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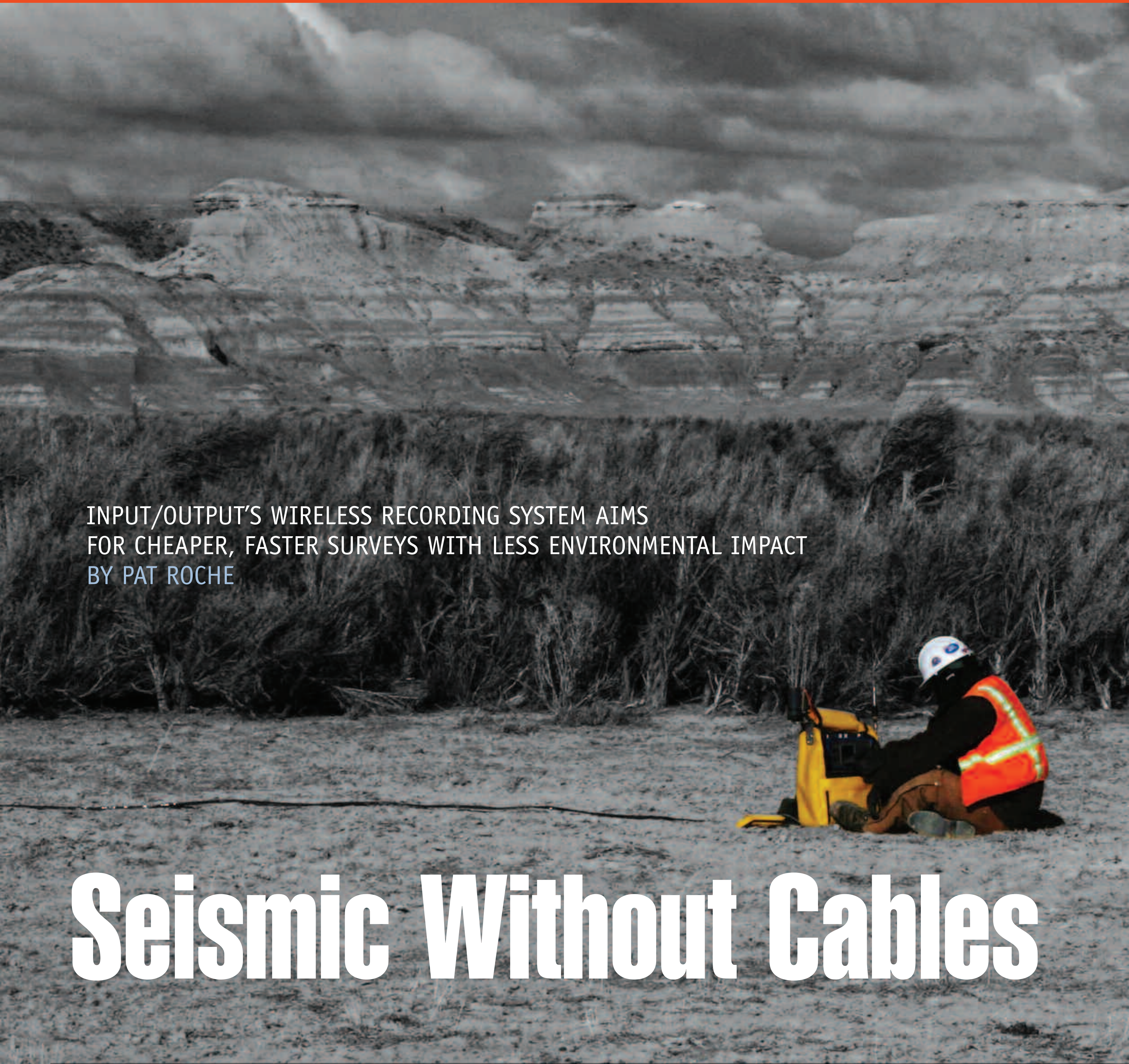
Seismic Without Cables

BP Uses I/O's Wireless Recording System At Its Wamsutter Tight-Gas Play

LAND SEISMIC REVOLUTION
At BP's Wamsutter tight gas play in Wyoming, use of the GPS-embedded navigation and positioning tool ensures data integrity of all the traces.



