UNITE cableless system and its real-time capabilities

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Land recording systems are composed of many receiver-points connected by cable to a central unit for synchronization, real-time transmission and quality control of the seismic data. With the growing amount of channels in use and the exploration of frontier areas cable systems may become less productive. In difficult access or environmentally sensitive areas, they are complemented or replaced by cableless systems (D. Mougenot, First Break, February 2010). Such systems are not new, but they used to be expensive and quite difficult to synchronize using conventional radio antennas. Since 2005, with the availability of low cost - low power consumption GPS chips used for synchronization, cableless systems have become more affordable and reliable. Today, they offer a cost effective alternative to the cable systems in some areas. In the Americas, the use of cableless systems is growing very fast while in other countries like China, India, Russia and the Middle East their use is still in infancy. One of the reasons is that the oil companies are still reluctant to perform acquisition without having the benefit of the (near) real-time data transmission, like they used to have with the cable systems.

Therefore, the challenge to further expand the market share of cableless systems is to provide them with some real-time capabilities as made it possible by the use of the WiFi technology. The UNITE cableless system as developed by Sercel was the first to include both GPS and WiFi capabilities. Depending on client requirement, the contractor can select a totally blind acquisition in which the Remote Autonomous Units (RAU) are continuously recording GPS-time-stamped data that will be recovered later on. This assumes a very high reliability of the equipment. More often than not, the client feels more confident when it is possible to control some of the RAU's located around a WiFi antenna to check in real-time GPS synchronization and seismic data quality. For particular operations like to record the micro-seismicity during a frac job, it may be even necessary to get all data in real-time via a Mesh network. Thanks to its flexibility in the data recovery, Sercel UNITE can easily adapt to all requirements. In addition, it offers a large choice in sensor configuration and battery autonomy.

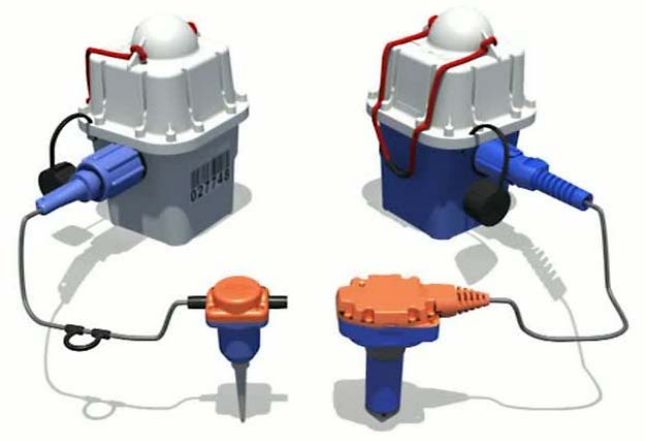

Figure 1: UNITE cableless system is proposed in various configurations: to the left the RAU is connected to an analog geophone, to the right the RAU-D powers a 3C digital accelerometers (DSU3SA).

Sercel's UNITE cableless system:

UNITE system is composed of Remote Acquisition Units (RAU) that behave like autonomous recorders which weight with the internal battery is less than 2 kg. On the top of the RAU case (Figure 1), a hemisphere includes both the WiFi and the GPS antennas. Reporting LED's provide an immediate status of each component of the RAU (GPS, WiFi, battery, instrument and sensor). Below the upper part including the electronic boards, they are two opposite connectors: one is for the sensor; the other to hot swap an external battery if necessary. This port also includes an Ethernet plug for settings and data retrieval that may complement the WiFi transmission. In the lower part of the case there is an internal Li-Ion battery and a non-volatile memory (16 to 32 Gb) able of four week autonomy (12h/day). A radio identification (RFID) is also included to ease the assignment that defines the relationship between the station and the RAU numbers.

RAU's are proposed in different versions in order to handle the different sensor types (Figure 1). The 1C version (RAU) is with a standard geophone connector (KCK2) to be associated with a single high sensitivity geophone (e.g. SG-5) or to a string of conventional geophones (e.g. SG-10). The three channel version (RAU-3) is to be connected to three sets of geophones at three successive stations or to a triphone. However, for 3C recording we would recommend the digital version (RAU-D) that power MEMS based accelerometers within a Digital Sensor Unit (DSU3SA). Each of these versions is now available with an extended internal battery (RAU *eX*) to reach two weeks autonomy (10h/day) without external battery. This option combined with a single geophone offers a configuration that may be more easily buried with the top of the RAU 10cm down the ground surface while all GPS and WiFi capabilities are kept (Figure 2). In the snow or in dry sand the burying depth may be even higher.

