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# Offshore wind site characterization
# Time for new ideas?

Professor Dave White
University of Southampton
Co-Director, UK Offshore Renewable Energy Supergen Hub

Oceanology, London
13 March 2024

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# OFFSHORE WIND SITE CHARACTERISATION

Presentation structure

- The Big Picture: the Energy Transition and Net Zero
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  - New regions, new seafloor conditions

What's new?

- Robotic and lean crewed platforms
- Sensing tools and technologies
- Data science, computing power
- GIS-based analysis

- Closing comments

Based on: White, D.J. 2023. Rapporteur's Report – Innovative Geotechnologies for Energy Transition. Proc. SUT Conference on Offshore Site Investigation and Geotechnics, SUT, London, September 2023.

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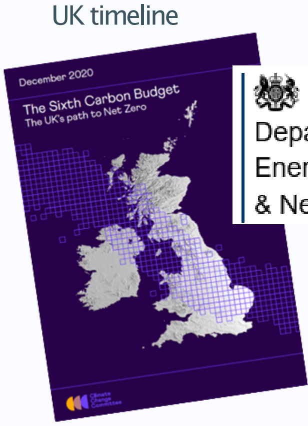
# NET ZERO – BY 2050

UK timeline




Department for Energy Security & Net Zero

STATUTORY INSTRUMENTS

**2019 No. 1056**

CLIMATE CHANGE

The Climate Change Act 2008 (2050 Target Amendment) Order 2019

*Made* *26th June 2019*

*Coming into force in accordance with article 1*

**Amendment of the target for 2050**

**2.**—(1) Section 1 of the Climate Change Act 2008 is amended as follows.

(2) In subsection (1), for "80%" substitute "100%".

https://www.legislation.gov.uk/uksi/2019/1056/article/2/made

The Climate Change Act commits the UK government by law to reducing GHG emissions to net zero by 2050. 75% of GHGs are from fossil fuels (IEA).

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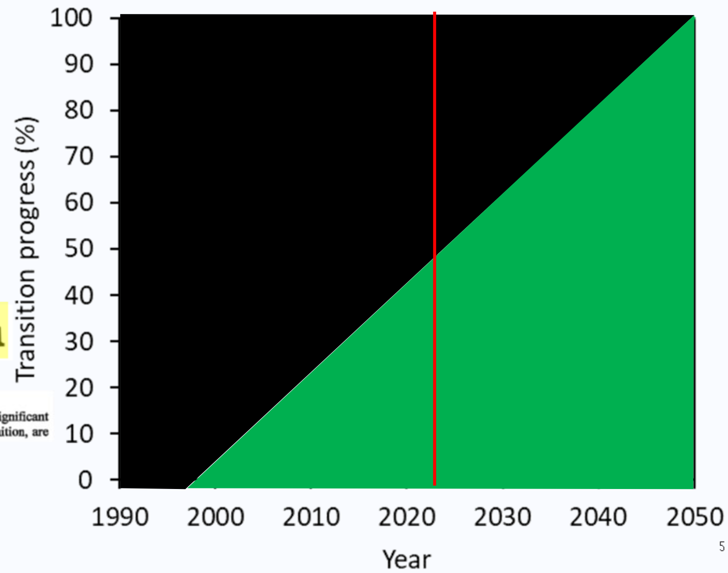
# ENERGY TRANSITION – ALREADY AT HALF TIME

- Our sector has been supporting the Energy Transition since the 1990s


2002 SUT OSIG conference

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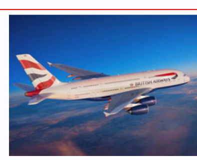
# NET ZERO – BY 2050

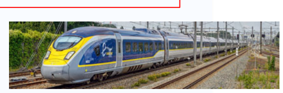
UK timeline

- UK is half way to net zero
  - Primarily by eliminating coal power stations
- Remaining steps are harder

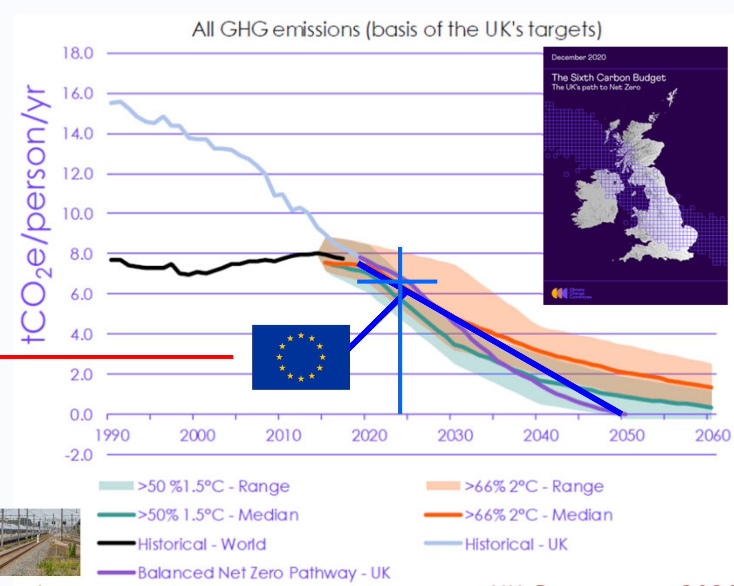


Return flight Houston-London 2.8 $tCO_2e$ (45% of UK 2024 "allowance")
https://flightfree.org/flight-emissions-calculator