INPUT/OUTPUT'S WIRELESS RECORDING SYSTEM AIMS
FOR CHEAPER, FASTER SURVEYS WITH LESS ENVIRONMENTAL IMPACT

BY PAT ROCHE

Seismic Without Cables

THE WINDSWEPT PLAINS AND BLUFFS OF SOUTH-CENTRAL WYOMING may not be everyone's idea of the best place to test new technology, especially in the dead of winter. Even today, few humans inhabit this bleak terrain. Vegetation is sparse and rainfall is limited. And during the past winter as Input/Output, Inc. did the first major field trial of its new cableless seismic recording system, some days were as cold as minus -29 C (-20 F). And that's excluding the effect of the wind, which blew almost constantly.

This is the home of the giant Wamsutter gas field, where BP plc plans to spend up to $2.2 billion (US) over several years to double production from its vast acreage. Oil and gas operations in this area don't have to contend with many permanent residents, but the environmental restrictions are formidable.

"The Wamsutter field is located in an environmentally sensitive and historically significant area. So before we can begin seismic operations we hire archeologists, biologists and a few other people to survey the area to identify places we need to avoid," says Craig Cooper, BP's seismic project co-ordinator for North America. "When you go into areas like this, you want to have the least amount of impact on the flora, fauna and wildlife as possible."

And one way to reduce impact, Cooper hopes, will be to record seismic data without cables. So when Input/Output, a Houston-based maker of seismic acquisition technology, wanted to field test its new cableless seismic recording system, BP was happy to oblige.

This isn't I/O's first pioneering product. Six years ago the high-tech manufacturer helped accelerate the geophysical industry's progress into the digital age with VectorSeis digital receivers. Unlike conventional geophones, which only measure seismic signals from one direction, VectorSeis sensors detect signals from multiple directions (Nickle's New Technology Magazine, June 2001). Now I/O hopes to reap the benefits of the wireless age with its FireFly cableless recording system.

The goal is to acquire better seismic data at less cost, in less time, with less risk of personal injury and with less ground disturbance. I/O says the combined weight of cables and related ground equipment on a seismic survey today can easily exceed 25 tons. Weight — which directly contributes to the cost of transporting gear and mobilizing a seismic crew — can account for up to 20% of the operational cost of a "typical" onshore survey in North America, I/O says. In creating FireFly, the company's goal was to eliminate about 80% of the weight on a conventional system.

"FireFly eliminates the cables. It eliminates the crossline connectivity. It eliminates some of the components in the field like the analog digitizer. And it also eliminates some of the components that control power in a cable system," says Marty Williams, I/O's senior vice-president for FireFly.

Cableless system

Known as a field station unit, or FSU, each FireFly unit is housed in a plastic yellow box about the size of a small lunch pail. About 10,000 units have been manufactured so far. Each contains a Linux computer with most of the features of a laptop except there's no keyboard or screen. A short wire connects each FireFly box to a VectorSeis sensor. Seismic signals measured by the VectorSeis receiver are recorded on flash memory inside the FireFly box. (An example of flash memory would be the tiny erasable memory cards used in digital cameras.)

Apart from the one small wire transmitting seismic data to the FireFly unit from the VectorSeis sensor a few feet away, the system is completely wireless. (This is the difference between FireFly and so-called telemetry-based systems, which have some radio-based communication and remote control features, but still rely significantly on cables.)

In FireFly's first field trial, BP acquired 28 square miles of three-component surface seismic data in the Wamsutter field. Three component, or 3-C, sensors such as VectorSeis obtain one vertical and two horizontal co-ordinates to paint a more precise picture of the subsurface than regular three-dimensional (3-D) data.

SEISMIC SOLUTION
The heart of the FireFly system is the field station unit (FSU), which consists of battery power, flash memory, a micro-processor as well as GPS and multiple communication protocols including Bluetooth and VHF radio. A short wire connects each FireFly box to the VectorSeis receiver.

"I think for a first-time deployment of a brand new, complex system such as FireFly, it worked very well," BP's Cooper says of the Wamsutter field trial. "That's not to say we didn't encounter problems, but I think the problems we encountered were things that you would expect to encounter with a first-time deployment — and many of the problems have already been corrected." As this article went to press, the raw data volumes were in the preliminary processing stages. "So we don't have any final volumes. However, the raw and quick-look processed data looks very encouraging," he adds.

