An Integrated Approach to Technology Development for Broadband Seismic on Land

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Introduction

The notion of broadband seismic recording on land is an age-old quest for the exploration industry. While many specific technologies have advanced in recent years it is the overall combination of mutually supportive technologies that has fundamentally changed the landscape of seismic data recording on land.

The industry has benefited from an explosive growth in channel count in recent years. Acquisition systems capable of recording 60,000+ channels in real time with a single central controlling station are now readily available. These advancements enhance operational efficiency and also enable virtually any survey design from spatially dense sampling to huge high productivity spreads specifically designed to take advantage of the latest Vibroseis technologies. The combination of high capacity acquisition systems, innovations in sensor technology and dramatic improvements in Vibroseis technology represent a well-balanced marriage of technologies capable of delivering dramatically improved seismic data.

3D Seismic Survey Design and the 60,000 Channel Capable System

High channel count systems enable the project designer to meet virtually any pre-project goal. In recent years we have added new project goals such as anisotropy, high density recording and longer offsets to the traditional list of mandates for project design. Wide azimuth projects with full offset sampling are now a practical reality. Consider a 3D patch designed to gather offsets out to 4,500 meters with a full azimuth requirement. A symmetrical grid of stations deployed at 40 meters requires about 51,000 channels for single component recording, well under the maximum channel count capacity of today's recording systems. While hypothetical and limited by the practicalities of cost and operations, this example is completely feasible from a technical systems perspective, illustrating the fact that the modern survey design is not limited by equipment constraints as they once were.

Figure 1 The plot above shows the low frequency response for current digital sensor technology.

Digital Sensors Come of Age

Digital sensors first emerged on the commercial market in the late 1990's. Lauded for their unique characteristics of a nearly flat phase and amplitude response, they are different from traditional analog seismic sensors. However, it is the low frequency response of the digital sensor which currently

creates a great deal of attention. A digital sensor is fundamentally capable of recording to DC in a compact and operationally efficient package. The ability to record, undistorted, very low frequencies enhances processing and interpretation alike. Additionally, with the earlier digital sensors, power consumption was problematic. In recent developments, the power usage is now so low that a fully digital recording system actually uses less power per channel than some recording systems configured with analog geophones.

Figure 2 Frequency response from geophones down hole highlight the difference between the improved vibroseis performance and an older vibroseis. Time variant spectra analyses using a linear sweep from 1 to 21 Hz in 20-s, (a) down-hole geophone at 24m using a standard vibrator; (b) down-hole geophone at 24m using a modified vibrator; (c) down-hole geophone at 76m using a standard vibrator; (d) down-hole geophone at 76m using a modified vibrator

Innovations in Vibroseis Technology

Vibroseis technology has undergone extensive improvement in recent years. Modern engineering methods have been systematically applied to meet the challenges of Newton's Law and the basics of mechanical constraints. By studying all the components of the Vibroseis system, it has been possible to improve low and high frequency performance, reduce harmonics, and increase the accuracy of designed sweeps in terms of fundamental ground force. In production shooting, the benefit of current technology combined with sweeps designed to meet low frequency requirements produces significant energy output as low as 1-3 Hz. The integration of multiple innovations makes this achievement possible.

Future Technology and Conclusion

Technology research to push channel counts higher and take Vibroseis to new low frequency capability is advancing and headed for commercialization. The 100,000+ channel systems are currently feasible but untested in a production environment. Prototype vibrators which outperform any system currently available show great promise in testing. The balanced approach to acquisition system development and an industry commitment to the broadband framework will continue to pay dividends now and in the coming years.

References

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