Solving the multi-objective acquisition problem through the use of cable-free acquisition technology

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Summary

The introduction of modern seismic acquisition systems with limited or no cables introduces many new opportunities to enhance seismic exploration including both technical and operational advantages. Although there are a variety of circumstances that benefit from cable free operations, this paper will examine only the case where there is more than one objective for seismic acquisition.

Introduction

Many geographic areas present competing imaging challenges that require different survey design parameters. Shallow targets generally require denser sampling for high frequencies, and can usually be sampled with relatively short offsets. This circumstance compels the geophysicist to record many traces within a restricted offset zone. Deep or steeply dipping targets require larger apertures, longer offsets, and different sampling intervals. A strategy for shooting both targets with a single geometry poses multiple challenges.

Cable System Architecture

Standard cable systems are, in general, geared for single parameter shooting designs. The technical complexity and operational constraints of cable systems significantly inhibit the ability of a seismic crew to acquire these complex designs effectively. A key limitation of cable systems in this acquisition mode is that cables are manufactured in fixed lengths, and they must be connected in a network which feeds data to the recording truck. The adaption of cable systems to dynamic design requirements introduces undesirable operational inefficiencies, resulting in an increase in equipment, manpower and cost.

Cables also create challenges in many areas because of the way that they interact with culture and animals. The template, or live shooting patch, for a 3D seismic design can cover as much as 50 square kilometers. In this region a grid of connecting cable is required. The usual practice is to design the survey in terms of orthogonal lines and cross lines. This deployment convention is as old as seismic acquisition, and is the direct result of cable restrictions. In an area with roads, businesses and homes, seismic design often is severely constrained by what is required operationally to deploy this cable network.

Survey Design

Survey design methods have matured in recent years. Exploration is no longer satisfied with single objective acquisition in many areas, as companies work to get more seismic value for less cost. In the past, surveys would be designed for the target demanding the most dense sampling interval, and in effect, over-sample other prospect targets. Sampling and offset criteria for survey design are always constrained by the seismic target. The offset requirement for 3D surveys will generally be equal or larger than the depth to the deepest target. When two targets are present in the same location, the designer is compelled to use the longest offset required. Sampling intervals are generally proportional to the expected frequency content of the data and dip. While dip can be the same for deep and shallow targets, the absorptive properties of the earth are such that shallow targets return higher frequencies, which in turn require shorter group intervals. If you combine the offset limitations of deep targets with the sampling limitations of shallow targets, the result is a survey with a dense sampling interval and long offsets. This usually results in a

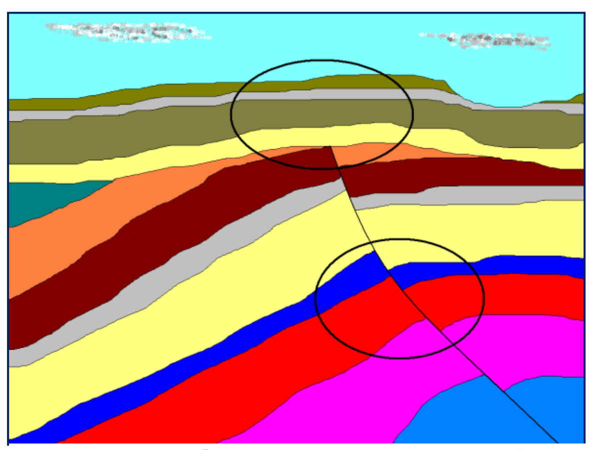

Figure 1 Cartoon shows a common prospect imaging problem.

dramatic increase in operation effort and cost. A great deal of this effort is expended to over shoot each target in a different way. Operational solutions can be improved dramatically in many cases with a cable free solution.

Multi-parameter or Multi-objective Shooting

There are two ways to achieve multi-parameter shooting: deploying independent nodes on top of an existing cable design or deploying all independent nodes. Deploying recording stations which are independent of cable constraints enables more complex and multi-parameter designs. Further, having recording stations that are passive eliminates the need to manage complex spread control as acquisition moves through the survey. The introduction of passive cable-free recording systems allows seismic acquisition to occur without script/template management. Independent recording nodes allow designs to be more geologically-driven for multiple objectives without the constraints of channel limitations, cultural and environmental issues that inhibit cable deployment.

Design example

Consider a simple model like the one shown in figure 1. The two zones indicated by ovals represent a common dilemma for seismic acquisition. There is shallow stratigraphic prospect which requires high frequency data overlaying a deeper structural prospect which can be successfully imaged with lower frequencies but requiring longer offsets. To successfully image both prospects with a single acquisition effort, a survey must be designed to accommodate the sampling requirements for both. A common geometry solution for this problem is to shoot two designs one on top of the other. Figure 2 shows a logical solution. The large portion of the geometry is designed to image the deep prospect while the center denser portion is designed to image a shallow target. This solution does not compromise sampling for either prospect, and the dense portion does not need to be extended to the fringes of the area. The shaded yellow zone is placed on the station geometry to represent a shooting template or in other words, the stations expected to be live for shots in the same region. A design like this is a challenge for the cable system architecture; this a challenge that cable-free meets easily. The whole survey can be acquired cable free or the large survey can be deployed with a standard cable system and that system can be augmented with cable-free channels to form the denser center section of the geometry. Furthermore, the cable free parameters can be adjusted to a denser spacing if needed. Since cable-free systems behave like a passive recording node, their existence relative to the cable system basically has no impact on the shooting or template. It is this flexibility that makes cable-free solutions extremely adaptable in nearly any situation. Cable-free nodes can be deployed nearly anywhere and in any configuration with or without cable systems.

