Exploration technology: Ready for the rebound

You want better-faster-cheaper? You got it! Innovative technologies continue to emerge.

Article By Rhonda Duey, Exploration Editor
Published Dec 9, 2009

This past year will not be remembered fondly by most in the oil and gas industry. But tough times did not equate to innovation doldrums. Here is just a sampling of some of the new technologies that appeared in 2009.

Better streamer steering

DSC Dynamic Spread Control automated vessel, source, and streamer steering technology was introduced by WesternGeco in 2007. The technique enables effective repeatability for 4-D time-lapse studies and increased accuracy in rich-, wide-, and full- azimuth surveys.

One component of DSC is the Q-Fin marine seismic streamer steering system, an in-sea wing that controls the lateral and vertical positions of the streamers. The Q-Fin has recently undergone a major redesign, and the new model is capable of generating twice the lift of the previous. The testing of the new wings has taken place, and the results show that the new Q-Fin can deflect streamers by up to six degrees against the natural feather. This will enable efficient exploration and high-quality time-lapse studies to be performed in stronger current environments than previously possible.

DSC and the Q-Fin work together, allowing the optimization of source and receiver locations for any arbitrary shooting plan. This is essential for coil shooting, a method of obtaining full-azimuth seismic data from a single towed streamer vessel. DSC also in effect enables oil and gas companies "to go exactly where they have gone before." Even small differences in the acquisition patterns of 4-D datasets can cause residual primary leakage on time-lapse difference data.

Faster velocity modeling

Prestack depth migration (PSDM) and its ability to move seismic reflections to their correct positions in space through velocity models has become an industry norm from Kirchhoff to wave equation to beam migration techniques.

Yet too often velocity modeling is a fragmented process defined by lengthy cycle times, a disjointed relationship between geologist and geophysicist, delays over migrations, and inadequate interpretation capabilities. The result is potentially expensive delays between the signing of leases and the go-ahead on drilling and an inability to improve efficiencies in the exploration workflow.

Petroleum Geo-Services (PGS) is addressing these challenges through the launch of PGS hyperBeam, a real-time velocity model-building solution developed around three core technologies – the AGS PSDM and tomography software, the PGS holoSeis visualization and model-building system, and PGS's hyper-Connect scripting language. Together, they form a single, cross-disciplinary workflow, providing real-time decision-making and interpretation capabilities and generating models in much less time – the AGS Beam Migration algorithm performs full pre-stack tilted transverse isotropy depth migrations on 116 sq miles (300 sq km) in less than five minutes.

This creates a real-time, interactive decision-making environment where the geophysicist is brought closer to the reservoir and where velocity models can be updated as the drilling takes place.

"What if" scenario testing and depth demultiples, delta models, Eta scans, and tomography parameterization can all be evaluated within the workflow. PGS hyperBeam also has advanced capabilities for isotropic and anisotropic velocity model-building and is designed to handle all geometries such as narrow-azimuth, wide-azimuth, and multi-azimuth acquisition.

Interactive interpretation

When Andrew Muddimer's clients began asking about alternatives to a mouse when doing geophysical interpretation, he took on the challenge. Muddimer, chief usability architect for Schlumberger Information Solutions (SIS), a division of Schlumberger, sent his teams out to look at different devices that might save interpreters the strain that comes with constant mouse use.

He found Wacom's Interactive Pen Display, a tablet that allows users to write directly on the screen to interact with their data. These pen displays allow users to work more quickly and naturally and provide precise cursor control in any software application, including applications developed for special uses.

"This gives you a direct connection between your cursor and the data," Muddimer said. "That direct connection is the big benefit that we saw."

The displays found their way into two SIS offices, where experimentation with Petrel seismic-to-simulation software began. Since Petrel is PC-based, it was a simple plug-and-play solution. The team was immediately impressed with the ease of use compared to a mouse.

So when Sarah Chulhan, GeoFrame commercialization engineer, began having hand pain from her job, she immediately thought of her little Wacom tablet at home and said, "Why can't I use this to interpret?" Within a couple of hours of asking Muddimer that same question, she had one on her desk.

GeoFrame reservoir characterization software, a Linux-based system, turned out not to be as easily adaptable. But a call to Wacom led to a call to Red Hat, and within three months most of the bugs were ironed out. "I've been working with it ever since; it's on my desk, and I love working with it!" said Chulhan.

According to Mike Dana, business development manager for Wacom, his company has worked closely with SIS to optimize the integration of Petrel and GeoFrame workflows with Wacom's interactive pen displays. "The relationship between our interactive pen display technology and SIS software is exposing new, user-friendly input methods to the petroleum exploration community," he said. "Through our work with Schlumberger, we have discovered that pen-on-screen input offers much more than added control and precision to Petrel and GeoFrame software sessions. Incorporation of Schlumberger workflows with Wacom devices creates an intuitive workflow that is natural and comfortable while providing increased speed and measurable gains in productivity for the exploration geophysicist."

Muddimer added that the next step is to examine other non-mouse alternatives as well. "From a usability and ergonomics perspective, variety is the key," he said.

Automated first break picking

The constantly increasing number of traces in 3-D land surveys is causing the industry to revisit the concept of automatically picking first arrivals for near-surface model building. But earlier attempts at fully automated picking were largely unsuccessful, resulting in a hybrid method of "interactive auto picking," which involves an interpreter picking first arrivals on a small number of traces. Even this will become impossible as the number of traces continues to grow.

Saudi Aramco is pioneering a method for auto-picking that uses large data volumes as an advantage, not a disadvantage. Statistics available from these large datasets, particularly wide-azimuth surveys, allow processors to worry less about the quality of each pick and instead depend on surface-consistent quality control and the travel-time inversion process to produce a high-quality near-surface velocity model.

