Offshore Wind in Greece

Site Investigations – Geophysical studies

Gunhild Myhr, PGS 23rd November 2023

A Clearer Image

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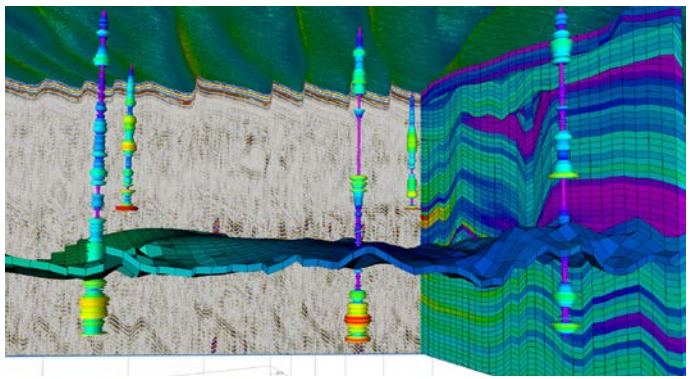
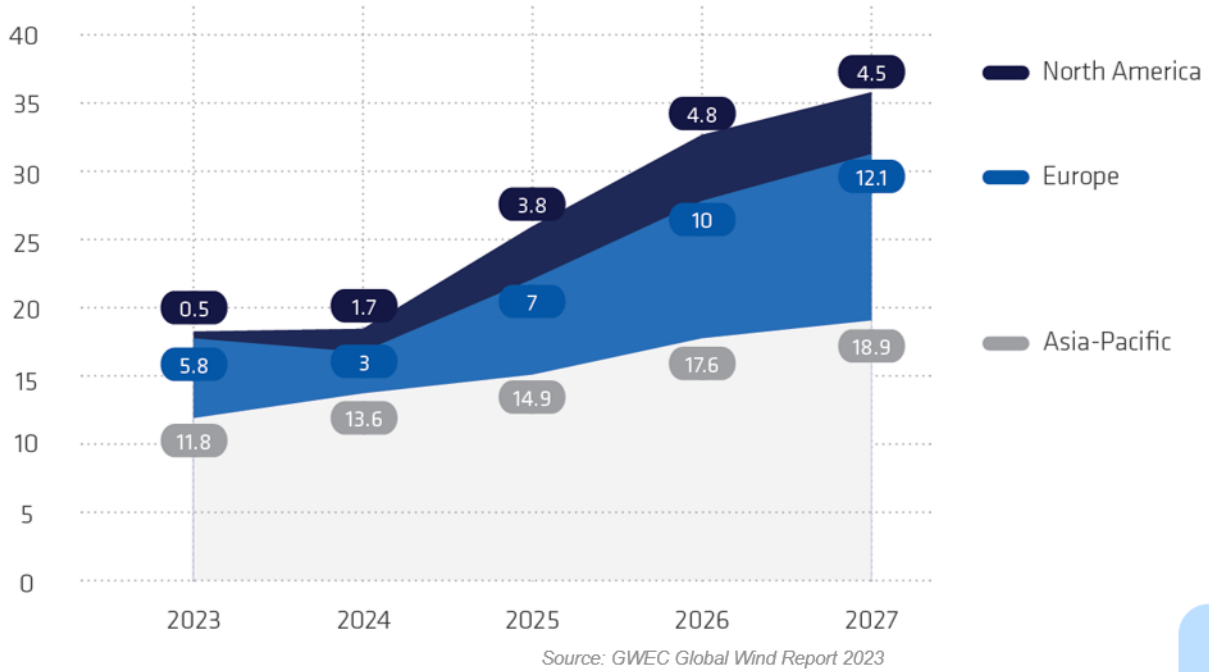


Offshore wind is in rapid growth

New installations offshore (GW)



