Ultra-high Resolution 3D Seismic with Autonomous Surface Vehicles to Build Windfarm 3D Geological Model

June 2023

Agenda

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- The Proposed Solution: UHR3D Seismic
- Example of Acquired Dataset
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Introduction

- Windfarm developers are required to submit a succession of plans for approval before installation of any facility, structure or cable. Site characterization surveys are a key part of these plans. In general, the required phases include high-resolution geophysical surveys followed by a series of geotechnical investigations. The current subsurface survey approach utilizes 2D site investigation methods developed in the 1970's

- The ultimate deliverable is a comprehensive site characterization that results from the integration of geophysical & geotechnical data. This approach involves the development of a 3D geological model

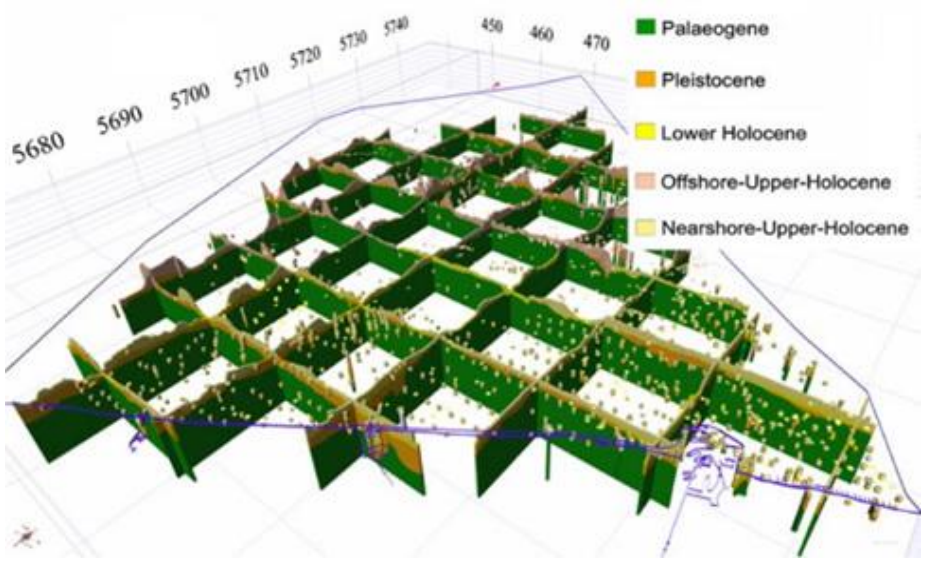
- **The purpose of this presentation is to highlight new ultra-high-resolution 3D seismic (UHR3D) with Autonomous Surface Vehicles (ASV) and demonstrate how they will increase efficiency, reduce uncertainty and risk and eliminate delays encountered during the development of a subsurface engineering model.**

Limitations of the Current Approach

- While the current approach is considered robust by the offshore wind industry, it has significant limitations in both spatial aerial coverage (2D) and resolution:
  - The SBP (Sub-Bottom Profiler) is still a 2D tool with a widely variable and limited penetration in the order of 5-100m
  - The SCS (Single Channel Seismic) and higher resolution MCS (Multi Channel Seismic) provide a nice profile (usually down to 1s or more) but these data suffer from imaging errors, since any seafloor or subsurface features with cross-line dip may be incorrectly migrated
  - In addition, both SCS and MCS suffer from signal-to-noise issues which can result in extremely poor vertical resolution
  - Moreover, the line spacing for the deeper penetrating 2D SCS or MCS system (150m to 300m) is so coarse that the features of interest (scale < 50m) may not have bee recorded, much less imaged.

