THE AMERICAN OIL & GAS REPORTER®
FEBRUARY 2011
The "Better Business" Publication Serving the Exploration / Drilling / Production Industry

Nodes Improve Seismic Quality, Cost

By Steve Mitchell

SUGAR LAND, TX.–From a quality control and survey design perspective, the weak link in any seismic acquisition project is the maze of cables that connects all the geophones and recording and monitoring equipment. Cables are susceptible to failure for a variety of reasons, and every failure leads to downtime and added survey cost.

When I began laying out seismic surveys, I learned a trick of the trade that has served many crews well over the years: When deploying cable on a ranch, especially one with scrawny cattle, it is a good idea to put down a block of mineral salt. Out of curiosity, animals will chew on seismic cables. When they do, they discover the cables have something tasty: salt from human hands. Unless the cows have an easier source of salt, they will keep chewing. That is good for them but not so good for seismic contractors.

The ocean-bottom cables used to acquire seismic data in shallow-water areas with production infrastructure and pipelines face their own set of threats, such as strong ocean currents and shifting sand. If its protective coating becomes damaged or a cable breaks, the inside fills with water, which allows signals to be conducted between the wires that transmit the data. This cross-feed transmission distorts the seismic data.

A typical shallow-water (2,300 feet or less) 3-D survey contains enough cable to stretch from Houston to Beaumont, Tx. No matter how clever the crew or how good the cable is, some of the seafloor cable eventually will fail.

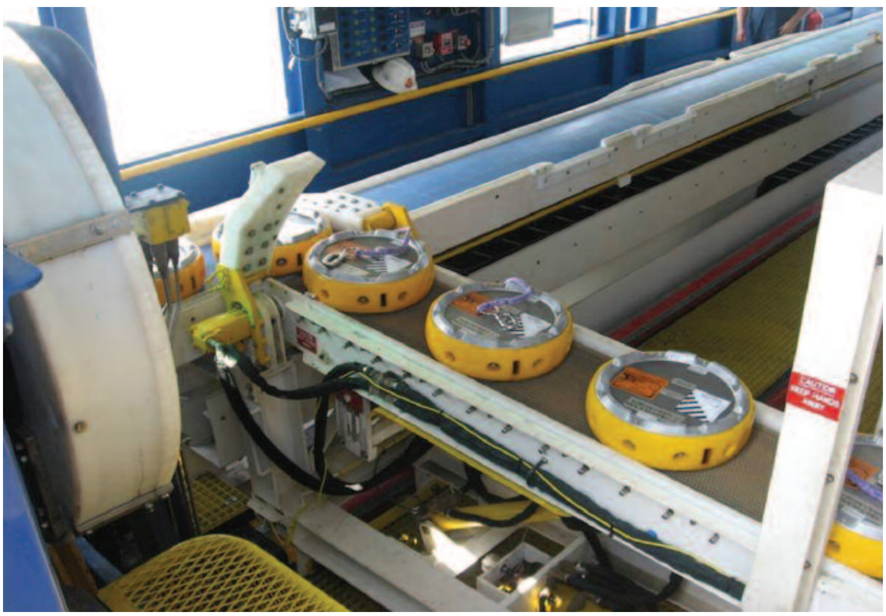
The traditional solution is to search for and fix cable problems. Even with an exceptional crew, finding and repairing cable damage consumes at least two or three hours a day that otherwise would be spent acquiring data. If the survey includes environmentally sensitive areas, such as oyster beds, or areas with infrastructure hazards, the troubleshooting can stretch to five hours.

Today, a simple solution is available: eliminate the cables.

