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## Over/Under Deghosting: The Practical Aspects of Acquisition and Data Processing

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### Abstract

The concept of the over/under acquisition technique has been known and understood since the mid-1980s. The technique was first proposed by Sønneland and Berg (1985) and first attempted by Geco. This initial attempt was unsuccessful as the two cables could not be kept vertically paired. The recent successful applications of the over/under technique have only been made possible by the development of the steerable cable. This paper describes how over/under data are acquired and some of the environmental challengers that have to be overcome during acquisition. How the data are processed, and what the technique delivers. These are illustrated via case histories that clearly demonstrate that the technology does deliver the benefits and improvements to the quality of the seismic data that the early papers on the subject predicted.

### Introduction

In a conventional towed-streamer marine acquisition configuration, shallow sources and shallow cables increase the high-frequency content of the seismic data needed for resolution, but attenuate the low frequencies needed for deep structural imaging and seismic inversion. Towing shallow also makes the data more susceptible to environmental noise. Deep sources and deep cables enhance the low frequencies, attenuate the high frequencies and the recorded data have a higher signal-to-ambient-noise ratio due to the more benign towing environment. A conventional towed-streamer survey design, therefore, attempts to balance these conflicting aspects to arrive at a tow depth for the sources and cables that optimizes the bandwidth and signal-to-noise ratio of the data for a specific target depth or two-way traveltime, often at the expense of other shallower or deeper objectives.

An over/under, towed-streamer configuration is a method of acquiring seismic data where cables are towed in pairs at two different cable depths, with one cable vertically above the other. The depths of these paired cables are typically significantly deeper than would be used for a conventional towed-streamer configuration. In conjunction with these paired cables, it is possible to acquire data with paired sources at two differing source depths. Again, the depths of these paired sources are deeper than would be used for a conventional towed-streamer configuration. The seismic data recorded by the over/under towed-streamer configuration are combined in data processing into a single dataset that has the high-frequency characteristics of conventional data recorded at a shallow towing depth plus the low-frequency characteristics of conventional data recorded at a deeper towing depth. This combination process is commonly referred to in the geophysical literature as deghosting.

The current proven benefits of over/under deghosted data compared to conventional data include:

- A significantly broader signal bandwidth, where the low-frequency content gives deeper penetration, and therefore, improved imaging beneath highly absorptive overburdens, such as basalt or salt.
- A bandwidth extension to lower frequencies making seismic inversion less dependent upon model-based methods
- A simpler signal wavelet, which in conjunction with the bandwidth extension to higher frequencies gives enhanced resolving power, allowing for a more detailed stratigraphic interpretation
- A simpler signal wavelet, which in conjunction with the bandwidth extension to lower frequencies gives better steep-dip imaging
- Higher signal-to-ambient-noise ratio as a consequence of the deeper towed-cable pairs.

The potential future benefits of over/under data include:

- Enabling ocean-bottom cable type multiple attenuation schemes for towed-streamer data
- The removal of sea-surface effects from 3D data, hence, improving repeatability when used in time-lapse analysis.

### Over/under acquisition

Figure 1 is a schematic of an over/under acquisition geometry, with paired sources at two different depths and paired cables at two different depths. The wavefield radiates from the seismic