Limitations of the Current Approach (cont'd)

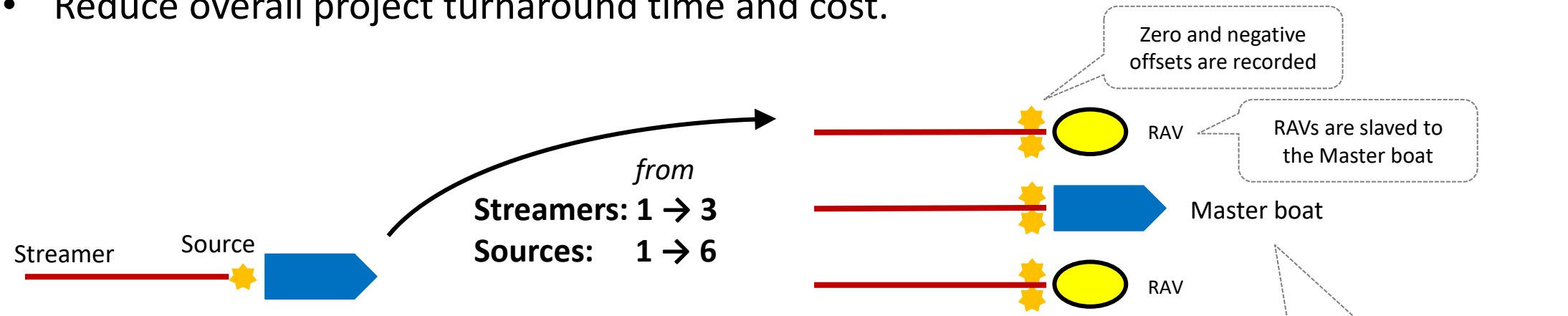
- None of these tools, alone or in combination provide a complete, continuous picture of the shallow subsurface
- Below example: 2D fence diagram geological model from the Belgian Continental Shelf
- With the current 2D methods utilized, the data falls far short of providing the entire picture.

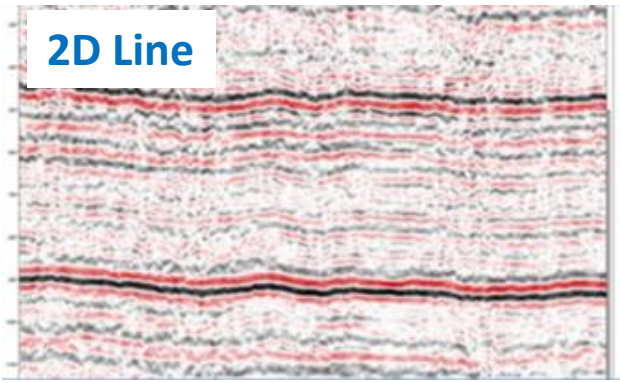


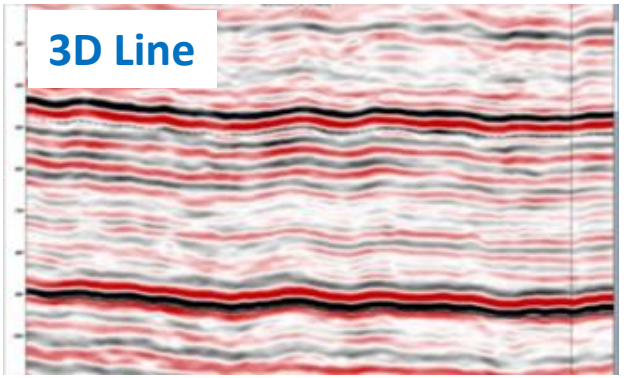
The Proposed Solution: UHR3D Seismic

Kietta proposes to replace the usual 2 surveys of 2D seismic acquisition by 1 survey of 3D using 2 ASVs alongside the usual master boat with objectives to :