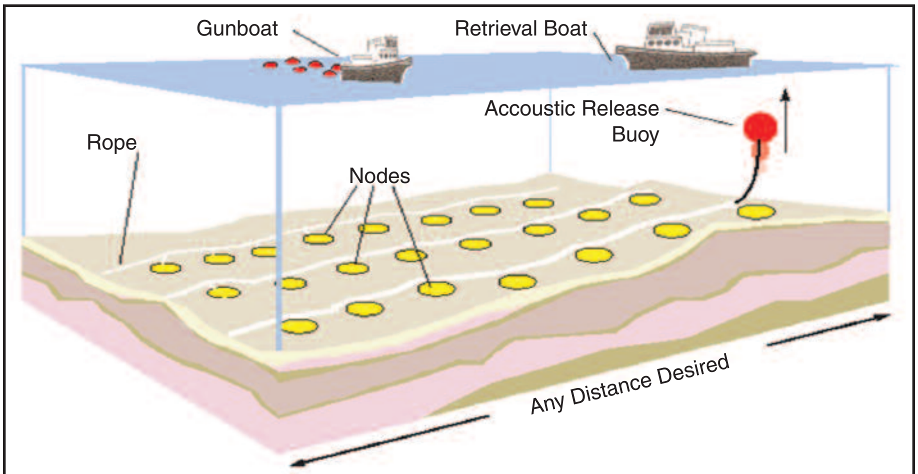
That is the premise behind nodal seismic systems. Because they contain no cables or wires, the systems' self-contained receivers eliminate the need to troubleshoot for cable problems. Once the nodes are deployed, the seismic crew can begin shooting instantly. For the client, that means lower costs.

Three other factors make nodal surveys less expensive than ocean bottom cable surveys. First, nodal surveys only require two vessels: a node-handling vessel and a dual-source shooting vessel. Neither needs to be dynamically positioned. In contrast, OBC surveys usually require a shooting vessel and two cable vessels, at least one of which needs to be dynamically positioned.

Second, the nodes and associated equipment weigh half as much and take up less space than the cables and equipment needed for OBC surveys. Since more receivers will fit in a given area and less equipment needs to be handled during deployment, the vessels and crews can be smaller. As a result, a nodal 3-D survey



Like all seismic nodes, these shallow water nodes store their data internally, eliminating the need for cables and the associated troubleshooting. Because of their cable-free operation and sturdy construction, nodes recover 98 percent or more of the data.



Offshore nodal surveys only require two vessels: a gunboat and a node deployment and retrieval boat. In shallow waters, the nodes are deployed by rope and retrieved using an acoustic buoy.

typically costs on the order of 40 percent less than a comparable OBC survey.

Finally, nodal systems can be deployed in virtually any geometry to meet acquisition requirements, whether surveying around seafloor obstacles or achieving high-resolution densities and obtaining long offsets with rich azimuths. Unlike cabled systems, nodes do not require a fixed interval or a straight line between receivers. If the crews need to place a node on an incline or survey around an obstacle, they can. This helps make deployment quick and efficient.

The flexibility of nodal seismic acquisition has an even greater benefit in that it enables surveys to reduce or eliminate gaps in the data. If the survey includes a coral reef, an oyster bed with an uncooperative leaseholder, or any other area that is off limits, the seismic crew can surround it with nodes. While there still might be a gap, it will be much smaller than the one in a cabled survey.

Even without filling in gaps, nodes achieve higher-quality seismic data. Instead of transmitting information through damage-prone cables, the nodes record and store data on internal circuitry that is protected by an aluminum housing wrapped in a high-impact plastic bumper. More often than not, that keeps the data as clean as the instant they were gathered.

Quality Control

Because the recorded data are stored internally and downloaded when the nodes are retrieved to surface, operating companies often express concern that they will not be able to see the data while they are being gathered. While this is true, it should not be a concern. During a cabled survey, the seismic crew needs to see the data so it can catch and fix problems. That is not a concern with nodes, however. They are highly reliable, achieving uptimes of 98 percent or higher in both land and offshore surveys. This is true everywhere from remote sites high in the Rocky Mountains, to urban neighborhoods in downtown Long Beach, Ca., to 8,000 feet below the surface in the ultradeepwater Gulf of Mexico.