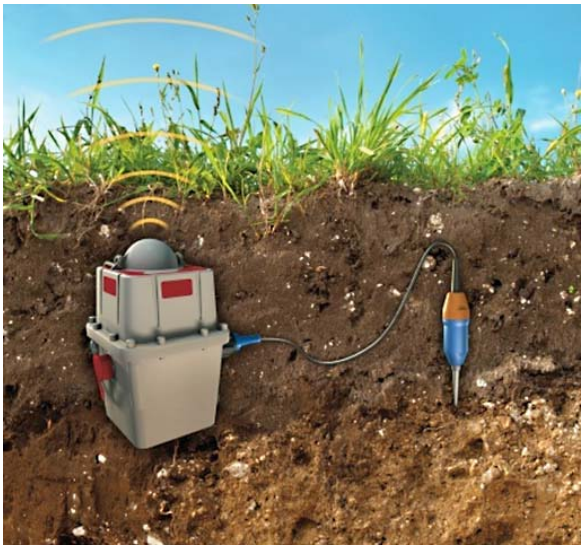

Figure 2: RAU *eX* with its expanded internal battery and a single geophone can be buried down 10 cm below the ground surface while keeping its WiFi and GPS capabilities.

Real time capabilities of the UNITE cableless system:

When activated with respect to a predefined schedule, each RAU is recording continuously. Quality controls (QC's) of the instrument and the sensor are performed periodically as set by the contractor. Without interrupting acquisition, just by moving along the line with a ruggedized tablet PC (RAU Field Terminal) connected to a WiFi antenna, data and QC's may be remotely harvested (Figure 3). For seismic data, this process is speed up by just recovering the samples corresponding to the shot points (few seconds after each T0) instead of the continuous record that

most of the time corresponds only to ambient noise. This remote harvesting has been performed from various means depending on the survey (pedestrian, pick-up, snow vehicle, air boat, helicopter, drone…). In the recorder truck or in the basecamp, the tablet PC is connected via Ethernet to a server loaded with a specific e-UNITE software that will process and QC the data exactly like Sercel's 428XL cable system. Once harvesting has been completed for a given shot-point, a SegD file is generated that may be displayed in real-time (Figure 4). In case of problem and even after harvesting, seismic data are still preserved in the cyclical memory of each RAU until they are overwritten after several weeks of continuous acquisition.

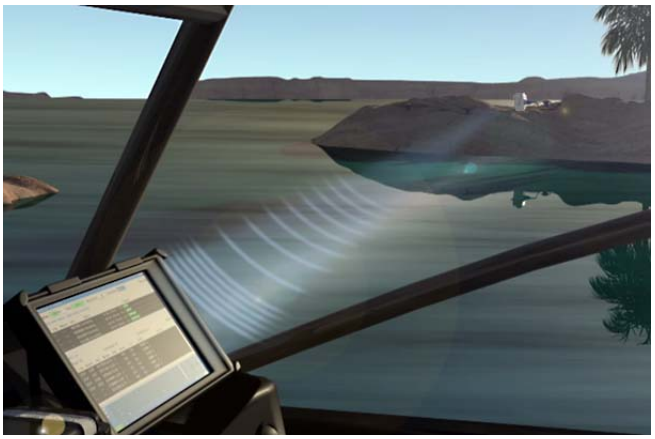

Figure 3: A tablet PC equipped with a WiFi antenna is used to remotely harvest seismic data and/or QC's while recording is still running.

Such remote harvesting is not real-time. For large surveys using several thousands of RAU's and providing the number of harvesters is enough, about three days may be necessary to recover all shot-points (R. McWhorter et al., First Break, January 2012). Thus, some real-time capabilities are in general required by the client to insure data quality. The most basic configuration is to get a high-capability WiFi antenna (Cell Access Node, CAN) connected to the server. Data from the RAU's located within a certain radius (up to 1 km in line of sight) around the recorder are saved in real time (Figure 5).

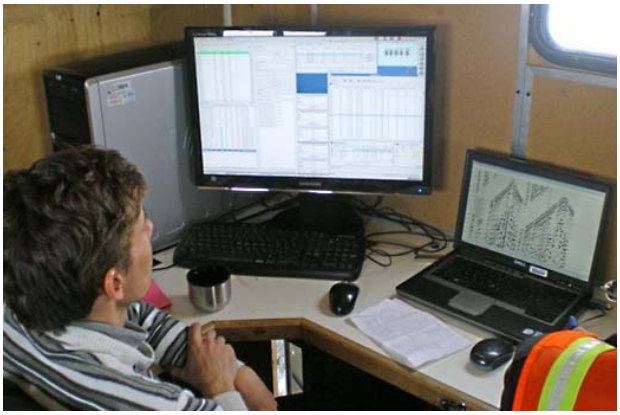

Figure 4: a UNITE central unit. To the left of the observer, the server is connected to different PC clients to display QC's and seismic data.

