Cabled versus cable-less acquisition: making the best of both worlds in difficult operational environments

Malcolm Lansley[*] offers some insight into the land seismic survey dilemma of whether to use cable, cable-less or a combination of the two in order to achieve the optimum results. Three case studies support his analysis.

During the last six to 10 years the seismic industry has experienced a dramatic increase in the number of channels being used to record 3D surveys. Much of this interest in large channel counts has resulted from the desire for surveys with greatly increased trace densities and wider azimuths. The areas in which these changes have been most significant have, in general, been in fairly open desert terrain in North Africa and the Middle East. We have already seen active recording spreads from 30,000 to over 100,000 channels in these areas. It is expected that several more crews with active channel counts in excess of 100,000 will commence operations early in 2012. In an area with quite rough topography in the Piceance Basin in Colorado, North America, a survey was acquired more than two years ago that required an active recording spread of more than 90,000 channels of which nearly 80,000 were recorded on disk for each shotpoint.

During this same time, several cable-less recording systems have been made available to the industry. More than 14 different systems have been released, although some of these are no longer being manufactured. Initially, this flood of new systems generated a lot of discussion about which type of system is better, cabled or cable-less. Much of the discussion was based on the weight of the equipment, battery management, (Lansley et al., 2008) and operational aspects such as deploying cables in the presence of many fences or other obstacles such as roads and rivers. Mougenot (2010) reviewed some of the more technical aspects that included radio frequency bandwidth and battery charging requirements in a crew's base camp, and concluded that we are unlikely to see the complete elimination of cabled systems in the near future, but will most likely see crews with a combination of both types of systems operating in conjunction, the systems being matched to the environment in which they are being utilized. Recent crew activity is already proving him correct.

In areas of easy open access such as deserts and the Arctic, cabled systems are still the preferred methodology, particularly when using small receiver group intervals and high channel counts. Data and battery management are much simpler and the observer has real-time quality control capability. In towns and other areas with many road or river crossings, cable-less systems are preferred. Cable-less is also preferred when using large group intervals such as when recording microseismic with buried arrays.

There are a number of FAQs or 'Frequently Asked Questions' that have arisen in the last few years during the increase in use of cable-less systems. Some of these are addressed below.

FAQs answered

'*How can I know if my receiver groups are still alive and recording good quality data?*' Traditionally, as an industry, we have worked with contracts that have specifications related to the number of inactive (dead) or noisy (bad) traces that are acceptable within the recording spread if the contractor is to be paid for the shot. In many contracts, these specifications include limits on the permissible noise levels and the number of adjacent receiver groups that may be bad, in addition to limits on the total number or percentage of bad traces that are out of specification. If these specifications are not met, either the contractor is not paid or some part of the survey has to be reshot. In some early cable-less surveys it was claimed that with adequate trace density a significant number of bad traces was quite acceptable. One survey was considered to be a success even though approximately one third of the data traces that should have been recorded were never recovered for processing.

Most companies do not accept this and would like to be able to confirm that the data quality is adequate and that the recording nodes and batteries are functioning correctly. Mougenot (2010) described how one system permits rapid data quality control and verification of system and battery performance from distances up to 1 km by the use of WiFi communications and harvesting of data using licence-free bandwidth. Using this system the field crew observer and oil company representatives can be sure of the data quality rather than 'shooting blind' as is the case with most systems. Examples of this will be given in the case histories below.

'I know that the receiver groups are valuable but the data are even more expensive if I have to reshoot. What if the boxes are stolen?' This has been a major fear of companies using

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cable-less systems, since with most systems loss of the nodes does mean loss of the data. However, it is possible to introduce an 'anti-theft' capability that permits location of the lost or stolen boxes and recovery of the data. The 'anti-theft' capability is similar to the LoJack system used for cars. This will be discussed in the case history from Tabasco, Mexico.