The processing flow begins by selecting a large time window centered on the first arrivals and shifting the start time of the window to zero. Each trace is transformed into a peak spike time series by resetting negative values and all values not corresponding to a positive peak to zero. This simplifies the algorithm. The window is then divided into a small number of non-overlapping windows.

The initial first arrival pick is the highest amplitude value in the window that has the highest increase in average amplitude compared to the previous window. This pick will then be revised when compared to adjacent traces. Picks that don't pass a quality threshold are deleted.

This fully automated technique enabled Saudi Aramco employees to reduce the process from months to days and, by using all available data, to get higher quality final images.

Acquisition independence

There is a new philosophy in exploration hardware: acquisition independence. Until recently, almost all equipment developed for use in land seismic was conceived to operate as part of a "holistic system." The sensors were part of the ground digitizing units, which were hardwired to a central system, connected to a source controller communicating with sources, which were limited in their movement because of restricting and preconceived ideas of how they would need to be controlled.

But there has been gradual pressure for this to change. Cableless ground units for a few years have allowed sensors to be placed anywhere and to operate autonomously, meaning receiver effort is no longer restricted by what the seismic cable can do or where it can be deployed. As regards source effort, new independent acquisition techniques can be seen as the antithesis of how most thought vibrators would need to work until recently. Like receivers, sources now can act free of any position or time connection to one other.

Seismic Source's subsidiary iSeis (The International Seismic Co.) has introduced a new breed of cableless acquisition system, Sigma. Although field-testing commenced with the original Sigma hardware only in 2008, Sigma has already been used in stand-alone modes on land and in shallow-water operations as well as working alongide existing cabled systems.

While such source and receiver freedoms are game-changing, it is essential to provide accurate supervision to be sure that exploration criteria are met. This may be in terms of safety, minimum fold, production rates, contractual requirements, etc.

Firstly, the monitoring provided within Sigma is by means of a proprietary license-free Mesh Radio Network, allowing two-way communication so ground units can be remotely controlled. Secondly, the monitoring of sources is provided via both SSC's "Vib Wifi" system (operating between vibes in the same fleet) and the TDMA Comms option, providing a two-way link between fleets and the central system. This provides the full range of test and quality-control.

Tying it all together is the Sigma-Observer software, providing integration between sources and receivers while giving full independence of operation. Sigma-Observer makes no assumptions about how any piece of equipment will be used while providing comprehensive monitoring and oversight functionality to the Observer.

LF workflows

Low frequency (LF) seismic draws on an analysis of the passive seismic wavefield of the earth to identify new attributes indicating the likely presence or absence of hydrocarbons. At a time when the global E&P industry is under increasing pressure to reduce exploration risk and manage costs while adding to its reserves portfolio, LF seismic's light environmental footprint and its ability to reduce risk and costs have made it increasingly popular.

From survey planning to acquisition, processing, analysis, and the presentation of the final high-quality results, the challenge is how to build the necessary software tools to ensure a seamless workflow.

Spectraseis is developing new software and new exploration techniques in parallel. This provides a unique opportunity to develop an integrated workflow and applications that streamline operational processes, ensure the quality of the technical information, support scientific research, and deliver tangible results that are easily adapted into operators' business processes.

To negate external noise, Spectraseis has developed sensor layout patterns which have been designed using a layout generator that enables a geophysicist to create a survey design that is optimized for the exploration objectives in the area. This design is then imported into standard geographical information software, loaded into a data acquisition management system, and then onto robust handheld devices. After the field measurements are collected, all the data, including photographs and metadata, are quality-controlled in the field and then sent to Spectraseis' office in Zurich for processing and analysis.

Spectraseis has designed software which is used to mark unwanted time windows in the data signals and allows the data analyst to view the raw signal in the time domain and in a Spectrogram, where the frequency components of the signal can be viewed in relation to time.

Software development for LF also supports research into this new technology. One example is Time Reverse modeling (TRM), which takes synchronous recordings from multiple receivers in a selected area and performs reverse modeling on these signals to determine the source location of the LF anomaly. Multiple sets of synchronous measurements and various time windows allow the geophysicist many alternative TRM runs for delivering reliable estimations that can then be stacked for improved signal-to-noise. The results can then be immediately integrated with the forward modeling applications that are tailored for the development of further research into this LF passive seismic technology. Integration with operators' own seismic and exploration development workflows can also follow.

Towed land system

At some point in the distant past, land seismic was modified for use in the marine environment. Now that modification is coming full-circle.

Using a technology called Continuous Land Streamers Technology, a start-up company called Geo-Scanning Technologies Inc. is pulling "streamers" across the landscape to acquire land seismic data. The tracks are arranged in a series spaced between 6 and 30 ft (2 and 10 m) apart and are pulled by a large vehicle. The total streamer length is 330 to 1,640 ft (100 to 500 m). Sources come from third-party vendors.

While land surveys provide challenges that marine surveys don't – higher background noise, cross-coupling between geophone elements, geophone misorientation, and mechanical wear, along with the obvious logistical issues – land streamer systems also have some attractive benefits. They can measure shear and surface waves, the latter of which can be as much as an order of magnitude larger than body waves. Streamers on land can also be relatively short and have very closely spaced geophones.

Geo-Scanning Technologies is following on work pioneered in Switzerland, Denmark, Illinois, Kansas, Michigan, Montana, and Sweden. All have shown good results when compared with traditional surveys, usually at a fraction of the cost. Most of these applications are for shallower surveying but can be used in oil and gas or mining exploration. "It is clear that coupling is a major issue, but used prudently in situations where sensors can make good contact, land streamers can provide excellent results," Geo-Scanning reports in its literature.