A cable-free land seismic system that acquires data in real time

Doug Crice[1*] explains the design details of a cable-free seismic acquisition system that retrieves data in real time and demonstrates its effectiveness on a recent survey in Kurdistan using 7500 channels - believed to be a world record for real-time wireless data acquisition.

Distributed, cable-based systems have basically settled into a common format. There is a central recording module in an enclosure commonly called a 'doghouse', a high-speed telemetry cable through or around the survey area, and in-lines with remotely digitized sensors. As the market and technology has matured, the number of companies providing these systems has become small. Ongoing development has focused on bandwidth, in the sense that systems with more sensors are now available to provide ever-closer spacing or larger arrays. When the industry is ready to field a system with one million sensors, the manufacturers will be ready.

Cableless seismic is a much younger technology, with a variety of solutions available from several manufacturers. The need has always been there. Several early attempts were made to develop a practical cableless system, always frustrated by the ever-increasing numbers of channels required. Now, the explosion of technology which has so impacted our personal and professional lives has spun off a whole series of building blocks that clever designers have used to implement a variety of solutions to eliminate cables: powerful, low-cost microprocessors with large memories, radio chips from Wi-Fi systems that can operate in licence-free frequency ranges, lithium batteries, sigma-delta A/D converters, and robotic surface-mount manufacturing. Because these technologies are widely used in consumer goods, a cable-free seismic system can be built at approximately the same cost as a cable-based system with the capability of large channel counts.

There are many problems using cables, mostly related to logistics – a modest-sized 3D survey is likely to employ 150 km or more of cable. In some areas, it is difficult to lay down cables because of terrain, environmental concerns, non-permit areas, and barriers like highways and rivers. In some areas, animals chew on the cables nightly, requiring repairs on a daily basis. HSE exposure is high with cables because a technician is burdened with perhaps 20 kg of wire and required to walk on the sometimes uneven terrain.

Because of these problems, geophysicists have long wanted to replace these cables, and various successful approaches have now been developed to achieve such a solution. Data quality from cableless systems is excellent and the individual units are highly reliable, but each cable-free system generally requires its own compromises.

The largest problem has to do with ensuring quality data – not the quality of the acquisition electronics – but the bad things that can happen when gear is left scattered on the ground. Environmental problems, such as wind or cultural noise, may go unnoticed. In the case of autonomous nodes (blind systems), the data may not be viewed until days or even weeks after it is acquired, generally when the units are no longer in position, and the results need to be downloaded and reformatted in a field-deployed processing system. Some cableless systems have made provision to harvest the data by bringing a device near the unit to perform a wireless download. Called 'drive-by' data harvesting, this method is a major step up, especially when combined with an in-the-field computer that can merge the files from a common-receiver gather into a common-source gather. Nonetheless, observers and client representatives would like to see all the data in real time, a feature routinely provided by a cable-based seismic system.