Source: GWEC Global Wind Report 2023

130 GW offshore wind expected to be added worldwide in 2023-2027 period

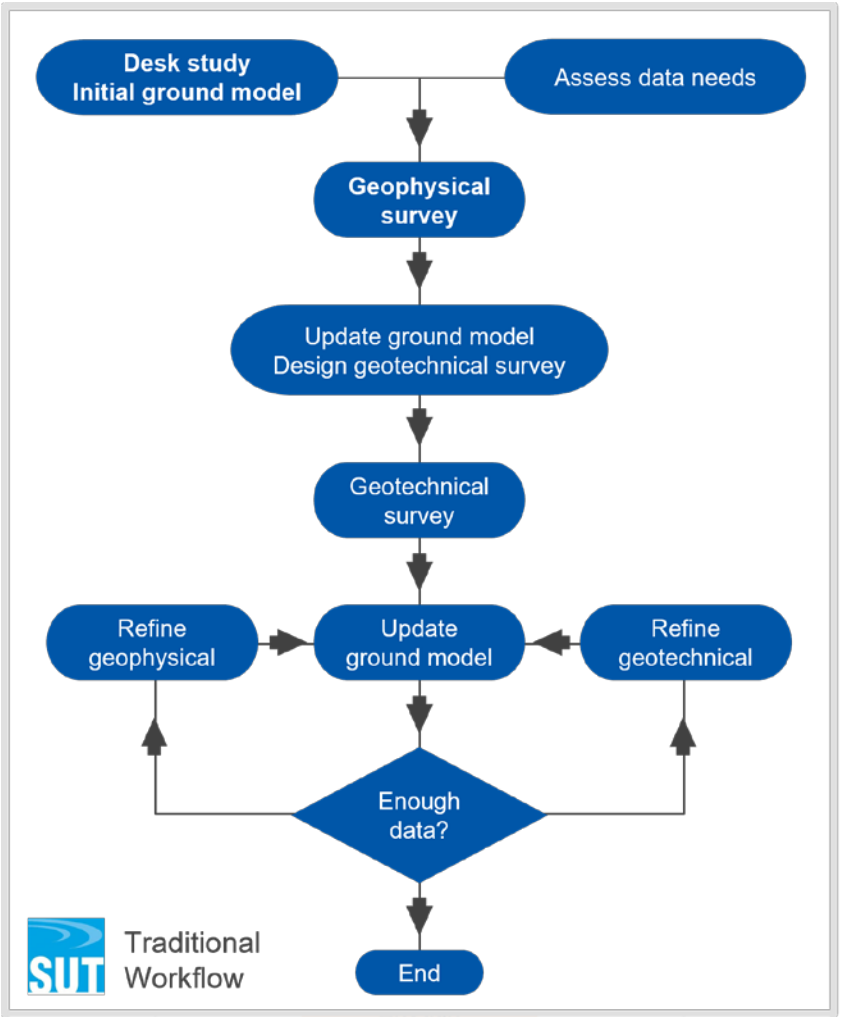
Time is of the essence

- For societies to reach climate targets
- For developers to secure project economics

PGS Goal

Cut time spent on site characterization by **50%**

Industry needs to reduce site characterization timescales



Existing 3D Seismic Data
Optimize early site understanding

Acquisition of **ultra high-resolution 3D**

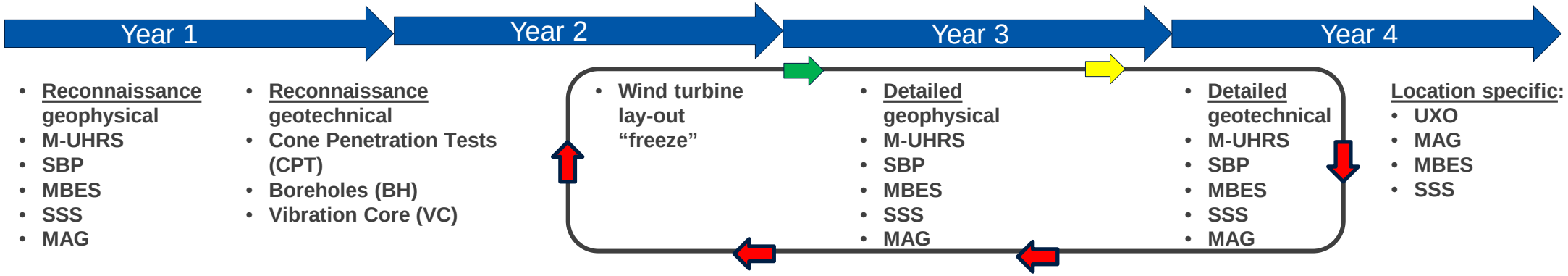
Includes: **rich, complementary multiphysics data**

Ground model based on **contiguous data** for optimal design of geotechnical survey

Faster time to site characterization

50%

Conventional approach to site characterization - delays



Delays to site characterization driven by:

- Preliminary nature of the reconnaissance geophysical campaign (2D UHR = leaving gaps).
- Reconnaissance geotechnical is not targeted at specific areas of interest.
- Wind turbine lay-out is "frozen" with much uncertainty in the ground model (more lay-out iterations following detailed geotechnical campaign). See above.
- Detailed geotechnical campaign(s) may have to be repeated.
- Long processing times – geophysical processing, geotechnical laboratory and interpretation.
- Procurement process, permitting, exposure to fishing activities, survey vessel capacity constraints.

The PGS UHR3D value proposition: “once and done”

3DUHR benefits:

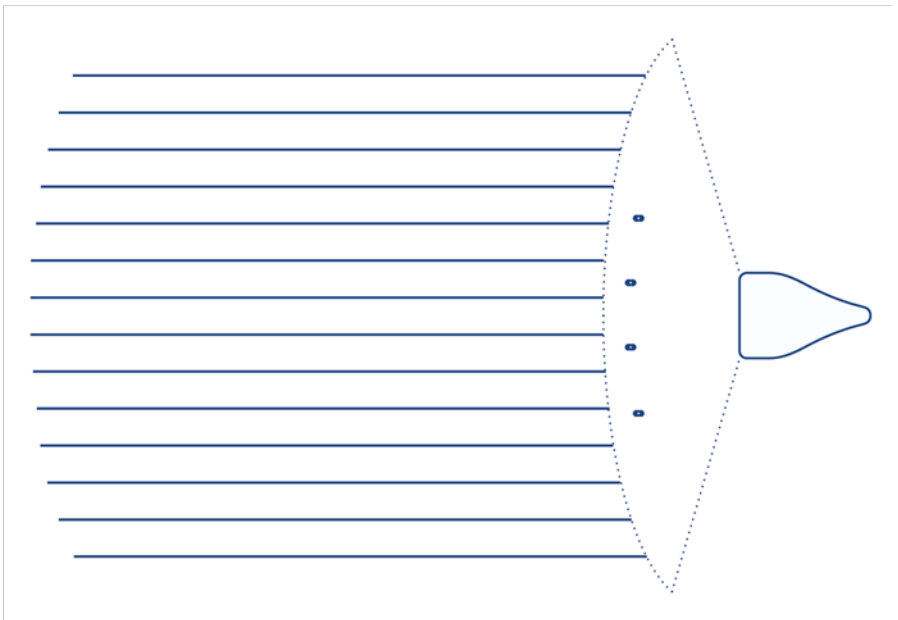
- Time spent on site characterization reduced with 50%
- Environmentally friendly – reduced number of surveys
- Shallow hazard identification
- Small scale hazard identification
- Flexibility for turbine locations
- Implement quantitative workflow for soil prediction
- Flexibility for turbine foundation and type
- Avoid permitting restrictions and delays for multiple surveys