'How hard is it to get all of my data into data processing?' With most systems the data are harvested and stored in common receiver domain. Since SEG-D does not support common receiver domain format, this means that these data are normally provided to data processing in SEG-Y format. Many processing companies do not like to receive the data in this format since their data initialization has traditionally been in shot domain. Also, when using Vibroseis as a source, the correlation must now be performed in the early stages of data processing rather than during data acquisition. When using mixed sources, such as explosives and both large and small vibrators with different source parameters, the data initialization can become quite complex. One system actually assembles the data into shot domain format and outputs the files in standard format SEG-D, therefore ensuring that all of the data for a given shotpoint are correctly acquired and integrated in the field to permit stacking, correlation, and full quality control.

'I have a survey that is mainly easy access but with a city in the middle. If I use both cables and cable-less, how do I integrate the data sets?' This was the situation in the Sabanalarga survey in Colombia which is discussed in a case history below. Most cable-less systems can operate in conjunction with cabled recording systems, but are not matched. For example, in many cases the cabled system would record data in shot domain in SEG-D while the nodes or cable-less boxes would record in receiver domain in SEG-Y. It is also quite possible that recording filters may not be the same. With Sercel's 428XL and UNITE systems the actual data acquisition electronics are matched and a single shot domain SEG-D file is perfectly integrated for each source point.

Case history: Sabanalarga survey, Colombia

This survey was acquired for Hocol by the Colombian seismic contractor Sismopetrol. The survey area is in Atlantico State in Colombia and the town of Sabanalarga is in the centre of the planned acquisition area (see Figure 1). The source type selected for the survey was explosives and on the pre-plan location map (Figure 2) it can be seen that no source points were planned within the town, while the receiver groups were to be planted along the roadways and in any areas with available access. Unfortunately, vibrators or accelerated weight drop (AWD) units that could have been used in the town were not available. Therefore, additional recovery shots were placed around the edges of the town to try and improve the data quality.

The primary target in this area is approximately 1600 ms and, therefore, recovering as many short offsets as possible was extremely important. Figure 3 shows the survey post-plot and it can be clearly seen that, as usual, both source and receiver locations had to be moved considerable distances from their pre-plot locations. The use of cable-less receivers greatly facilitated their deployment in the urban area. Data recovery was accomplished routinely using 'opportunistic harvesting' (patent pending) from vehicles that were merely driving through the town. The cable-less data were then

