Manta FreeDive; A novel node for sparse receiver surveys

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Introduction

It is generally accepted, by the industry, that seabed receivers deliver superior seismic reflection measurements and that ROV deployed seabed receivers are the optimum methodology to ensure position repeatability and seafloor coupling consistency.

Recently, the industry has benefitted from the geometry flexibility of the seafloor node method to deliver ultra-long offset / full azimuth measurements, as an input to a velocity inversion. This velocity inversion solution has looser requirements in terms of receiver sampling, positioning to pre-plot and measurement type; and is consequently open to different, and more efficient, deployment and recovery solutions.

In this paper we review the design and some early testing of a prototype seafloor node, currently referred to as “Manta FreeDive”, that was designed primarily for collection of diving waves for velocity modelling. The driver for this effort is to understand the optimum combination of deployment method, coupling solution and sensor package for a node designed for sparse node acquisition.

Deployment and Recovery Solution

If you accept that precisely positioning the nodes at pre-defined locations is not necessary, as is the case for velocity model building workflows, then a deployment and recovery method in which the node dives through the water column using gravity and surfaces using buoyancy, can be considered. There is an obvious requirement to change the buoyancy after the seismic experiment is complete. This is most commonly achieved by detaching from a bio-degradable weight which remains on the sea-floor.
The use of weight to dive the node to the seafloor and buoyancy to surface the node is not a new concept. Academic institutions have been using this method as part of a refraction study solution for decades and more recently EM acquisition contractors have been using this method to deploy their version of a seafloor node. More recently experiments for hydro-carbon exploration have used methods in which the nodes are deployed through gravity and recovered by ROV.

PXGEO started a project to design a node which would use this deployment and recovery method. Initial designs around this idea used the Manta node with additional buoyancy, a detachable weight and a USBL receiver so the dropped node can be located on the seafloor and recovered (Figure 1 Top Left). Very early on in this investigation it was recognized that this approach would be limited. With the additional volume taken up by the buoyant material the available vessel storage was consumed by a

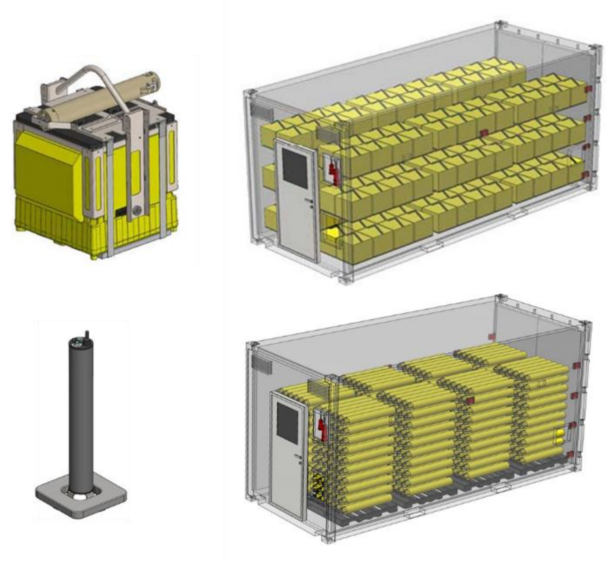


***Figure 1** Suite of cartoons detailing the progression of the design of the FreeDive node. Top Left - Initial design for the FreeDive node, Top Right - Cartoon detailing the storage constraints with this design, Bottom Left - Second cylindrical design of the FreeDive node, Bottom Right – Improved storage capacity of this alternate design*

small number of units (Figure 1 Top Right). Alternative and lower volume designs, which utilized the underlying Manta electronics were reviewed and a cylindrical design was finalized on (Figure 1 Bottom Left and Right).

Measurement Requirements

If the driver for the technology is limited to providing a measurement for an acoustic FWI inversion it is only necessary to record pressure waves. If the measurement requirements are limited to a pressure only solution, it is not necessary for the node to couple to the seafloor. In this case the node would be slightly positively buoyant and tethered to a weight on the seafloor. If this unit was additionally equipped with a three component particle velocity measurement, 3D deghosting / wavefield separation could be used as part of an imaging workflow (Figure 2 Left). If there is a desire to collect shear wave measurements it is necessary for the unit to couple to the seafloor (Figure 2 Right) which would also allow for the resulting measurements to be used in an elastic FWI implementation.

Prototype Designs

PXGEO manufactured three versions of the cylindrical node. The three versions included a weight coupled seismic node with the cylindrical node attached directly to a base-plate with a similar foot print to the manta node, a tethered water coupled node floating approximately 0.5m above the seafloor and a node with a spike which utilizes the dive speed to penetrate the near surface.

