## An overview of MEMS value for Land and OBN single sensor acquisition and inversion

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### OBJECTIVE

With nowadays major deployments of single sensor Land and OBN acquisitions, the sensing fidelity of unitary sensor becomes an important element of the acquisition chain. In parallel subsurface imaging solutions involve an iterative minimization to match the amplitude and the phase of modelled data with field data (expressed in physical units) over a growing number of octaves for all available wavefield components. This calls for a sensing device to sense ,with great fidelity, all components of the seismic wavefield over more than six octaves. In the following we illustrate with Land and OBN field data how MEMS sensors fulfil all requirements of leading edge single sensor acquisition and inversion.

### MEMS benefits

Contrarily to MEMS sensors, geophone technical specifications are affected by changes in temperature, sensor aging and manufacturing tolerances, the latter only yielding an amplitude/phase variation in response up to 3 dB/10° in low frequencies, the so called data jitter effect (Tellier et al., 2021). These uncertainties in sensor response are particularly difficult to model in practice, and become a concern especially when operated in a point-receiver or blending context. These have two major consequences (*Figure 1*):

- A lack of phase control over the low frequencies, detrimental to phase matching inversion.
- An additional source of variations in Time lapse seismic, difficult to correct for.

On the high frequency side geophones suffer from spurious frequencies (*Figure 2*) which add undesired noise over frequency bands over which the signal is weak due to attenuation. This is not the case for MEMS.

Another differentiating point in favor of MEMS compared to geophones takes place when vibroseis land data are processed in particle displacement (m) rather than in particle velocity ($ms^{-1}$) (Cordery, 2020) . For MEMS the double integration requires a +12dB boost over the low frequencies, while a +18dB low octave boost is requested for the Geophone below its corner frequency.

MEMS can detect the gravity vector, this makes them the sensors of choice for 3C OBN. It avoids the need for tiltmeters with their typical 3° precision and offers the possibility of smart factory calibration which ensures an unmatched orthonormality between the three components. Doing so the 3C MEMS OBN have a certified vector fidelity performance confirmed through field experience from exact verticalization and Radial Transverse separation to Shear noise removal on the vertical component using the horizontals.

### When theoretical statements are confirmed by production field data

A 23,000 channel MEMS-based OBN project is going on in the Middle East, and already delivering a promising dataset. While the excellent phase and amplitude response of MEMS has been demonstrated in land environment (Tellier et al., 2023), this observation is further confirmed in OBN, where MEMS outperform hydrophones and geophones in low frequencies. 3C MEMS sensors with 0 Hz sensing capability also exhibit much better accuracy in terms of verticality and vector fidelity, without prior pre-processing: the ground acceleration is measured with a very accurate separation of horizontal and vertical components, and with true amplitudes and timings. In a shallow water context, Z MEMS would e.g. not record the horizontal water breaks (*Figure 3*). The high-fidelity data recorded in this way thus enables e.g. rigorous analysis of anisotropy or enhanced denoising of the Z component when compared to traditional calibration with the hydrophone, while offering the quality of low frequencies required for full-waveform inversion or imaging. Further observations and comparisons will be presented and discussed, supported by field data from the Middle East.

## Conclusion

On the seabed, the sensing performances of 3C MEMS remain unrivalled. Besides the true phase an amplitude sensing capability of 1C MEMS, signal can be reconstructed with a true verticality, while the vector fidelity of the 3C axis is significantly improved. This added to other properties of MEMS, makes this sensor an awaited driver for the development of OBN acquisitions – especially for sparse, blended or 4D.

