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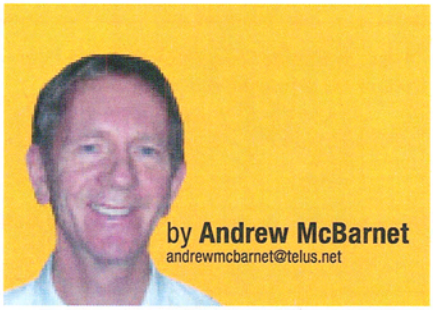

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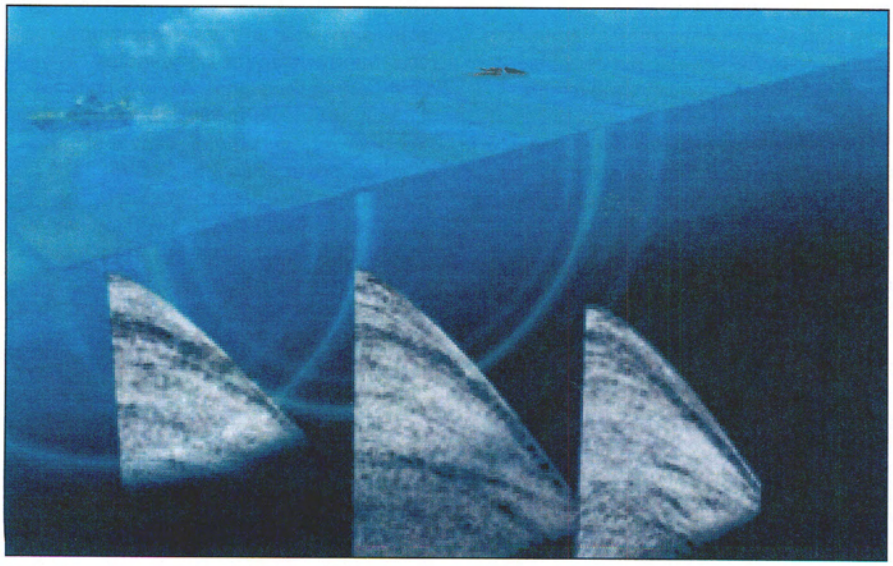
Moving up the Q

The story of Q-Marine is worth telling. It is primarily a cautionary tale about introducing new technology into the E&P business. Overnight success is not the expression that comes to mind, more like slow and steady wins the race. **Andrew McBarnet** explains.

The reality is that even a seemingly winning concept like Q-Marine takes an immense amount of effort, conviction and commitment to commercialise. So, staying power is a major component in realising innovation, particularly in the oil and gas industry which, for lots of reasons not all admirable, has traditionally been slow to adopt innovation. Latest example of this suspicion of all things new is the rate of take-up for marine controlled source electromagnetics (CSEM), at one point hailed as an industry revolution but now struggling to cross the barrier to routine deployment by more than the early converts.

With Q-Marine, Schlumberger and its WesternGeco business unit has undoubtedly achieved its intention of producing a comprehensive marine acquisition and processing technology that genuinely differentiates the company from its competitors. It is part of the Q-Technology suite of advanced seismic services and technologies for exploration and enhanced reservoir delineation, characterisation and monitoring. Q services have marine, land and seabed applications and can cover the life of the field from exploration through to improved oil recovery with the idea of providing operators a superior method for managing risk and making reservoir management decisions (*OE* August 2000).

The marine application of Q has been focused primarily on the improved results that the technology can bring to the 4D (3D time-lapse) seismic survey arena. Its big claim is that Q-Marine surveys achieve an average 40% improvement in bandwidth and are three times better than conventional systems in terms of repeatability, the key element of any 4D survey if data comparisons are going to be informative. The four key components of the technology are calibrated point-receivers, calibrated



Coil Shooting: an acquisition technique using circular geometry full-azimuth with

sources, a positioning system that deploys a full acoustic network along the entire streamer length and steerable streamers. Needless to say, some pretty heavy duty proprietary data processing is involved to deliver the full package.

It is hard to quantify success in the marketplace *vis a vis* other contractors, partly because there is no other technology quite like it. Furthermore, virtually all the company's 4D seismic business for which Q-Marine is purpose designed comes from outside the normal tendering process because it is a complete acquisition and processing package. Clients who come to WesternGeco have effectively made an evaluation and decided that Q-Marine is the optimal solution for their requirements.

