Steerable Streamer Benefits

There are two aspects to the benefits of using steerable streamers utilising DigiFIN devices:

1. Seismic Contractors - looking for cost/time/efficiency/HSE benefits

2. Oil companies – looking for geophysical benefits

The latter is probably easier to promote, as oil companies in general appreciate that the key factor influencing the success of 4D studies is repeatability, i.e. the preservation in the monitor survey of all the operational and geometrical aspects of the baseline survey. The use of steerable streamers and automated shot control means that source-receiver positions, and therefore CMP positions, can be more closely replicated. Most 3D seismic shot in the North Sea has some 4D objective and this is increasingly the case in other regions of the world where environmental conditions make 4D surveys feasible.

However, this study will look at the contractor argument only:

Contractors

As the actual buyers of the DigiFIN system will be the seismic contractors, they have to understand what benefits can be achieved, given that they already have a significant investment in in-water equipment.

For them, the situation is simple, i.e. Time = Money. Saving time saves money and increases revenue earning vessel ulilisation.

Things that cost money / take time:

1. Mobilisation, transit to prospect and crew changes

2. Deploying equipment

3. Shooting the survey

4. Line changes

5. Keeping the vessel fuelled and supplied.

6. Chase boats

7. Infill shooting

There is also the HSE consideration. The less time the survey takes, and in particular the fewer small boat operations, then the less the likelihood of an LTI.

How can DigiFIN reduce any of these?

Streamer deployment can be speeded up. Using steerable streamers with the DigiFIN units active during deployment, the streamers can be steered away from each other as they are laid. With a wide enough vessel this could allow for four streamers to be deployed simultaneously without fear of entanglement, whereas currently on some of the broader-beamed seismic vessels, only two streamers are deployed simultaneously. This implies that a contractor can halve the time taken for deployment. This could save 1-2 days at the start of each survey. Against this, crews may not have sufficient personnel to safely deploy multiple cables at the same time.

Shooting the Survey: In terms of shooting the prime lines, DigiFin would allow the cables to be steered more accurately for coverage. This could also permit closer approaches in restricted areas, for instance in undershoot operations. See the section on infill.

Line changes: The key factor in coming onto line is to have most of the cable essentially straight as the vessel reaches the first shotpoint. This constrains the length and tightness of the line change, especially with 'tear-drop' style line changes. DigiFIN should in principle allow the streamers to be turned onto line more rapidly, thereby reducing the line change time. Additionally, with ORCA, more efficient shooting patterns for a given configuration can be developed. For a survey with 100 sail-lines, a saving of 20 minutes per line change would deliver an overall saving on the survey of about 33 hours.

Infill: This is where the real savings can be made. Shooting infill can add days or even weeks to a survey. DigiFIN can reduce infill by simply making sure that there are fewer holes left in the prime coverage to fill in. The main cause of holes are large feather angles which may not be matched at the adjacent line, and aberrant cable behaviour such as the 'trouser left effect' or 'swallow-tail effect', where the streamers diverge towards the back of the spread, thought to be a consequence of interaction with the vessel prop-wash. This is particularly unwelcome, as it can create low far offset coverage extending along the entire line length – often requiring a complete re-shoot of the line. One approach tried in the past to counter this has been to physically constrain the centre cables with a cross-bracing rope. This has noise implications and can lead to unnatural 'bowing' of the cable shape. It also involves small-boat operations online, increasing HSE exposure. Steerable cables obviously allow for better feather matching. Steering the streamer will also mean that on a single infill pass it is easier to fill in multiple gaps in the coverage that may be on opposite sides.

Two case studies are presented below using data from real surveys. In each case an estimate is given of the time saving that steerable streamers might have produced.

Case Study 1

This was a 3D multi-streamer survey shot off West Africa by a major contractor.

The configuration was 8 streamers of 6000m with twin sources. Navigation was by Spectra and the cables were controlled and positioned by DigiCourse compass-birds and acoustics.

The survey was affected by large cross-currents causing excessive feathering and difficulties with feather matching. It also suffered severely from cable 'swallow-tailing', whereby the centre cables diverged due to prop-wash interaction.