## REFERENCES

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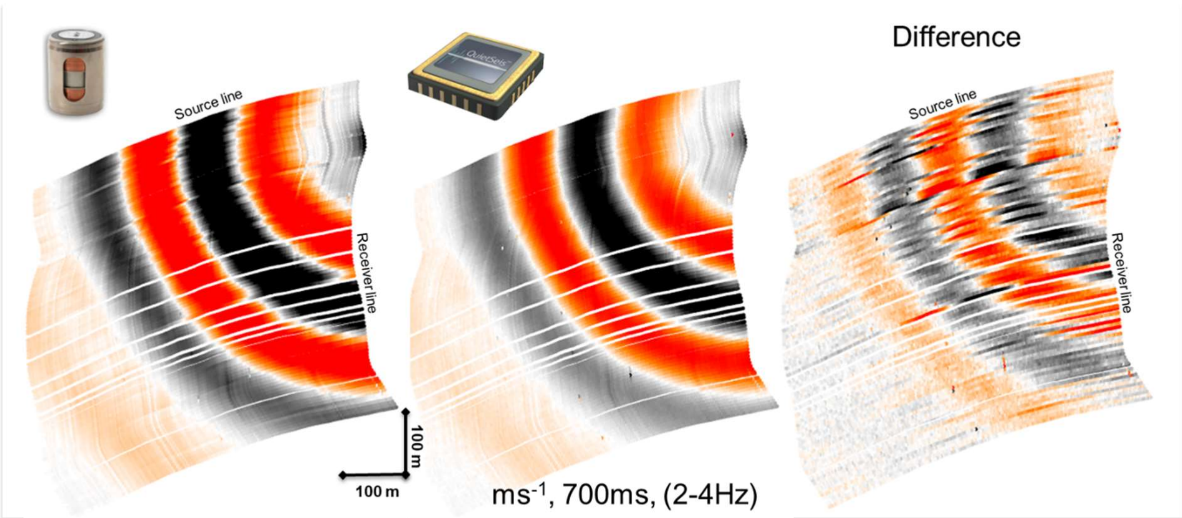


*Figure 1* Portion of a Land cross spread with collocated MEMS and Geophone sensors, both in $ms^{-1}$ units, band passed over a (2-4Hz) band. One can notice the significant amplitude and phase variations across the geophone receiver line which illustrate the so called geophone data jitter. MEMS are immune to data jitter leading to an exact sensing of the wavefield amplitude and phase.

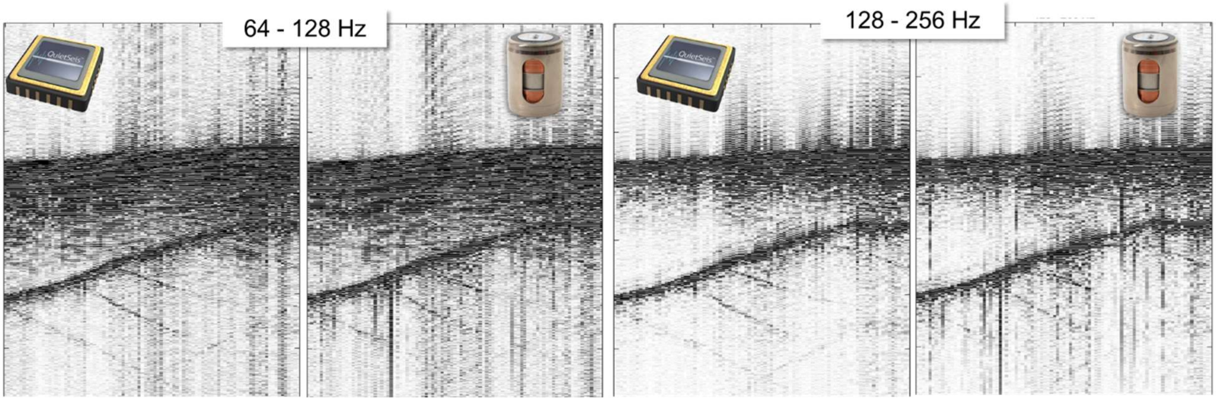


*Figure 2* Land Common shot gathers band passed over high frequency octave illustrate the absence of resonant frequency noise onto MEMS records while spurious frequencies noise are stimulated with first breaks and air waves.

