Land cableless systems: use and misuse

Denis Mougenot* of Sercel discusses the emergence of cableless land seismic acquisition systems and compares them with conventional cable architecture concluding that they provide complementary applications depending on terrain and spread configuration.

The majority of seismic systems are based on field digitizing units connected by cables for power and data transmission. Today, equipment manufacturers advertise new land systems where digitizers are not connected by cable. Field units are directly powered by batteries, one or two per station, and they include some of the functions of the recorder (data storage, quality controls) in order to be more autonomous. These systems are called 'cableless' even if cables still exist to connect geophones and the optional external battery. These cableless systems are sometimes presented as the new paradigm and the future for land acquisition. It is stated that downtime related to cables and connectors is the main cause of productivity losses that become increasingly unacceptable as the size of the receiver spread and the number of live channels increase. In addition, cables are often damaged, require expensive maintenance, and represent a significant part of the overall weight of the field equipment. Their transportation requires manpower and vehicles, both of which have a detrimental impact on operational costs and HSE.

Though the market share of cableless systems is expanding, still 95% of the channels sold to geophysical contractors over the last two years were cable-based. Crews have been able to keep high productivity while using cable lines laid out on areas sometimes larger than 200 km² for a single spread. For some single sensor high density surveys the amount of live channels transmitted by cable is about 30,000 and the 90,000 landmark was reached last fall during a 3D-3C in a rough area of the Piceance basin (Colorado). Although these figures often correspond to acquisition in open desert areas, some of these large surveys have been acquired in densely populated and industrialized or mountainous regions. 3D projects in complex mountain areas have been productively recorded by cable with 6000+ channels. Recently, one of the major contractors presented a cable system capable of 150,000 channels real time @ 2 ms. Therefore, it seems that the limit of cable systems has not been reached.

This begs the question of the interest in cableless systems by so many contractors and oil companies. What is new in this equipment compared to previous radio systems? Which technologies have enabled the development of so many different cableless systems (six at least)? Are the arguments proposed for the change to cableless systems all justified? And what is their future: are they to coexist with or replace cable systems?

Previous centralized radio systems

For nearly 20 years radio units have been in use based on communication by VHF (100-300 MHz), a proven technology with a possible range up to a few tens of kilometres. The incentive for their development was to preserve near real time data collection and transmission while the receiver lines were interrupted due to obstacles (river, canyon, highways,) or difficult environment (urban area, transition zone, mountains). They were based on field units disconnected from the receiver lines and communicating via antennas to the recorder. These stations were multi-channel (often 4–8) to compensate for their cost due to the addition of radio, quality control capabilities, memory, and batteries. This of course meant that a significant amount of analogue cable was required around each station to connect the different groups of geophones.

An important feature of these radio systems was their centralization: data and status were collected at the recorder by a large antenna that provided the necessary synchronization and time break to all stations. Since radio capability is a compromise between range and data rate, VHF may transmit seismic samples at a high rate (1 Mbps) but for a limited distance (< 10 km), or at a much lower rate (5 kbps) over longer distances (> 30 km). Using this last configuration required that station are able to store seismic data into local memory that will be harvested later on in the basecamp or in the field.

Most of these systems set to transmit data by radio were not very successful because of cost and operational issues. The requirement for specific VHF licence for radio communication for large antennas to centralize and synchronize stations, the high power consumption, and the continued requirement for large amounts of cable and, last but not the least, the risk of not triggering records or recovering data did not facilitate the acceptance of these systems. Their technology was not mature enough.

