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QC Measures for Ocean Bottom Seismic Data Acquisition: Case Studies From Mumbai Offshore Region

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Abstract

OBN seismic data acquisition gained momentum in Indian Basins after the first project carried out by ONGC in 2018-19. The quality of high density multicomponent OBN seismic data passes through several QC checks starting from field deployment; node positioning measured by several ping solutions to data driven solution FBP. The position information is always incorporated in fold coverage calculation for all the stages to assure Full Azimuth data acquisition target. This paper also presents the importance of RMS Amplitude Map in terms of sensor strength check and rotation attributes. A case study on the role of NFH data to analyze the cause of gun pressure drop is also presented here.

Introduction

Seismic data is backbone of hydrocarbon exploration and Oil industry is improving the quality of data bank from time to time with cutting-edge technologies. Ocean Bottom Node (OBN) Seismic is modern day technology, which started its journey around two decades ago and gradually dominating the seismic industry due to its inherent advantages like; flexibility in offset and azimuth, cable free independent recording system, no operational constraints for water depths, operational suitability in congested oil fields to get seamless coverage and multicomponent (4C) recording, less noisy high quality broadband data etc. which have the ability to resolve the shortcomings of conventional streamer seismic technology. A full-azimuth multi component high density OBN seismic survey not only increases the trace density but also piled up the responsibility to maintain the data quality from navigation-positioning to seismic trace. The current paper contains the major QC techniques applied in ONGC's OBN projects in Mumbai Offshore region.

QC Measures:

1. Node and Shot Positional Accuracy:

The Schematic analysis in FIGURE-1 represents all the possibilities of node and source position shifting from their corresponding preplot locations where each cell is considered as (6.25m x 6.25m) in size. Now, to avoid the foldage stripping (especially in near offset) for bin size of 25m x 25m, upto +/- 12.5m drift tolerance was allowed for both shot and receiver.

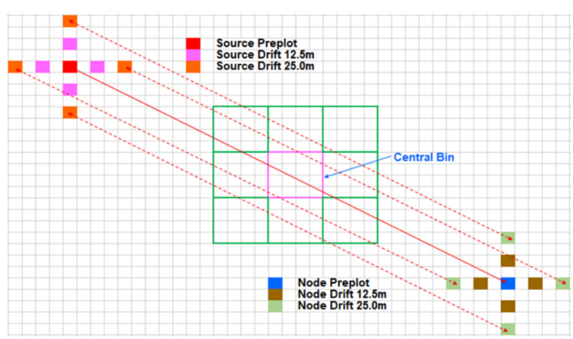

Figure 1: Schematic analysis of Node-Source position drift with CMP coverage.

2. Underwater Node positioning:

The node deployment time was optimized by attaching acoustic pinger (transponder) with every alternate node considering the water depth for this region. The position accuracy level for the inbetween interpolated nodes gave excelent match with First Break Position (FIGURE-2).

To ensure the underwater node positioning during the recording in the shallow water environment (water depth 30-80m) where there was a high chances of node dragging due to fishing activities or strong underwater currents, two additional acoustic pinging runs; post deployment and pre recovery were conducted to find any movement. The comparison chart in FIGURE-3 represents a case of drag node which can be easily determined from difference plot. The the new positions of nodes caused by drag was included in fold calculation to check maximum possibility of fold loss before node retrieval.

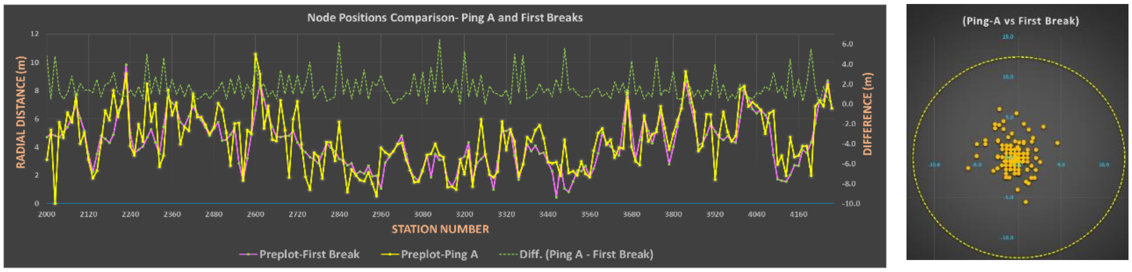

Figure 2: Left: Comparison of node radial distance from preplot between post deployed ping (Ping-A) and First Break Position (FBP) Right: Difference between Ping-A & FBP.