Cut time spent on site characterization by

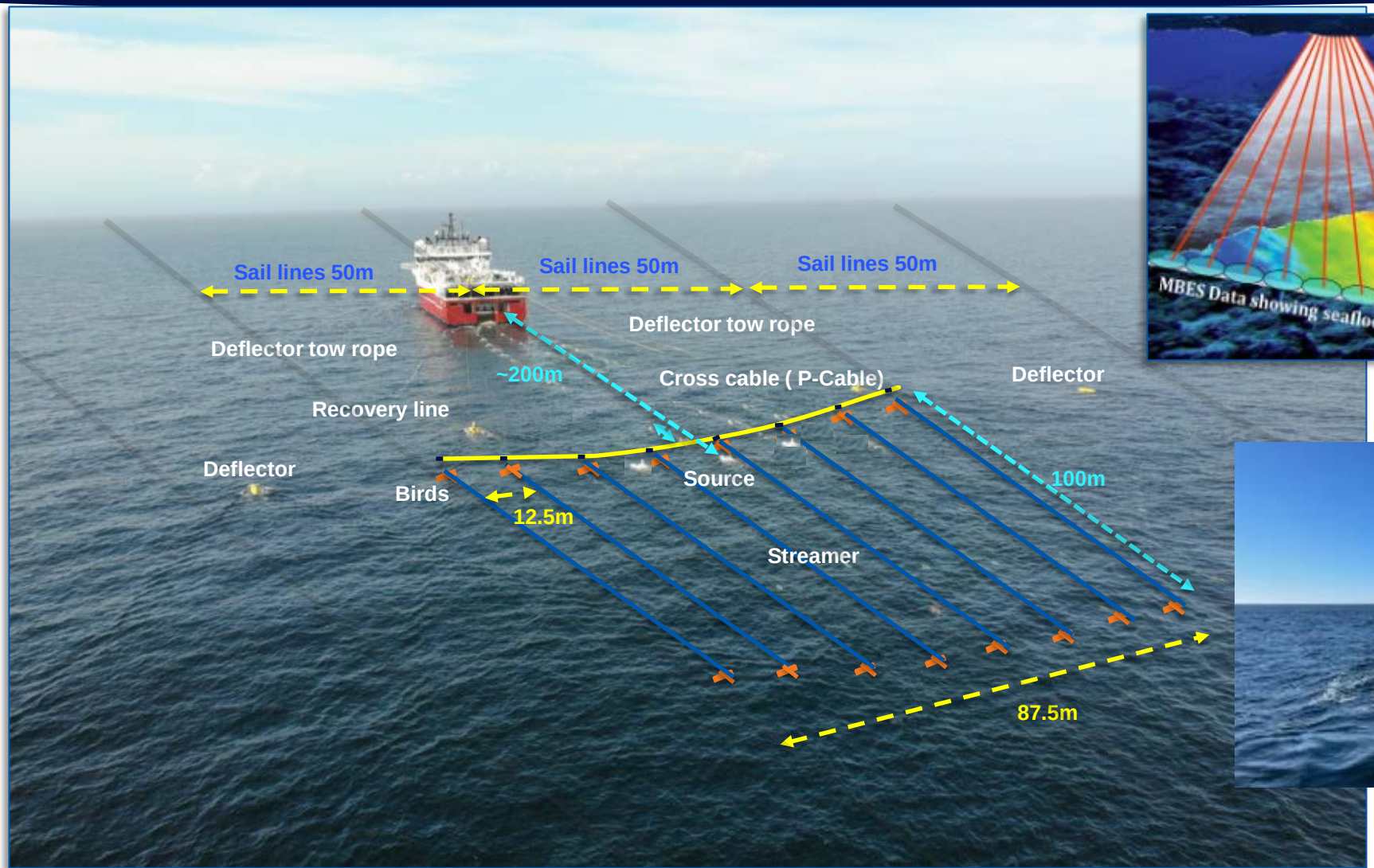
UHR 3D Designs enabling efficiency & resolution