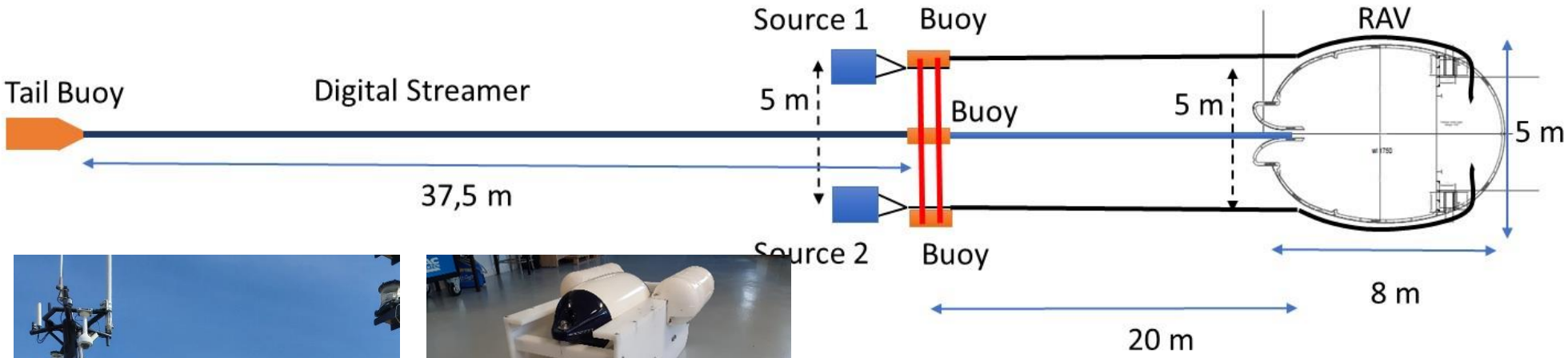
- Deliver a 3D subsurface image to help in foundation micro-siting and subsea cable route
- Get site investigation results without need of a second survey
- Reduce overall project turnaround time and cost.

