Cable Free Seismic Acquisition in the South of México

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Summary

In recent years there has been much discussion about the relative merits of cabled versus cable free seismic data acquisition systems on land. Most of these discussions has been focused on the weights of the systems, battery management and whether real-time quality control is necessary when using recording systems with large channel counts. This paper will provide a case history of a 3D survey acquired in a very difficult operational area in Southern México using a cable free system that provided retrieval of all the seismic data within 48 hours to ensure data quality.

Introduction

The south of México is characterized by high humidity and extreme topography (rivers, lagoons, jungle, marsh areas, mountains, canyons, etc.) where access is very difficult and sometimes very dangerous. In addition there are several large cities, roads, highways and numerous densely populated towns where for many years, 2D and 3D cabled seismic projects have engendered social unrest with resulting high levels of damage to and theft of the seismic acquisition equipment.

The effect on recording production levels and the number of dead recording channels can be significant and has usually resulted in poor fold of coverage. The high levels of ambient noise together with the low fold makes the data processing quite challenging and has routinely made the seismic data very difficult to interpret.

This survey was planned to provide data across a producing oil field which is located beneath a city of approximately 100,000 people. Because of the population density and the expected high levels of noise, the oil company client wanted to have rapid quality control of the data being acquired to ensure that it would meet the survey objectives. However, it was clear that the use of a cabled recording system in the town would not only irritate the local population but also be very difficult because of incidental and intentional damage to the cables.

The system selected for the survey was the Sercel Unite system that can work both in autonomous and Wi-Fi modes that enabled real-time monitoring of the data close to the recorder and very rapid data recovery for the remainder of the spread without having to retrieve the data acquisition modules. The crew was equipped with 8500 remote acquisition units (RAUs) and utilised geophone arrays with 12 geophones per group. Because of the varied terrain the source varied with location, with explosives being used off-road outside the city and small vibrators along roads within the city. The crew also had some larger vibrators that were used for testing and comparisons but these were not used during production.

Survey design

Since this survey is over a producing oil field, in addition to the normal urban obstructions (houses, offices, roads, etc.) there were also a number of pipelines and oil wells. Permitting was a major difficulty and approximately 50% of the source locations had to be moved more than 50m, with some being relocated 300 m from the original preplan. Because some of the roads were too busy they were also declared as “no-permit.” Exclusion zones ranged from quite small where individual landowners would not allow access to quite large in areas surrounding factories and oil field facilities. In one area there were 19 individual landowners along one kilometer of receiver line.

The survey geometry template was nominally 16 active receiver lines with 191 live stations per line for a total active spread of 3056 channels. The receiver line length that was laid out at any time was limited to 250 stations in order to avoid having too much spread accessible to theft. The receiver station interval was 50m, and the receiver line interval was 550m. Receivers, however, were positioned wherever feasible (Fig 1.) The source lines were diagonal but typically made as much use of available access along roads as possible. However, in such a problematic area the word “template” is just a concept rather than a reality.

Figure 1: Receiver station planted in median in suburb of the city

In addition to the 16 active receiver lines two additional receiver lines were normally being laid out in advance in order to minimise the time when rolling to adjacent swaths.

The vibrator effort used in the towns was 2 Envirovibs (nominal peak force = 17000lbs) with 8 sweeps of 14 seconds.

Crew operations

Crew operations were limited to daylight hours and would alternate from explosives to the vibrator sources as needed depending upon the locations. The contract with the oil company client required that all of the data that had been acquired was actually available in the recording truck for data quality control and processing within 48 hours of when the shotpoints were recorded. The system permits data recovery or harvesting directly from the RAUs to the recording truck over a limited distance (~1Km) without the use of additional antennae. This facility was used to permit direct QC that the data acquisition was proceeding normally and that the noise levels were not too large.

For the receivers that were further from the recorder, remote harvesting units were utilised, either in a back-pack mode or on vehicles that could be driven along roads These harvesting units do not require that the RAUs are plugged directly into the harvesting unit since they can use Wi-Fi to retrieve the data. An average day’s production can be harvested within the time it takes for a person to walk past the RAU at a normal pace. With the high-gain antenna that is used on the truck-mounted harvester it is possible to recover data from a distance of several hundred metres. Data acquisition and harvesting can continue in parallel with no interference.

During the survey acquisition the city experienced very heavy rainfall and severe flooding that caused complete cessation of recording. Many areas were under more than a metre of water and, because of the ground anchors, many of the RAUs were completely submerged (Fig 2.) Ultimately, data acquisition in one portion of the survey area was abandoned (see Fig 4,) but it was a great relief that when the RAUs were recovered it was found that most were still actively recording data and that the data that had been stored could be successfully retrieved.

Figure 2: Submerged RAU still acquiring data

Equipment theft and data recovery

One of the major concerns when operating with autonomous cable free acquisition systems in areas such as this is that if any of the units are stolen, the data could be lost. Even though the acquisition units are not inexpensive, the value of the data that is stored in them is considerably greater since to reacquire the data will take a considerable amount of effort and time and may necessitate re-drilling of shotholes, etc. In many cases it may be impossible to reshoot the portions of the survey that were lost.

Figure 3: Ground anchor for securing RAUs

In the Introduction it was mentioned that in this area there has been significant social unrest and animosity towards oil exploration and seismic crews in particular. Special ground anchors (Fig 3) were designed that were buried approximately 50cm into the ground and onto which the RAUs were locked.. Despite these anchors, during the acquisition of this survey approximately 1500 of the RAUs were stolen during the operations. (~300 of these were recovered after the survey was completed.) The people here are very determined and over the years have become very adept at disrupting seismic operations, using tractors and pickup trucks with chains to pull the anchors out of the ground.