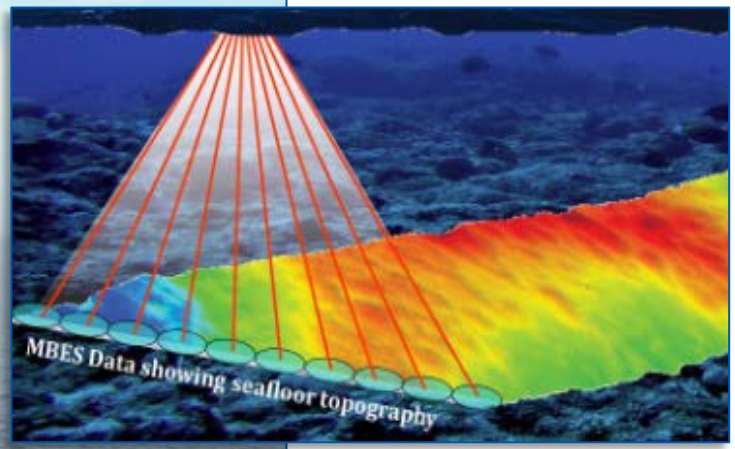
Streamers:	10 x 6.25 m x 100 m
Sources:	wide-tow triple source
Bin size:	~ 1 - 1.5 m
Source line spacing:	~ 10 m
Sail line spacing:	~ 30 m

Streamers:	14 x 12.5 m x 100 m
Sources:	wide-tow quad source
Bin size:	~ 1.5 - 3 m
Source line spacing:	~ 22 m
Sail line spacing:	~ 90 m



PGS 3DUHR acquisition, MBES and Lidar Measurements





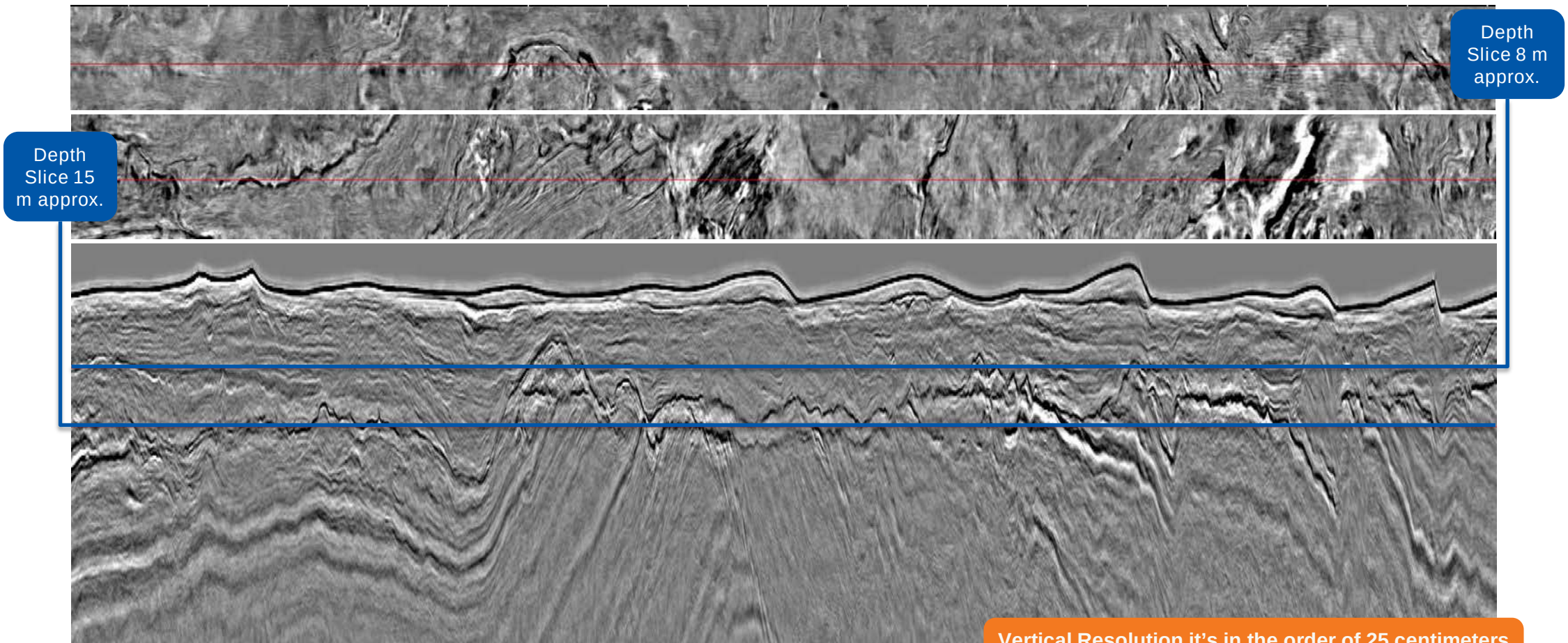
Sources – Important for permitting process and data quality

Source type	*Dura-Spark*	*S-Boom*
Length (mm)	1806	1806
Height (mm)	710	554
Width (mm)	650	650
Width with Float (mm)	1450	1467
Weight (kg)	160	120
Source level	221dB re 1µPa at 1m (typical)	222dB re 1µPa at 1m with 1000J (typical)
Pulse length	0.25ms (dependent on power applied)	0.3-0.5ms (dependent on energy applied)