Towards cableless and radioless systems

It is only in the last five years that new technologies have made it possible to move from centralized radio systems

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to more autonomous cableless systems. A decisive breakthrough has been the availability of low cost, low power consumption, high sensitivity miniaturized GPS chips. This GPS is not intended to be used as a positioning device since seismic requires the accuracy of the differential mode, but as a synchronization clock to time stamp seismic samples. This accurate timing (30 ns) has been the key to eliminating centralized radio systems opening the way to autonomous stations called remote acquisition units (RAU). Other enabling technologies have been compact lithium-ion (LiO) batteries, high capability flash memories (4-16 GB) required for continuous recording, and low power consumption and compact electronics. These have made the manufacturing of single receiver stations economically feasible, and operations possible without any infrastructure for antennas. Eliminating radio capabilities has helped to reduce the price of RAUs although they are still more expensive than the equivalent cable stations. In addition, most of these radioless systems are not totally cableless: an external battery per station is still necessary for sufficient autonomy as well as cables to connect and deploy the string(s) of geophones. The advent of single sensors based on MEMS accelerometers has reduced the amount of cable required.

The drawback of these cableless and radioless systems is that we must shoot blind: no more state of health seismic data are made available for quality control, at least not in near real time. It is risky and it may not be acceptable for some clients. This explains why several cableless systems continue to use a centralized infrastructure based on long range VHF radio to broadcast GPS timing and to collect QC status (battery, sensor, communication) as well as some seismic attributes (first break, signal-to-noise, trace energy decay.

A more flexible approach based on Wi-Fi communication has been developed (Heath, 2004). This technology implemented in the unlicensed part (2-5 GHz) of the microwave band made it possible for larger amounts of data to be transmitted (up to 5 Mbps). The drawback, of course, is a reduced range (from 0.5–4 km depending on terrain

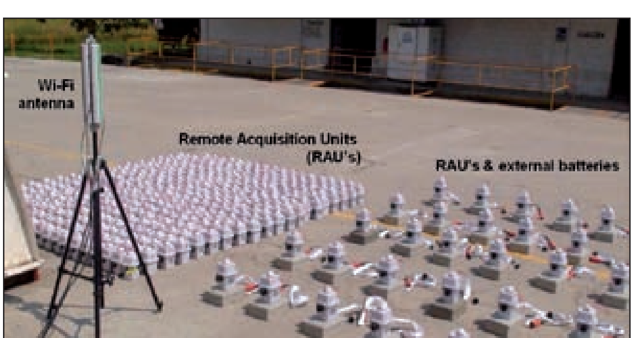

Figure 1 Cableless system made of RAUs communicating with a Wi-Fi antenna for set-up, quality controls, and data harvesting.

Figure 2 Mobile harvesting (patent pending) using a pick-up equipped with a Wi-Fi antenna.

condition, antennas, and protocol used). There are several ways to overcome this limitation. One is based on an infrastructure of antennas (Figure 1). Each one collects data in a small radius cell (~500 m) using the standard protocol (2.4 GHz). Then, thanks to a longer range protocol (5.8 GHz), data are transmitted between antennas back to the central unit via a redundant 'mesh' network. Though this approach should be able to perform near real time telemetry, like some previous centralized radio systems, it may be time-consuming to establish such a dense network on the whole spread and to move it as the spread rolls along. A smart solution to this problem has been to use mobile antennas in vehicles or in backpacks (Figure 2). By moving along the receiver lines, quality controls are performed and seismic data are remotely collected during acquisition. This mobile harvesting is more efficient from an operational point of view than the individual connection of each station to a hard disk, even if the transfer rate is lower. It makes it possible for a continuous flow of data to be available while acquisition continues.

Cableless systems at the base camp

The compact 'cableless' stations (RAU) range from 2–4 kg in weight (with sensor and external battery) if any and their autonomy in continuous recording mode is from 10–15 working days. This field equipment supports the claim that cableless is lighter and require less manpower than cable systems. However, at the base camp the picture is quite different. For high channel count surveys, several trailers may be required to host specific harvesting racks for data collection and charging stations. These racks are connected to a powerful server and to disks that will perform data recovery, sorting, and formatting. The server runs a specific piece of software, the data off-loader (DOL). Basically, it is a table with shots and receivers as the two axes (Figure 3). Each element in the table corresponds to a seismic trace and it is colour-coded to indicate its status: already harvested, not yet harvested, or not to be harvested. For 5000