The deployment process contributes to nodes' reliability. Before they are deployed, each node conducts a set of internal diagnostic tests to verify it is ready to go. When the nodes are retrieved, they upload their data while the internal batteries are recharged. The upload only takes a few minutes, and once it happens, the system can check the data's quality and make sure the node still is working properly.

These quality checks happen every time the nodes are retrieved, which occurs when their batteries are almost drained. Onshore nodes can run continuously for 12 days, while nodes designed for use in shallow waters to depths of 2,300 feet can run for 15 days. Deepwater nodes, which can operate in depths to 10,000 feet, can run for 60 days before needing to recharge. The battery life of the onshore nodes can be extended by programming them to shut down when the seismic crews are off duty.

To deploy the shallow-water nodes, the node-handling vessel uses a process that resembles the one the fishing industry uses to place crab pots. The nodes are hooked to a high-strength rope as it is being lowered into the water. Once all of the nodes are attached, the vessel releases the rope, allowing it to sink to the ocean floor. An attached acoustic buoy makes each rope easy to retrieve. Each step is automated as much as possible to reduce health, safety, and environmental risk. Ideally, to minimize idle time, the node-handling vessel lays the nodes ahead of the shooting vessel, and then circles behind it to retrieve the nodes that are no longer needed.

As with surface surveys, the gunboat times the shots using global positioning systems. Since GPS does not work underwater, the nodes are equipped with extremely accurate double-oven oscillator clocks that have linear drift. To compensate for the drift, the nodes record when they are deployed and when they are retrieved in GPS time. By comparing the GPS time to the time on the clock, the vessel's computers correct the drift.

Because of their robustness, cable-free nodes were used to conduct a survey in the Red Sea that involved what likely ranks as the most difficult shallow-water environment in the world. The combination of strong currents, high salinity and other environmental factors would have made cabled seafloor systems unreliable and expensive. Add in coral, and using cabled systems would have been impossible. So would using streamers. Like cables, they would have been torn to shreds.

The nodes worked well. Because the nodes could be placed anywhere, the crew was able to work around the coral. Meanwhile, the nodes' robust exterior and internal electronics allowed them to withstand the currents and sand.

Deepwater Nodes

The amount of infrastructure in the shallow waters of the Gulf of Mexico and North Sea can preclude towed-streamer surveys, but that is not the case in the vast open reaches in deep- and ultradeepwater plays around the world. In general, streamers are less expensive to deploy than seafloor systems. Nevertheless, nodes still have application in deeper waters.

The most obvious application is filling gaps in streamer surveys. By putting nodes around or underneath obstacles, surveyors can image areas streamers cannot approach. This includes areas directly beneath platforms. Since platforms usually are immediately above the producing field (the area of most interest), imaging beneath them is extremely valuable.

In comparing data uploaded from nodes with data recorded by streamers, processors will notice the primary appeal of using nodes in deep water: The data are cleaner with less noise and distortion. This makes sense, considering that the nodes never move and are located in the extremely quiet environment beneath thousands of feet of water. Nodes also record the full seismic waveform to capture shear wave data for imaging gas clouds and helping interpreters resolve anisotropy and velocity issues.

In addition, nodes make it easy to gather wide-azimuth data to image complex and deep geology such as Lower Tertiary reservoirs beneath the Gulf of Mexico salt canopy. They are azimuthally symmetrical, meaning they are equally accurate in every direction. Contrast that to streamers, which need to approximate azimuthal symmetry by adopting different shooting orientations in the same area using multiple source vessels or multiple passes of the same vessel. That, of course, takes time and adds cost.

A 2007 survey illustrates the benefits of nodes. The survey covered 83 square miles in the Deimos Field in the Mississippi Canyon area of the Gulf of Mexico. Shell, the operator, decided to use nodes because the technology offered the most affordable way to acquire wide-azimuth data in a small, infrastructure-rich area. The wide-azimuth data enabled the company to accurately image structural features below a salt overhang.