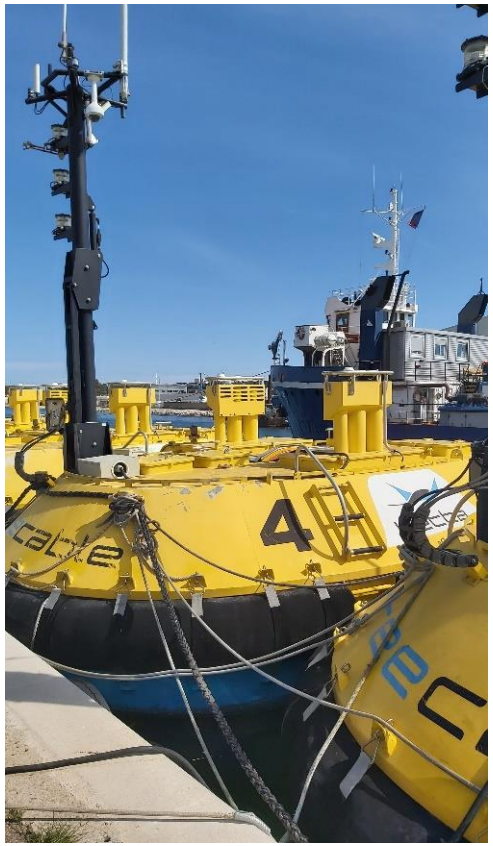


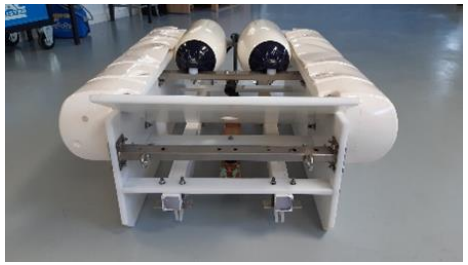




Operations



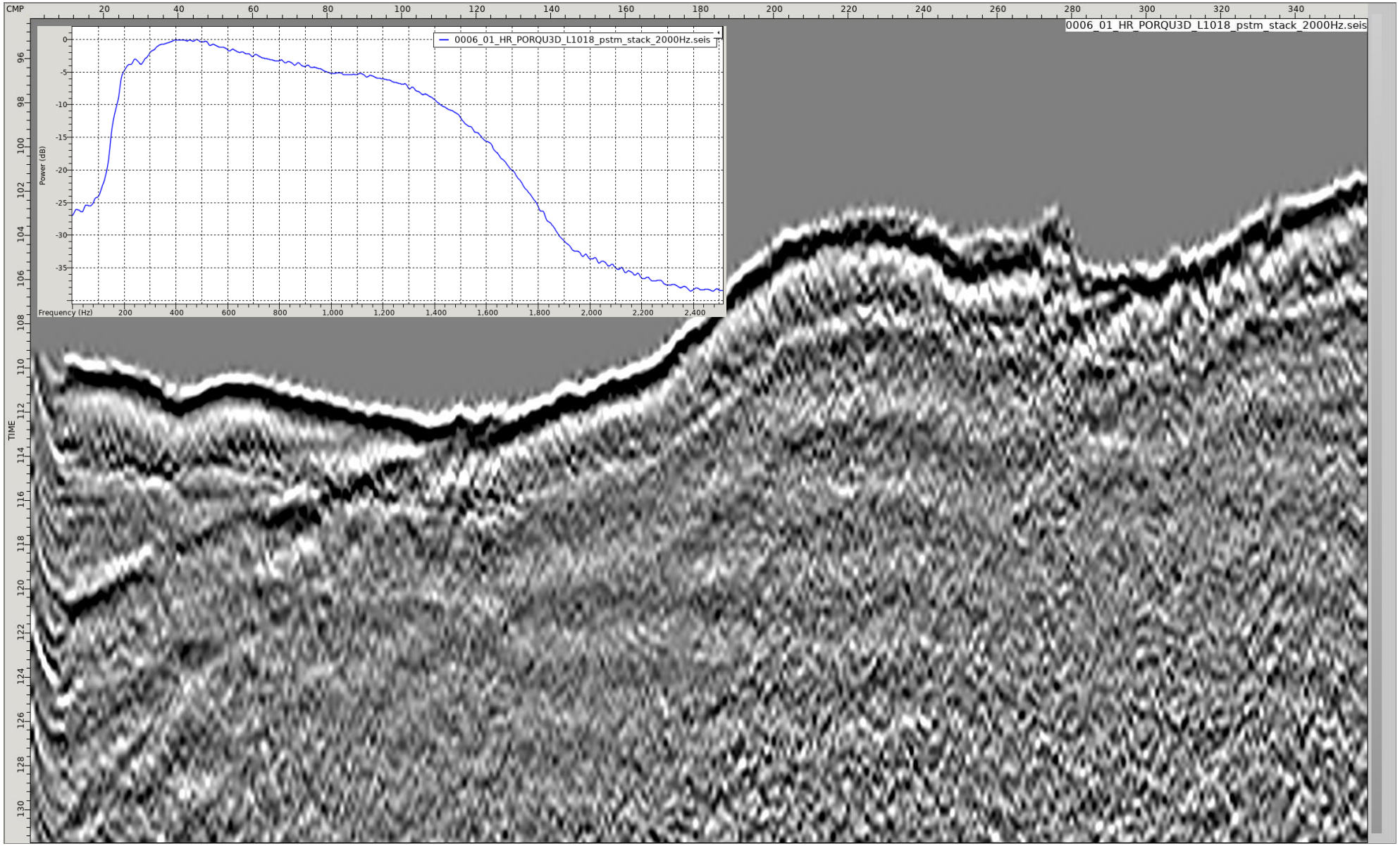




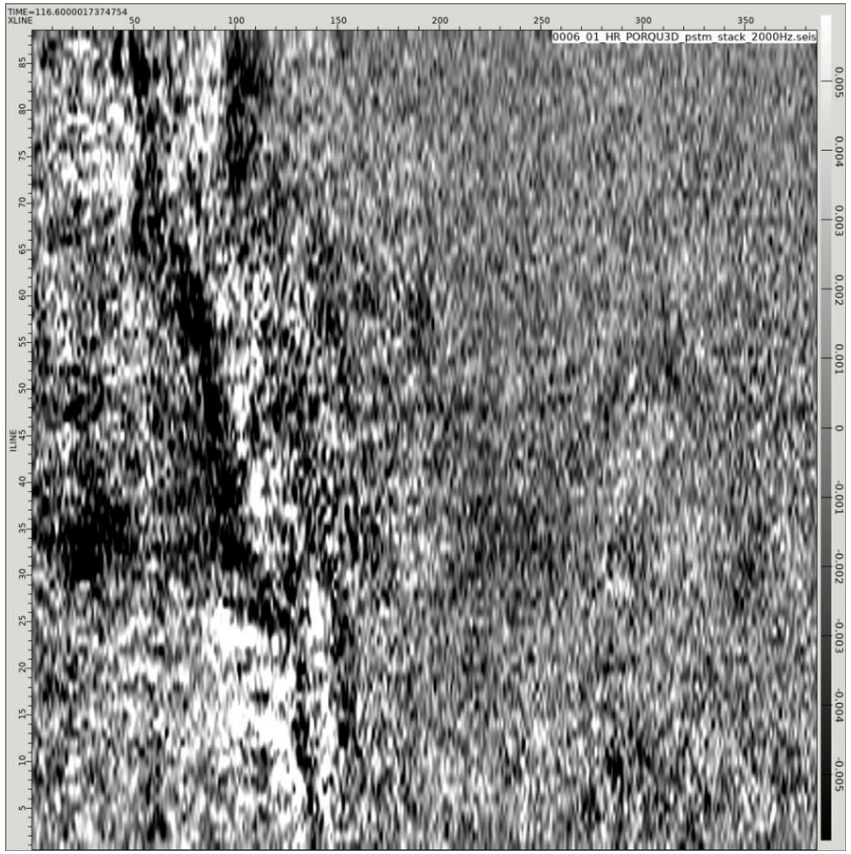
FreeCable Advantages & Benefits

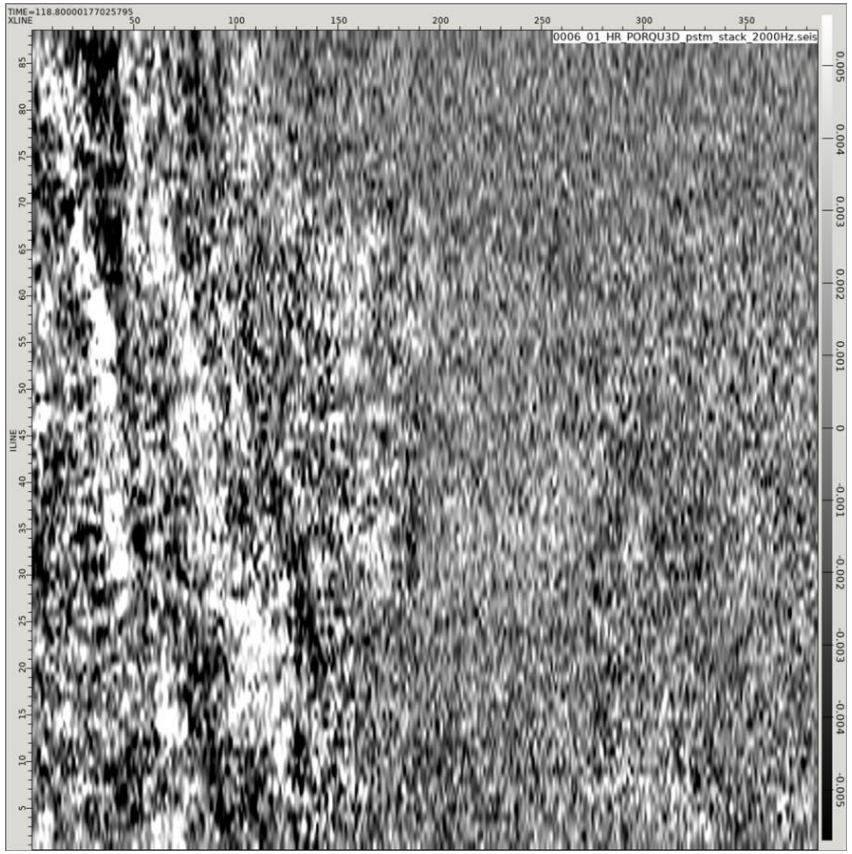
- **Superior seismic data quality (3D vs 2D)**
  - The system being quasi-static and immersed, it enables to deliver high signal-to-noise, full-azimuth, full-offset, high-fold and broadband data
- **High productivity and competitiveness**
  - The proposed solution will be **150%** faster and **30%** cheaper than existing methods
- **Easy deployment and mobilization; custom-fitted for windfarm surveys**
  - ASVs have been designed to be easily transported & mobilized worldwide
- **HSE**
  - **Reduced crew mobilized for offshore operations**
    - The master boat crew can manage the 2 ASVs: the number of people / days of operations is reduced
  - **Regulation compliant**
    - ASV authorization to sail is simple to get when ASVs are related with a master boat
  - **Low-carbon footprint and marine life-friendly**
    - Reduced CO_2 with respect to seismic vessels. Zero impact on seafloor and marine life, the sensors being in midwater.