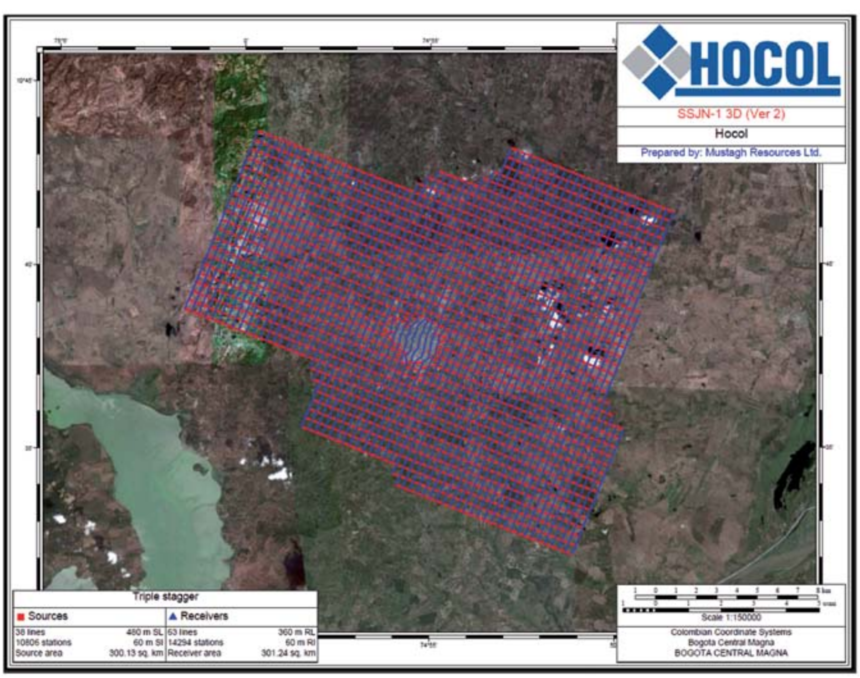

***Figure 1** Pre-plot map of Sabanalarga Survey showing town in centre.*

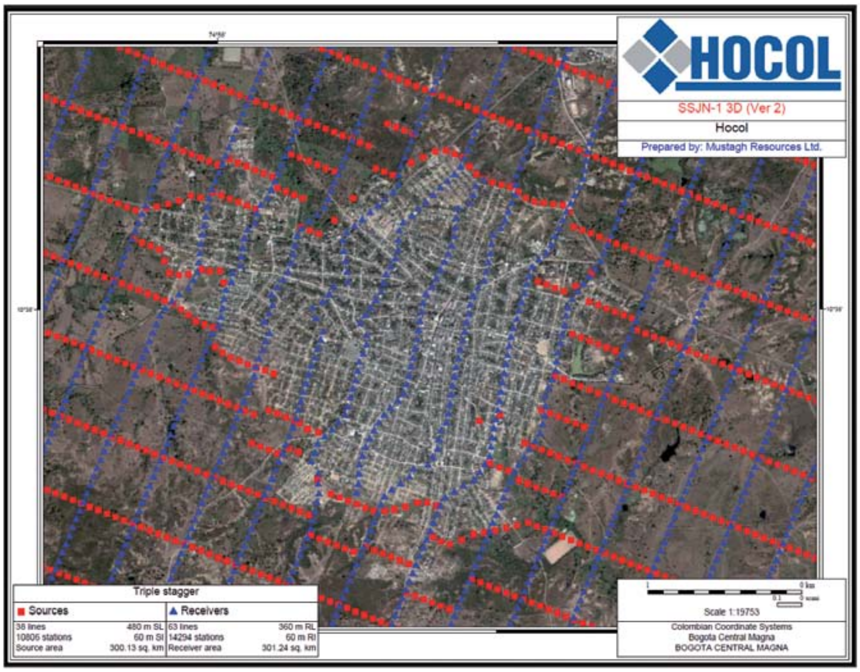

Figure 2 *Zoom of pre-plot showing planned geometry through the town.*

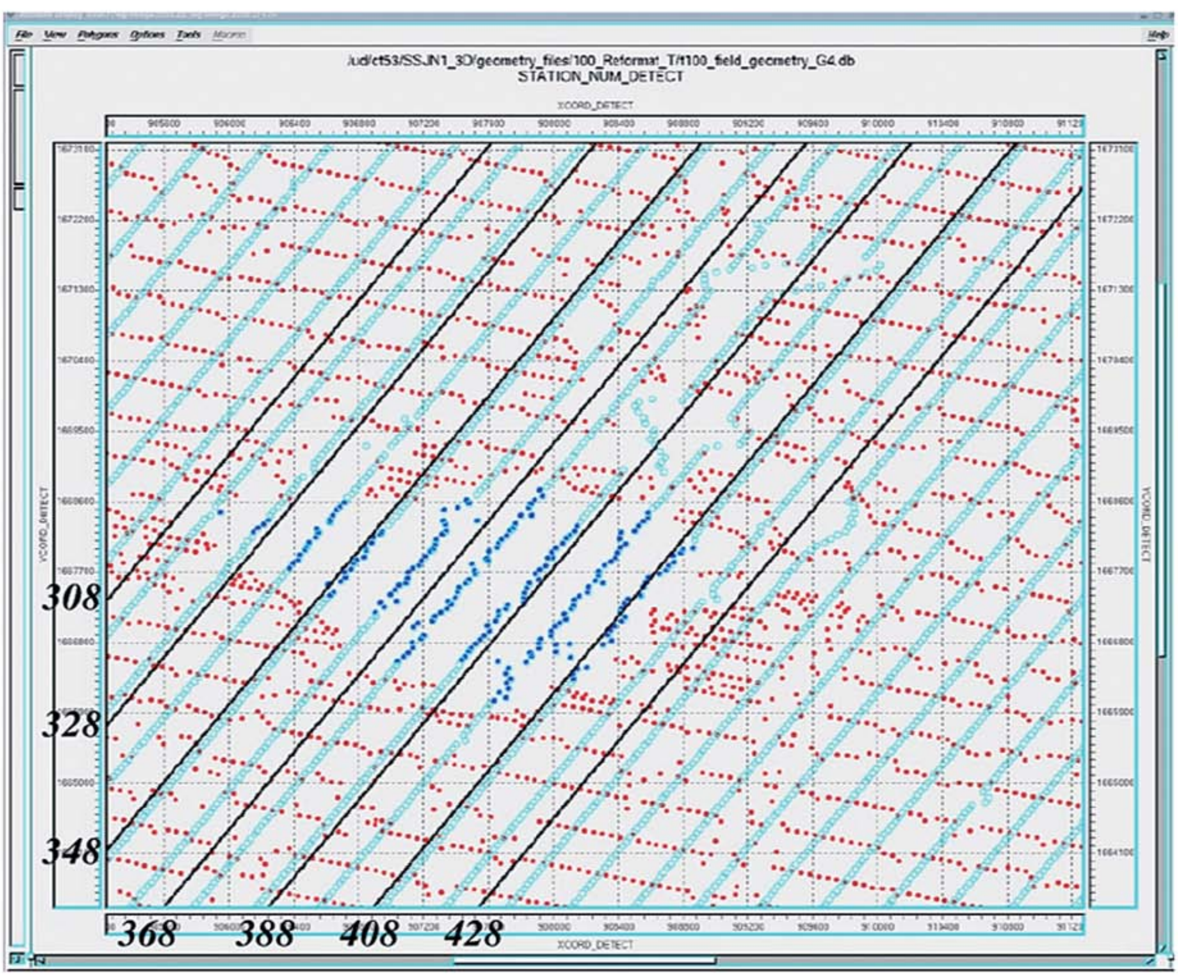

