The Drive for Better Bandwidth

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Summary

As the saying goes, you can never be too rich, too thin,… or have too much bandwidth. Consequently the desire for better bandwidth has been never ending.

Actually, the term "bandwidth" is sometimes used a little loosely. For instance, "bandwidth" and "resolution" are often used interchangeably, but actually there is a fine distinction. Bandwidth relates to the range of frequencies in the spectrum, and thereby refers both to Fmin and Fmax. This is an attribute relevant for discussions in inversion. Resolution refers to the ability to delineate things like thin beds and pinchouts in wiggle trace displays. Although opinions vary, from a pragmatic and empirical perspective, many geoscientists feel this is tied chiefly to Fmax. That is, the specific value of Fmin is not particularly relevant to resolution – as long as at least two octaves of "bandwidth" are present.

Causes that limit recoverable bandwidth and resolution are many. They include ghosts, multiples, noise and arrays. The industry has had some success at addressing these causes by changing how the wavefield is sampled. For instance in seabed surveys, sampling both the pressure and particle velocity components of the wavefield allows signal to be acquired more continuously from Fmin to Fmax – thereby improving bandwidth. This is because the corresponding ghost notches are staggered.

On the other hand, by sampling just one component of the wavefield, but doing so more finely in a spatial sense, noise trains can be suppressed better. This is because the noise trains are no longer aliased and can therefore be easily attacked by various FK or adaptive filters. This is the strategy in single sensor surveys. In the case of ground roll in onshore surveys, this can have benefits at both ends of the temporal spectrum. For instance, direct-travelling ground roll is often strongest at low frequencies; so removing it from a data set can allow the low frequency content in the underlying signal to be seen – thereby effectively lowering the Fmin value. However, if scattering is prevalent, the contamination of the spectrum at high frequencies can be significant too. This is because the amplitudes of scattered waves are proportional to the square of the temporal frequency. Hence, in such cases, being able to remove scattered ground roll from a data set can allow us to see the high temporal frequencies in the signal – thereby increasing the effective Fmax.

Analogously in the marine case, by sampling the swell noise more finely along the streamer, we are able to remove it more successfully than in the past. This allows us to tolerate the acquisition of more noise in the raw data. Therefore, the streamers can be raised to shallower (noisier) depths. By doing this, the receiver ghost notch in the signal is shifted to a higher temporal frequency often permitting dramatic improvements in resolution.

Finally, improvements in data processing and interpretation have also permitted improvements in the drive for better bandwidth. One case in point is the full waveform prestack inversion as enabled by formulations that exploit the genetic algorithm. This method simultaneously finds the correct NMO velocity and the correct amplitude variation with angle. Consequently both low- and high-frequency model components are derived by the inversion.