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'Cable-Free' New Mantra In Acquisition

By Dennis Freed

SUGAR LAND, TX.–It is often said that one can never have enough of a good thing.

Well, seismic data are no exception.

This holds true like never before in today's geophysical industry, given that oil and gas operators are focusing on increasingly complex hydrocarbon reservoirs that are often difficult to image. Such targets require myriad data in order to acquire the most accurate possible image of the subsurface.

To meet the growing need and demand for massive volumes of data, the geophysical service companies are being challenged to provide more recording channels per survey than at any time during the more than 100-year history of the seismic industry.

Typical of the industry, technology is the key to growth and positive change. As technology has evolved, there have been corresponding advances in the number of data channels that can be recorded.

Today, surveys utilizing as many as 20,000 recording channels already are becoming the norm–a far cry, indeed, from the half-dozen or so channels that were possible early in the last century. It is likely that field crews will be recording 30,000 channels in the near future and perhaps as many as 250,000 channels by 2025. It is entirely conceivable, in fact, that geophysical companies will field 1 million-channel crews at some point in the future.

The question is a matter of when–not if–this will happen, and what kind of advances will be required in the technology mix to make ultrahigh channel counts a reality.

As we segue toward the future, it is enlightening to take a close look at where the industry stands today in order to understand how current technology in general imposes considerable limitations in the data acquisition milieu.

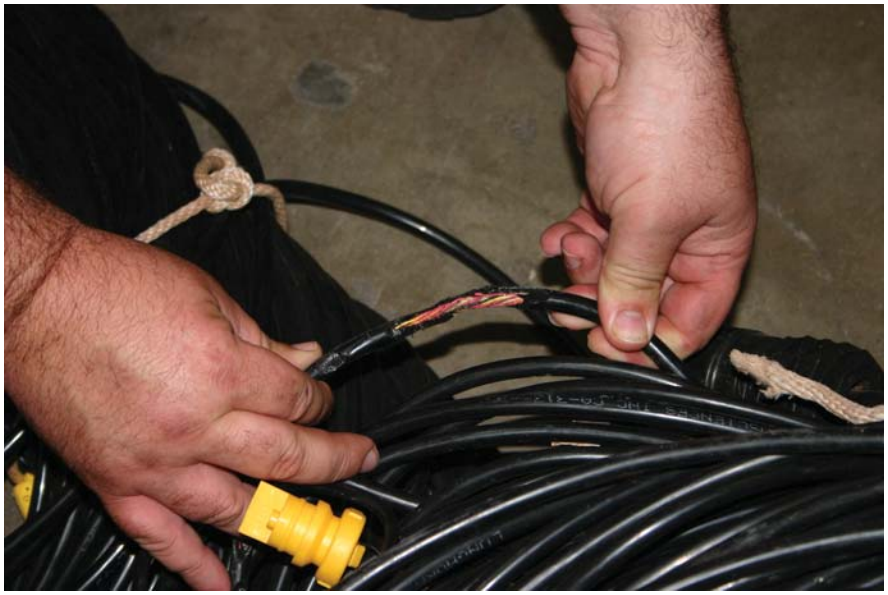
The bulk of seismic data being acquired using advanced technology requires a central terminal (a "doghouse") to synchronize crew activity and provide accurate timing to the remote acquisition units deployed over the survey area.

A central recording system (CRS) controls all timing and synchronization operations of the data acquisition system. The CRS uses either a cable or radio frequency (RF) link, or both, to telemetrically relay information to the remote units and seismic sources and to retrieve the acquired seismic data.

Cabled Acquisition Systems

The majority of acquisition systems operating today use some type of cable to connect the sensing units–geophones, hydrophones and micro-electromechanical systems (MEMS)–to a remote acquisition unit. Once the data are acquired, amplified, digitized and filtered, they must be placed on some sort of storage medium. A few systems store the data onsite inside the remote units for later retrieval. Most systems, however, transmit the data by ca-

Conventional cabled seismic acquisition is encumbered by a maze of cable, connectors, external batteries, power packs and other ancillary equipment. Each geophone string and piece of equipment typically requires one or more external cables.



Cable-free acquisition systems eliminate potential damage or other problems to cables and connectors–the most vulnerable link in a conventional seismic surveying system. The technology also dramatically reduces weight and logistical requirements while offering unlimited expansion and improved surveying productivity.

ble, or sometimes RF, to the CRS.

