

Efficiencies increase in 4-D surveys

A new acquisition methodology provides 'acceptable' data at considerable cost savings.

By RHONDA DUEY, Senior Editor

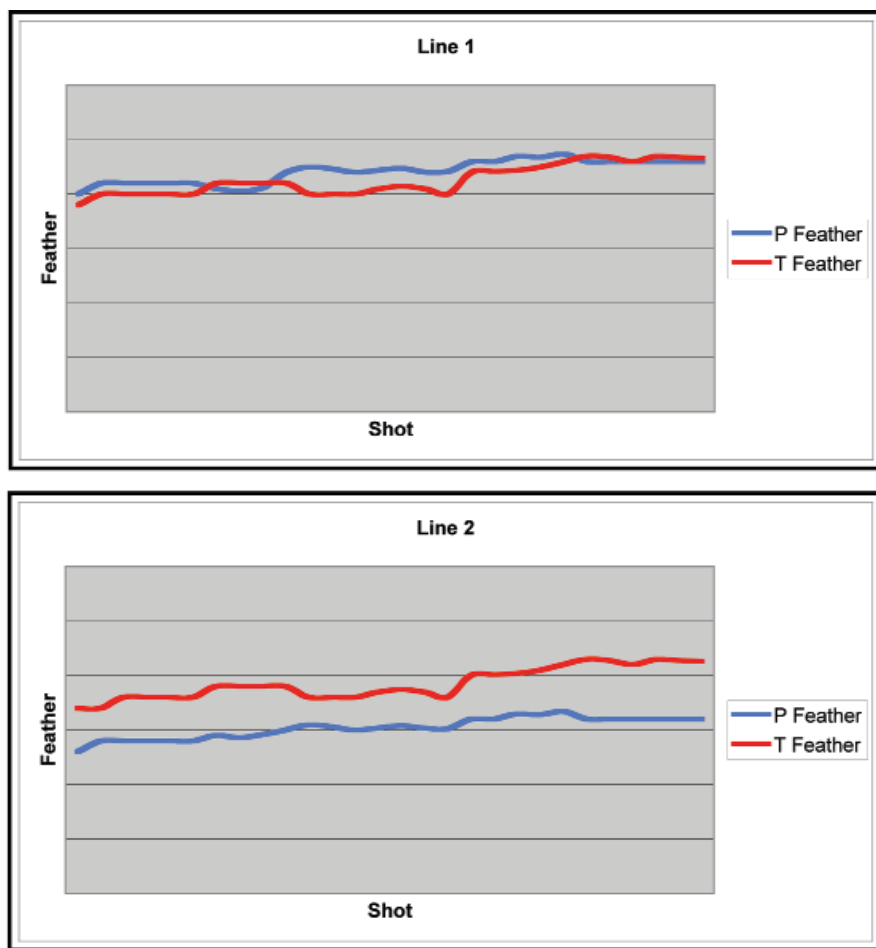
When it comes to increasing production and identifying new infill drilling locations, 4-D seismic is one of the most popular techniques because of its ability to track fluid flow in the reservoir and locate potential lack of communication between injector and producer wells as well as identify bypassed pay.

For years, 4-D seismic surveys have been dominated by two "abilities," repeatability and detectability. If the baseline survey cannot be mimicked closely enough, it is difficult to determine whether differences in surveys are due to changes in the reservoir or a lack of similarity between the acquisition parameters. If a change in the reservoir is too subtle to be detected by repeat seismic surveys, attempting additional surveys can waste time and money.

A new approach to offshore survey design is attempting to lower repeat survey costs by minimizing overlap and infill while maintaining monitor survey integrity. At the recent meeting of the European Association of Geoscientists and Engineers (EAGE), P.B. Sabel of Statoil summarized the problem: "We've made our lives unnecessarily difficult by using 3-D thinking for 4-D acquisition."

Repeating the unrepeatable

Shooting 4-D surveys on land is not difficult, assuming a city has not been erected over the original survey site. Offshore is a different animal. In addition to changes in streamer location caused by wind and currents, platforms and other obstructions can exist where they had not existed