As a contribution to the business of WesternGeco, company president Dalton Boutte (*OE* April) said that Q-Technology as a whole including marine, land and seabed amounted to $1.14 billion or 38% of the company's full year revenue. The order has gone out that all new WesternGeco vessels will be Q-Marine, the clearest possible indication of the company's belief in the technology and the perceived demand for the service. Currently the company's fleet of 14 vessels is split half and half between Q-Marine and conventionally equipped 3D seismic vessels. But all eight new vessels on order, the first of which arrives later this year, will be Q-Marine. WesternGeco backlog for Q-Marine surveys is greater than that for conventional surveys, but the company makes clear that some conventional capacity will be maintained for the foreseeable future because by no means all marine seismic business requires such a sophisticated solution.

To date WesternGeco has undertaken 160 or so Q-Marine surveys, enough to suggest that the technology has some real traction in the industry. About half the surveys have been exploration and the other half for 4D projects, either baseline for future reference or repeat reservoir monitoring surveys. What surprised the company following the launch was that the early adopters were not as expected the larger commercial oil companies but instead national oil companies like Pemex, Petrobras, ONGC and Statoil along with some enterprising independents wanting to steal a march on their bigger colleagues. That pattern is now changing as is the geographical focus. Initially the UK and Norway saw most Q-Marine activity but now the technology is global with surveys completed in Southeast Asia, offshore India, West Africa and South America, and of course in the Gulf of Mexico.

Getting to this scenario has taken what

Western Spirit: *Seventh Q-Marine vessel to join the WesternGeco seismic fleet.*

for the geoscientists and engineers who kicked off the idea for this technology in the early 1990s. At that time 3D seismic was just beginning to come into its own as the method of choice for the oil industry replacing 2D seismic which had been the staple of the exploration business since the 1960s. The main benefit was the appreciably better imaging of the subsurface for the identification of prospective hydrocarbon-bearing structures. Advances had been made possible by the growing size of streamer spreads from the single cable characteristic of 2D surveying, onboard data processing, and improved navigation and positioning. New computer technology also had a lot to do with the emergence of 3D seismic although a worry in those days was how the enormous extra volumes of seismic data generated by 3D acquisition could be managed in a reasonable time frame.

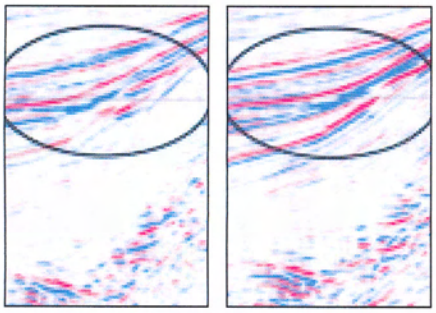
Precision and accuracy

The legend in Schlumberger is that the Q-Technology research people began with the admirably far-sighted view that the future for seismic would belong to those companies which not only could offer the best quality high resolution data but, with the advent of 4D seismic in mind, could facilitate repeat surveys over the same area with the greatest precision for reservoir monitoring purposes. In essence, emerging 3D seismic applications such as imaging for well placement, predicting pore pressure or monitoring fluid fronts all required extremely accurate data.

Opinion at the time was that there was be possible with conventional 3D seismic: for much of the 1990s that was not much of a concern because contractors were working flat out simply meeting the massive demand from oil companies for the immediate imaging benefits from 3D acquisition over new prospects and previously surveyed acreage. Increased streamer counts to harvest more 3D data in one survey seemed to be given the highest priority.

Yet, after what was apparently an exhaustive assessment, the Schlumberger research teams concluded that the main challenge to taking 3D seismic resolution to the next level lay in tackling the problems of noise and positioning accuracy of the streamer acquisition spread. Basically high quality seismic data depends upon as high signal-to-noise ratio as possible and wide bandwidth, meaning the range of frequencies contained in the signal. According to an account published in 2001, the plan was to identify every significant source of noise in seismic data, then suppress or minimise it. The dominant sources of noise were revealed to be swell and wave action at the surface, variation in source characteristics and positioning errors associated with receiver groups along the streamer cables. Some of these issues were acute enough to complicate or distort interpretation of the data.

When Q-Marine was finally launched in 2001, the most radical element of the solution was seen as the introduction of the first point-receiver acquisition system in which the returning seismic wave data is digitally recorded from each individual sensor buried in the streamer cable. This means recording



*Difference in clarity between conventional solid streamer (*left*) and Q-Marine prestack time migrationseismic data (*right*) .*

20 streamers, a capability of 80,000 channels although this many has not been achieved on a commercial survey to date. Nonetheless the vastly increased data flow is a vast improvement on conventional seismic acquisition where traces from a group of receivers are summed in a step called analogue group forming providing a significantly less informative picture. The concept of acquiring data from each individual sensor, defined as a digital group forming process, was first proposed in the late 1980s by Shell geophysicists, but was beyond the compute-power of that era.