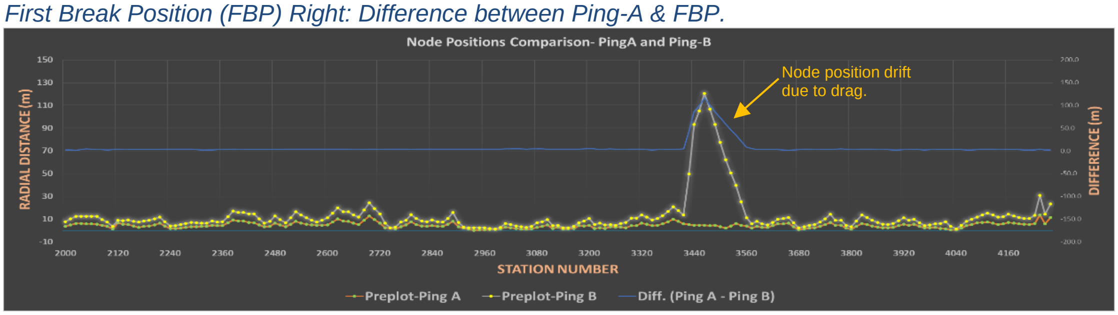

Figure 3: Comparison of node radial distance from preplot between post deployed ping (Ping-A) and pre retrieval ping (Ping-B).

3. First Break Positioning & LMO check:

Position accuracy of Pinging data depends on several factors e.g. close grid water sound-velocity profile, sea floor morphology and pinging vessel speed. To cut down all the errorous posibilities the actual node positions are determined by data driven solution, named as “First Break Positioning” (FBP). Therefore ping data are used to control the node positions during the operations but FBP is essential for all the nodes to avoid the pinging uncertainities due to node movement. FIGURE-4 represents a case study of Linear Moveout (LMO) check used to detect the uncorrected node position, dragged during secondary shots and after application of FBP techniques whereas FIGURE-5 describes FBP technique to detect the

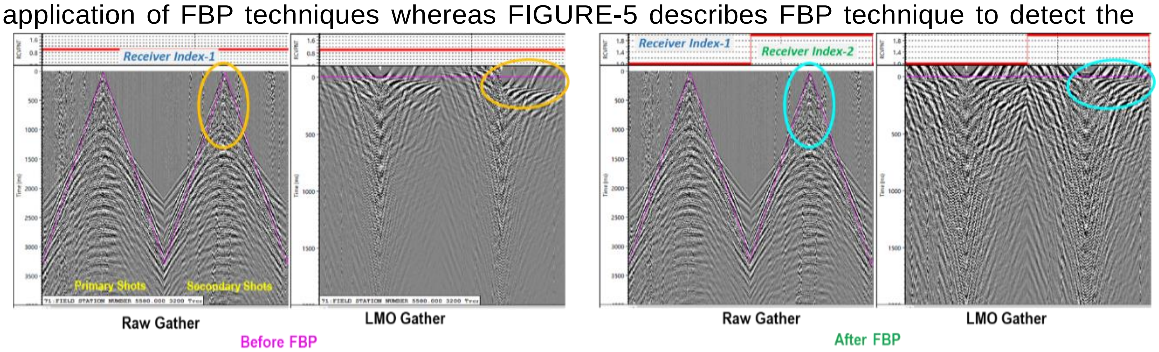

Figure 4: Case study of LMO check to find the mis-positioned node with a small drag, which is not clearly visible in raw gather for Double Sided Parallel shooting geometry.

actual node positions. Another example of position correction due to drag was described in "Challenging Full-Azimuth 4C-3D OBN Survey in Congested Oil Fields of India" by Ghara, et.al. 2020.