Dura Spark 400 + 400

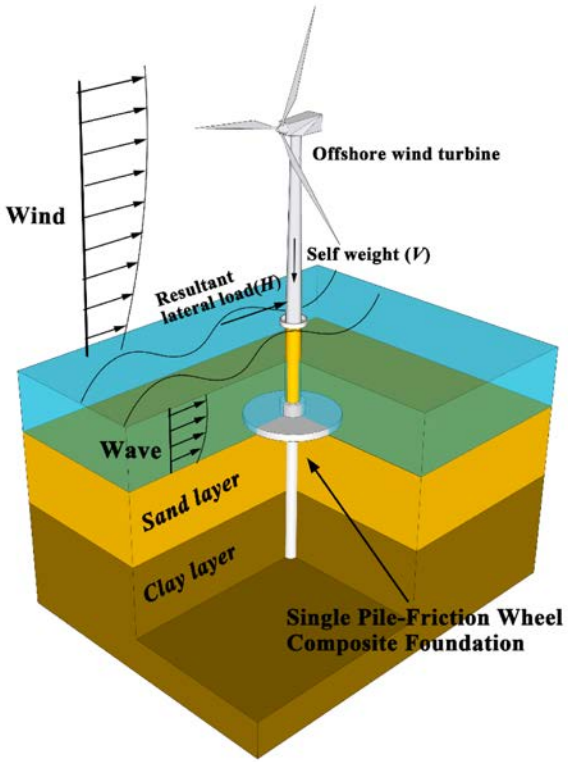
Triple Plate Boomer

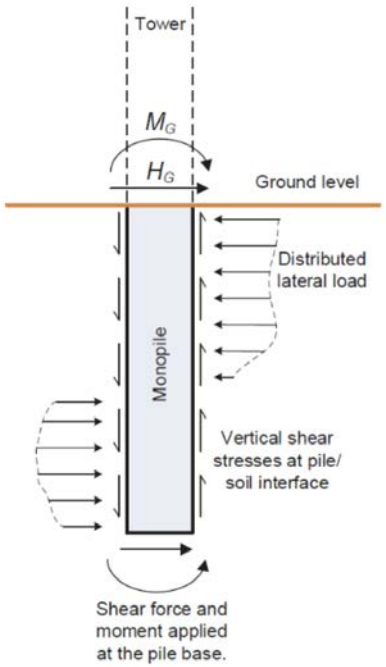
High Quality Fast Track UHR3D
Data reveals subsurface complexity



Vertical Resolution it's in the order of 25 centimeters
Lateral sampling in order of 1m

Ultimately end users need geotechnical properties





- Developing offshore wind ground models demands a comprehensive approach that addresses various geotechnical, geophysical, regulatory, and stakeholder aspects

- High-resolution 3D geophysical data for windfarm projects enable the development of an accurate **3D ground model** for **integrating subsequent geotechnical and geophysical measurements**, reducing the need for costly new surveys when adjusting turbine foundation locations.

- Historically, **CPT** (Cone Penetration Testing) has been the primary **geotechnical** measurement, augmented by **seafloor / bathymetric surveying**, and in some cases, by sparse **2D** ‘site survey’ seismic data.