5.2 years



11.7 global circumnavigations




UK Government 2020

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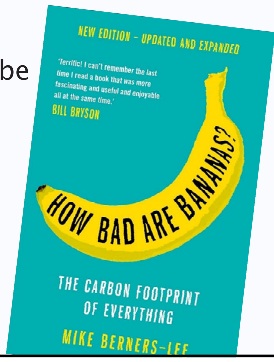
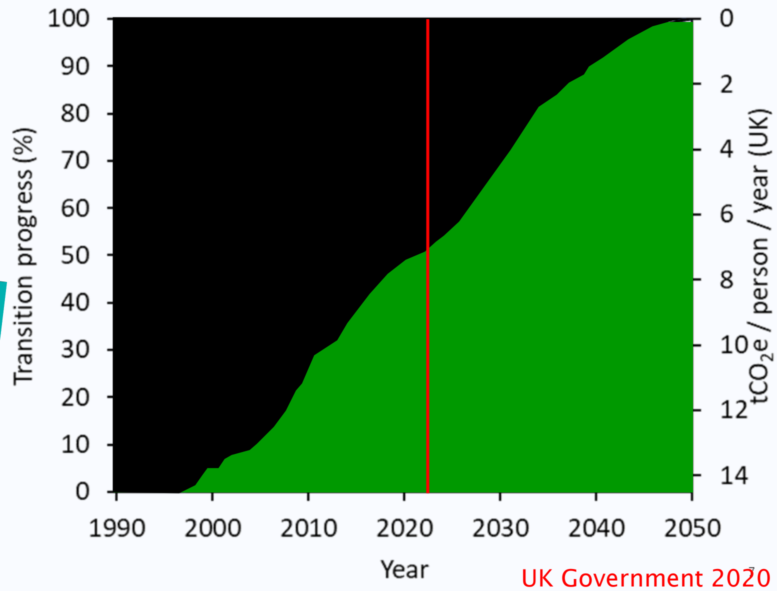
# NET ZERO – BY 2050

UK timeline

- UK is half way to net zero
  - Primarily by eliminating coal power stations
- Remaining steps are harder
- Let's all be carbon literate!




UK Government 2020

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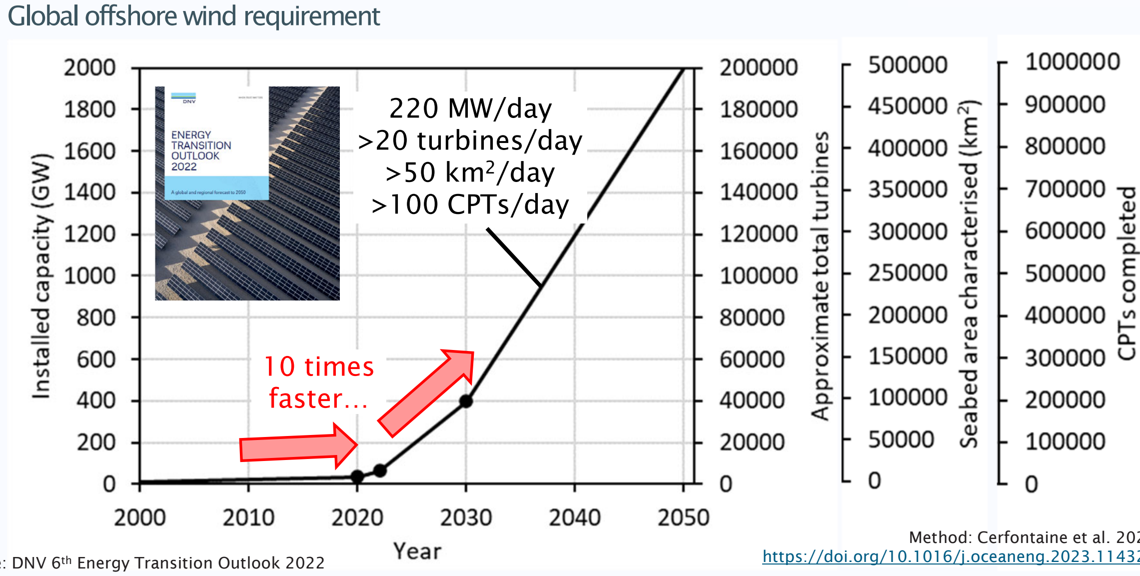
# PATHWAYS TO NET ZERO BY 2050

Global offshore wind requirement




Source: DNV 6th Energy Transition Outlook 2022

Method: Cerfontaine et al. 2023
https://doi.org/10.1016/j.oceaneng.2023.114327

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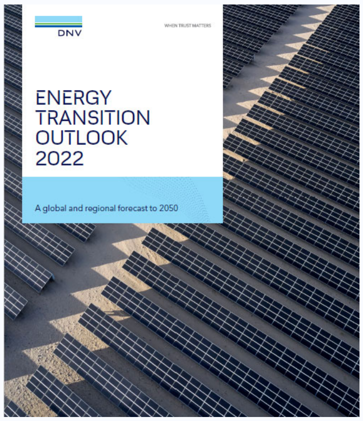
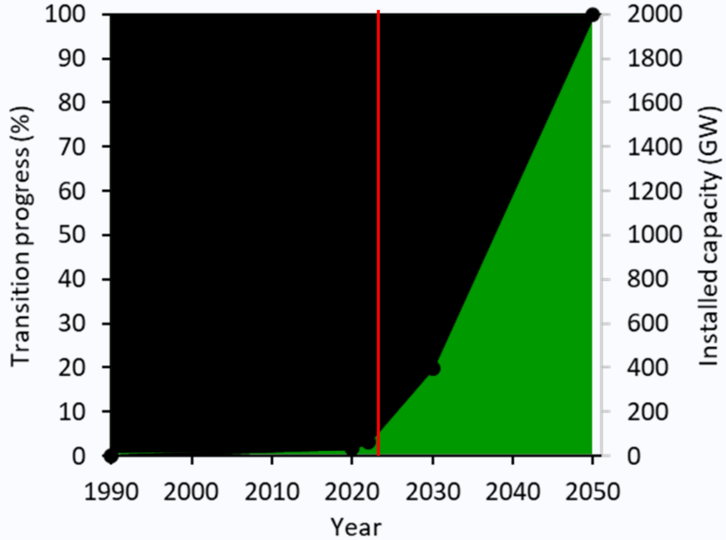
# PATHWAYS TO NET ZERO BY 2050

Global offshore wind requirement




From DNV (2022)