Figure 3 *Post plot map of urban area with location and numbering of CMP lines.*

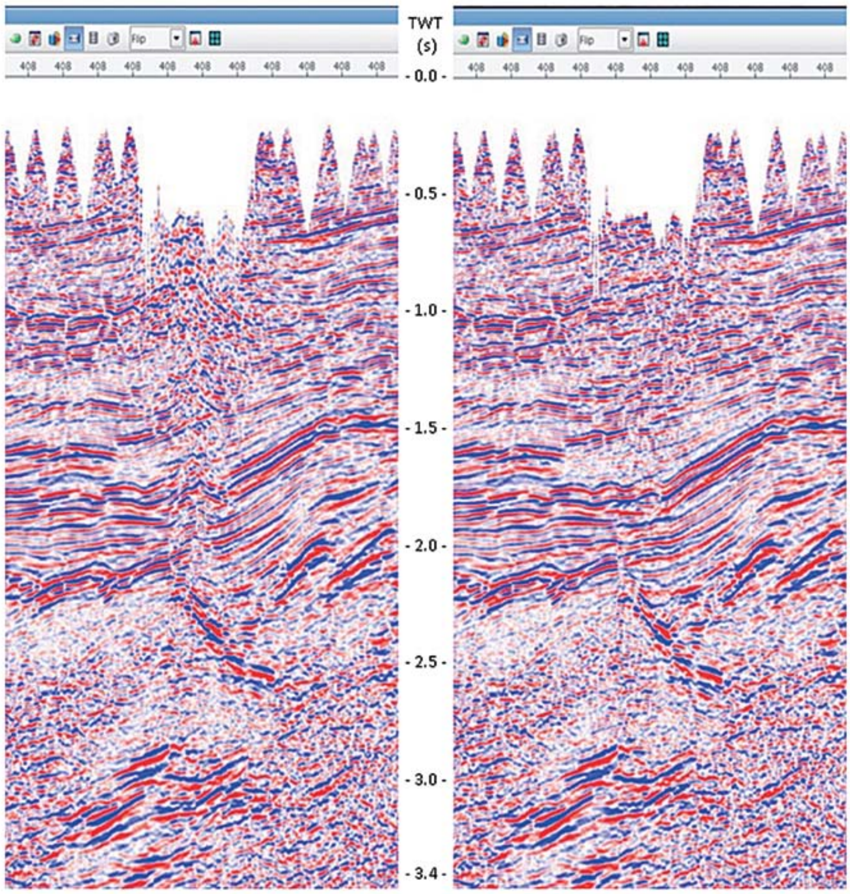

Figure 4 Migrated stacks of CMP line 408, without (left) and with (right) cable-less data.

seamlessly merged, on the field crew, with the data from the cabled recording system for direct input to data processing.