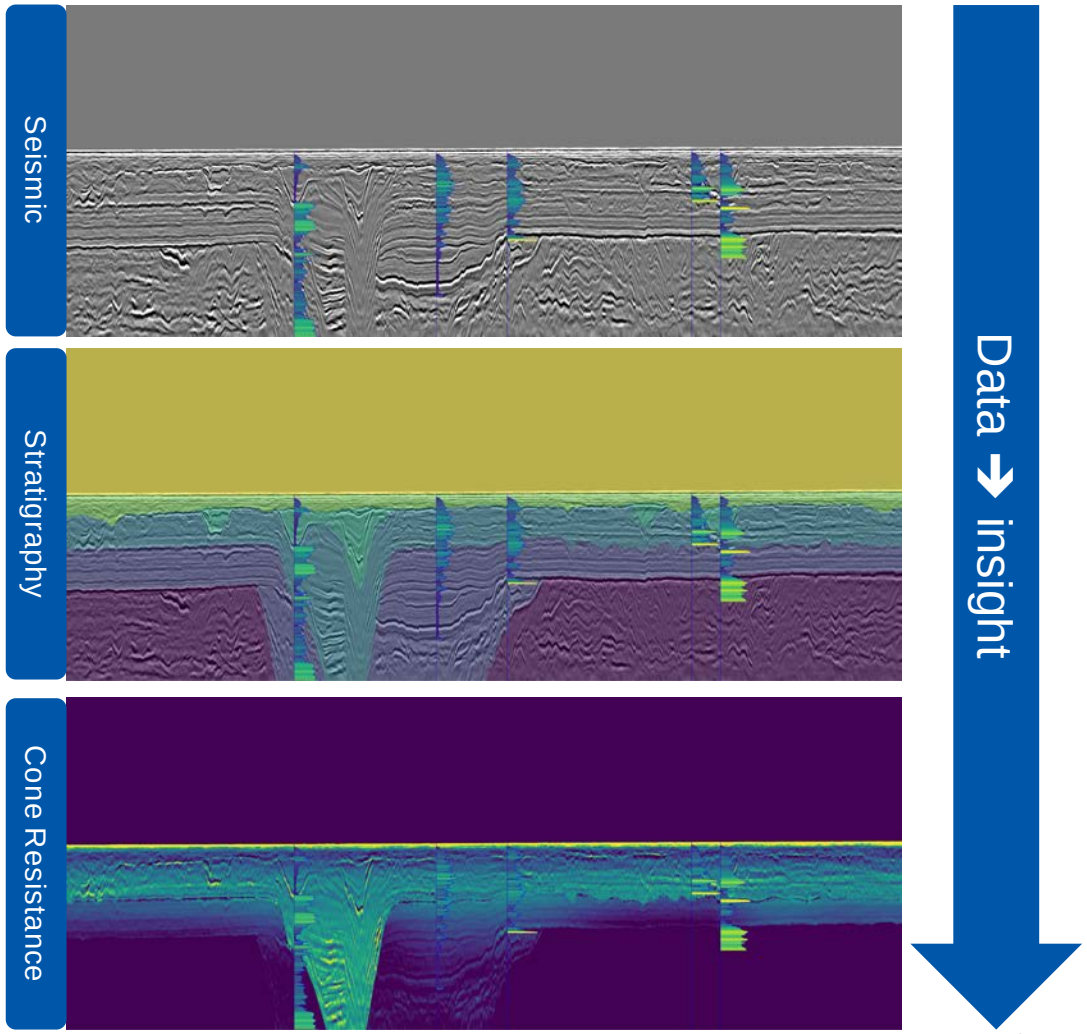
Integrated Ground Modelling

Using dense 3D seismic data, it is possible to build ground models:

- In greater detail
- Address ground conditions with greater confidence
- Build more bespoke solutions to challenges

This presents exciting new opportunities to:

- Advance ground modelling techniques to embrace 3D data
- Adjust how other data streams are incorporated to make the most of all information
- Reduce iteration in ground modelling



Subsurface: Extracting information from the Data

PGS is building on several initiatives to extract the maximum insight from UHR3D seismic to address the subsurface challenges facing the OFW industry

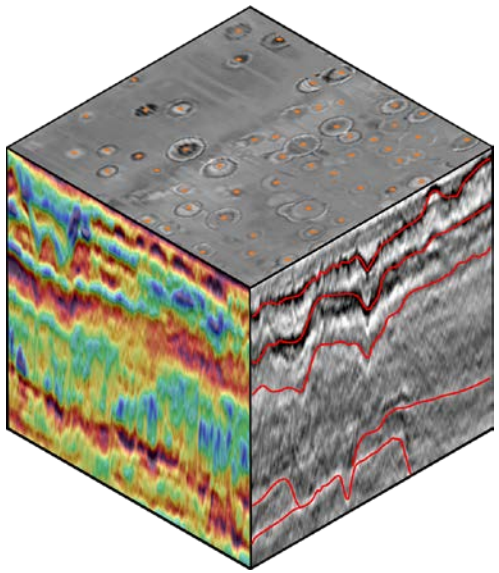
Seismic Properties ➔ Geotechnical Properties

3D distribution of geotechnical properties generated in a data driven manner with minimal incorporation of borehole and CPT data allows robust blind trialling of the results