Source: DNV 6th Energy Transition Outlook 2022

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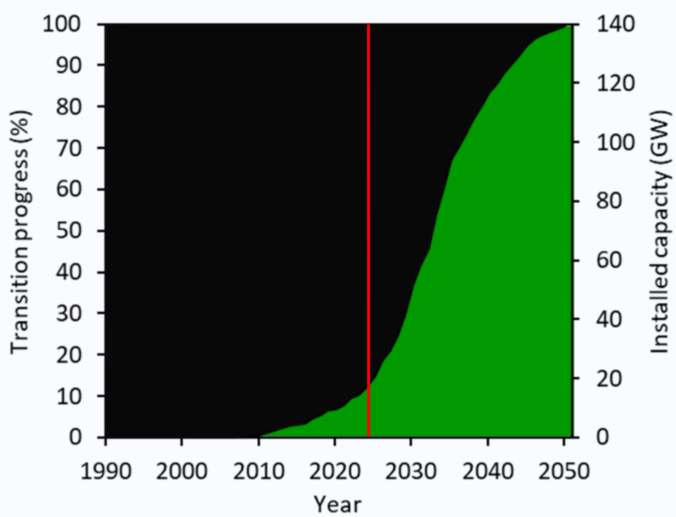
# PATHWAYS TO NET ZERO BY 2050

UK offshore wind development

- 2010-2020: Steady growth in UK offshore wind:
  - 0.9 GW/year
- 2030 target has risen from 30 GW (in 2019) to 50 GW (in 2022)
- 2050 target for net zero:
  - Crown Estate uses 140 GW from 6th Carbon budget
  - Higher values (>300 GW) with Hydrogen and more electrification
- Next decade 6× faster than last…
- …and mainly floating, not fixed
- …plus repowering expired farms

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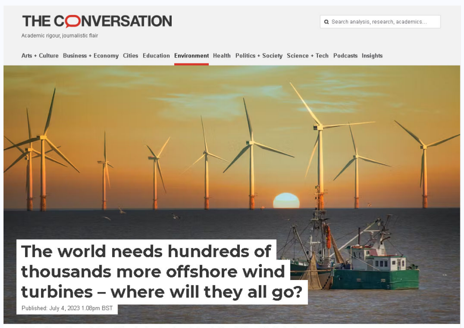
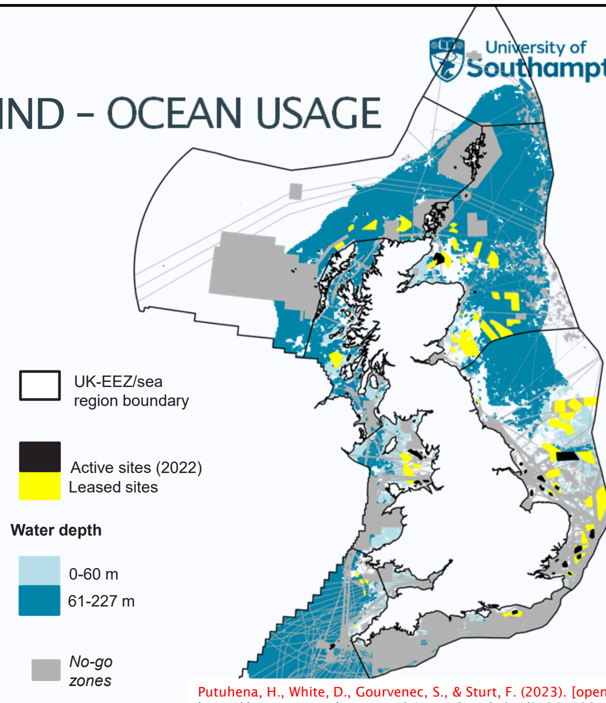
# UK NET ZERO OFFSHORE WIND – OCEAN USAGE

## Mapping of available space

- Offshore wind expansion can fit within existing levels of co-location and co-usage of ocean space.
- But, as ocean space fills, interaction increases and offsetting is harder.




Putuhena, H., White, D., Gourvenec, S., & Sturt, F. (2023). [open access]
https://www.sciencedirect.com/science/article/pii/S1364032123002150

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Source: University of Southampton GDP37 2021-2022, North Sea Energy Island; www.uosdesign.org
Monika Nikolaeva, Caspar Krens, Chris Wijnberg, Jaimie Jobson, Said Latreche, Joseph Li; Benjamin Cerfontaine, David White

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- Robotic and lean crewed platforms
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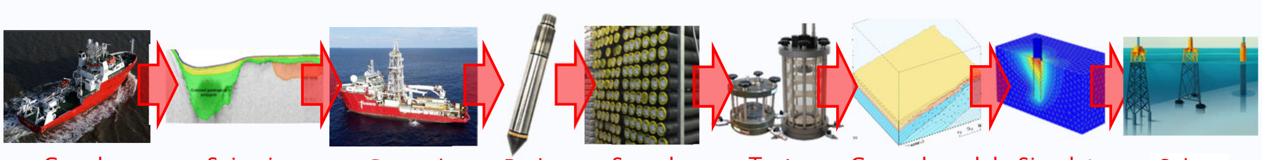
# OW SITE CHARACTERISATION TODAY



Geophys Seismic Geotech Probe Sample Test Ground model Simulate Select

~5-10 years

We cannot reach net zero if
we don't speed up this process

We will cut the process time by over half by:

- reducing consent time from up to four years down to one year.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What's new?