Figure 3 Cartoon of the three nodes used in the test

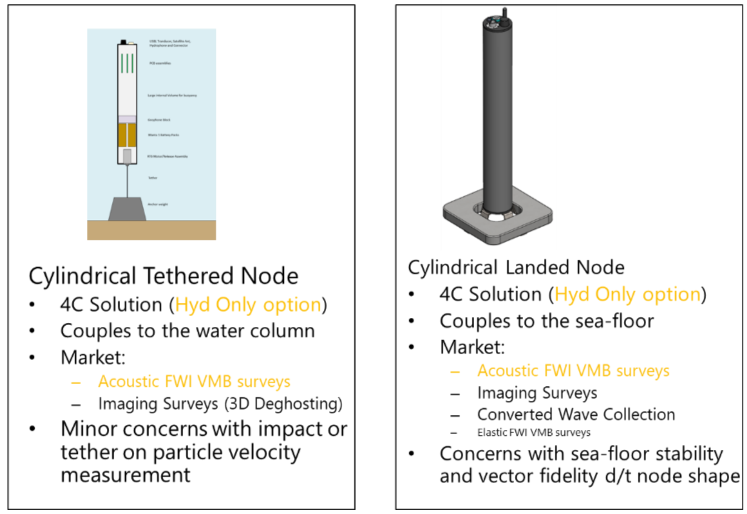


Figure 2 *Cartoon detailing the measurement options with this refined use of the seismic node*

Test Surveys

All three prototype nodes were deployed and recovered by ROV alongside a Manta node at a water depth of approximately 500m. A short 1000m source line, utilizing a single gun source, was acquired over the cluster of seismic nodes. The test was not intended to evaluate the deployment and recovery method but ensure that these novel designs would adequately measure the seismic response of the earth.

Some limited front end processing was applied to the acquired datasets and the different FreeDive datasets were compared to each other and to the reference Manta nodes. Figure 4 details comparisons of the vertical geophone response. In all cases the three prototypes record a comparable measurement of the earth response with shallow reflection events and sea-surface reflections recorded on all datasets.
With some comfort that the concept was viable a second test was performed on a production project in the North Sea recording a full 3D source carpet into the novel nodes. Two coupling methods were tested; One used the tethered water coupled unit and one using the base-plate ground coupled device. The seismic data in addition to two production nodes were given to an industry leading data processing contractor to pass the data through an ocean bottom seismic processing sequence. The sequence used followed a standard approach with the exception that we could not rely on any shot sorted processes to address the noise. Even so the results were very encouraging (Figure 5).

Conclusions

While the testing to date is quite limited the results are very promising. The same nodes have been deployed on a production project and will collect a full azimuth source carpet which will be used to further evaluate the geophysical validity of the node designs. Additional engineering is ongoing in parallel.