The downside to telemetry is that the CRS can become a bottleneck because the seismic acquisition industry is running out of bandwidth. This means we are nearing the limit to retrieve data using either real-time telemetry, where data acquired from one sample interval are transmitted prior to the next sample interval, or by "reasonable-time" telemetry, which uses the time lapse between records to send the data to the CRS.

The magnitude of the problem is underscored using a hypothetical example, which entails retrieving 10,000 seismic channels of two-millisecond data acquiring an eight-second record, on average, every 60 seconds. This equates to 120 million bytes of data, or 960 million bits of data being acquired for each record; all of these data would need to travel by telemetry from the remote units to the CRS.

Real-time telemetry (cable) data retrieval would require an aggregate bandwidth of 120 Mbps to keep up with the data throughput. In-line telemetry cables typically are limited to less than 20 Mbps rates, so multiple cables would have to be used to distribute the load. Some manufacturers offer a 100 Mbps telemetry rate but only for backbone or cross-line units.

Reasonable-time telemetry (RF) data retrieval would require an aggregate bandwidth of 16 Mbps to keep up with data throughput. Multiple RF links would likely be used to distribute the bandwidth load. Unlike cable, RF shares a common transmission medium; regardless of the number of RF links, the overall bandwidth remains essentially unchanged.

In addition to limited bandwidth, the data gatherers continually are grappling with problems associated with the myriad cables and connectors used in seismic acquisition programs to attach sensors and external batteries to the remote acquisition units. Cables also are commonly used to connect all of the remote units together for the purpose of telemetry and/or power supply. The sensors ordinarily are composed of a string of anywhere from six to 72 geophones wired together by cable.

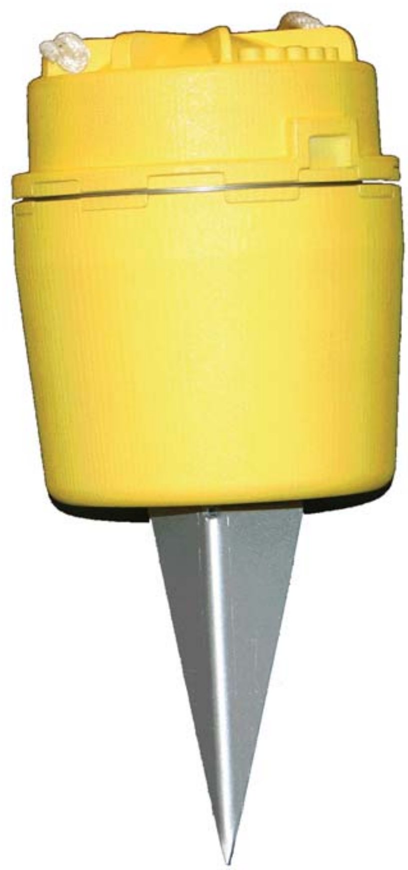
Besides the spread cables and geophone string, the typical 3-D land seismic crew is encumbered with an array of ancillary equipment, including external batteries and power packs, crossing line cables or an RF antenna for each remote unit, and much more. Each geophone string and piece of equipment requires one or more external cables.

Joined At The Hip

Today's systems essentially are "joined at the hip" by some method of telemetry, creating a vast network of interdependent remote acquisition units that are in constant communication with the CRS. In other words, we are awash in a virtual sea of cables and connectors.

Deploying, maintaining and retrieving this massive array of equipment can be a daunting task. For example, a typical 10,000-channel cable system using a 25-meter station interval and a string of six geophones per receiver station with external batteries deployed in 20 lines of 500 channels per line requires an enormous inventory of equipment, including:

- 10,000 acquisition unit links (spread cables). Each cable with associated acquisition electronics to acquire one seismic channel would be 27.5 meters long and weigh about 4.0 pounds per link, reaching a total of 40,000 pounds.
- Each of the 10,000, six-geophone strings would measure 27.5 meters long and weigh 7.5 pounds per string for a total of 75,000 pounds.
- A total of 220 power stations to provide DC power through the links to the remote units; each power station together with a 12-volt DC 65 AH battery



Self-contained remote nodal acquisition units overcome both the bandwidth bottlenecks and limitations associated with cables and connectors on high-channel count seismic surveys, completely eliminating the need for external cables and connectors to acquire data.

would weigh about 60 pounds. This would provide power to keep that portion of the spread active for perhaps two days at 68 degrees Fahrenheit.

- 20 crossing line units with associated crossing line cable. Each crossing line unit, together with one crossing line cable, would weigh 42 pounds for a total of 840 pounds.