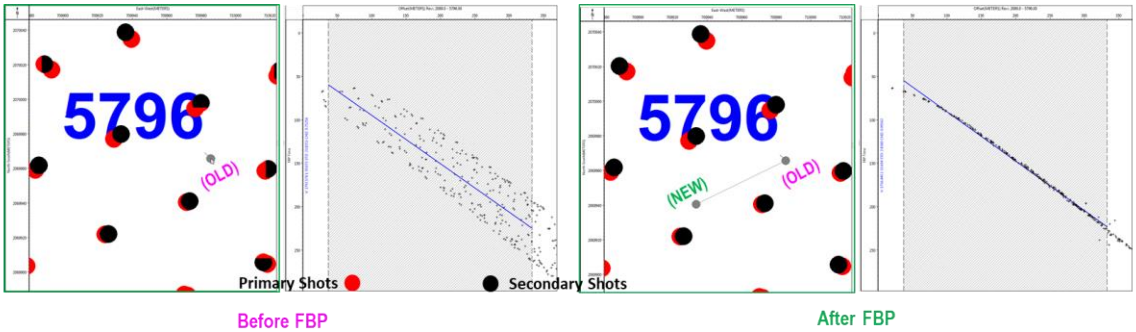

Figure 5: Example of FBP Technique to find the new location for the dragged node by using regressive curve fitting method. Reference geometry: Double Sided Parallel shooting.

4. Fold Coverage & Infill:

Fold Coverage is the most significant part for Field QC, especially where it has a commercial aspect. Loss of fold has an impact only in Signal to Noise ration but also designing of processing parameters like; velocity analysis, angular domain processing etc. which ultimately leads to a low image quality. The infill was planned for targeted fold loss, caused to several obstacles like; safety distance from platforms, rigs, barges, shallow water, node drag etc. and was filled by additional combination of both the receivers and shots depending on the flexibility. But for a full azimuth data acquisition project, the aim of the infill plan was not only concentrated in fold build up but also filling up both the offset and azimuth gap. FIGURE-6 is a case study where several nodes were dragged in NE part of the area which caused a huge foldage gap in several bins in different Offset-Azimuth ranges but the infill plan was optimized to fill those gaps to achieve full azimuth target.

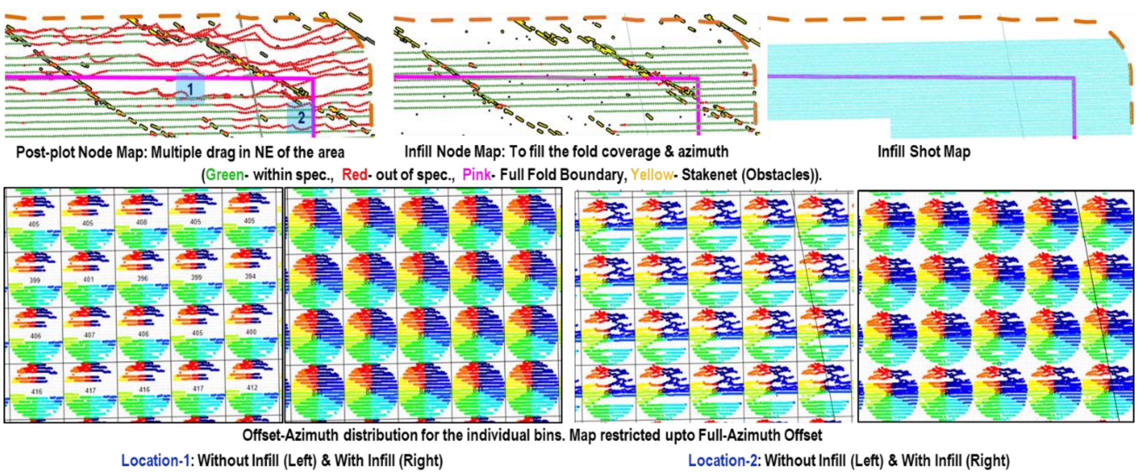

Figure 6: Case study of Full Azimuth Infill recovery plan to fill the Offset-Azimuth gap as well as to enhance the fold counts, caused by node drags.