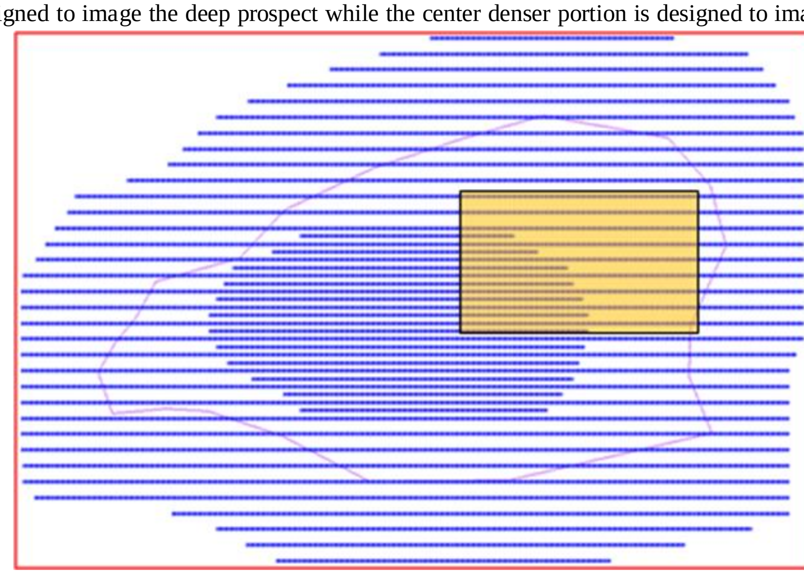

Figure 2 Two survey designs in one acquisition

Case History

An example of a project was executed in the field in Hungary in early 2009. Cable-free equipment was successfully integrated into to a relatively large cable system shooting in south east Hungary near the small town of Gyula. One of the benefits of a passive system is that integration, or slaving, into other systems is an easy process. All that is generally required is that you can successfully capture time breaks from the master system along with the usual timing data for the cable-free system. Since post processing of the passive data is required to assemble fixed length records, the time breaks form the critical link between the two systems. The case history to be presented will discuss the process of integration of the two systems in detail. The data example shown below in Figure 3 illustrates a direct one to one comparison between the results from the cable system and the cable free recording from the same source.

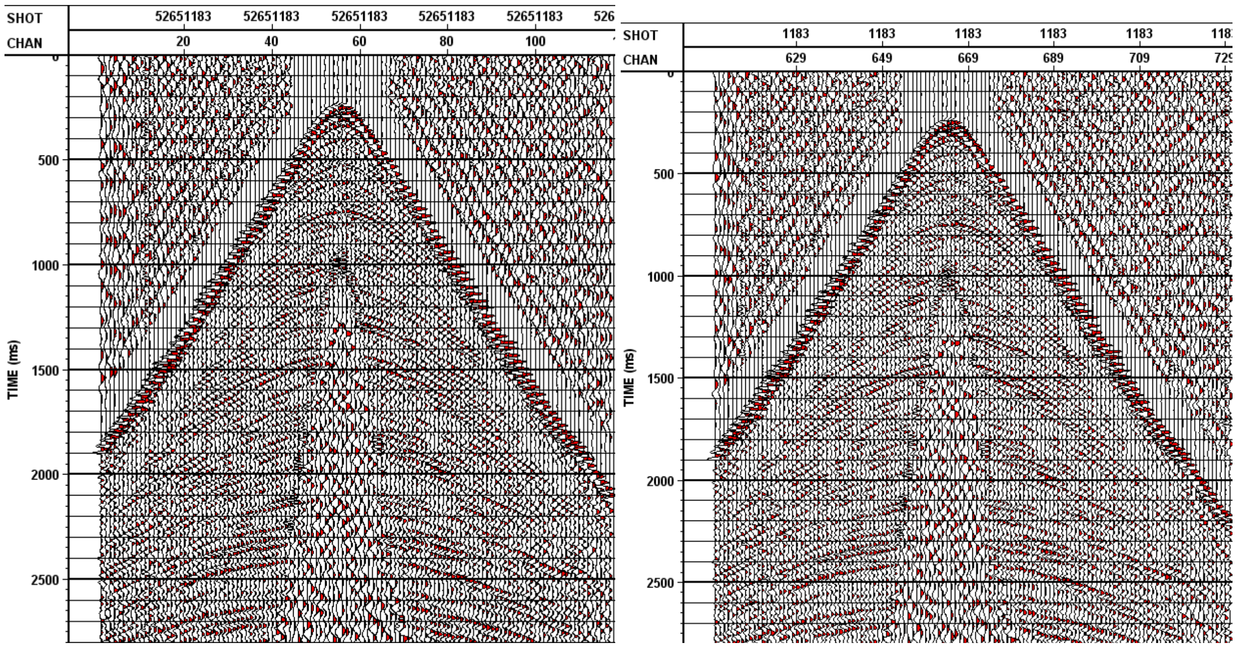

Figure 3 The record on left is from cable-free system and the record on the right is from the cable system at coincident receiver locations.

Conclusion

The cable-free seismic acquisition architecture is very flexible compared with cable-based systems. This flexibility enables several new concepts in survey design and helps solve many long-standing issues that cable-based systems struggle with today. Variable density designs represent only a single class of operational issues that can be addressed. Shooting in urban areas or areas with difficult terrain represent a broad category of challenges that are not addressed in this paper, but lend themselves to flexible deployment strategies.