***Figure 1** Juggie loaded down with cables.*

[1] *Wireless Seismic.*

[*] *Corresponding Author: E-mail: dcrice@wirelesseismic.com*

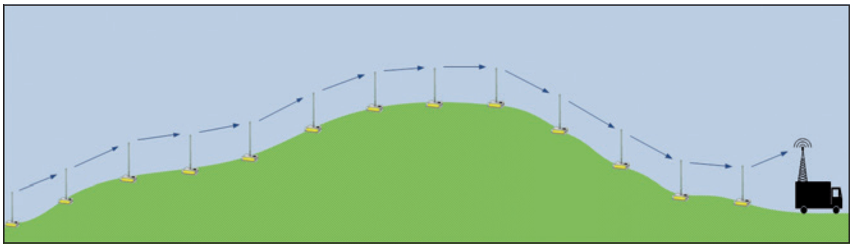

Figure 2 *Communication path for data transmission.*

Figure 3 *A line of recording units passing data over a hill.*

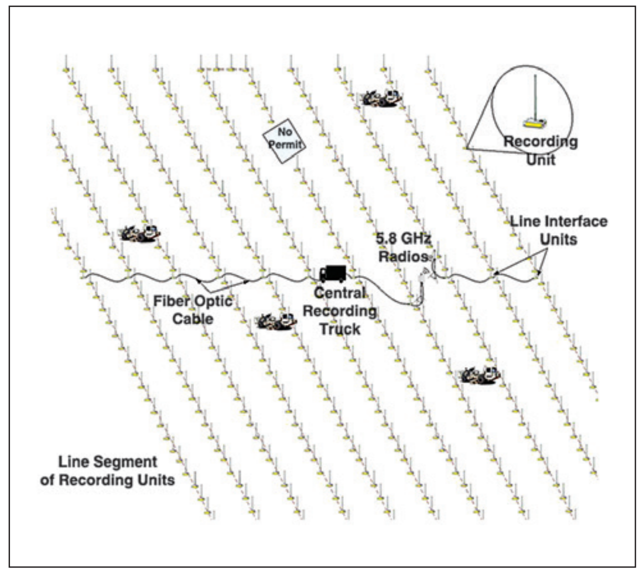

Figure 4 *Example of deployment with multiple units on the ground, fiber backhaul, and a central recorder.*

So, how do you build a cableless seismic system that delivers the data in real time and can scale up to the thousands of channels required for a modern 3D survey? You use radios, of course, to transmit the data from the geophone to the doghouse. However, several problems conspire to hamper this effort. The first issue is that thousands of geophone stations need thousands of radios, and there just aren't enough radio channels available, even if they could be licensed. Many seismic projects have varied terrain, so you can't count on line-of-sight transmission, a problem with the high-frequency radios. How about batteries? If every station requires an automotive-scale battery, the system is no more portable than a cable-based system.

A solution to the problem has been developed and involves what is informally called a 'bucket brigade' where each acquisition unit becomes a radio relay (See Figure 2). Each unit contains a small, 2.4 GHz transceiver that communicates with adjacent stations on either side of the unit. The radio is a single integrated circuit operating on one of the handful of channels in the band. Because each radio only needs to communicate one group interval, it can operate at very low power, which means that each recording unit can run for an extended time on a small lithium battery.

The thousands of units in the survey can avoid interfering with each other because of the limited transmission range. Because the path is short, the units can maintain line-of-sight even in uneven terrain, marching up and over hills. In the rare instance where there is a geographic obstruction, units can be configured as radio relays to jump the signal path over obstacles. Acquiring and passing the data is a continuous process, with half the units transmitting and half receiving at any one time.

The configuration of the system resembles a traditional cable deployment with parallel in-lines and a central crossline backhaul. The in-lines collect and pass data up the line toward the backhaul on the 2.4 GHz band. An identical series of acquisition units on the opposite side of the backhaul perform a similar function. A Line Interface Unit (LIU) receives data from the two in-lines and connects to a 5.8 GHz radio on a small tower (See Figure 5). For each pair of inlines, there is one LIU. Because in-lines are normally separated farther than the stations, these radios have to transmit at a greater distance and at a higher bandwidth (to support passing the data from the whole array of stations). These units require more substantial batteries to power the commercial radios, but only a handful are required. A fibre-optic cable can also be inserted between any pair of the LIUs, if needed.

The inside of the recording truck feels very much like that of a cable-based system. Multiple screens display the status of the acquisition units (instrument tests, geophone tests, battery status, and functionality), a real-time noise monitor, a representative map of the survey, and data. The data is stored on disk drives and can be archived on removable disks (See Figure 6).

Case History: Real-time wireless survey in Kurdistan

The Kurdistan region of Iraq is one of the richest petroleum regions in the world. The region is bounded by mountains on the northeast side; this area contains most of the blocks currently being awarded for exploration. In the summer of 2013 Asian Oilfield Services Limited (AOSL) based in Gurgaon, India, conducted a survey in the southern area of the Kurdish Autonomous Region of Iraq. The 3D-survey covers more than 270 km^2 over a variety of terrains – from flat plains with villages to steep hills and rocky cliffs. Laying cables can be logistically challenging in the region due to its rugged environment and very unpleasant working conditions – temperatures will easily reach 52°C (125°F) during the day. And, even though the region is experiencing economic growth, remnants of the recent war are still a major concern regarding safety issues. The focus on reducing overheads and manpower was clearly a primary consideration.

AOSL decided to deploy the RT System 2 cable-free seismic acquisition system, manufactured by Wireless Seismic, for the Kurdistan survey because of its ability to field a large number of channels and still deliver the data to the doghouse in real time. The survey was noteworthy because it reportedly set a new record for cable-free acquisition with continuous, real-time data retrieval – more than 6000 live channels on the ground from an array of 8000 deployed.

