



VectorSeis® Fidelity

According to Leon Thompson of BP, “Multi-component data are said to have vector fidelity if a unit impulse, directionally aligned with a given component yields the same impulse response function on that as for the same impulse directed along any other component, and zero response on all other components.” In other words, particle motion on one axis should produce a response only on that axis.

With conventional sensors, sources of vector fidelity problems include:

- Mechanical misalignment of the sensor elements
- Off axis motion of proof mass¹
- Mechanical cross coupling in gimbals (if used)
- Implicit array response created by cable stiffness (if sensor is not decoupled from interconnect cables)

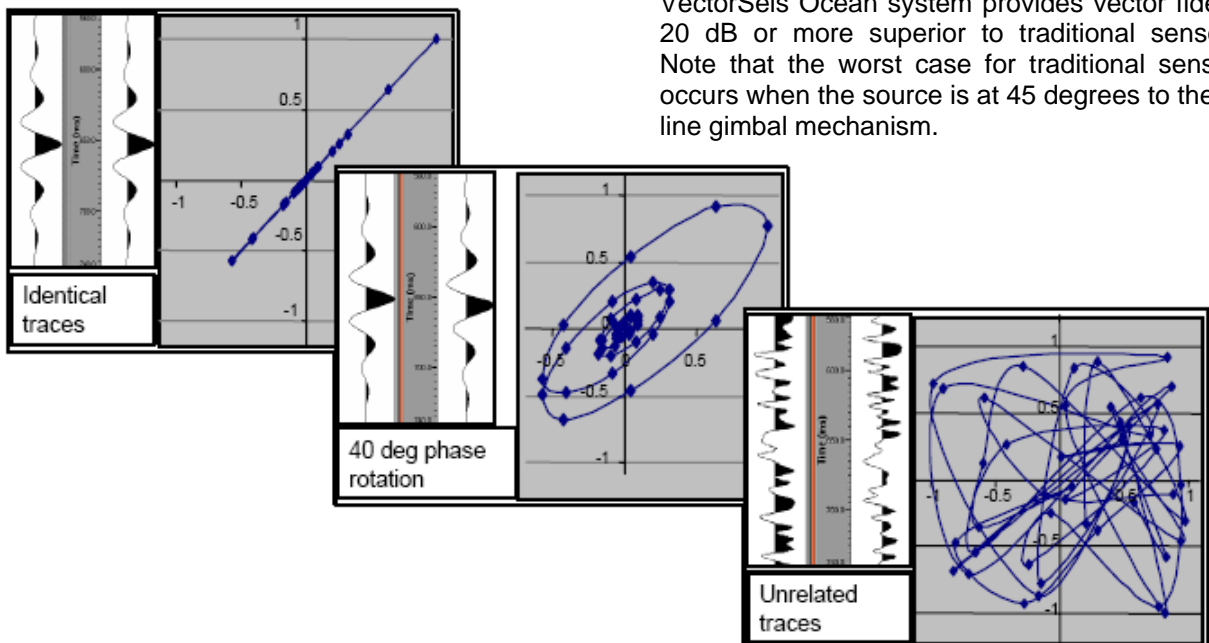
With VectorSeis, misalignment of the sensor axes is kept within 0.5 degrees, while off-axis motion is all but eliminated². Since VectorSeis does not require gimbals² to ensure the correct orientation of the sensor axes, this source of vector infidelity is also eliminated.

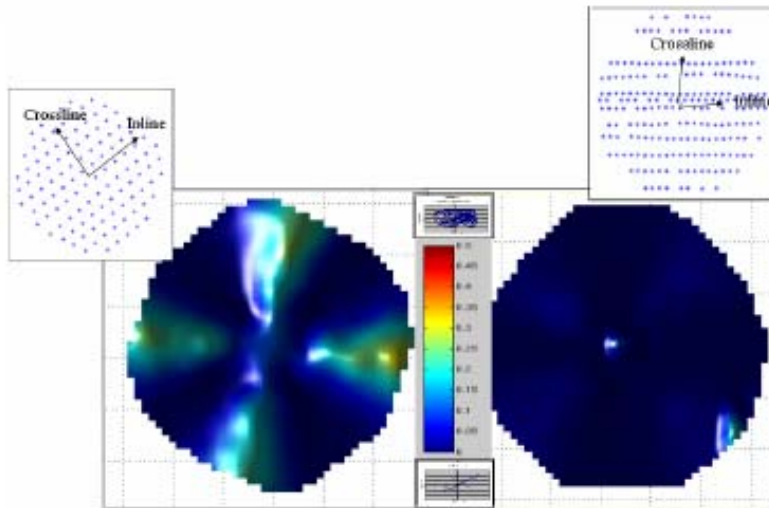
In the VectorSeis Ocean System, a mechanical

decoupling device is used to ensure that any acoustic energy in the cable is passed through the sensor node, without coupling to it. In the SVSM we couple the module to the ground and use a flexible cable to connect to the telemetry cable. This decoupling both eliminates a major source of noise, and maximizes vector fidelity.

