The Role or Cable-less Seismic Equipment and Small Vibrator Sources in Low Impact Seismic Recording

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Abstract

Cable-less seismic recording operations have proven their effectiveness in many environments in recent years and as a result, cable-less equipment now plays an important role in global geophysics. Cable-less equipment represents many benefits in comparison to traditional seismic cable equipment but also introduces a few added burdens. Operators have learned to modify field operations to accommodate changes in field procedures to operate an efficient cable-less crew. The enhanced ability to operate in any terrain along with the freedom to implement virtually any geometry type have proven to be of high value in recording higher quality broadband data. Improvements in source technology also play a significant role in improving broadband recording. Smaller more agile vibrators are now operated in many environments once thought accessible only by dynamite crews. We will discuss the impact of small vibrator source combined with cable-less crew operations and how this combination of equipment can be very effective at acquiring cost effective, high quality seismic data in areas of difficult terrain or urban development. Further, we will look at examples of cable-less operations compared side-by-side with cable crew and the quality of seismic data realized from small vibrator sources. We also discuss the potential for very low environmental impact seismic operations in virtually any environment.

Introduction

A great deal of the regions in South America were seismic is shot are in areas where there are urban populations or where the terrain or vegetation complicates field operations. While it is always desirable to have minimal footprint during seismic operations, in these specific areas it is a primary concern. In the past, seismic operations have been executed with conventional cable systems successfully, but the availability of cable-less systems opens up a new opportunity of seismic recording to be accomplished in any environment with a greater focus on low impact seismic.

Traditional cable systems require large spreads of interconnecting cables. These spreads usually require creative solutions when they cross roads or are near population centers. Connecting cables must be deployed under roads or stretched over roadways in order to protect them from the daily activities of the people. In addition, deployed seismic equipment can sometimes be a tempting target for tampering or theft (Yates 2011). While equipment theft was initially thought to be a major risk for cable-less equipment, tampering by curious children has proven to be the most common issue. Cable-less systems excel in these conditions because they are easier to hide due to the absence of visible cables on the surface.

In challenging areas, the energy source is always a concern. Dynamite is not a desirable solution in urban areas because of the risk of exposure to the local populations and the hole-drilling required for deployment. The alternative is the vibroseis source. Large 60000lb vibrators have been used successfully in urban areas, but the availability of small vibrators offers a less intrusive option for operators, and they have been proven effective on deep targets. Operators and clients alike take advantage of additional benefits such as lower operating

Small vibrator operating in urban environment

costs and the ability to maneuver in confined locations. Small vibrators have proven to be very effective broadband sources capable of sweep frequency ranges from 1.5Hz to over 200 Hz with a high degree of accuracy, making the geophysical benefits of this source type obvious. Broadband sources extend the frequency range of the data into the lower frequency range 1-6Hz which enhances interpretation. High frequency data extends the resolution of the recorded seismic data and reveals details in prospects.

Combining cable-less systems with small vibrator sources represents an ideal combination of technology for urban areas or environmentally sensitive areas.

Effective Cable-less Operations

There are several categories of commercially available cable-less systems. The most efficient and effective variety is the autonomous node with the ability to communicate remotely with field crews for quality control and trouble shooting. The node technology combines the benefits of a continuous recording station which requires no supporting infrastructure with the ability to communicate status and data attributes via remote links. Systems that are dependent on supporting infrastructure to establish communications networks are not well suited to urban environments and areas of difficult terrain. In general they require crews to deploy and manage more equipment in the field. Autonomous nodes have a demonstrated track record for reliability, with data recovery rates usually exceeding 99% of the deployed geometry. The communication with autonomous nodes may be accomplished with several off-the-shelf technologies, but the familiar Wi-Fi technology has proven to provide the best combination of range and data rates. Status and QC of deployed equipment may be accomplished at ranges as great as 500 meters and up to 1 kilometer. Crews have used walk-by, drive-by and even fly-by methods to gather telemetry on the health of deployed equipment. As mentioned previously one of the greatest advantages of an autonomous node is the ability to hide the deployed equipment in the recording environment. Systems with secondary communications networks do not achieve the same level of stealth, and expose additional expensive equipment to the environment such as wireless backhaul transmitters which require power and line-of-sight operations.

Small Vibroseis

Vibrators less than 35000 pounds are now commercially available in a variety of configurations. The primary operational benefit is usually realized in operating costs and in maneuverability. Short wheel bases give units a turning radius smaller than 11 meters which greatly simplifies operations in close quarters. Smaller units attract less attention from local inhabitants, use less fuel, make less noise and have fewer emissions. In areas where line cutting is required, the small vibrator can maneuver down cut lines as narrow as 3 meters wide. This greatly reduces the cost of project preparation and the ultimate environmental impact of the project. While the size of the units is one of its greatest virtues, its geophysical performance is impressive as well. Vibrators of this class have been successfully utilized in nearly every environment for production sweeps as low as 1.5 Hz and as high as 300 Hz where very high frequencies are required. (Wei, 2012,2014)

Cable-less Operations Compared to Cable

In 2010 a detailed study of cable-less equipment was undertaken to determine the benefits of a cable-less system compared to a cable system. The test was executed in the Ordos Basin of China and was done by running a cable system and a cable-less system side-by-side simultaneously along a 2D line in very rough terrain. The area of the test consisted of sharp hilly terrain punctuated in some areas by dense forest and low shrubs. A majority of the terrain was accessible only by foot or small ATVs. In this study, the contractor concluded that the cable-less system provided an overall cost reduction to the operation of 17% when compared with the modern cable system. This estimate included operational metrics such as equipment deployment, battery management, and vehicle use, plus staff requirements. The contractor also compared data results and found that there was no reduction in data quality.

Photo from the Ordos Basin in China illustates the difficult terrain

Data Quality from Small Vibrators

While it is easy to appreciate the benefits of the small vibrator in terms of size, the geophysical performance is impressive. Small sized vibrators are capable of sweeping to very high frequencies which a larger vibrator cannot achieve and vibrator testing and configuration opportunities allow the geophysicist to fine tune the source effort for each project. A recent study completed with a 26000 pound vibrator shooting into a VSP array at 2286 meters depth revealed frequencies as high as 140Hz. At a shallower depth of 822 meters the VSP revealed that frequencies as high as 280Hz were generated and recorded at depth.

A recent production project in the South Georgia Rift Basin in South Carolina captured data at depths exceeding 4500 meters. Combined, these examples demonstrate that small vibrator sources can deliver significant performance in terms of high frequency generation and depth penetration.

Conclusions

The benifits of cable-less systems and small sized vibrators can be utilized independently, but the combination of new technologies creates a system that has a very low environmental impact and very high geophysical performance characterisitics. Cable-less systems have proven to be highly reliable alternatives to the traditional cabled systems. The elimination of interconnecting cables allows field crews to deploy systems in nearly any environment with limited exposure to the local populations. The small sized vibrator can access areas where larger vibrators cannot go. A particulalry apealing aspect of the small vibrator is its broadband capabilities with proven frequency performance from 1.5Hz to over 200Hz. The combination of new technologies like cable-less systems and the broadband performance of the small vibrator enhance the opportunity to record high quility seismic data in diffucult areas.

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