The noise monitor was useful when the wind rose to an excessive level and when road construction started on one line segment, as well as to confirm system operation for setting the vibroseis sweep parameters. Without cables, the lines could run through the village easily, and the observer received a warning when the villagers interfered with the acquisition units.

Regulations require a relatively high percentage of local hires for the crew. Some very basic training was necessary for the non-skilled local labour, including simple tasks such as attaching geophones or batteries to the wireless remote units (WRUs). Deployment has been much simpler than would have been the case with a cabled system, operating with a much smaller crew than would be required and with much lower HSE exposure. At times, the ground was so steep that the units had to be secured to stop them from sliding down the slopes (See Figure 9).

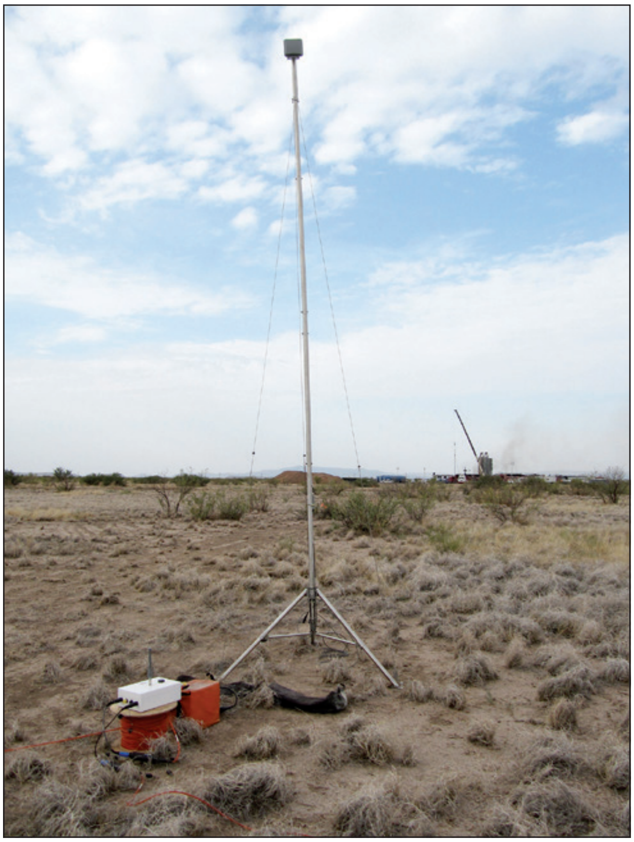

Figure 5 *The radio tower, with a LIU and armored fiber, can be easily carried to the site.*

Figure 6 *Central recording system with four monitors inside doghouse.*

Figure 7 *Rugged Kurdistan terrain.*

Figure 8 *Wireless remote units deployed in Kurdistan village.*

There are some new skills involved in troubleshooting the wireless system. Wireless Seismic has a team of highly experienced customer support engineers that provide training for the system. They are used to working in jungle, Arctic, and desert conditions while remaining sensitive to local customs and indigenous people. One or more WSI field service engineers are sent out with every system purchased until the customer is skilled enough to take over, as with the Kurdistan deployment.

The system was laid out in the general configuration of a cable system, with receiver in-lines and a cross-line backbone, which connects the individual receiver lines to the central recorder. The receiver in-lines of the WRUs transmit the data in a relay fashion towards the backbone, as described earlier in this article. The backbone is also wireless, comprising high-bandwidth commercial radios. The Kurdistan 3D survey used 8000 channels with more than 4700 channels in the live patch recording data from a fleet of three vibrators controlled by the acquisition system. AOSL deployed up to 450 stations on each receiver line with up to 14 active receiver lines. Additional receiver lines are deployed and rolled into active status from the central recorder. For the Kurdistan survey, the crew deployed 14 backbone towers with two radios on each tower to relay the data up and down the line. None of the optional fibre-optic backbone cables were used.

Figure 9 *A worker deploying RT System 2 wireless remote units in Kurdistan.*

Conclusion

The RT System 2 has performed very reliably on this project, and Rahul Talwar, CEO of Asian Oilfield Services, commented that 'RT System 2 is living up to the promise of a truly real-time wireless system under very challenging conditions.'

Acknowledgements

The author would like to thank AOSL for permission to print the article and staff from Wireless Seismic, Inc. for their help in preparing the paper, particularly Patricia Jonesi and Mick Lambert.

Reference

U.S. Patent 7,773,457 Wireless Exploration Seismic System.