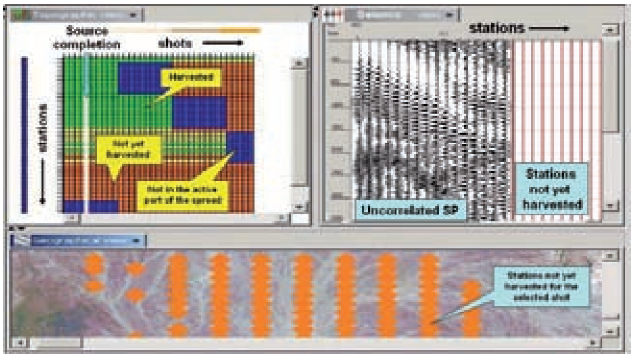

Figure 3 *Data off loader (DOL) interface for a cableless system.The table view (each case corresponding to a seismic trace) is completed by the display of seismic data selected in the table and by a GIS interface with the location and status of the RAUs.*

live stations and 500 shots a day, this corresponds already to 2.5 million pixels, more than the amount on a full HD screen (2.1 million). These 2.5 million traces recorded at 2 ms for 5 s represent 25 GB of data to be retrieved, controlled, and sorted from common receiver points (gathered by the RAUs) to common shot points (only SEG.D compatible collection). In addition, the DOL should include the seismic display of the traces selected on the table and a GIS interface with the status of the RAUs: to know the location of the stations to be downloaded or to be picked up is very important for managing the harvesting crews.

To perform like a recorder, the DOL has to be complemented by many of the capabilities of a conventional recording system for source management, survey input, and to process, format and export data. Compared with a cable system where the data flow, already sorted into SPs, is controlled, processed, and stored in (near) real time, a cableless system requires more careful data management because of the additional steps (harvesting, off-loading, gathering, and sorting) necessary to get the final records.

Good reasons to adopt cableless systems

As we can see, cableless systems bring their own constraints. However, the obvious interest of contractors and oil companies is whether they fulfil some of their requirements. Laying cables in terrains with difficult access and in congested or environmentally sensitive areas is an issue. Cable chewed by animals or cut by farmers is a worry in some countries. From a more general point of view, the cost of cable maintenance and transportation (not only the telemetry, but also the geophone cables) is a concern for contractors. This issue gets worse when the predefined cable interval between digitizers (often 55 m) is in excess of what is required for a high density single sensor survey (5–20 m interval) or when the cable length is not enough for large spacing (>100 m) as it may be used by node type acquisition. Cableless systems offer more flexibility to meet the requirement of variable receiver intervals. One interesting application is the use of multiple spreads recorded simultaneously (Aston and Criss, 2009): to locally increase the spatial sampling (around a well or at the top of a structure); to record simultaneously 1C and 3C data; to obtain far offset data that may be helpful in imaging the deep structure; or to monitor a field by recording continuously the micro-seismicity (Figure 4).

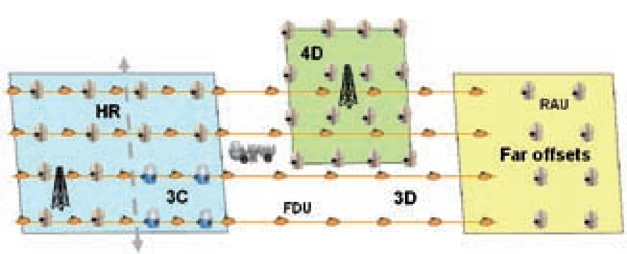

Figure 4 *Multi-spread configuration: a cable system (FDU) is completed by RAUs to locally increase spatial sampling (HR), to change the type of sensor (3C), or to record far offsets. Continuous monitoring (4D) of production may also be performed.*

Another group of problems is related to the architecture of cable systems, including their serial reliability (if one station fails the transmission along the whole line may be down), and the requirement for well defined proportions of different types of field equipment (digitizer, line booster units, cross-line units). A cableless system made of all identical RAUs has no serial reliability issue and does not require different types of field unit.