Another feature of this recording system was of particular benefit in this situation and was another of the reasons for its selection. This is known as the “lo-jack” or “anti-theft” mode. When the RAU is in this mode, although not recording data it will wake-up periodically and send out a signal giving its GPS location and asking whether there are any harvesting units within Wi-Fi range. If there aren’t any, it will revert to its dormant state until the time for its next check. This helps conserve battery power.

If the RAU receives a confirmation that a harvesting unit is within range it will begin to communicate with the harvester and can be instructed to download all of its data that is stored in its memory. Since the high-gain antennae permits communication over considerable distances this permits data recovery even if recovery of the actual units is impossible. In this way, despite the significant loss of RAUs the majority of the data were recovered. Since the GPS locations of the RAUs are also known this would permit their recovery if this was considered advisable.

Quality control of the recording operation

During recording the noise on the recording spread was being continuously monitored using the portion of the spread that was visible in the truck. Vibrator similarities and other quality control procedures were also maintained normally. The data that was being harvested during the data acquisition from both the truck-mounted and the back-pack harvesters was uploaded to the recording system and checked for any geometry errors. Once the geometry and data quality had been confirmed the data was accessible for field QC data processing and for downloading to SEG-D for submission to the client and data processing centre. Brute stacks of selected lines were routinely processed on the crew as is typical for many crews.

Conclusions

We feel that this is the best acquisition system for seismic projects in urban areas with difficult access and social conditions. This is due to the flexibility of layout, HSE advantages, the speed of layout and pick up and the “anti-theft mode”. All data were harvested and delivered to the base camp for initial field processing within the 48 hour target set by our oil company client. Due to the system flexibility it was possible to easily deploy field units in areas where it would have been very difficult with a cable system and, as a result, sufficient receiver density was obtained, even in the center of the city, which allowed for a high resolution final image (Fig 4.)

LED visual inspection and field equipment QC results were monitored in real-time, in order to ensure that the clients specifications with regard to dead / faulty channels were adhered to. For real-time acquisition and noise monitoring it was helpful to have some units transmitting seismic data back to the recorder truck. Depending on local conditions (vegetation, buildings, etc) signals were received from field units up to 1 Km distant.

Acknowledgements

The authors would like to thank Pemex, Comesa, Nunez y Associados and Sercel for permission to present this paper.

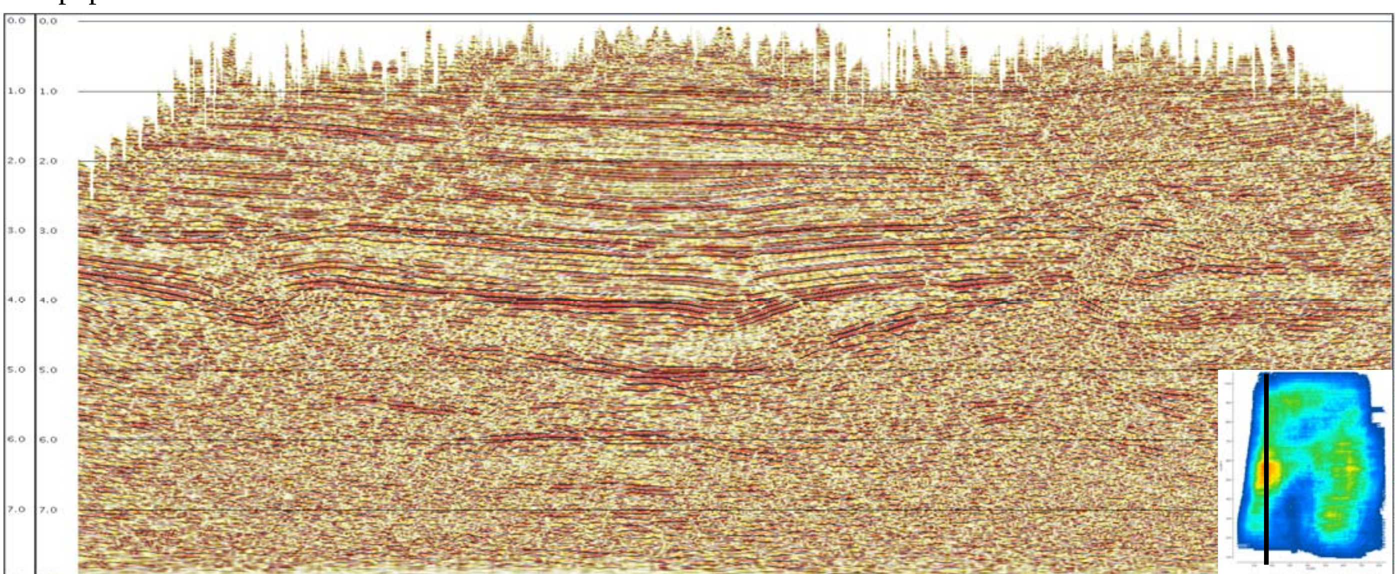

Figure 4: Post-stack QC migration of crossline from the survey. The black line on the inset fold map shows the line location, with the warm colours indicating the higher fold in the centre of the city. The degradation of the data quality on the right corresponds with the lower fold caused by the abandonement 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.