Objects

Boulders, Faults…

Properties



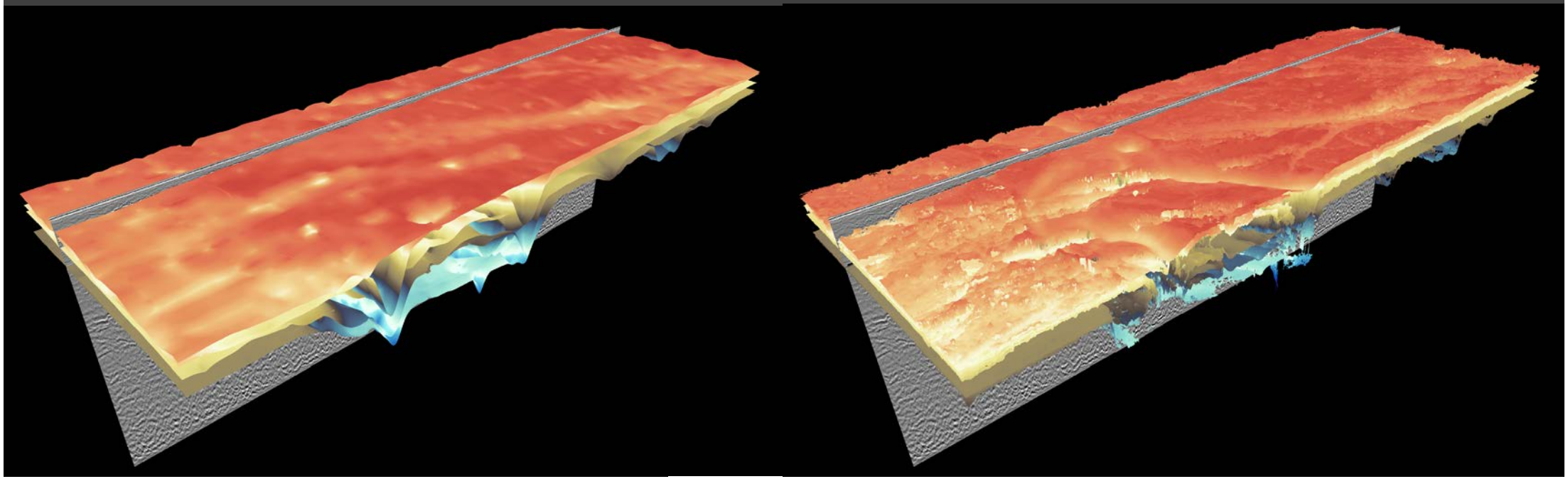
Framework

Enhanced Ground Modelling for Engineering Challenges

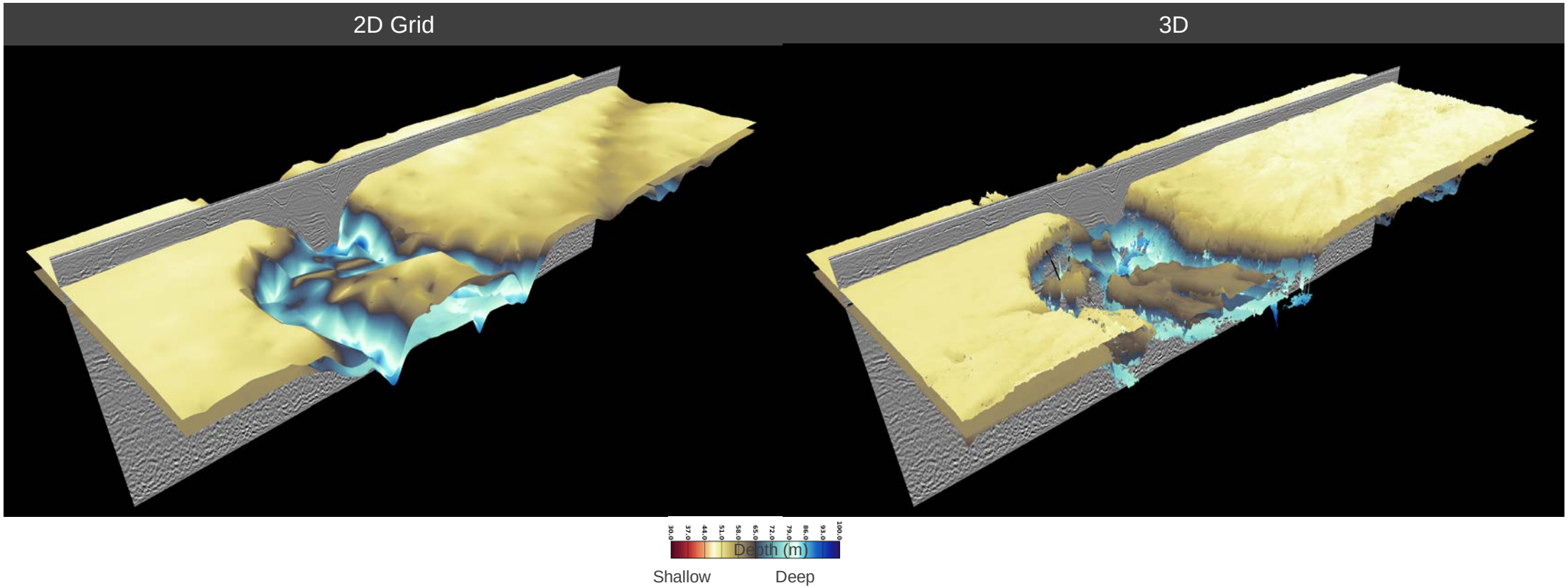
Framework: Final interpretation comparison

2D Grid

3D



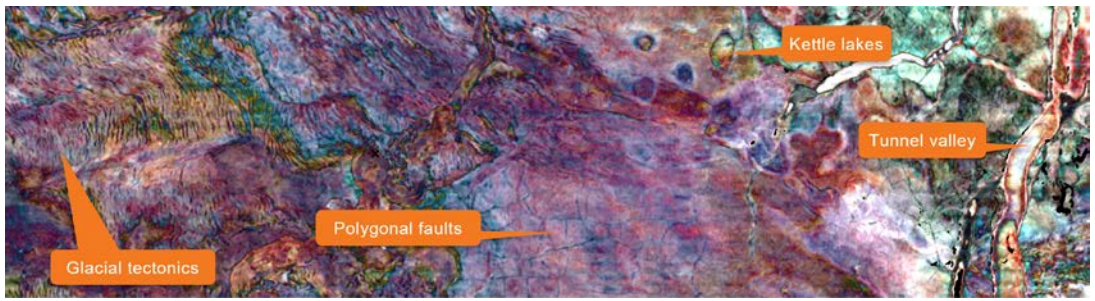
Framework: Final interpretation comparison



