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L-16 MARINE SEISMIC CABLE STEERING AND CONTROL

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Schlumberger has developed a new generation of Positioning and Steering Control Systems for towed marine seismic hydrophone cables. The primary goal for the system is to allow lateral steering of the cables. The requirements for Streamer Control involved development of new cable mounted steering devices, an in built acoustic ranging system and a new Integrated Navigation System.

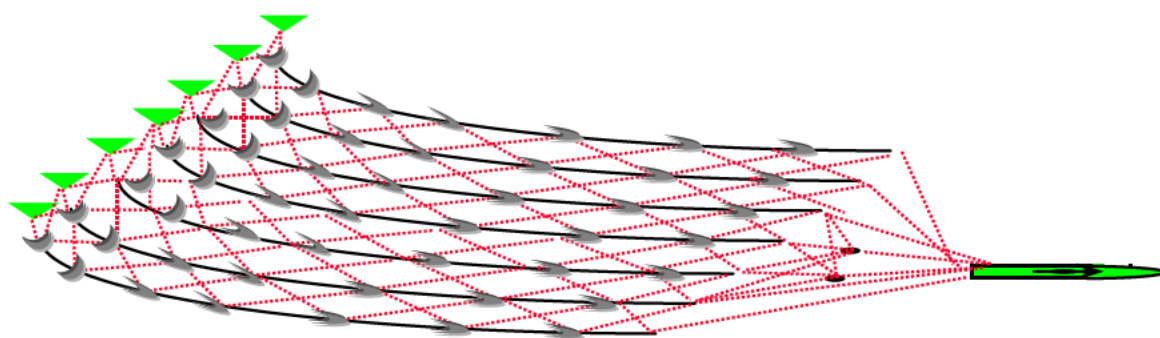


Figure 1 Streamer Control Conceptual Diagram – Full Streamer Acoustics and In-Line Lateral Steering Devices

It is now possible to steer up to 3 degrees laterally from the natural streamer feather angle. This ability is coupled with developments in cable positioning such that the entire seismic spread can be positioned with much improved relative and absolute accuracy. A major benefit of streamer steering is that it allows streamers to be towed closer together with reduced risk of entanglement, enabling wider application of seismic surveying with dense cross line sampling intervals. In addition there are efficiency gains through shortened line changes and reduced infill. More accurate receiver positioning will reduce errors in processing and binning (Morice et al., 2000) and improve repeatability for time-lapse seismic.

Positioning

Studies of achievable precision and reliability for positioning with the new acoustic networks are presented below. For simulation purposes, the measurement errors used to propagate error to the position domain are hypothetical but approximate field experience. The acoustic receiver network nodes consist of two positioning receivers 50 meters on either side of the steerable device (see figure 2). With steering devices located every 400 meters on the streamers, the largest separation between two acoustic positioning receivers will be 300 meters. Future generation networks will be even more dense with 100 meter receiver separation.

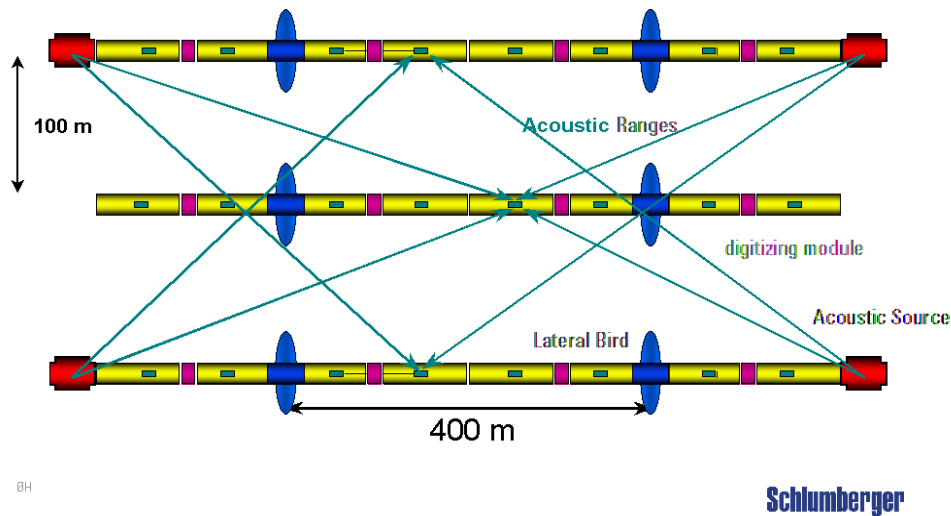


Figure 2 Streamer Control illustration of acoustic transmitter and receiver placement

Figure 3 below illustrates the potential accuracies, which can be achieved by the new Streamer Control Positioning System. The network studied consists of 6 streamers, 6 kilometers long. The streamers are separated by 75 meters. The error ellipse semi-major axis is aligned in the cross line direction. The values plotted on the y axes are the one-sigma values in meters.