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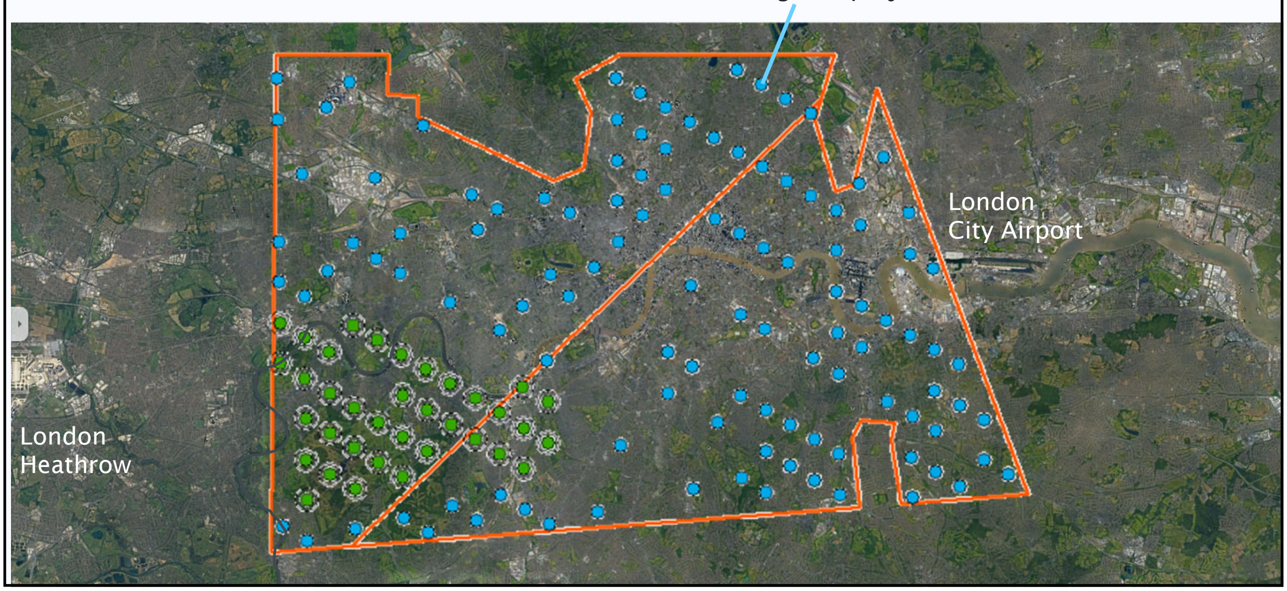
# SPATIAL EXTENT

Seagreen project turbines (from EIA)

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## COMMODITISATION

ULS-dominated (~300, ~30 floating)

UK North Sea

Accumulated SLS / FLS (~10,000, ~5,000 floating?)

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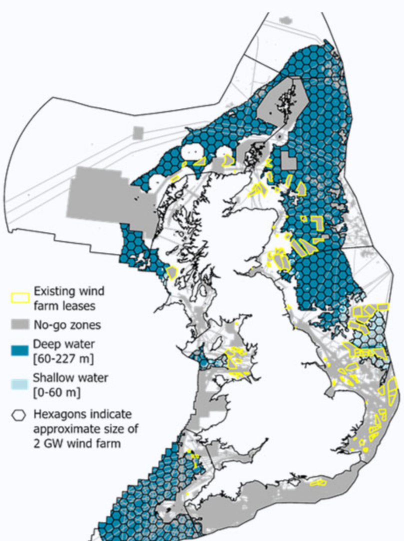
## CHANGING SEAFLOOR CONDITIONS




Putuhena et al. (2023)

Changing seafloor sediments

Celtic Sea

Scottish North Sea

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# CHANGING SEAFLOOR CONDITIONS

Griffiths et al. (2018) OMAE77130
MeyGen project

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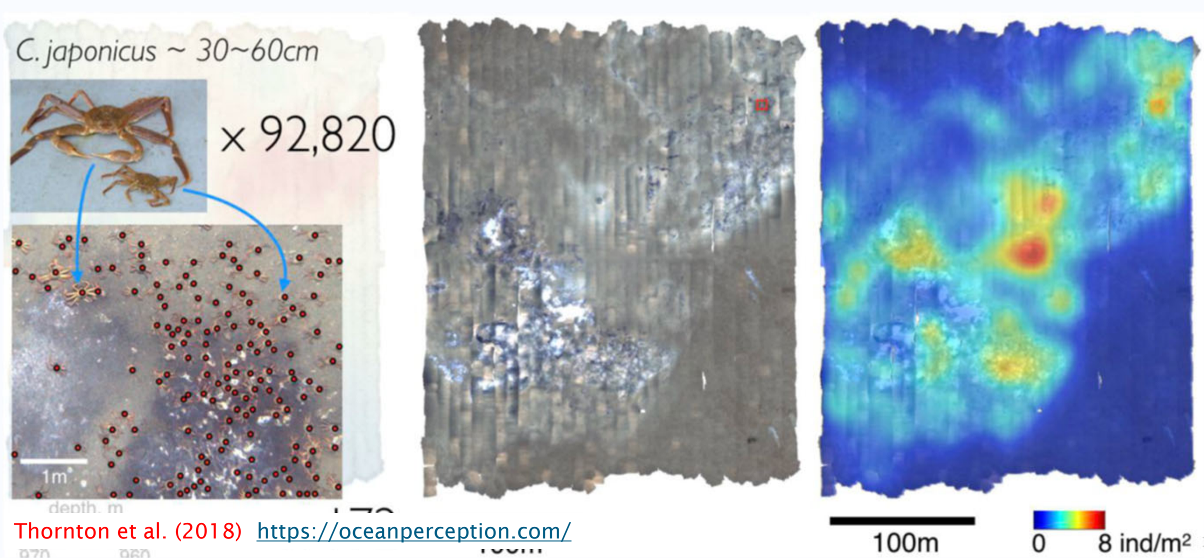
# PARALLEL CONSENTING – OTHER DATA NEEDS




Thornton et al. (2018) https://oceanperception.com/

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## ROBOTIC AND LEAN-CREWED PLATFORMS