The survey recorded about 7,200 shot points over 28 square miles — a dense design meant to acquire a multi-azimuth dataset. Cooper doubts the same survey would have been practical with a cabled system — just because of the amount of cable it would have been necessary to deploy. "With all that cable on the ground I think we would have had too much of an impact on the environment," he says.

Sometimes, because of environmental, safety or logistical restrictions, geophysicists designing a survey for a cable-based system are forced to make tradeoffs in data quality. A cableless system, I/O hopes, will allow surveys to be designed and deployed differently to get the best possible spatial and vertical resolution. For example, in a tight-gas play such as Wamsutter, fractures can play a crucial role. "So your ability to generate a high-quality dataset that allows you to draw conclusions or make interpretations about fracture orientation and density with a lot of confidence is also very important," Cooper says.

On the Wamsutter shoot, cables would also have created potential personnel risks that would have forced BP to make design tradeoffs that would have potentially sacrificed some aspect of data quality such as vertical or spatial resolution. While not nearly as rugged as the Rocky Mountains, the survey area did include some steep gullies and cliff faces. Even for a telemetry-based crew, stringing cable along some of those steeper slopes would have been riskier than FireFly's wireless system, Cooper says.

"I think the FireFly system helped us reduce that safety risk for the crew," he says. "The equipment is lighter [and] deployment is nearly hands-free, which allowed the crew to navigate pretty effectively. And the use of helicopters to drop the backpacks at strategic locations ahead of the deployment crews all contributed to a safe operation." Fully loaded, the ergonomically designed FireFly backpacks weigh 25-27 kilograms (55-60 pounds). Each backpack holds six FireFly units, external battery packs and VectorSeis receivers.

During the BP trial, the backpacks were distributed by helicopter at regular intervals along the deployment route. Each crew would drill a hole to plant a VectorSeis receiver, lay out a FireFly box on the

ground, then walk to the next station and repeat the process. So a full backpack wasn't carried more than a one-station interval, and the weight decreased with each station.

As a backpack was emptied of the last FireFly/VectorSeis combination, there was another full backpack waiting on the ground. "So we just took the empty backpack off, staked it to the ground, took a GPS reading, then lifted a full backpack and walked to the next station," Cooper recalls.

Besides the potential for better data and less environmental impact, FireFly is designed to shorten survey cycle times — from survey design to data processing — in several ways.

Traditionally, if seismic was going to be shot somewhere, a land surveying crew had to be dispatched first to mark off the area with stakes and flags. I/O hopes FireFly's real-time surveying capability will eliminate the need for land surveyors, except to mark off zones to be avoided for environmental or safety reasons.

Field methods

Here's how FireFly's real-time surveying works. A geophysicist designing a survey programs the locations of both sources and receivers into the navigation/positioning system, which guides the field crews to each position where a FireFly unit is to be deployed. As each unit is laid out on the ground, the crew takes a GPS reading, which is accurate within a few metres or less, depending on the positioning equipment chosen. The same technology is used to locate the sources.

Another time saver is combining the geometry, or position data, with the trace data. Typically, when processing shops get raw seismic data from the field, the processors have to manually merge it with the position data. Both are usually in separate files. This takes time and introduces the potential for human error. FireFly eliminates this step by combining the position information with the seismic data during acquisition. That saves time and improves accuracy.

After the Wamsutter shoot, some of the little yellow FireFly boxes were under about four feet of snow, yet crews could still find them by using the system's navigation tool, Williams says. Once collected, the FireFly backpacks are racked in a staging trailer where the units can be hooked up to download seismic data, recharge batteries and install any software updates — all without being removed from the backpacks.

Though FireFly is a new system, its wireless functions rely on established technologies. The wireless link between the VectorSeis receivers and the FireFly units is Bluetooth — a commonly used standard for short-range communications such as wireless keyboards, wireless printing and wireless headsets. A navigational tool on top of the VectorSeis sensor takes GPS and compass readings and "Bluetooths"

FIREFLY TAKES FLIGHT
Top: Six FireFly field station units and VectorSeis sensors are stored in each backpack. They are transported by helicopter to field locations. Right: FSUs are stored during data download and batteries are simultaneously recharged.

the information to the FireFly box, where it's written directly onto the headers of the seismic data files — thus eliminating the need to merge the seismic and positional data during processing. Cooper says the Bluetooth link worked fairly well during the initial field trial.