Spread 1 has a fully braced acoustic network from front to tail. This will be the standard Schlumberger Streamer Control positioning configuration where we observe positioning accuracy to be 2 to 3 meters for the entire seismic spread. This is a significant improvement over conventional marine seismic positioning. In addition it is conservative in the number of measurements per acoustic positioning hydrophone and testing in the field suggests that we achieve slightly better results in real life.

Spread 2 has a fully braced acoustic network from front to tail with compass direction lines along all streamer baselines. These plotted error ellipses suggest that the existence of streamer mounted compasses in the spread add only a marginal improvement to precision when fully braced acoustic networks are in place.

Spread 3 has front and tail 3rd party acoustic networks, and baselines with compass direction lines along the streamers connecting the front and tail nets. This is how we acquire seismic positioning data today where we find our main inaccuracies in the middle of the streamer. The Streamer Control/Steering positioning accuracy requirement can not be met with this configuration.

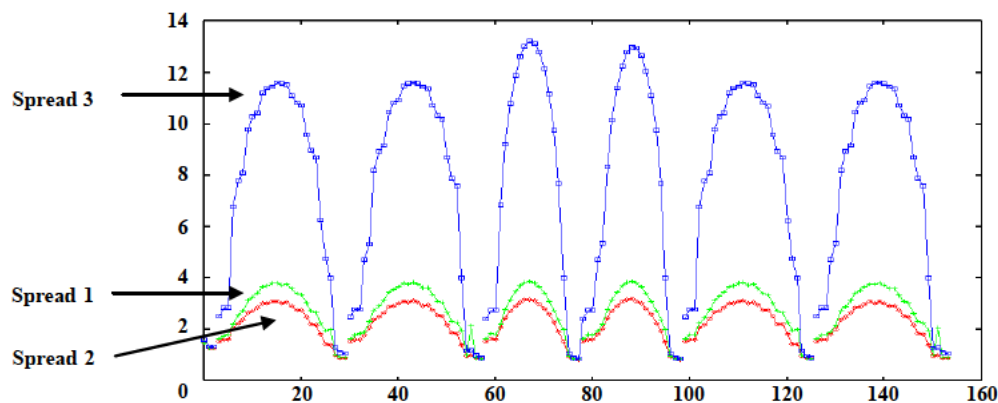


Figure 3 Semi-Major Axes of Position Error Ellipses for a 6 Marine Seismic Cable Deployment: y-axis is in meters, x-axis is positioning network node number

The new acoustic ranging system is interfaced directly to the acoustic solver. This allows for a feedback loop enabling better detection of reflections and refractions. The feedback loop increases the likelihood of eliminating the requirement for measurement conditioning in post-mission. Post mission positioning will in fact become obsolete due to the accuracy requirement for online cable steering. Cable steering shifts the strictest position accuracy requirement from the geophysical realm to Streamer Control and Steering.

Seismic Cable Steering

The inline steering device is fully integrated into the seismic cable and is placed every 400m along each streamer. A steering device consists of a one meter insert section with a titanium body and a pair of removable wings. The titanium body contains sensors, electronics and wing actuators. The steering device is powered through the streamer, but it does also have rechargeable batteries as a backup. The design of the steering device has been for extremely high reliability with a mean time between critical failure at 150 years per unit.

The total lateral force generated gives a possibility to steer up to 3 degrees away from the natural streamer feather angle. Although it may sound little, computer simulations as well as offshore tests have shown that the forces available are sufficient to obtain a high degree of maneuverability of the streamers.

The cable steering devices are controlled by an advanced software application placed on the vessel. The on board controller receives the measured position for each steering device from the new positioning system. The actual position is then compared with a demanded position, and a desired lateral force is calculated and sent down to each device. As in the steering hardware the reliability of the control system is paramount and there has been high focus on ensuring that the system can revert to neutral lateral force mode in the case of lack of position, communication or other main system failures.