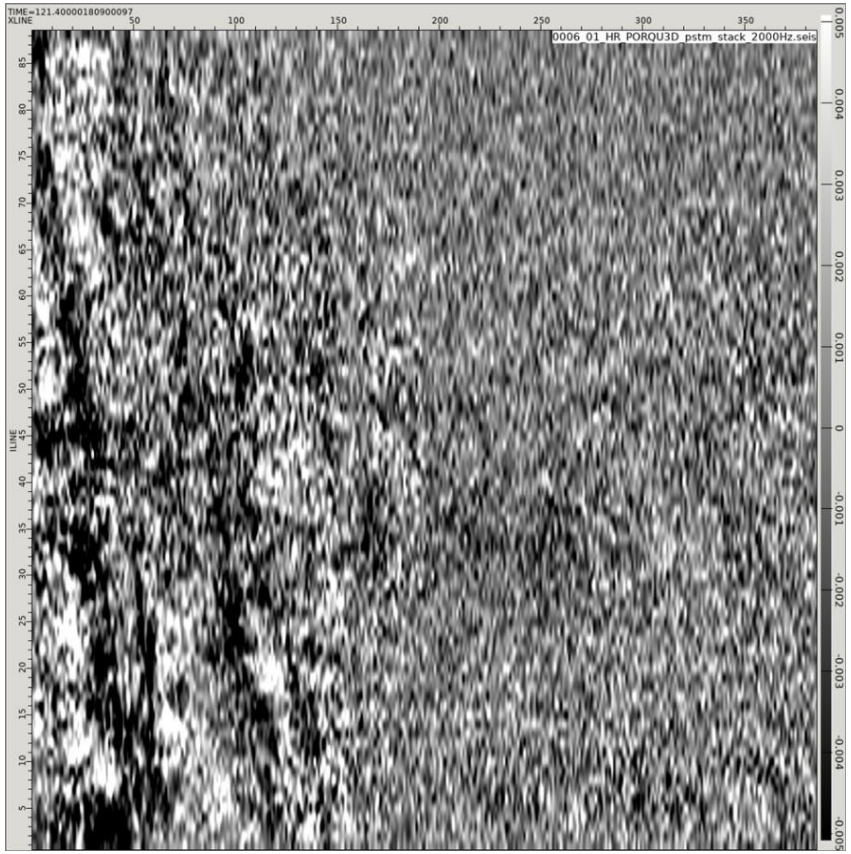
Cross-section Example (Pre-Stack Time Migration with Amplitude Spectrum)



Time Slices - 116.6ms (left), 118.8ms (middle), 121.4ms (right)







Conclusion

- The UHR3D will provide data throughout the entire survey swath along lines of planned wind turbine generator infrastructure
- This will decrease uncertainty of the 3D geological model
- In the geotechnical investigations that will follow, UHR3D will allow a targeted approach
- Operated with ASVs, this will lead increase productivity and decrease HSE risk, which lead to additional cost savings and reduced delays during the project.