GPS gives each FireFly unit its exact location — the horizontal X and Y co-ordinates. To get the elevation (the vertical Z co-ordinate), FireFly uses LiDAR, which works on the same principle as radar except it uses infrared laser light instead of radio waves.

At Wamsutter, BP flew a LiDAR survey over the area before doing the seismic survey. "So the combination of the GPS for X, Ys and LiDAR for Zs, or elevation, gives you a nice combination of technology that allows you to pretty accurately locate yourself in 3-D space — without necessarily the need for a lot of conventional surveying effort," Cooper explains.

Meanwhile, communication between each FireFly box and the central recorder is via VHF radio. (VHF is any radio frequency in the 30- to 300-megahertz range, which includes FM radio stations in the 88- to 108-megahertz band, TV channels up to 13, and bands such as police, fire and aircraft.)

FireFly was designed to be deployed by two people rather than the four-man crew typically used for cabled systems. The Wamsutter field trial started with two-man crews. But because the radio-based communication tool was taking "so doggone long" to register the units with the central recorder, deployment ended up being done in two stages, Cooper explains. Rather than having crews standing around for long periods in cold weather, two people laid out the boxes and planted the VectorSeis units as planned, then a third person would follow later to boot up the units so they could radio their position to the central database. (However, I/O says subsequent changes to the validation process will allow the use of two-man crews on the next field trial.)

Because of the extreme cold and the delays, FireFly's lithium-ion batteries (the same type used in laptop computers) were severely tested. "We were averaging about 10 degrees (F, or -12 C) with some days as low as -20 (-29 C)," says I/O's Williams. Because of weather-related interruptions and other delays it was no surprise that most of the batteries eventually needed to be changed during the field trial.

"The batteries were designed so they should have been able to stay out there for about 30 days before they needed recharging," says Cooper. "[But] some of the boxes were on the ground for about two months." Also, due to technical glitches (which I/O says have since been fixed) some of the units didn't power down when they were supposed to, so some of the batteries drained prematurely. "But a majority of the boxes recorded a majority of the shots, and a number of the boxes recorded all of the shots," he says.

So how much time does FireFly save compared to a cabled system? As this article went to press, BP was still doing its appraisal. The question is relatively complex because it's unclear whether the same survey could have been acquired at all in that area with a cabled system. For example, it was deployed in single-sensor sensor mode (no arrays) and "we actually designed it to be a really dense acquisition effort that resulted in the wide, or multi-azimuthal, recording and with a relatively small bin size."

One aspect of the field trial BP doesn't hesitate to declare a success was the shooting pace. "We were restricted to no more than a six-hour shooting day because of weather and light.... During one of those days — it wasn't even quite a full six-hour day, it was probably a $5\frac{1}{2}$-hour day — we got 1,001 shots recorded," recalls Cooper. Using dynamite as a source, the crews averaged about 500-600 shots a day. And they never recorded fewer than about 460 shots a day.

To further test the system, Apache Corporation agreed to do a field trial this spring in northeastern Texas. The oil and gas company hopes to record 15 million traces over 77 square miles during an estimated one-month deploy-record-retrieve cycle.

Meanwhile, I/O hopes to start selling FireFly commercially by the third quarter of 2007 at a yet-to-be-determined price.

For its part, BP was encouraged by the Wamsutter test and is looking forward to seeing how FireFly performs in the Apache field trial. BP hopes to do another field trial of its own later this year or in early 2008. "This was a completely new system and pretty complex," says Cooper. "My view has always been that we'll need two or three field trials to completely work the kinks out."

Depending on efficiency gains and improvements in data quality, the British-based oil and gas producer could potentially have big plans for FireFly. BP is the biggest player in the Wamsutter field with 950 operated wells and an interest in 352,000 leased acres. "One of the big decisions that we were trying to reach here is whether or not we should re-shoot the entire field with a system like FireFly," says Cooper. "That's a huge undertaking because the field area covers 1,600 square miles."

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