Reasons to continue with cable systems

Over the last 15 years cable systems have seen a decrease in size, weight (reduced by 10% digitizer, down to 350g) and power consumption (reduced by 2.7 per channel to less than 100 mW). Through cable, a standard 12V battery is able to power up to 120 channels for a few days while each of the RAUs requires its own battery and often two of them (one internal and one external). In fact, moving from cable to cableless means that we replace cables by batteries, and this has an effect on the overall weight and cost for operating the system. The weight per channel of a cable system decreases with the interval between stations (as cable length is more or less adapted, and one single battery can manage more channels). In contrast, the weight of a cableless system stays constant whatever the interval. It has been shown (Lansley et al., 2008) for two systems (cable and cableless) based on digital sensors that at 50 m interval the total weight (including all field equipment) is equivalent; at 15 m interval, the cable system may be half the weight of the cableless if the cable interval is adjusted.

In case of obstacles, the flexibility of cable systems has also been improved thanks to multi-path telemetry (optical fibre for detour, relays using VHF, Wi-Fi, or laser). To prevent transmission loss, the ability to recover data has increased via data buffering by the spread and transmission rerouting (secondary transverses or snaking between receiver lines). Not only is data recording easier, but also the recovery of field equipment. Using cable as a guide has proved to be very convenient in case of snow or limited visibility. GPS guidance is not required to locate the next station to be picked up and if one digitizer is missing (stolen) you only lose electronics, not electronics and seismic data.

Considering the central control unit, the contrast is even more obvious since harvesting racks, powerful server, and disk clusters may not be required. As an example, it is possible with a laptop, a GPS, and a cross-line unit (total weight of less than 5 kg), all powered by a single battery, to record 2000 channels @ 2 ms in the case of explosive source.

Conclusion: the future of cable and cableless systems

In the foreseeable future, cableless will not replace cable systems which have strong advantages from both capital (a channel is less expensive) and operational (productivity is higher) points of view. In station count, cable systems connected to conventional geophones still represent at least 90% of the market share (Figure 5) and this is only expected to decrease slightly. Cable and cableless architectures will coexist for long time, like vibrator and explosive for the sources, geophones and digital sensors for the receivers. Cableless just adds to the palette of tools made available to optimize a survey (Yates et al., 2009).

What can be expected is that their combined use, necessary to adapt to various terrain conditions and spread configuration, will be facilitated. Since the two systems do not obtain data at the same time, separate recorders synchronized in master-slave mode are mandatory in order that one central unit is not delayed by the other. To facilitate the further merge of traces, consistent data should be generated, and identical quality controls and format should be applied This has been obtained by implementing the same type of field electronics and software in both cable and cableless systems.

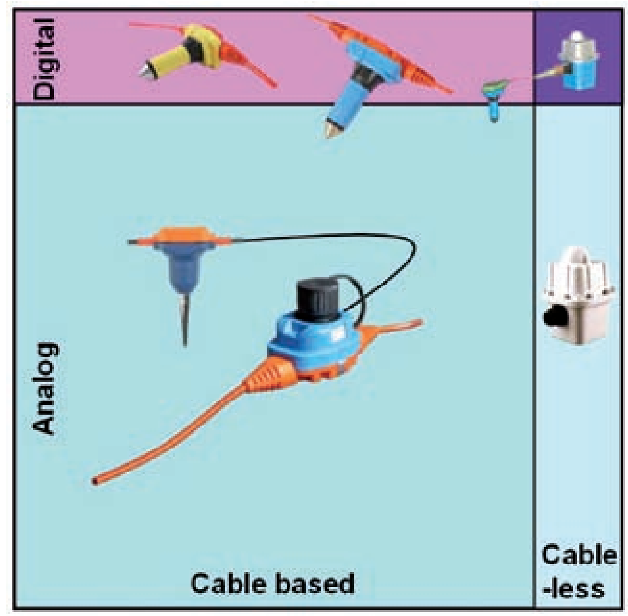

***Figure 5** market segments between cable and cableless systems using analogue or digital sensors. In station count, 90% of the market is still made up of cable systems with standard geophones.*

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