A 2005 survey conducted in the Atlantis Field demonstrated another benefit to using nodes in deep water: accurate positioning. During the survey, remotely operated vehicles deployed 1,628 nodes at locations spread over 150 miles in water depths ranging between 4,500 and 7,000 feet. When ROVs retrieved the nodes, 75 percent of them were within five meters of the locations the ROVs indicated they had been placed. With such accurate positioning, it is easy to place nodes in the same place every time they are deployed. This turns every deepwater nodal survey into a base-line 4-D survey. Node-based, time-lapsed 3-D surveys are more accurate than towed-streamer seismic and more affordable than permanently embedded cabled seabed surveys, especially for smaller 3-D grids or a limited number of repeat surveys.

As their benefits become better established, cable-free nodes can be expected to be employed in a growing number of deepwater surveys. As batteries improve, electronics shrink, and manufacturing costs fall, nodes' costs will get ever closer to the cost of streamer-based surveys. Eventually, nodal systems' superior data likely will make them the method of choice in all water depths.

Seismic nodes' small footprint makes them ideal for ecologically sensitive areas and urban environments.

Land Systems

As in offshore seismic surveying, nodal systems offer superior data quality and eliminate the need to transport, deploy and troubleshoot miles of cable in onshore acquisition projects.

In the 1970s, Amoco developed the first cable-free system, which used what was essentially a cassette tape with a rubber band drive to record data. The system proved extremely useful in the swamps and coastal transition zone of Louisiana.

Today, node systems represent the state of the art in land recording technology. The cassette tape and rubber band drive have been replaced by internal flash memory, and countless improvements in battery life, material design, and quality control have been made over the past 30 years.

Another key improvement is putting the geophone inside the unit. This eliminates the wire that would otherwise connect the node to the geophone, making the node completely self-contained and exceptionally robust.

Nodal systems work so well partly because they are easy to bury. In addition to keeping the nodes out of sight, burial protects them from wildlife and vehicle traffic, as well as weather and other natural and human effects.

One survey was conducted in a place where cabled systems have great difficulty: a cattle pen. The crew used drills to dig eight-inch holes, placed the nodes inside, covered them with a few inches of dirt, and began shooting. The cows went about their business and the crew achieved 99.5 percent data recording efficiency.

Because nodes are so easy to bury and can be deployed in any configuration, they excel in urban environments. Signal Hill Petroleum, which operates the Signal Hill Field underlying the cities of Signal Hill and Long Beach in California, decided to use nodes because a previous survey had shown how difficult cabled surveying can be in urban environments.

The nodal crew buried the cables in four lines alongside highway rights-of-way and on private land. Then, after obtaining the expected public works permit and the equivalent of a parade permit, it sent vibrating trucks down the road. To minimize the survey's effect on residents, Signal Hill confined acquisition to only certain hours of the day. Even so, the seismic crew recovered 11 miles of data in 12 days.

The small footprint and flexibility that make nodes ideal for urban areas also provide advantages in ecologically sensitive areas, from the jungles of Peru to the pristine wilderness in the Rockies and the ice fields of the Arctic.

One other benefit of nodal systems bears mentioning: rapid deployment. In fact, because nodes are so lightweight and compact, and require no cables or connections, a nodal crew is at least 25 percent smaller than a cabled crew.

In the Barnett Shale, nodal technology was used to conduct time-lapsed and microseismic surveys while two wells were being perforated and fractured. Although those placing the nodes had limited experience with seismic in general and only an hour of training with nodes, they achieved an average installation rate of one node a minute. ❒

STEVE MITCHELL *is a vice president of FairfieldNodal. His group is responsible for designing, manufacturing, and selling FairfieldNodal's nodal seismic recording systems. Prior to his current position, Mitchell led Fairfield's marine operations group. During his 35-year career, Mitchell has run seismic operations ranging from dry land, through swamps and marshes, and into ultradeep marine environment.*