V017

Intelligent Infill for Cost Effective 3D Seismic Marine Acquisitions

P. Capelle* (Total E&P Nigeria) & P. Matthews (Total E&P Nigeria)

SUMMARY

TOTAL E&P NIGERIA (TEPNG) presents a new approach to infill management by leveraging the power of interpolation available during processing, the real time and offline coverage maps and availability of steerable streamers to obtain more cost effective 3D seismic marine acquisitions.
The approach was fully implemented by TEPNG over high density (6.25 x 12.5m bin size) surveys (EGINA, PREOWEI), a long offset survey (GTB), leading to significant cost savings and illustrated through the EGINA 3D HD survey located in the Deep Offshore Nigerian waters where fan mode shooting was applied for the first time worldwide.

Introduction

There is a natural limit to the resolution of the 3D seismic image that can be made of the subsurface. Knowing the physics of this, the bin (or pixel) size of the 3D acquisition grid can be determined in order to adequately sample the subsurface.
As the high frequencies are attenuated at longer offset and depth, the bin size can be increased with offset and depth without damaging the quality of the images. However, current seismic processing algorithms require a constant bin size. So, seismic acquisition grids are always designed to properly image the shallowest and nearest offsets to be recorded. This results in a massive over-sampling at depth and farthest offsets.
In practice, feathering of the cables, linked to unpredictability of water currents, means all bins cannot be acquired with all offsets with a single pass of the survey vessel. Consequently, additional infill passes are required.
The challenge is to minimize infill rate by acquiring only relevant traces leading to optimized quality, turnaround and cost. It is most important now due to the high increase of 3D seismic marine acquisition rates the last 4 years (between 200 and 300 %).
Day and Rekdal, 2005 described an infill assessment methodology where the coverage requirements for any hole size was evaluated by modelling the effects of coverage holes in migrated data, methodology implemented on a survey acquired along pre plots lines (Strand et al., 2008).
In this paper, TOTAL E&P NIGERIA (TEPNG) presents a new approach to infill management by leveraging the power of interpolation available during processing, the real time and offline coverage maps and availability of steerable streamers to obtain more cost effective 3D seismic marine acquisitions.
The approach was fully implemented by TEPNG over high density (6.25 x 12.5m bin size) surveys (EGINA, PREOWEI), a long offset survey (GTB), leading to significant cost savings and illustrated through the EGINA 3D HD survey located in the Deep Offshore Nigerian waters where "fan mode shooting" was applied for the first time worldwide.

New Approach to infill management

<u>Potential of trace interpolation at processing</u>
Based on the optimized acquisition variable grid versus offset and that one empty bin can easily be interpolated at processing, we have considered (confirmed by intensive testing on real data) that one to several nominal empty bins versus offset can be interpolated at processing stage (Figure 1).

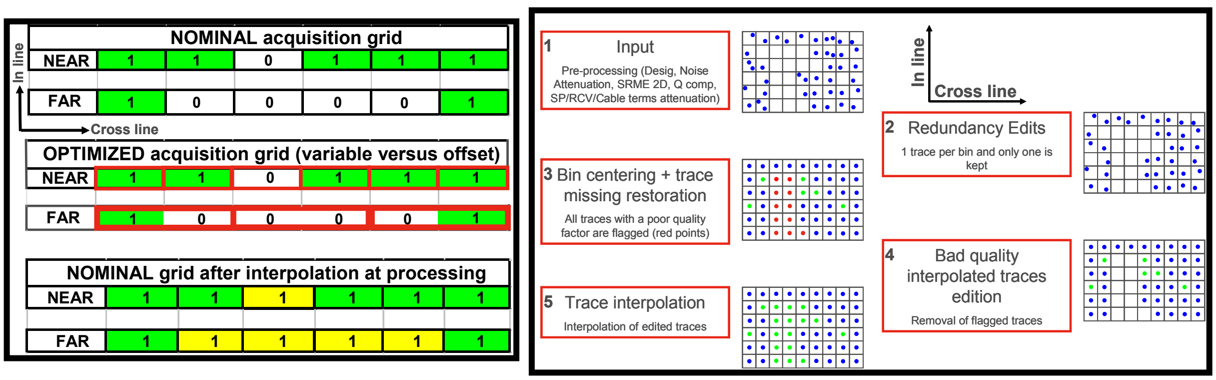

***Figure 1:** Left), potential of interpolation at processing versus offset. Right) Methodology of regularization at processing applied at least by CGGVeritas and WesternGeco.*