The entire system above would top out at 134,540 pounds. The batteries would have to be exchanged every two or three days, and the system's power consumption would be more than two kilowatts when in operation. More than 345 miles of cable and 30,000 connectors would have to be deployed, maintained and retrieved.

The example system can be scaled up to 50,000 or more channels to see the increased telemetry rates that would be necessary and the quantity, weight and power consumption of the equipment needed.

Maintenance is perhaps the most challenging issue today in survey methodology. Batteries must be monitored constantly, and communications must be maintained to ensure the equipment is capturing and recording the seismic reflections. Given that the exposed cables and connectors are highly susceptible to environmental and cultural damage, they must be monitored on an ongoing basis.

Transition Point

Clearly, seismic technology has evolved markedly since the industry's humble beginnings. Yet, we have reached a transition point where the methods currently used to conduct the business of seismic data acquisition are rapidly becoming unworkable as a means to support the mega-channel crews needed to acquire copious volumes of data demanded by the exploration, drilling and production industry.

In a sense, the technology evolution of the past already is being supplanted by a revolution of sorts, as demonstrated by the new minimal cable systems now coming into the marketplace. In fact, systems that are entirely cable free, such as nodal systems, are already on the cusp of becoming a reality.

Many of the new minimal cable systems are referred to as "cableless" because they have no interconnecting cable between the remote acquisition units. In essence, cableless systems have been in existence for 30 years, given that every radio telemetry system introduced in the past has been designated as cableless. Even though the elimination of telemetry cables has freed these systems from a number of limitations, it is misleading to label them as cableless, because few of them are entirely without cables. In fact, the majority of these systems still depend on external cables and connectors.

It is appropriate to divide the available cableless system options into two classes: minimal cable and cable-free. Besides offering a solution to the bandwidth bottleneck, each of these two systems theoretically is capable of expanding the number of recorded channels to an almost infinite number. They locally record acquired seismic data onto memory (typically flash) in the remote acquisition units, and they can sense, amplify, digitize, filter and store the data inside the individual remote units.

Minimal cable systems are much like the cableless RF systems of the past in that they have eliminated interconnecting spread cables, crossing-line units and crossing-line cables. This facilitates deployment, providing much-welcomed flexibility in the field.

Although each of today's minimal cable systems can acquire multiple channels, the remote acquisition units must be connected to an external sensor(s) and external batteries are required for power. The need to deploy, maintain and retrieve external exposed cables and connectors is integral to these minimal cable systems.

Most of these systems still require a clear communication path between a central location and the individual remote units. Some, but not all, of them return quality control data to a central location, so the operator must acquire an RF license and possibly share bandwidth and perhaps use repeaters to help spread the signal throughout the deployed remote units.

Remote Acquisition Nodes

In order to fully overcome both the bandwidth bottleneck and the limitations imposed by cables and connectors, we must adopt a cable-free system (i.e., a nodal system). Self-contained remote acquisition nodal units completely eliminate the need for any external cable or connector to acquire seismic data.

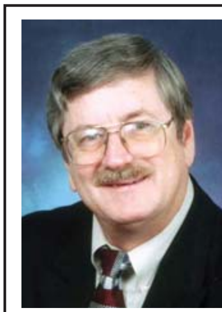
Each cable-free, self-contained acquisition unit must encompass a number of critical elements:

- Sensor;
- Analog preamplifier;
- Analog-to-digital converter;
- Filter;
- Central processor unit;
- Synchronous disciplined clock;
- Local memory storage for acquired data; and
- Batteries.

Because all external cables, connectors and sensors are eliminated, an individual cable-free node could weigh less than five pounds. A 10,000-channel cable-free system could weigh as little as 50,000 pounds overall–a reduction of almost 270 percent compared to the 134,540 pounds of a conventional cable system.

Besides eliminating the most vulnerable equipment on a seismic crew, there is no need for any quality control data to be sent from the remote acquisition units to a central location. The sophistication, power requirements and reliability of the acquisition electronic circuitry has become so reliable that a random sampling of remote acquisition units on a rotating basis is sufficient to be assured of proper operation. Spatial oversampling, like digital oversampling, will ensure that sufficient receivers are acquiring data to enable operators to implement blind acquisition.

The advantages of a cable-free seismic data acquisition system include no bandwidth requirement for operation, and no cables, connectors, repeaters, or RF license requirements. In addition, cable-free systems have unlimited expansion opportunity, less weight and environmental impact, and facilitate increased productivity because of decreased need for troubleshooting. ❒



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