During initialisation of the steering system, the user can select between a number of different steering strategies. The choice of strategy is based on the type of operations (online/offline/line change/streamer handling) and on the survey configuration. The user also takes into account whether to optimise for efficiency, optimal coverage or streamer tangling risk minimisation, or a combination of the above.

In addition to improving the quality and efficiency of current seismic surveys, active lateral steering enables new types of seismic products. By having better control of the streamers and selecting a tangling avoidance steering strategy, cross line separation surveys down to 25m can be performed without significant risk for tangling of streamers.

In current 4D surveys, the difference in the positioning of streamer cables from one survey to the next is one of the greatest sources of errors when it comes to repeatability. By making use of old navigation data, it is possible to steer the streamers towards the streamer positions in previous seismic surveys, thereby reducing heavily that source of noise in 4D processing.

Acoustic noise tests have confirmed that the hydrodynamically optimised shape of the new Streamer Control devices have made them far less noisy in the seismic frequency band than comparable clamp-on devices, like birds and traditional acoustic positioning systems (see figure 4).

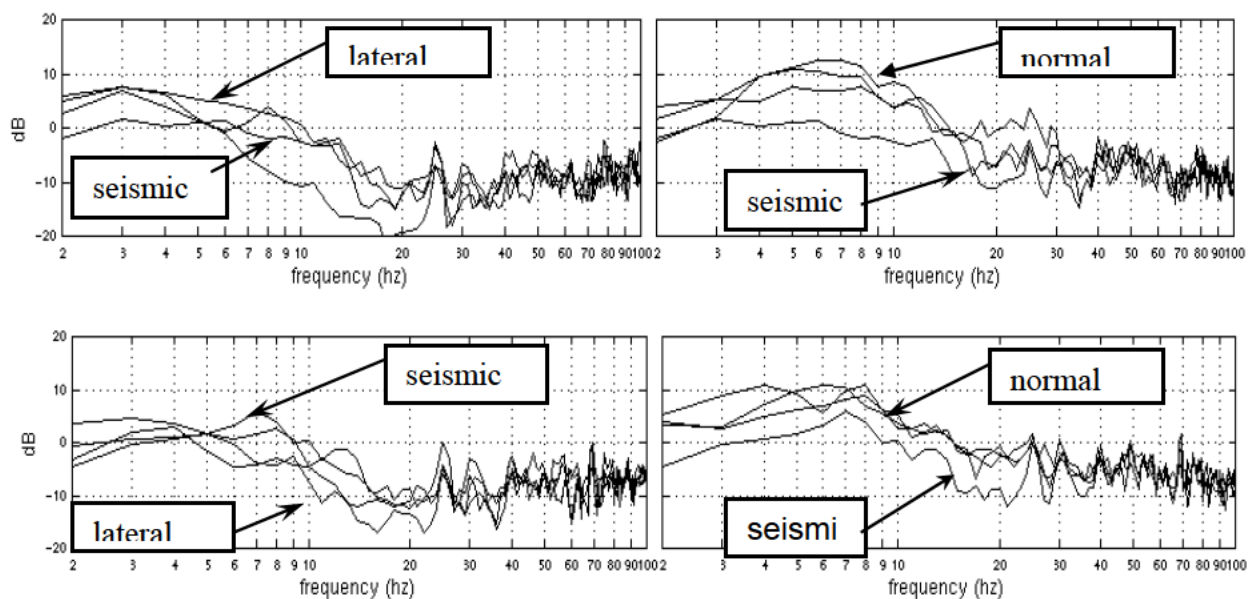


Figure 4 Comparisons of noise levels for lateral streamer steering devices and conventional birds used for streamer depth control against the seismic noise floor

The Schlumberger Streamer Control system has been tested extensively in the Caspian Sea on conventional seismic cables. The second-generation system is already under development, the main difference being the ability to detect and acquire more acoustic ranges for more accurate positioning.

Streamer Control offers a step function in seismic acquisition. The application of lateral steering opens up new seismic acquisition methodology in geophysical prospecting.

References:

Morice, S., Ronen, S., Welker, K., Canter, P., 2000. The impact of navigation errors on amplitudes and phases in seismic data. Submitted to EAGE Conference, Glasgow, 2000.

Acknowledgements:

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