3D data and enhanced interpretation enables early selection of foundation types

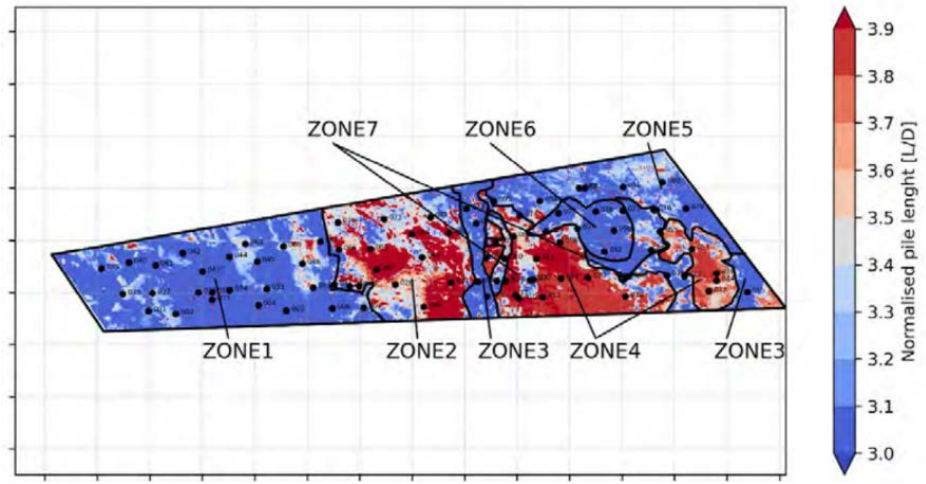
Enhanced interpretation of geoscience data

Accurate and reliable UHR3D data is an essential ingredient in enhanced and automated interpretation.



How to derive engineering parameters from geoscience data?

Moving to direct prediction of foundation types and zones



Predicted normalized pile length and 7 associated zones. The zonation is determined by a combination of the pile length, the geology and the synthetic CPT response.

"Capturing uncertainty in quantitative ground models" 2023 - M Vardy, G Sauvin, RT Klinkvort, M Vanneste, A Kort, CF Forsberg

Summary & Outlook

- Yearly (Predictable) Licensing rounds and robust financial models will give the wind developers more security to invest and develop offshore wind in Greece. Predicable Framework and regulations is a key. The Netherlands Enterprise Agency (RVO) and Crown Estate (UK) are examples.

- Getting better and faster 3DUHR seismic data is key to accelerate the development of wind farm projects. This can cut the time spent on site characterisation by 50%.

- Key areas can be covered with 3DUHR data and other geophysical measurements in a very efficient way within the next 3 years prior to planned auction in 2026-2027 to meet the target of 1.9 GW within 2030.

- 3DUHR data can characterise near subsurface to strength property level, this could offset the extensive CPTs and Boreholes otherwise required bringing significant cost reduction for fixed and floating wind sites in Greece.


Thank You

Ground Investigation for Floating Turbines [GIFT JIP]

"What type and extent of ground investigation is needed to produce reliable, certifiable and installable anchoring designs for floating wind turbines?"

JIP Aim:

- Reduce GI costs in the industry
- Reduce potential mitigation related costs
- Help industry standardise/optimise anchor design and fabrication

JIP Objectives:

- Move away from geotechnical GI per anchor towards Environmental Class design as in DNV-ST-0119
- DNV-RP to optimise Environmental Class – accepted by DNV ST 0119

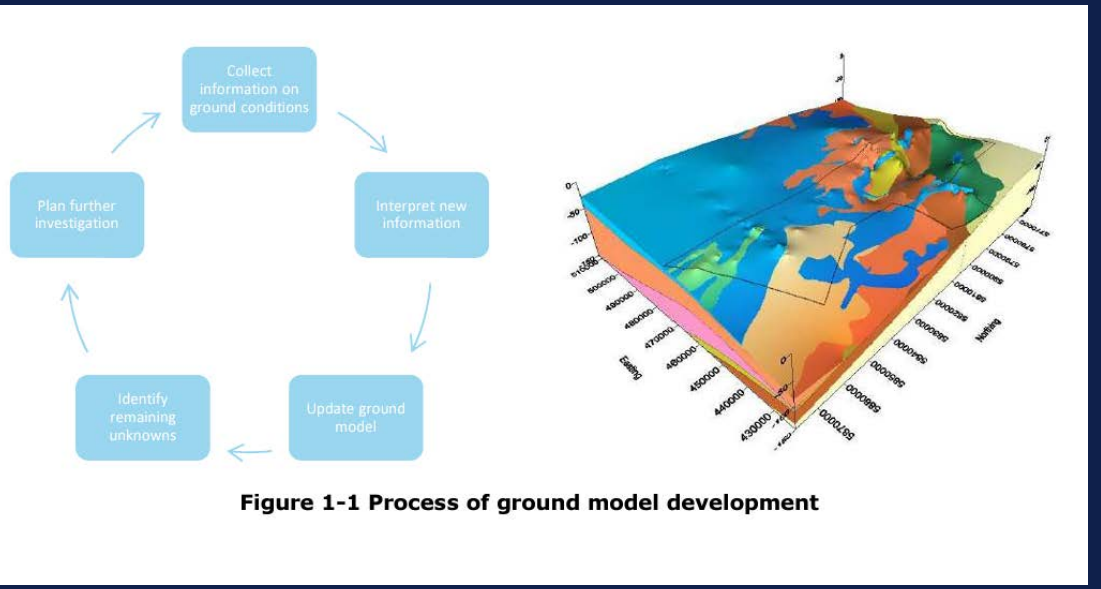


Figure 1-1 Process of ground model development

How:

- Greater focus on and increased confidence in ground modelling
- Optimise geophysical surveys: data inversion → correlations with geotechnical parameters, 3D?
- Relevant (and latest) anchor types for defined soil provinces/Env. Class
- Case studies - both simple and complex / extreme cases. Worldwide

DNV