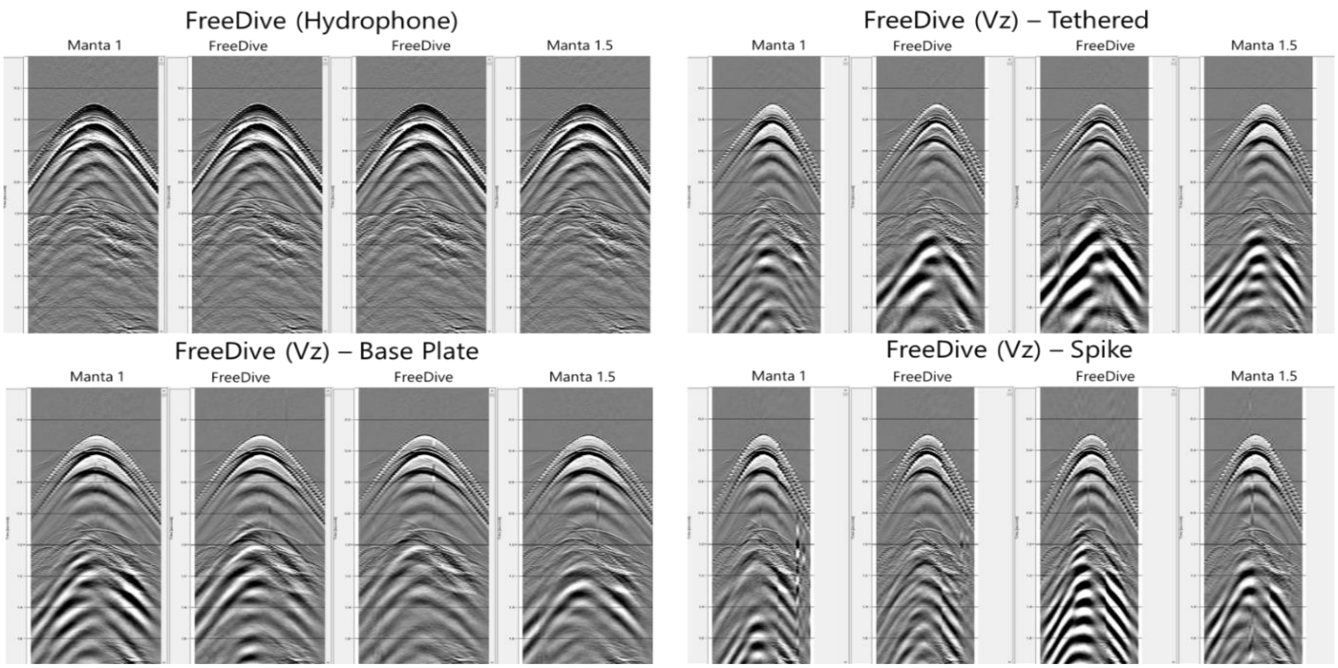
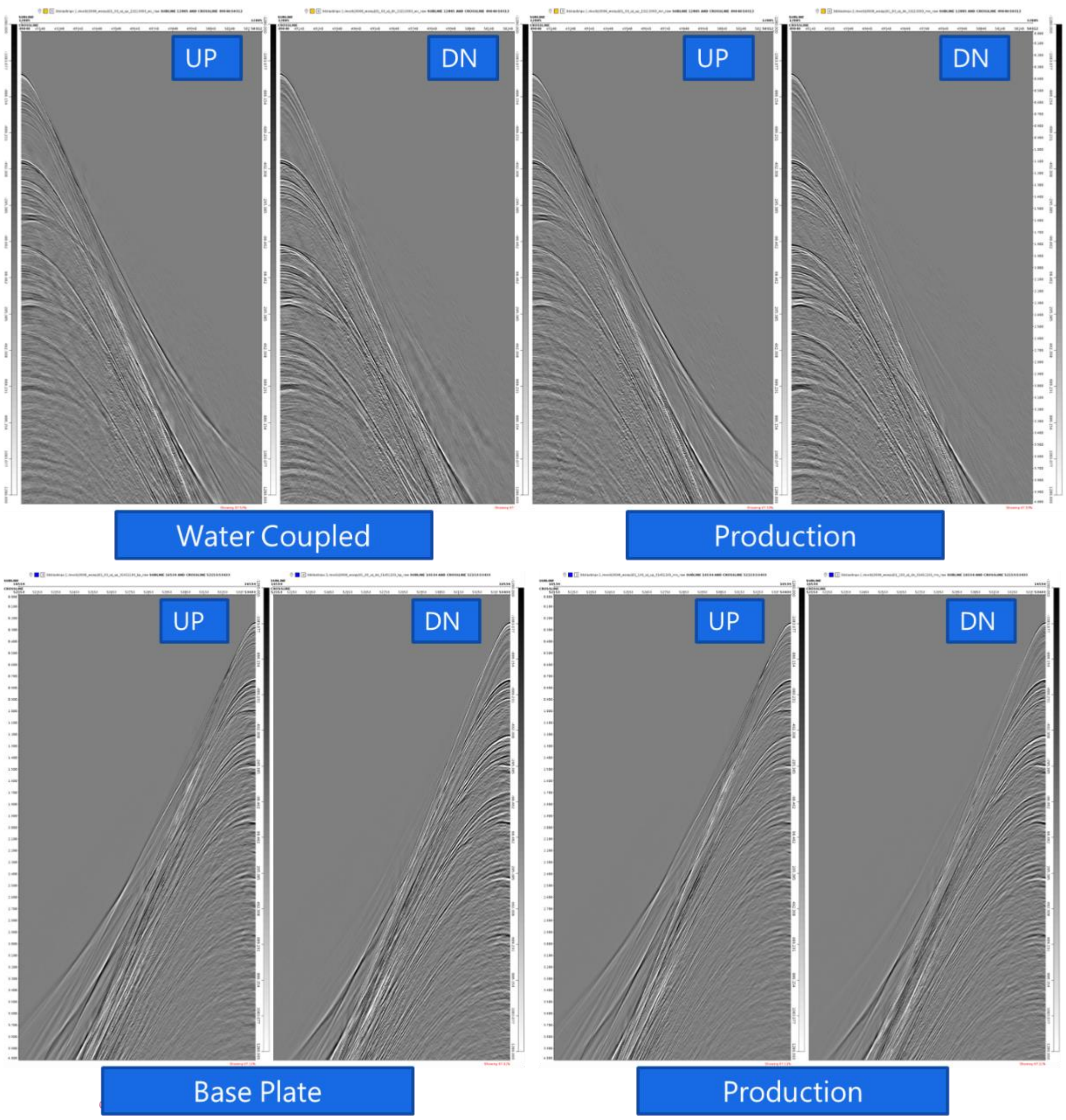


Figure 4 TX plots comparing the seismic response of the FreeDive nodes with the co-located Manta nodes. Top Left - Hydrophone response, Top Right – FreeDive water coupled node, Bottom Left – FreeDive weight coupled, Bottom Right – FreeDive node with spike to penetrate the near surface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