Ocean Infinity website

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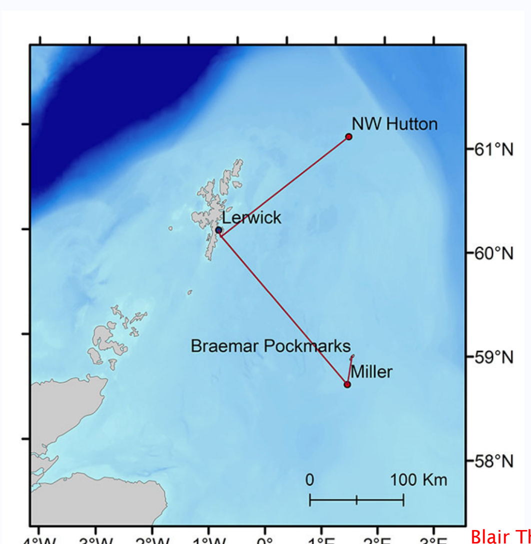
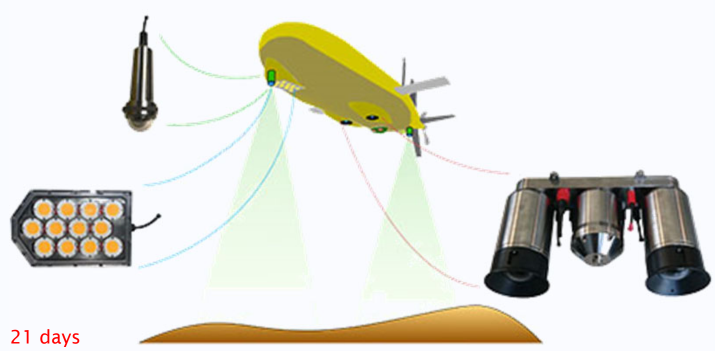
## ROBOTIC AND LEAN-CREWED PLATFORMS



21 days
1000 kilometres
Energy: 2 litres of fuel (>1,000 mpg)

Blair Thornton, UoS and NOCS: AT-SEA Project: www.oceanperception.com 24
https://noc.ac.uk/science/projects/autonomous-techniques-infrastructure-ecological-assessment-sea-project

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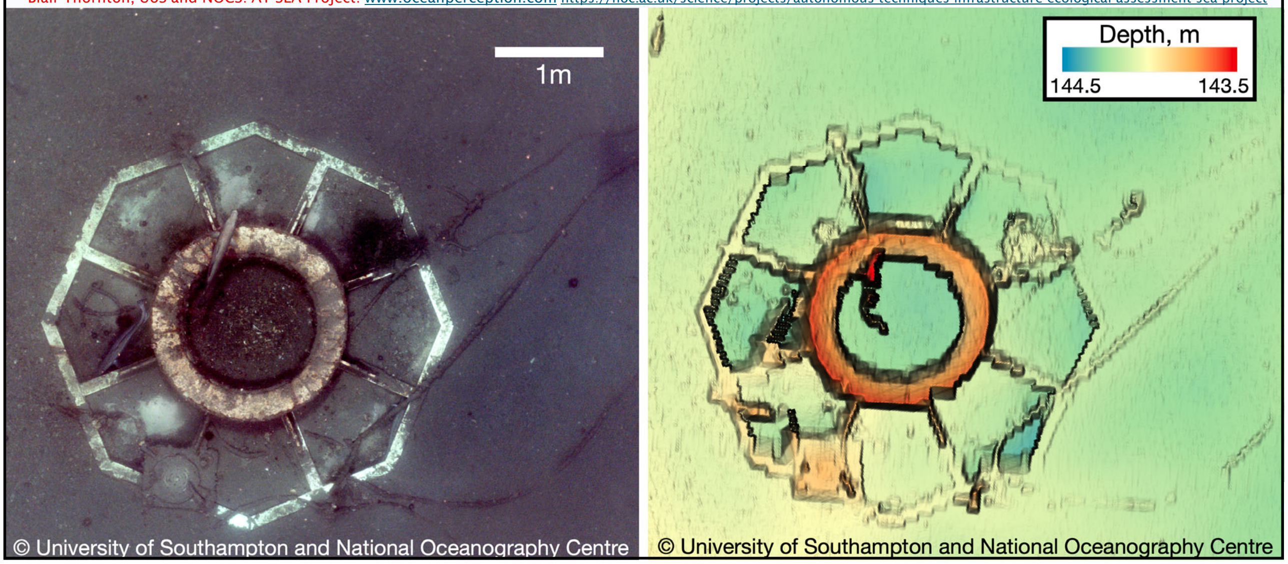


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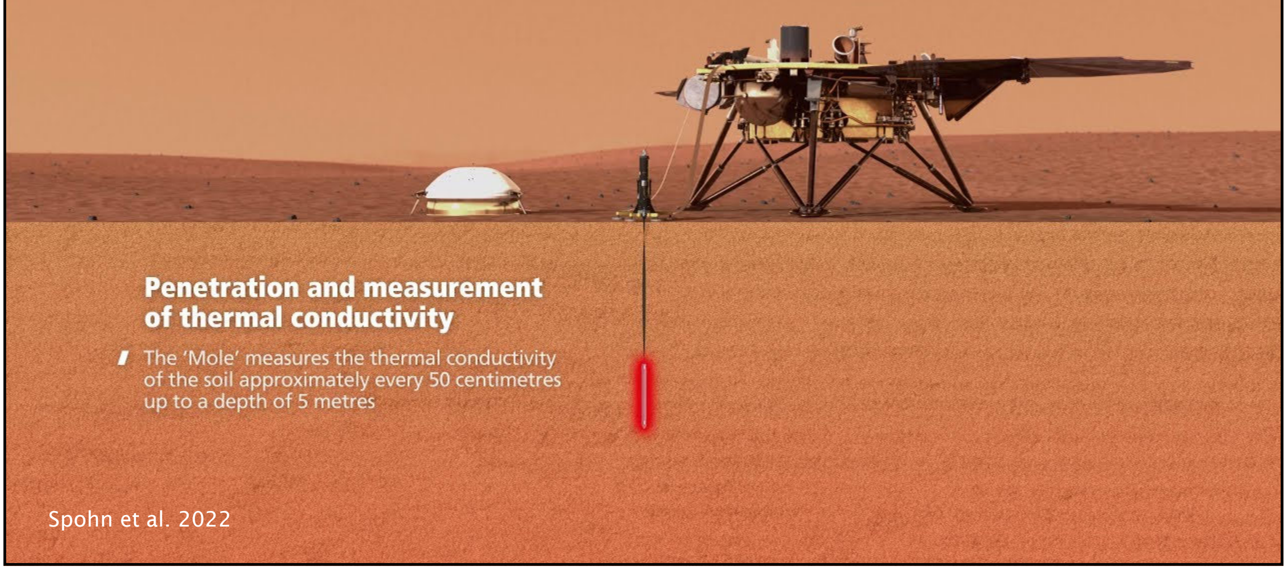
## CATCH UP WITH SPACE SCIENCE