New coverage specifications and displays

Coverage specifications have been set up based on the number of empty columns of bins versus specific single offset planes driven by bin size characteristics and the potential of the trace interpolation performed at processing. For the EGINA HD survey, the maximum number of empty columns of bins accepted was ranging between 2 columns for near offset plane to 5 columns for the far offset plane 5425-5500m. These values correspond to a bin expansion from 200 % to 500% while conventional specifications were ranging from 0 to 100 %!

ONLINE, driven by these new specifications, new real time coverage displays (figure 2) have been used for optimization of the steering when shooting for coverage. A single offset class (fold 1) is now displayed instead of a multi offset classes. That binary information provides very precise information through direct access to the number of empty columns leading to sharp steering and an optimization of the overlapping of the near or far offsets.

OFFLINE, single offset displays before and after flex binning simulation (figure 2) driven by these new specifications offer a real and perfect idea of the quality of the coverage offset by offset. The infill program can then be easily optimized.

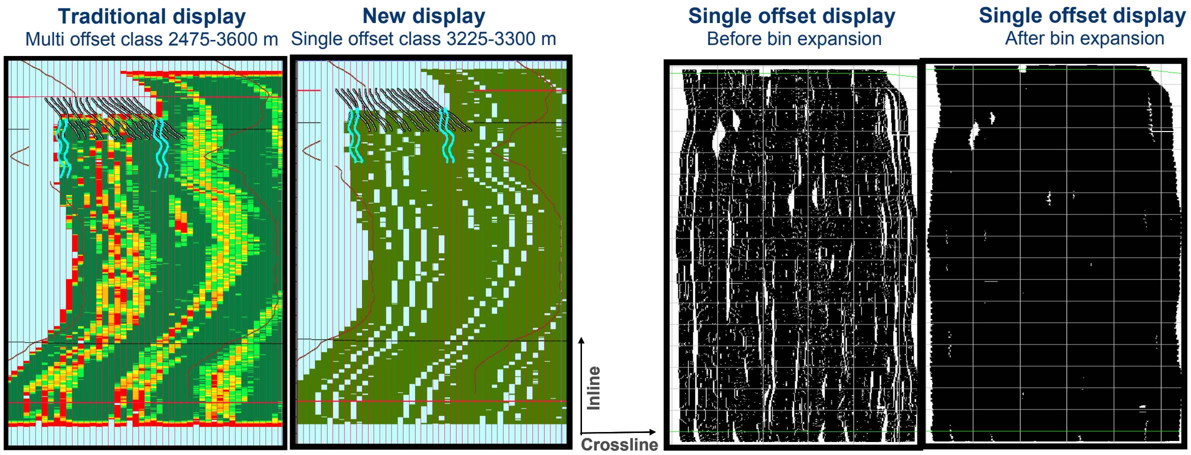

Figure 2: left*) ONLINE - Comparison between traditional and new coverage displays used for steering. Right) OFFLINE - Single offset display before and after bin expansion.*

Potential of specific seismic acquisition equipment- "Fan mode shooting"

For the first time worldwide, the ability of steering the streamers with the "Q marine" system of WesternGeco, was used partially over the 2007 EGINA HD for simulating a variable streamer separation with increasing offset. That specific acquisition spread provides an optimized grid of bins variable with offsets which adequately sample the subsurface tuned to the seismic signal behaviour. That method of acquisition was named "fan mode shooting" (figure 3).