Of the 121 lines shot, 29 had comments on the logs relating to problems with cable movement and subsequent poor coverage.

The following statistics are extracted from the QC consultant navigation line logs.

Survey Statistics

Survey Area	1730 km^2
Number of Pre-plot lines	84
Pre-Plot line km	4600 km (including run-out but disregarding line changes)
Number of actual lines shot	121
Number of infill lines	27
Percentage infill as coverage	15%
Total time for survey	48.2 days
Time spent on infill	10.5 days
Percentage infill as time	22%
Number of infill shots	44094
Additional sailing km due to infill	2060 km (including line changes & run-outs)

First it can be seen that the percentage of coverage which needed to be in-filled was significantly less than the percentage time spent in acquiring it. This is due in part to the difficulty in planning an optimal shooting scheme to efficiently move the vessel around the prospect to fill-in scattered and irregular coverage holes. A second point worth noting is just how far the vessel travelled in order to complete the infill programme. A large 3D vessel will use a lot of fuel in 2000 km.

Estimating Steerable Streamer Effects

How could DigiFin steerable streamers have affected the performance of this survey?

As noted, the main cause of infill for this project was strong cross-currents and 'swallow-tailing'. Cross-currents tend to produce high feather angles, and although DigiFIN may only be able to achieve a few degrees of correction, it would have nonetheless decreased the feathering. Let's say it might make a difference in the degree of infill by 2%. However, the 'swallow-tailing' could probably be reduced significantly. This tends not to be as pronounced a problem in terms of deflection angles. As the graphs at the end of this section show, for near offsets out to 2000m DigiFin can induce crossline movement of ~ 100m. This is sufficient to counter-act any swallow-tailing. For this particular project, a conservative estimate would be that if swallow-tail effects were removed the infill requirement would be reduced by 5%.

The combination of these two effects reduces the infill percentage from 15% to 8%. Noting that the percentage time spent acquiring the infill in this case is ~ 1.5 x the infill percentage, this implies that the infill time percentage drops from 22% to ~ 12%. For this case this represents a saving of 4.8 days due to reduced infill.

Another possible saving due to the use of DigiFin is shorter line changes. If it had been possible to shave 10 minutes off each line change for this prospect then 1200 minutes, or 20 hours, would have been saved.

Finally, add-in a potential 1 day saved in deployment by using DigiFin to steer the cables as they are laid.

Added together this means that from a 48 day survey approximately 6.5 days could be saved.

Case Study 2

This was a two source, eight streamer survey shot in the Mediterranean by a major contractor. Navigation was again by Spectra with Digicourse compass-birds and acoustics.

This had fewer problems than the West Africa survey described above in terms of strong local currents - however 'swallow-tailing' was a problem. In an attempt to counter this, a spreader rope was attached between the centre pair of cables. This had only a limited benefit, as it tended to give the cables an unnatural shape and also induced noise onto the cables. Also, on more than one occasion snapped spreader ropes required additional small boat operations to carry out repairs.

Out of a total of 168 lines shot, 28 had comments regarding loss of coverage due to cable movement.

Survey Statistics

Survey Area	2500 km^2
Number of Pre-plot lines	117
Pre-Plot line km	6600 km (including run-out but disregarding line changes)
Number of actual lines shot	168
Number of infill lines	25
Percentage infill as coverage	Not available, estimate 9%
Total time for survey	57 days
Time spent on infill	8 days
Percentage infill as time	14%
Number of infill shots	38803
Additional sailing km due to infill	970 km (estimating 1500 km including line changes)

This survey had considerable less infill than the case Study 1, although again, much of the infill could be attributed to poor cable separations. As described above, DigiFin should be able to almost completely remove the 'swallow-tail' effect. In this particular case, a conservative estimate would be that infill would reduce from 9% by coverage to ~5%.
This would imply that the infill as a time percentage would drop to 8%, i.e. a saving of 3.5 days for the survey in terms of reduced infill.

If we consider the possible reduction in line-change time, again proposing a saving of 10 minutes per line, that means 1680 minutes, 28 hours.

Finally add-in a potential 1 day saved in deployment by using DigiFin to steer the cables as they are laid.

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