5. RMS Amplitude Map Analysis:

RMS Amplitude Map of each node can be displayed in the form of plane chart, which can be used to perform quality control to the rotation of raw data and the abnormal amplitude of raw data such as zero value, extreme value, etc. to ensure the correctness of raw continuous data (Wang Jianfeng, et al, 2021). Few examples given below represent the utilization of RMS Amplitude Map along with the raw data in Node QC.

a. ***Sensor Strength Check****:*
RMS amplitude map is a tool to identify the relative strength of each sensor of a node. Any abnormality in RMS map can be caused by node movement or sudden change in sensor sensitivity. The correlation between the amplitude and RMS amplitude used to identify the drag moment. Depending upon the weakmess in the strength of a records (gather), nodes are categorized into weak & partially weak. The weak traces are flagged for processing and removed from fold calculation.

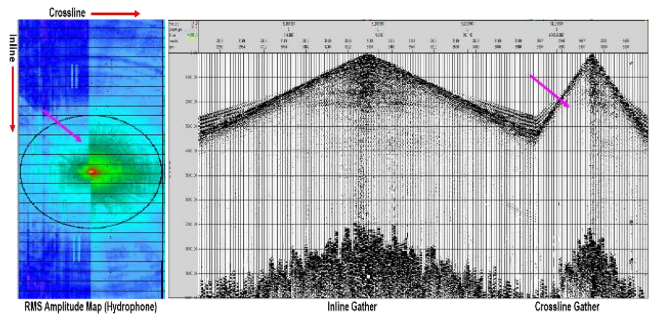

Figure 7: Partial Weak Hydrophone(Left: RMS amplitude Map, Right: Receiver Gather with nearest Inline and Crossline shots)

Rotation Analysis: The rotation of all three orthogonal geophones are needed to be checked to rectify the angle error recorded by orientation sensor or missing/abnormal record (Jianfeng, et al, 2021). The correctness of angle mismatch was found by comparing the energy and polarity of raw data before and after rotation. Following three are examples of rotation correction:

a. ***Orientation Correction due to Error Angle Record:*** Orientation correction by Yaw scan was run for every node to rectify the angle error. FIGURE-8 is an example of orientation correction to transfer the residual energy from both the horizontal geophones to the corresponding components.

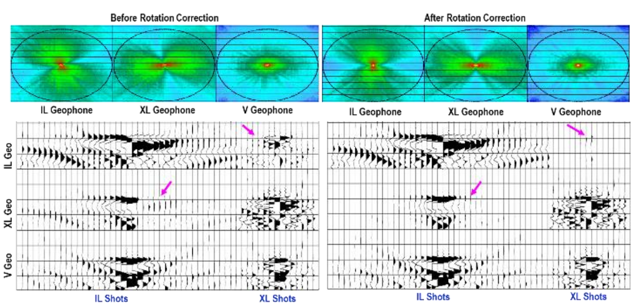

Figure 8: Orientation Correction. Upper: RMS Map Lower: Inline & Crossline Nearest LMO. The arrow shows the change in amplitude.

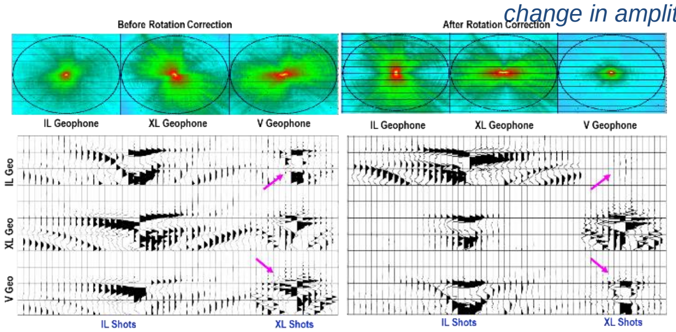

Figure 9: Edge Deployed Error and correction. Upper: RMS Map Lower: Inline & Crossline Nearest LMO. The arrow shows the change in amplitude.

b. ***Edge Deployed (abnormal record):*** The field orientation values in FIGURE-9 suggested the node as Edge Deployed. After reviewing the unrotated data it was observed that the node was not Edge Deployed and the Manual Yaw scan was performed on the node which transfer the energy from vertical geophone to horizontal geophone.

c. ***Weak Horizontal Geophones:*** The example in FIGURE-10 represents a case of weak horizontal geophones where the field rotation values show that both inline and crossline geophones were oriented parallel but after removing the field rotation it was found that crossline geophone has no energy. Therefore those nodes are removed from the production calculation, as it can't meet the PS requirement.