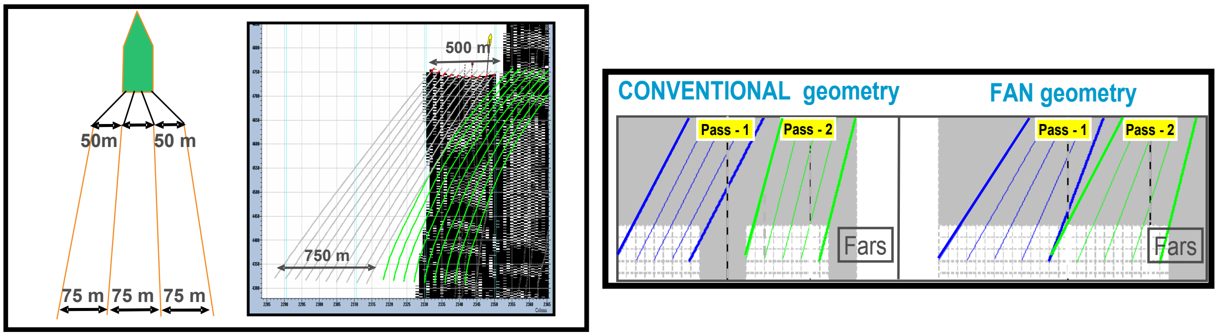

Figure 3: *left) Schema of "Fan mode shooting" method and online coverage display with fan mode spread. Right) Impact of streamer geometry on far offsets coverage with slight feather mismatch.*

Main Results (EGINA HD survey)

The “Fan mode shooting” method, which is part of the infill management approach, has contributed sensibly to reduce the infill rate and produce a more uniform coverage distribution. The increase in footprint of the far offsets gives a more even coverage (figure 4) where feather mismatches occur and permit the steering point to be brought in nearly all instances closer to the front of the streamers. Thereby, when shooting for coverage, it reduces the cross-line corrections required (figure 4) and the amount of overlapping of nears coverage when greater feather lines are shot alongside lesser feather lines.

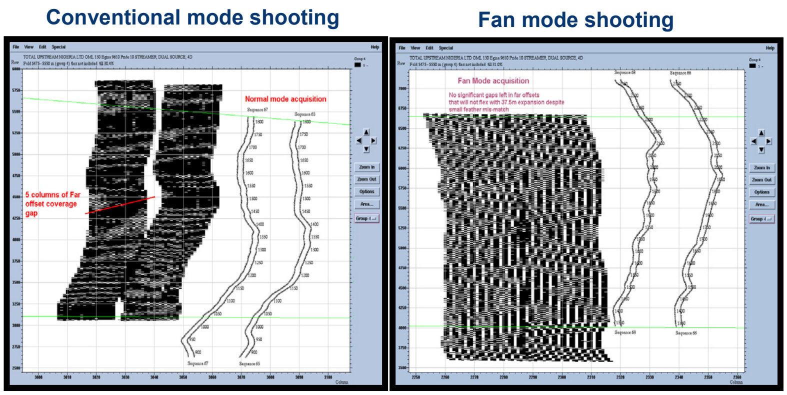

Figure 4: *Coverage map of a far single offset for conventional mode shooting and fan mode shooting.*

The final coverage maps have shown a high average coverage percentage, with a low percentage of infill in spite of the unpredictability of the currents. The interpolation at processing has handled the one to five empty columns of bins with efficiency (figure 5).

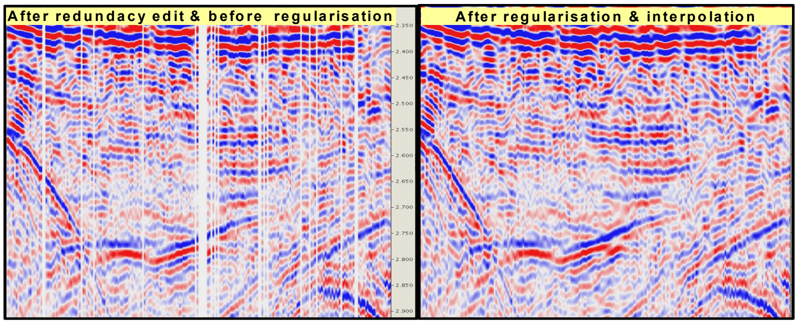

Figure 5: *Comparison before and after interpolation – Cross line – offset 4000 m – Shallow part.*

The provisional migrated images of the 2008 3D HD processing are outstanding, mainly due to the HD acquisition, with no evidence of degradation due to the infill strategy applied when compared to the final migrated image of the 2005 3D exploration reprocessing (figure 6).