On Figure 3, the black lines annotated with numbers show the location of several CMP lines through the area of the town. Figure 4 shows a comparison of migrated stacks without and with the data from the cable-less remote acquisition units (RAUs) close to the edge of the town. The benefit of using the RAUs is very clear.

***Figure 5** Receiver station planted in median in suburb of the city.*

Urban data acquisition in Tabasco, Mexico

This survey was acquired by Mexican contractor Comesa for the National Oil Company of Mexico, Pemex. The survey encompasses a major city in the State of Tabasco and because of the many roads and the city infrastructure it was decided to use a cable-less system for the entire survey. Figure 5 shows a group of geophones and associated recording equipment in the median of a road in a suburb of the city. In this city and the surrounding area there had been many previous 2D and 3D projects that had resulted in very poor relations between the local people and the seismic contractors. This frequently led to high levels of damage to, and theft of, seismic equipment. Thus, verification of the actual performance of the recording equipment was extremely important to Comesa, as was the ability to recover the seismic data in the case of theft of the RAUs. Therefore a cable-less system with its 'anti-theft' capability was a natural choice.

The survey used explosives in the areas surrounding the city similar to the Sabanalarga survey but also called on IVI Envirovibs through the city. 8500 RAUs were available on the crew for deployment and because of the expected problems, special stakes (Figure 6) were driven more than 50 cm into the ground to try to reduce the number of RAUs that were stolen. Despite this, a very large number of RAUs were stolen during the course of the survey, of which 300 were later recovered. It was felt that recovery of the other stolen RAUs was inadvisable because of safety issues. However, because of the ability to locate and recover the data using the anti-theft system, none of client specifications for lost or dead traces were exceeded and excellent data quality was maintained. Note the data quality in the area of the city centre in the middle of Figure 7. If the crew had been shooting blind in this area the survey would probably not have been successfully completed.

During the acquisition of this survey there were very strong storms that caused flooding in the south-central part of the area. (See inset map in Figure 7.) Despite being submerged, the majority of the flooded RAUs maintained their GPS lock and continued recording without any problems. Data were successfully harvested from these RAUs. Because the flood waters took a long time to recede, continued data acquisition in the affected area was abandoned and a reduction in the CMP fold resulted.