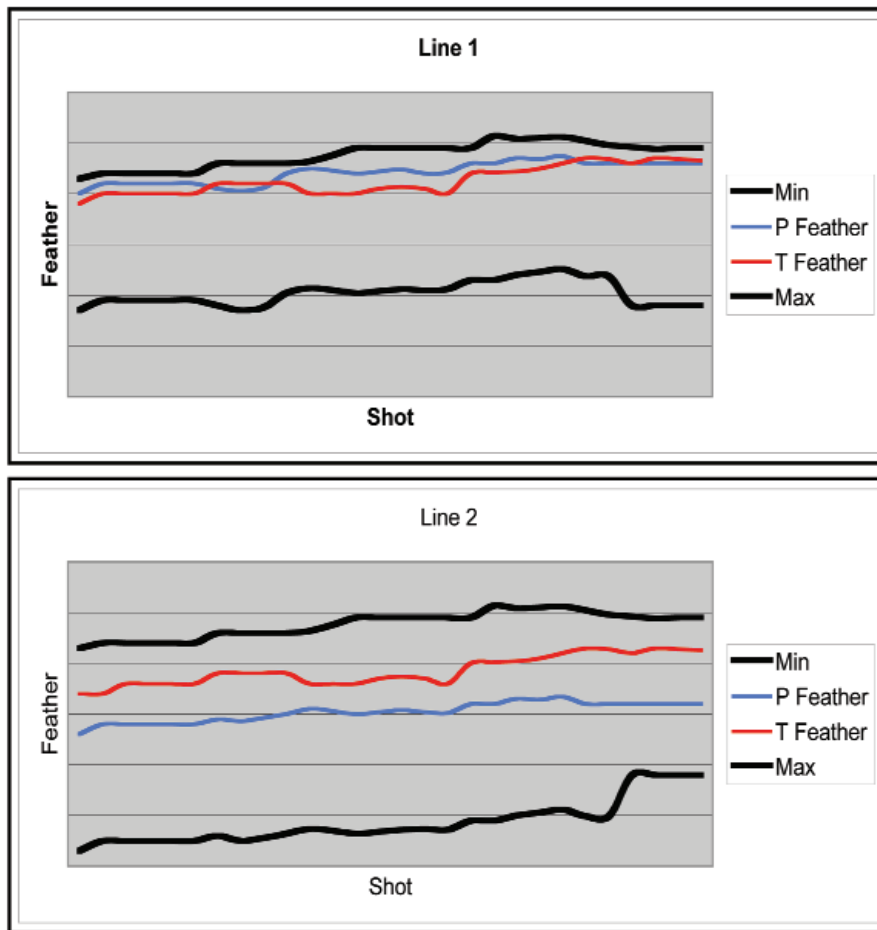
In the conventional approach, images show the predicted feather in blue and the target feather in red for two lines in a 4-D survey. Line 1 has the better average match and, using the conventional approach, would be the better choice. (Images courtesy of RIL)

originally. As a result, operators and seismic contractors have been creative and thorough in their efforts to mirror the original configuration.

This can be costly. In the past, a target "feather" or drift had to be computed for each line of the survey and then matched up during the repeat survey. "Historically, we looked at the baseline

data and targeted the feather," Keith Watt, managing director of Reservoir Imaging Ltd. (RIL), said. "The guys in the field tried to use software to predict it. But if you look at the overlays, it's not a target – it's more of a window."

As an alternative, several companies, including Statoil and RIL, have suggested the group of lines can be viewed



In the new approach, it is clear the predicted feather for Line 1 is close to the top edge of the tunnel, leaving little room for error. Line 2 shows the predicted feather running closer to the center of the tunnel.

as a feather “tunnel,” allowing more flexibility in the line selection process during the survey and resulting in more efficient “acceptable” repeatability rather than focusing on precisely feathering each line in repeat surveys.

“The change was getting away from the concept of a ‘perfect’ survey,” Watt said. “You really don’t need perfection. Repeatability is not absolutely perfect, so you can save 20% and get acceptable results.

“It’s standard with any technology as it matures,” he added. “Ten years ago, 4-D was mostly a research project. Now they’re shooting repeat surveys four and five. They know what they can get away with.”

RIL began a major analysis of typical baseline data and introduced the tunnel concept. The concept has been added to RIL’s Osprey software. Currently, the software is being applied in the UK,

Norway, West Africa, and the Far East.

Watt said sea conditions can dictate how narrow the feather tunnel is. In calm seas, the tunnel can be narrower because it is easier to achieve a closer match to the original survey. In bad weather, a wider tunnel can be used to approximate the original survey.

“You have a better chance of hitting the target and reducing the risk of selecting a bad line,” he said. “You reduce your 4-D infill.”

Development of the software has coincided with other advances in 4-D surveys, including the ability to steer both sources and streamers, also optimizing the accuracy of the monitor surveys. As a result, RIL will create a second generation of tunneling software enabling optimal 4-D repeatability by ensuring streamers are steered down the center

of the tunnel. This also makes future monitor surveys easier to repeat.

Only important lines are shot

RIL first tested the concept in 2008 to see if the idea had merit, Watt said. Statoil was working toward the same concept from a slightly different direction.

From Statoil’s perspective, it helps to study the baseline survey and its feather regime carefully. According to the EAGE abstract, questions can include:

- The size of the feather;
- The predictability of the feather;
- The cause of the feather – mostly tidal, for instance; and
- The size of weather-induced deviations.

The information then is used to prepare cable count requirements.

“Based on geometry criteria like offset and azimuth, the baseline survey’s sail lines were analyzed for their unique coverage contribution,” the abstract stated. “In the case of two equally unique lines, the seismic quality was assessed, and the less noisy line was chosen. If a sail line did not match the uniqueness criteria, it was designated a low-priority line and not to be shot in the monitor survey.”

In one example, the company removed 15 “non-unique” sail lines from the monitor survey, saving US \$1.9 million without jeopardizing data quality. Potential coverage or repeatability gaps were created only in areas where it was possible to compensate the feather of adjacent lines. “This new technique has enabled sail line reduction by adjusting the target feather of the monitor pre-plots to remove these coverage/repeatability gaps during the design phase,” the authors noted.

Statoil has coined the term feather aperture to describe the robustness for feather compensation, in other words, how much deviation from the baseline feather can be allowed before unique coverage is lost. Feather aperture value is assigned to each line to provide a wide range of target feathers.

Statoil authors have said the technique should “change 4-D QC (quality control) and also significantly improve acquisition efficiency.” **ENR**