Spohn et al. 2022

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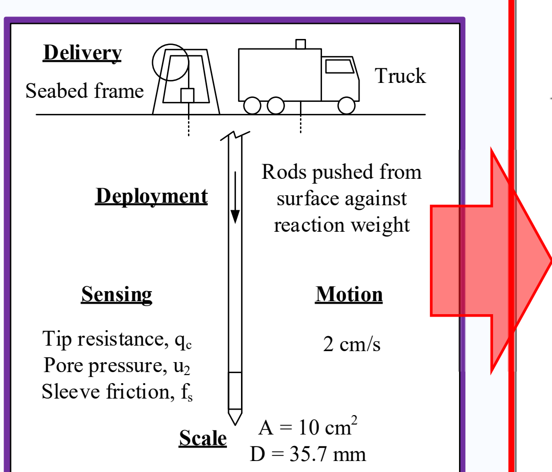
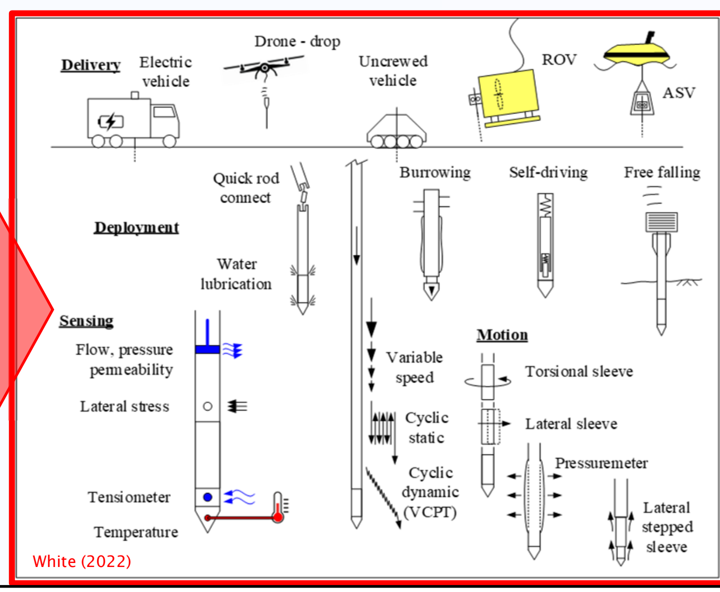
# SENSING: MAKE SMARTER USE OF IN SITU TESTING




White D.J. 2022. CPT equipment: Recent advances and future perspectives. Proc. 5th Int. Symp. on Cone Penetration Testing (CPT'22). Bologna.
https://www.taylorfrancis.com/chapters/oa-edit/10.1201/9781003308829-5/

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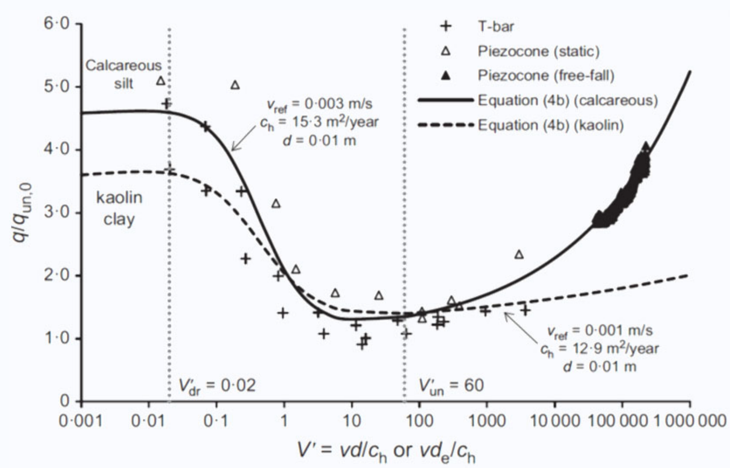
# SENSING: MAKE SMARTER USE OF IN SITU TESTING

- Changes in speed
  - Slower or faster
  - Wait then restart
  - Cycle, wait, cycle
- Advantages
  - Additional information, especially in soft soils




Chow, O'Loughlin, Zhou, White & Randolph (2020)
https://doi.org/10.1680/jgeot.19.P.069

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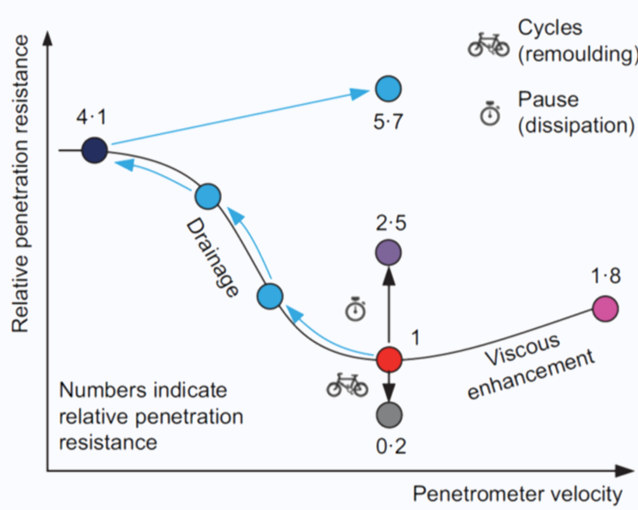


Chow, O'Loughlin, Zhou, White & Randolph (2020)
https://doi.org/10.1680/jgeot.19.P.069