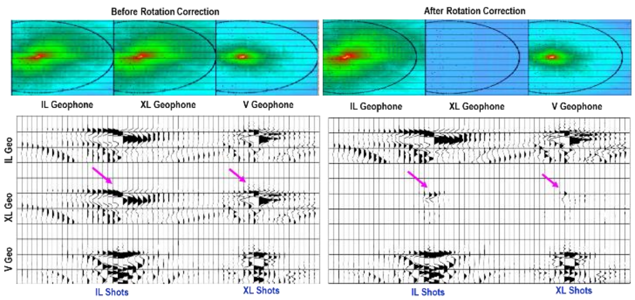

Figure 10: Weak Horizontal Geophones. Upper: RMS Map Lower: Inline & Crossline Nearest LMO. The arrow shows the change in amplitude.

6. NFH Data Analysis :

The source has a pivotal role in high density OBN survey and NFH (Near Field Hydrophone) data is the key attribute to identify the shot characteristics. In FIGURE-11 presents a case to find the sudden pressure drop during a line, identified from NFH data. The non aligned primary pulses in NFH display for individual gun-cluster indicated the early fire of the Guns. The detailed investigation revealed that a sharp turn (constant speed) near the platform exclusion reduced the shot-to-shot distance as well as cycle time which ultimately resulted in sudden gun pressure drop. The traces having >10% pressure drop were found as weak and removed from coverage calculation.

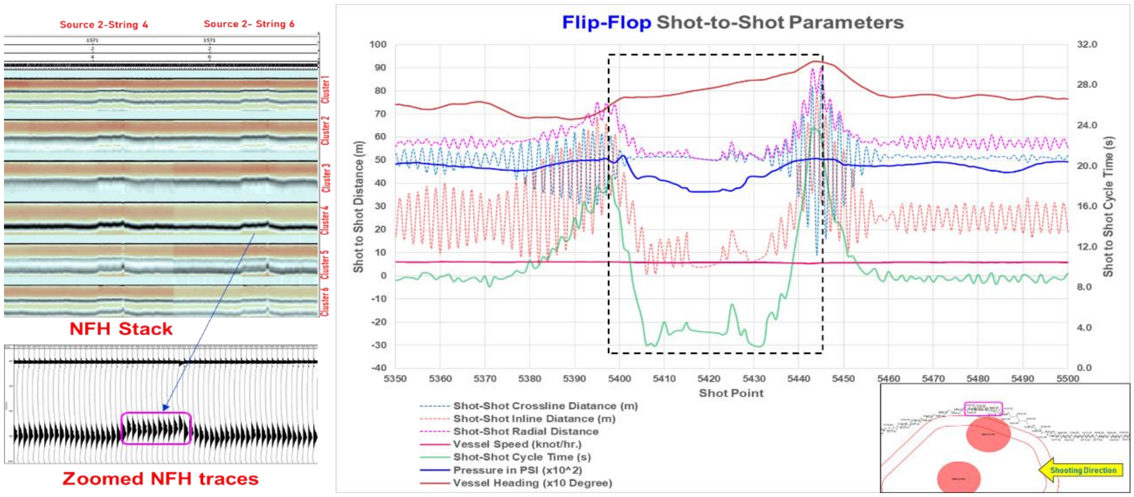

Figure 11: The correlation between NFH and Shot-Shot information to investigate the cause of pressure drop and early shot timing.

Conclusions

As the nodes are placed at sea bottom during shooting, there is no physical control on their position from surface. Node positioning was always a key focus for all stages of the data acquisition; viz. deployment, recovery and FBP to produce realistic fold coverage map for the projects. The infill designs are also focused not only fill the foldage gap but also the offset gap in all azimuths. The paper also tried to described the key use of RMS Amplitude Map to check sensor strength and rotation attributes to obtain the high quality seismic data. The abnormality in NFH display inspired to investigate the root cause of those shot characteristics to flag the bad shots and improve the data quality.

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*Views expressed in this paper is that of author(s) and may not necessarily be that of Oil and Natural Gas Corporation Ltd.

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id-280-challenging-full-azimuth-4C-3D-OBN.pdf (spgindia.org)