The Vector fidelity tests conducted by ConocoPhillips on the Ekofisk field in the North Sea indicate that VectorSeis performance is 20dB or more superior to traditional gimbaled phones. These tests are detailed in the paper presented at the EAGE in Stavanger, June 2003: *Ekofisk VectorSeis Test: Improvements in Vector Fidelity of 4C Seismic Data* by Grant Byerley & Claus Clausen (Conoco-Phillips) & Jon Tessman (ION).

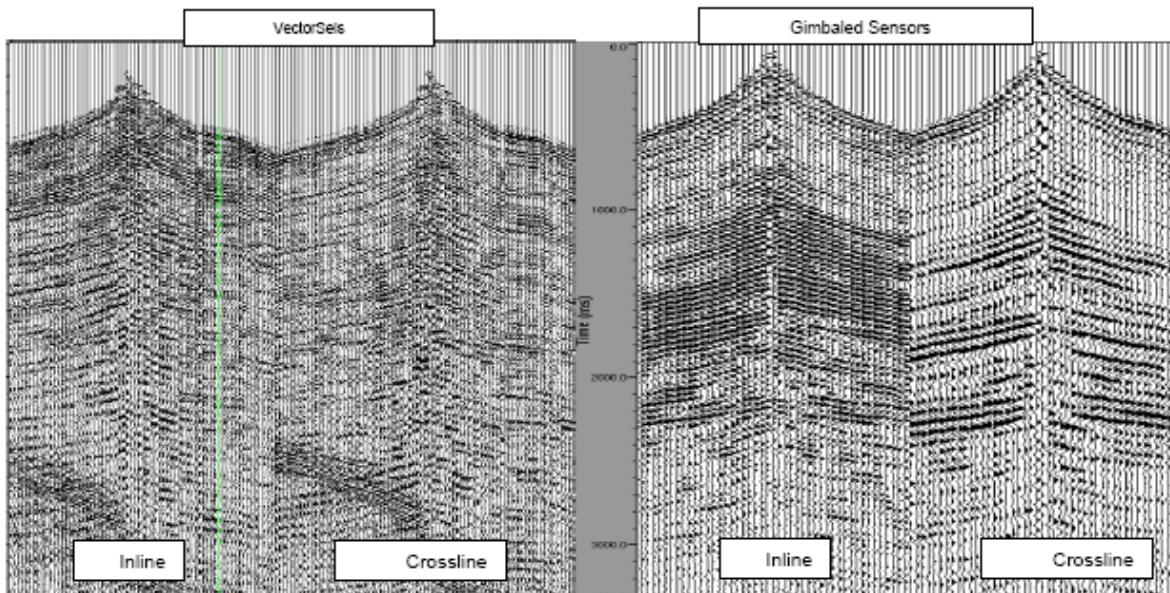
This paper quantifies Vector infidelity, by measuring Ellipticity (ratio of semi major axis to semi minor axis) of the minimum ellipse that encloses a hodogram of the horizontal components. Ellipticity is a measure of both the vector fidelity of the sensor and the anisotropy in the earth between the source and the receiver. ConocoPhillips eliminated the anisotropy term, by restricting the analysis to first breaks. Since water displays no anisotropy, ellipticity is a direct measure of vector infidelity in this case. A block of shots around a receiver was analysed for both VectorSeis and a traditional gimbaled system. The results shown below indicate that the VectorSeis Ocean system provides vector fidelity 20 dB or more superior to traditional sensors. Note that the worst case for traditional sensors occurs when the source is at 45 degrees to the in-line gimbal mechanism.





Another way to characterize the same benefit is to compare common receiver gathers for a line of shots at 45 degrees to the receiver in line direction. In the ideal case, the inline and cross line sensors would show data with very similar character and frequency content. This is observed with VectorSeis. However, on the conventional sensor, the 2 components exhibit significant differences in both noise and signal character.

Vector Fidelity problems can significantly delay processing turnaround, and impair the accuracy of the final image. A multi-component sensor exhibiting high vector fidelity will provide data that has the best representation of the full vector wave-field ground motion. This is important for accurate shot-receiver rotations to be made and for sophisticated noise attenuation algorithms (e.g. adaptive polarization filtering³) to perform best.



1. A proof mass is the reference for seismic measurements in geophones (coil) and in VectorSeis accelerometers (mass).
2. See VectorSeis VOR fact sheet.
3. See Adaptive Filtering fact sheet.

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