In case UNITE complements a cable system, additional CAN antennas may also be connected to the crossing units (LAUX) on the 428XL transverse to remotely extend the number of RAU's recovered in real-time. In case UNITE is used by its own and particularly for fixed spreads, like those used for passive reservoir monitoring, extended real-time capabilities are provided by specific antennas part of a Mesh network (Figure 6). Each Mesh node is connected via a first 2.4 GHz antenna with up to 100 RAU's if located within a radius of 800 m. Between Mesh nodes up to a distance of 1500m, a continuous stream of data is transmitted to the recorder via 5.8 GHz antennas.

Therefore, RAU data can be retrieved at any time, even during production, using the means of transmission best suited to the survey condition and to the client request. Within 1000m line of sight and through a license-free wireless communication, data is stored safely in the recorder. Such flexibility makes it possible different application of the UNITE cableless system.

Figure 5: via a CAN WiFi antenna directly connected to the recorder some real-time seismic data and QC's are transmitted to the server.

Applications of the UNITE cableless system:

In congested, difficult access or environmentally sensitive areas wide spread of RAU's have been deployed to perform large 3D surveys including both vibroseis and impulsive sources (R. McWhorter et al., First Break, January 2012). In such terrain conditions, these surveys would not have been possible with cable system due to permitting issues or to the hostility of the local population (M. Lansley, First Break, January 2012). In case RAU's are stolen, a "LoJack" capability permits to detect (even with the external battery disconnected) the approximate location of the units and to remotely recover seismic data by WiFi. More often than not, data from the RAU's around the recorder are transmitted in real-time. On a daily basis, a quick QC of the spread may be performed by helicopter before to start acquiring. Remote harvesting of seismic data is completed by various means during recording, but some contractors prefer to perform data collection while rolling the RAU spread. Recovery is in general excellent with more that 99.6% of the data recovered. Overall, such full cableless acquisition needs less manpower than an equivalent one made with cable. However, battery management, RAU assignment and data harvesting require careful supervision.

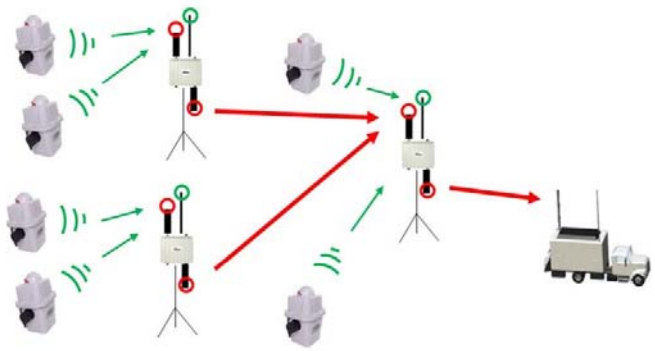

Figure 6: for full real-time data transmission, a Mesh network is used. It is composed of nodes, each one collecting RAU data at 2.4 GHz (green) that are propagated between antennas at 5.8 GHz (red).

Many contractors also use UNITE as a complement (infill) of the 428XL cable system to continuously layout regular receiver lines across urban areas, dense jungle (GPS timing is not prevented by the canopy) or still water. The same electronics and processes being used in both systems as well as the same server (but not the same software) it is possible to generate from this composite spread a single Seg-D file. Several comparative tests were performed including in

China by Sinopec (You Taoru et al., Equipment for Geophysical Prospecting, 3, 2011). They show that shot points coming from cable and cableless stations are strictly identical. Today, infill by UNITE is used in production (M. Lansley, First Break, January 2012) and it provides seismic data and QC's not different from those that would have been recorded with cable. Thus, we can state that the trend is not to replace cable with cableless systems, but to consider them as complementary systems to be used in different proportions depending on terrain conditions.

The full real-time capabilities of the UNITE system are mainly required in case of fixed spreads as those used for the passive monitoring of the oil & gas fields, particularly during the hydraulic fracturation of the unconventional reservoirs (P. Roche, New Technology Magazine, August 2010). In such case, large array of stations are laid out around the borehole to detect low magnitude micro-earthquake generated by the high-pressure water. Real-time tracking of this seismicity permits to map fracturing, to optimize injection and to check that shallow water layers were not contaminated. The issue for equipment is that a large spacing between stations may be required and that they must not be connected by apparent cables, particularly within the congested rig pad (Figure 7). Thus, the most convenient is to use autonomous stations like RAU's equipped with WiFi and a Mesh network to recover data in real-time. From the continuous record of each RAU accurately synchronized by GPS, it is possible to detect and localize the micro-seismic events. This monitoring can be performed via remote control of the UNITE recorder. Its client-server architecture offers unmanned capabilities providing that a distant client used for control and display is connected via internet.

Figure 7: RAU recording micro-seismicity during a frac job in a congested rig pad.

UNITE is a unique cableless system that pushes back current acquisition limits to offer an unprecedented level of flexibility and quality control for exploration in the most challenging environments. With the most advanced technology and full compatibility with Sercel 428XL recording system, the reference in the industry, UNITE is without doubt the most advanced cableless system. This explains why about 110,000 RAU's have been already sold to 27 different clients including the main Chinese contractors.