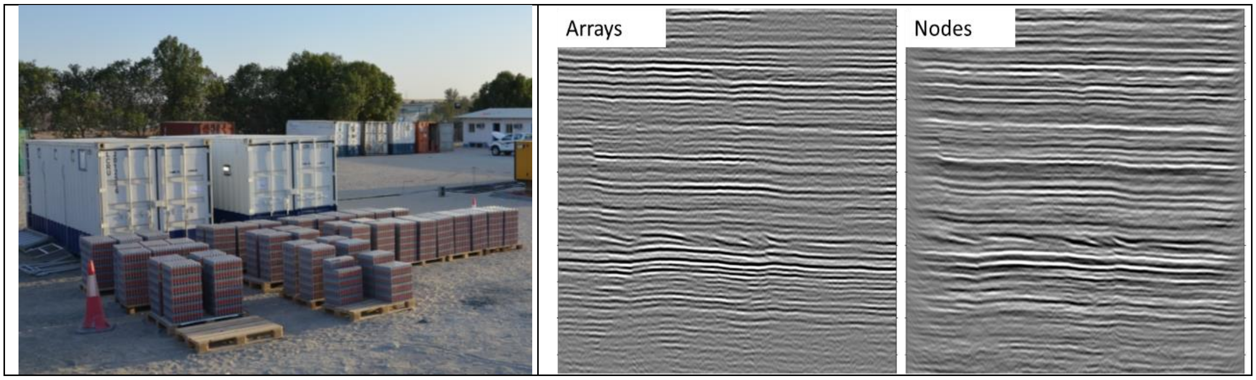

Figure 5 - Large scale field trial acquired by ADNOC in 2019 using 50,800 nodes (Ourabah and Crosby, 2020). Left, ~35,000 nodes on the ground in front of the charging and harvesting container and the cleaning container. Right, comparison of legacy data acquired with cable array system versus the new ultra-dense survey acquired with nodes.

Although designed to respond to the need for denser surveys in the oil and gas exploration industry, it has become evident that nodal systems are sturdily replacing cables and making high density seismic much more affordable to other industries. Their seize, weight and nimbleness are attractive assets that line up with the new standards of minimal environmental footprint, while providing these new industries with efficient tools to acquire the right seismic necessary for their success.

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