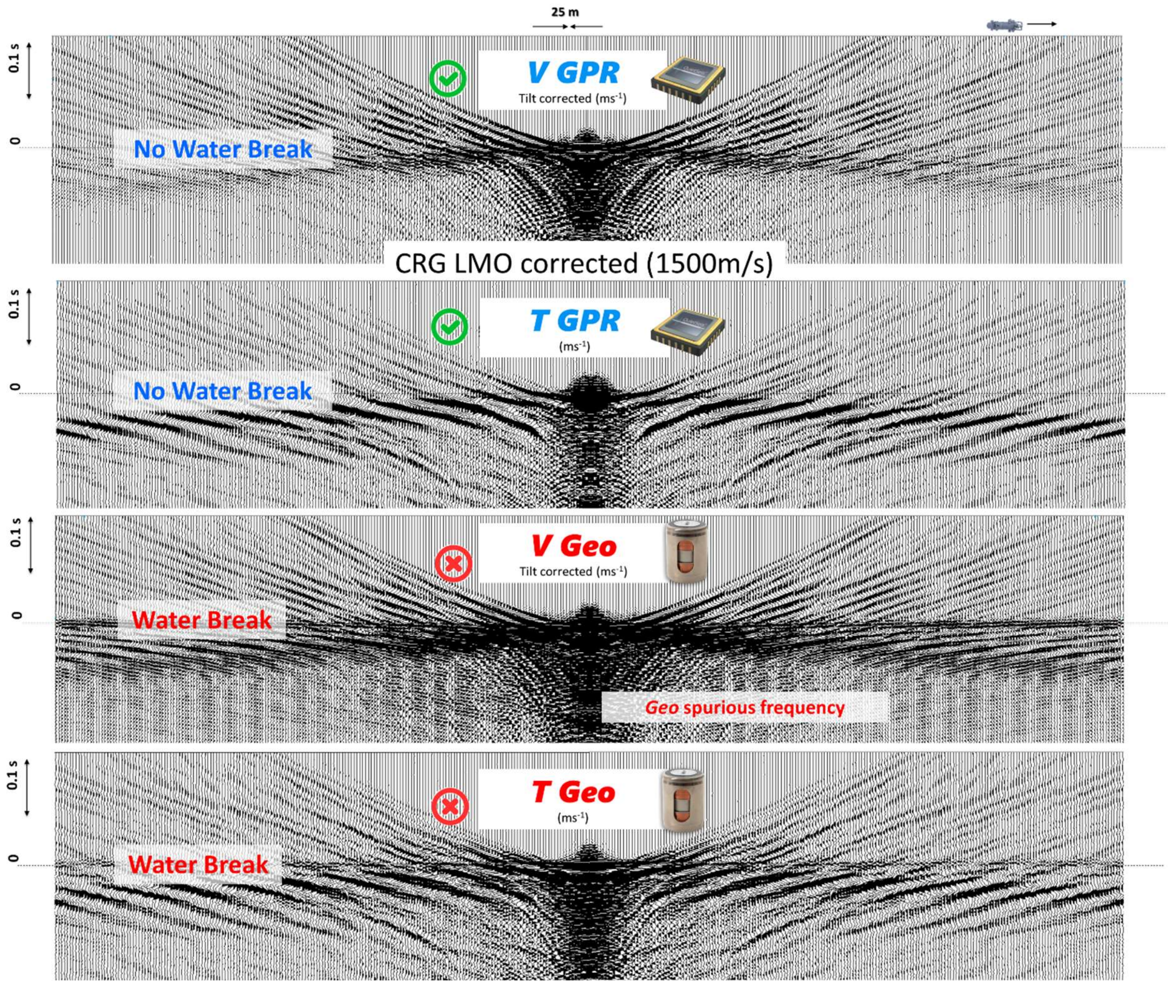


*Figure 3* In a shallow water context (water depth 22m) it is expected the direct water break will be polarized on the radial component only. The perfect vector fidelity of the 3C OBN MEMS is illustrated on a LMO corrected 1500ms-1 CRG gather with the absence of water break onto the vertical and transverse components. Which is not the case for the collocated 3C OBN Geophone.