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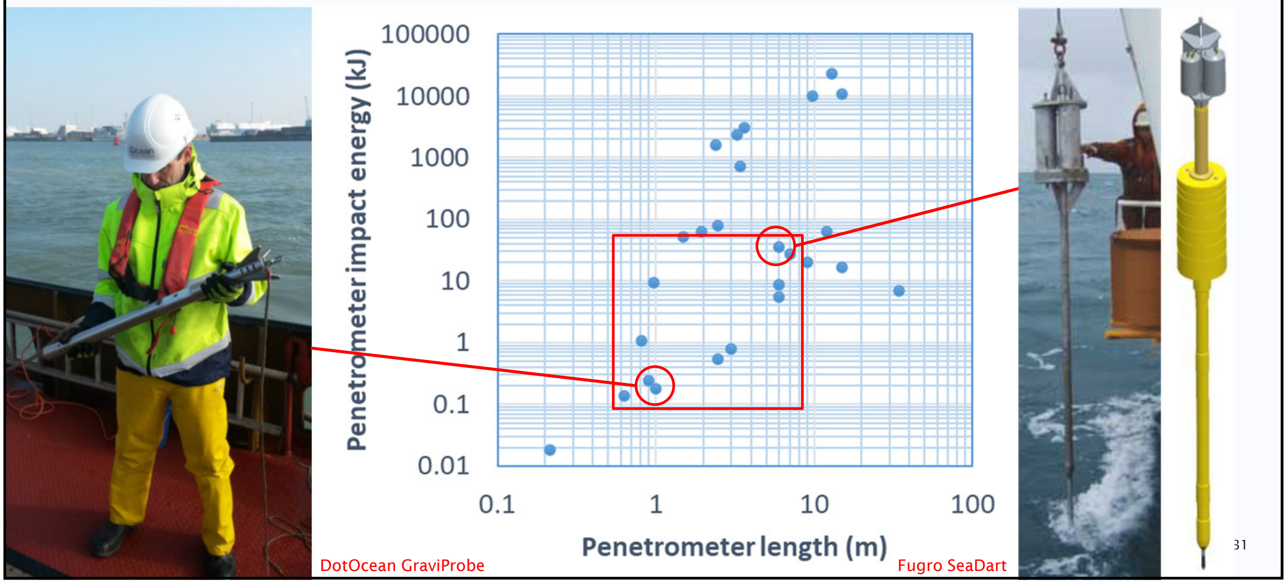
## SENSING: RAPID IN SITU TESTING

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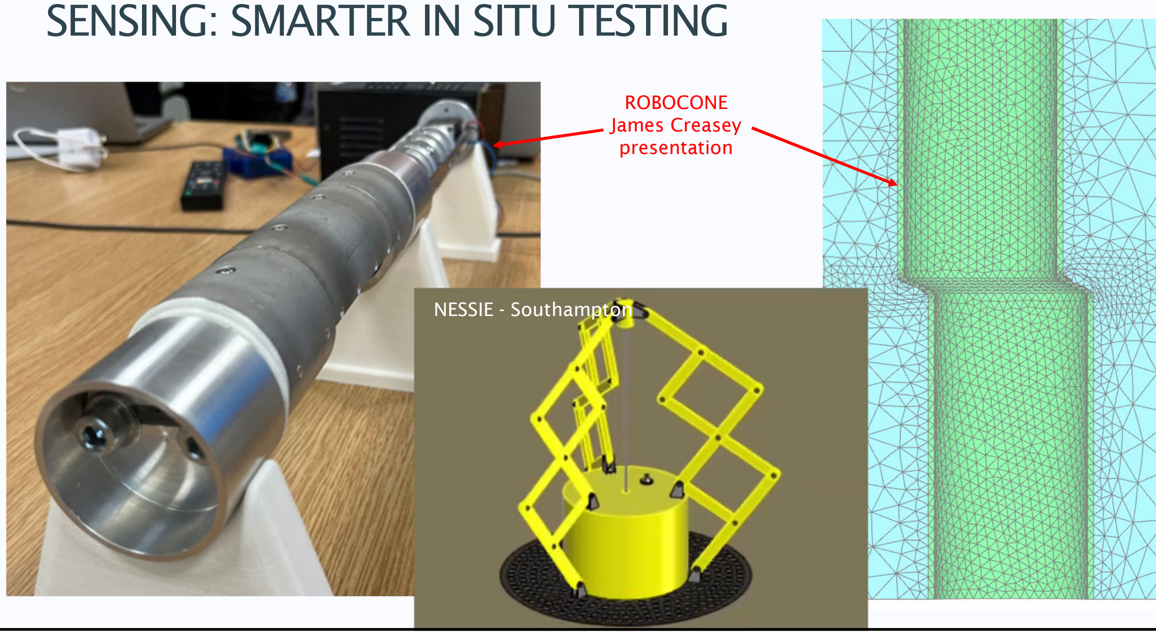
## SENSING: SMARTER IN SITU TESTING

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  - GIS-based workflows

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## DATA SCIENCE AND COMPUTING POWER

Example: estimation stiffness degradation response

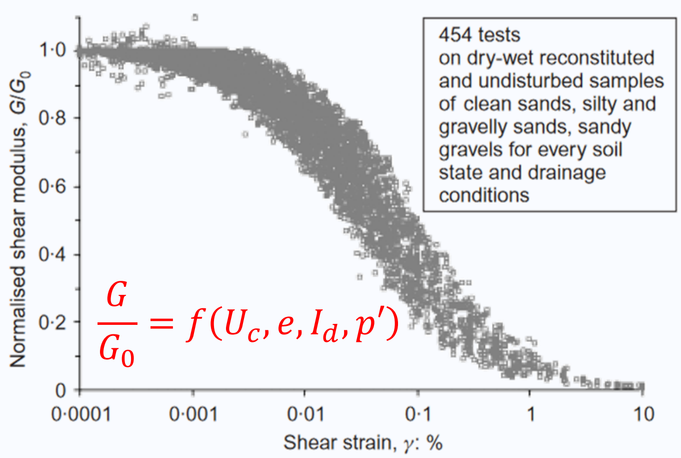
- Essential for monopile design – derived from advanced lab testing
- Can be estimated from database correlations:

$$\frac{G}{G_0} = 1/\left[1 + \left(\frac{\gamma - \gamma_e}{\gamma_r}\right)^a\right]$$

$$\gamma_r(\%) = 0.01 U_c^{-0.3}\left(\frac{p'}{p_a}\right) + 0.08 e I_d$$

$$\gamma_e = 0.0002 + 0.012\gamma_r$$

$$a = U_c^{-0.075}$$




Oztoprak & Bolton (2013)