Figure 6 *Ground anchor for securing RAUs and batteries.*

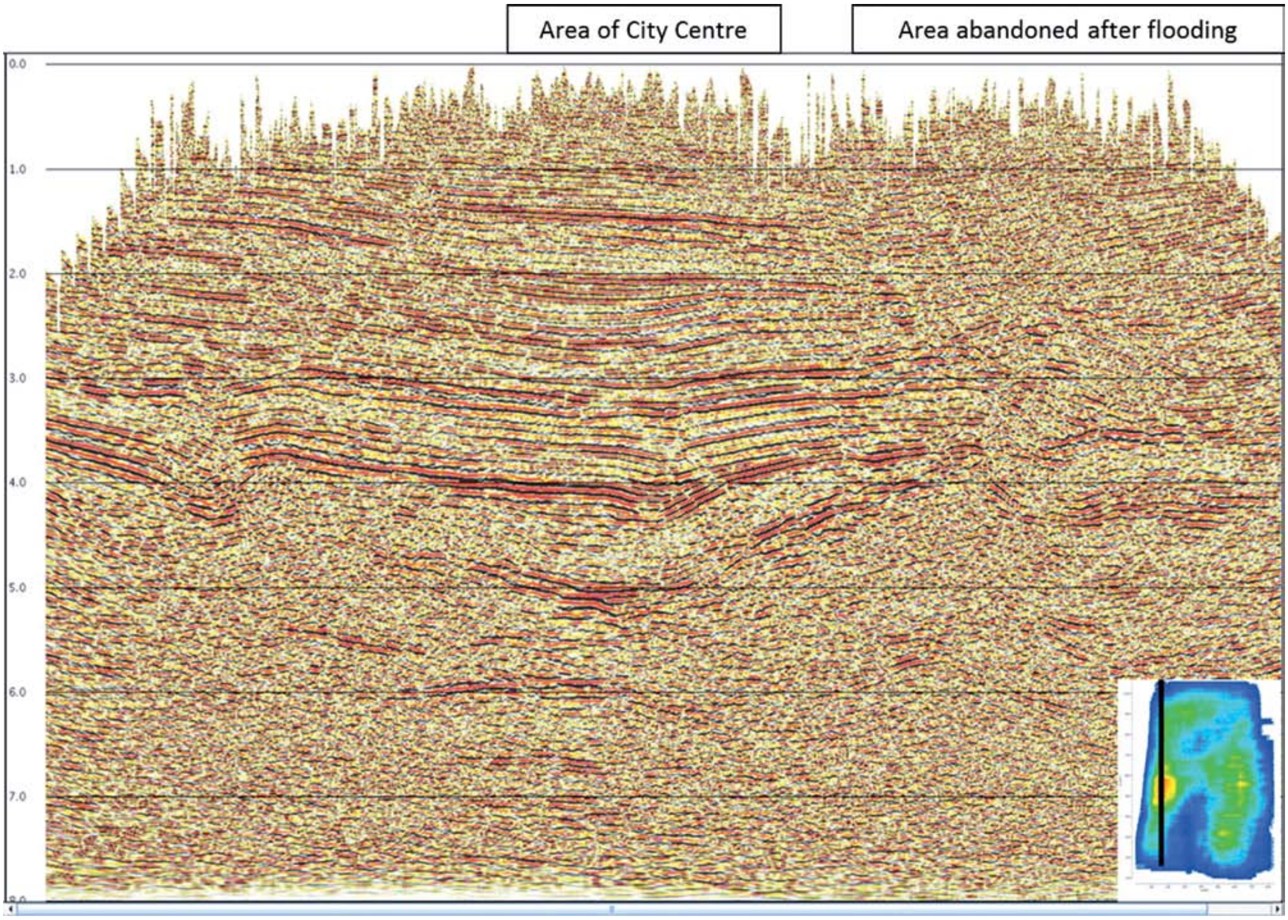

Figure 7 *Post-stack QC migration of crossline from the survey. The black line on the inset fold map shows the line location, with the warm colours indicating the higher fold in the centre of the city. The degradation of the data quality on the right corresponds with the lower fold caused by the abandonment of that portion of the survey after the flooding. This is indicated by the blue colours in the South central part of the fold map.*

Figure 8 Wooded hillsides in part of the Brookside Survey.

Figure 9 Flooded areas after Hurricane Irene.

Brookside survey, Pennsylvania, USA

The Brookside Survey was acquired by CGGVeritas as part of a large scale multi-client project over the Marcellus Shales in Pennsylvania. Much of the topography is wooded hills (Figure 8) interspersed with roads and towns. The initial parts of the survey were recorded with Sercel's 428XL cabled recording system and the UNITE system was added to facilitate crossing of the roads and recording through the towns. After very successful results using the cable-less system, the decision was made to convert the crew to 100% cable-less acquisition.

During this transition, at the end of August 2011, Hurricane Irene hit the northeastern states of the USA and caused severe flooding (Figure 9) over much of the survey area. In order to continue recording with minimal downtime due to the flooding, it was decided to perform quality control of the recording spread using the WiFi capabilities of the cable-less system deployed in a helicopter (Figure 10.)

Figure 10 Data harvesting equipment with high gain antenna mounted on basket on helicopter side.

All of the standard QC reports from the RAUs could be made with the helicopter flying 30–60 m above tree level at speeds of up to 45 knots (83 kph.) In many cases the information could be acquired from two adjacent receiver lines simultaneously. The use of the helicopter enabled the crew to continue recording with minimal disruption.

Conclusions

Although there are some very obvious situations in which the selection of either a cabled or cable-less system is quite clear, there are a number of cases where a combination of both types can optimize the recording operations. With selection of the correct equipment, the integration of the data can be greatly simplified to enable accurate and rapid input of the data for processing. With systems that permit location of lost or stolen RAUs and remote harvesting over distances up to 1 km, many of the fears of losing very valuable seismic data can be alleviated.

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