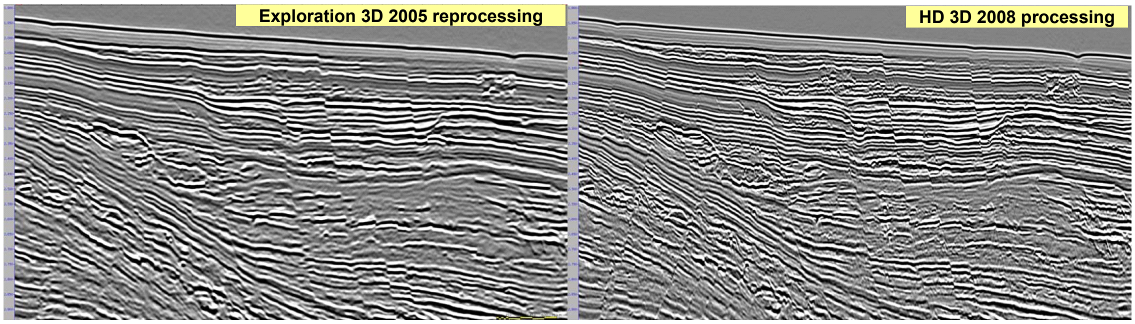

Figure 6: *Final 3D original exploration reprocessing (random line) versus 3D HD provisional processing (inline).*

Benefits & Conclusion

With this new approach to infill management (figure 7), the infill rate was minimized by acquiring only relevant traces leading to optimized quality, turnaround and cost

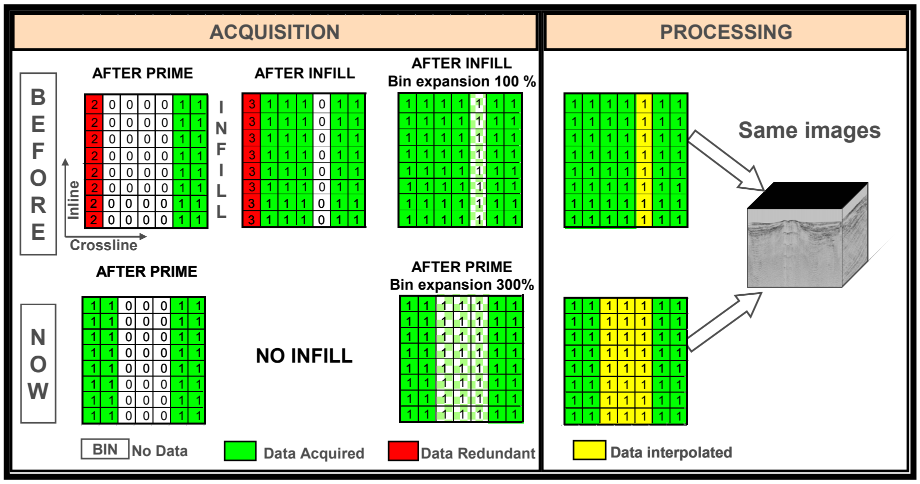

Figure 7: *Synopsis of new approach to infill management. (Zoom of one single offset grid with holes).*

The cost saving to the EGINA HD and GTB long offset surveys is estimated at 1.4 & 6.7 M USD respectively. We estimate that this new approach to infill management, results in 30% less infill required to fulfill a survey objectives.

We are convinced that this new approach to infill management, implemented successfully over several surveys in Nigeria, will generate significant cost savings for future 3D marine seismic surveys and will be further enhanced by the increased availability of steerable streamers.

Acknowledgments

The authors would like to thank M. Erbetta & P. Charron (Total E&P Nigeria) for their advice, trust and support towards the approach, R. Rushby & P. Melody (RPS QC reps) who have executed the implementation of the methodology on the field, WesternGeco for their close cooperation and our partners of OML 130 (NAPIMS, CNOOC, Petrobras & Sapetro) for their permission to show this work.

References

Strand, C., Buchan, I., Mostavan, A., Ross, J. and Monk, D. [2008] Evaluating infill requirements when acquiring a marine 3D seismic survey along pre-plots lines. 78th annual SEG meeting expanded abstracts, 70-74.

Day, A and Rekdal, T. [2005] Determining infill specifications based on geophysical criteria. 75th annual SEG meeting expanded abstracts, 80-83.