The point receiver system epitomises the calibration approach to the acquisition of towed streamer 3D seismic data embodied in Q-Marine to make it a viable alternative to surveys based on ocean bottom cable recording which offer obvious advantages in terms of survey repeatability but at a price oil companies have proved reluctant to pay. This is why in some respects the steerable streamer aspect of the technology has probably attracted more attention over time. If imitation is the sincerest form of flattery, then it is significant that Petroleum Geo-Services (PGS) with ION Geophysical and CGGVeritas subsidiary Sercel are both developing steerable streamers, presumably treading carefully around the patents owned by Schlumberger for its Q-Fin streamer steerage system, not to mention virtually every aspect of Q-Marine technology.

Q-Fins are typically placed at 400m intervals along each streamer and two remotely controlled wings can adjust the depth and horizontal position of the streamer to within ±4m laterally and 0.5m vertically. This is important for countering the effect of wind, waves, currents and other variables in repeat surveys. Currents, for example, can cause streamers to 'feather', ie go off course even to the extent of getting tangled with each other. In 4D surveys over producing reservoirs where infrastructure obstructions may be an issue, steerable streamers allow more flexibility in covering the target area. Redesigned shortly will further improve the steering, according to WesternGeco.

Two problems designers had to overcome with the introduction of steerable streamers were: creating a sufficiently accurate positioning system to track the location and shape of the whole spread during acquisition; and eliminating extra noise from lateral steerage movement which could potentially interfere with the seismic data recording. As a result Q-Marine has a calibrated control system which uses acoustic location data received by the hydrophones and emitted by separate coded sources. This provides an extraordinarily accurate positioning record for the whole spread that can also be replicated in a subsequent survey. The TRISOR digital gun control system which is also used on WesternGeco's conventional seismic vessels provides additional marine source calibration to the system.

Robin Walker, group marketing director for WesternGeco, who in previous posts has been involved in much of the process of bringing Q-Marine to market, says the task of developing a successful steerage system should not be underestimated. 'Over the last seven years we have got better and better at attenuating the noise, but it took us a long time to learn how streamers behaved through water when you steer them.'

Practical benefits

According to Walker, the Q-Marine highly calibrated approach to seismic data acquisition and the experience gained with steerable streamers has some very practical benefits now that wide-azimuth surveys are emerging as the best towed-streamer option for imaging subsalt and other complex geological settings. He states that all the company's multi-client wide-azimuth surveys use Q-Marine because in complex imaging environments the point-receiver system can uniquely capture half or a full octave more lower frequency data than conventional systems and this makes 'a fantastic difference to the final result.' He also makes the point that WesternGeco set itself the challenge of only using one Q-Marine vessel for its wide-azimuth surveys, especially when they are smaller or remote and cannot justify the mobilization of large spreads. 'Some surveys have deployed a cluster of source vessels and maybe two recording vessels. The problem will come if a client wants to narrow down a second survey to, say, 1000km² for clearer data or a 4D purpose. Mobilising a second survey with this kind of armada, especially outside the Gulf of Mexico, will be very difficult and costly. We won't have such a challenge.'

Walker is excited about a new method launched following a number of commercial proof-of-concept surveys. The new Coil Shooting system builds on an old idea of circular shoots to image the substructure from different angles, now made more practical by using steerable streamers and all the other positioning and recording bells and whistles of Q-Marine. 'This will be a major change,' he says, 'and it makes perfect sense. We are shooting continuous line changes and can control the shape of the streamers.' Better coverage with less turning and infill requirements are just some of the advantages.

Up to now much of the evolution of Q-Marine has needed stealth marketing for reasons which go back to the less than favourable climate in which the technology was launched. Back in 2001, the marine seismic business was in the tank. Contractors were virtually buying surveys to keep vessels busy or undertaking totally speculative unfunded multi-client surveys. Neither was a recipe for a success. The introduction of a novel acquisition system from the Schlumberger camp was unfortunate timing. The technology was perceived as complex with a lot more electronics and the industry understood that WesternGeco would be looking for a premium price to justify the substantial development costs but also to compensate the potentially excellent high resolution results. Some companies were also resistant to being bound to WesternGeco for seismic data acquisition and processing, tasks which are often divided between different companies. Many others simply played it safe with a wait-and-see attitude.

Over the next several years the company did actually win a growing trickle of supporters for the technology, but obstacles such as client confidentiality prevented the opportunity to present the torrent of case studies which normally accompany such advances in E&P geoscience applications. For example, the Norne field project on behalf of Statoil was for a long time the only Q-on-Q repeat survey case study available in the public domain. Even today there is relatively little illustrative material on Q-Marine. Robin Walker hopes that this will change very soon. 'In a number of cases, it is nothing more than getting the time with our clients to put together the history.'

Ironically, the current boom in demand for seismic acquisition surveys is so intense that oil companies feel compelled to take whatever vessel and technology is available in order to meet their short-term E&P goals. It's a trend that seems to mitigate against getting the gen out on