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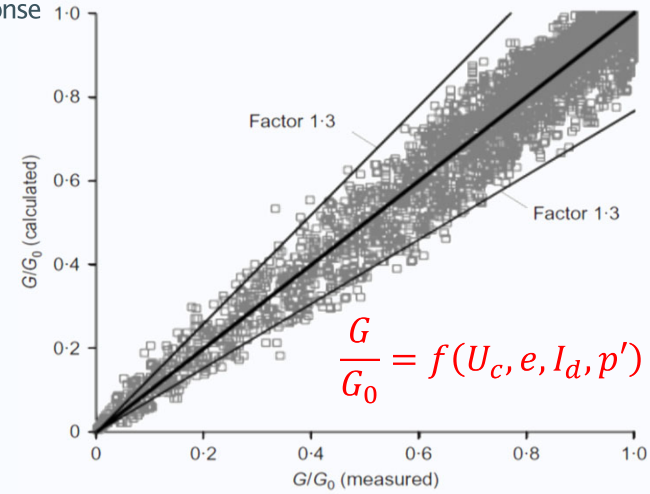


Oztoprak & Bolton (2013)

35

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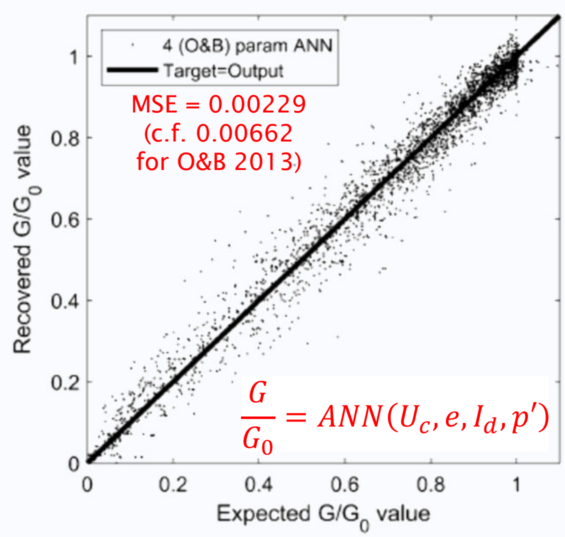
- Trained ANN provides $G/G_0$ degradation curve from any combination of index properties




Charles, Gourvenec & Vardy (2023) https://link.springer.com/article/10.1007/s11440-023-01879-4

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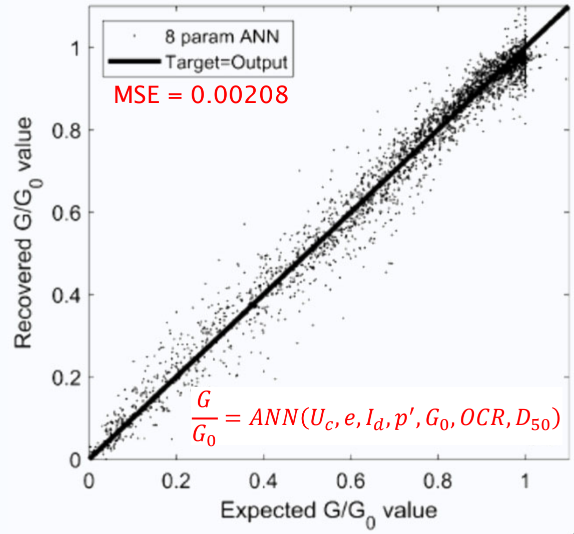


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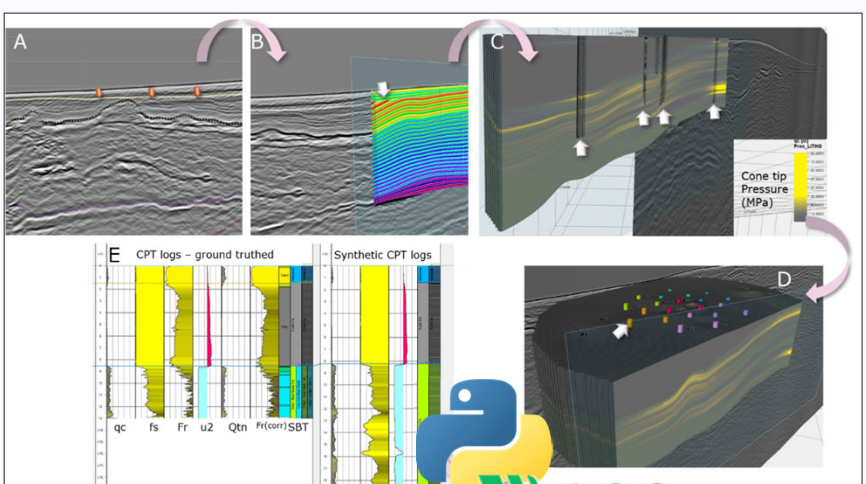
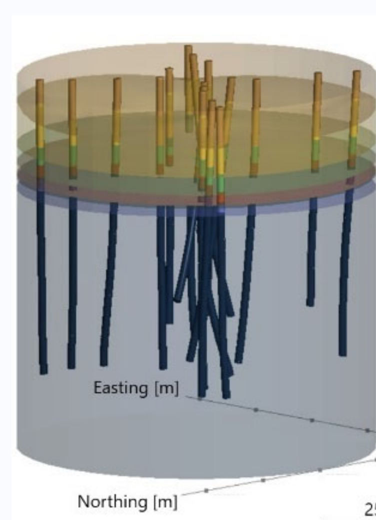
# GIS-BASED WORKFLOWS

From SUT OSIG 2023 conference: free online access




AGS

Patel et al. (2023), Senanayake et al. (2023)




Peuchen et al. (2023)

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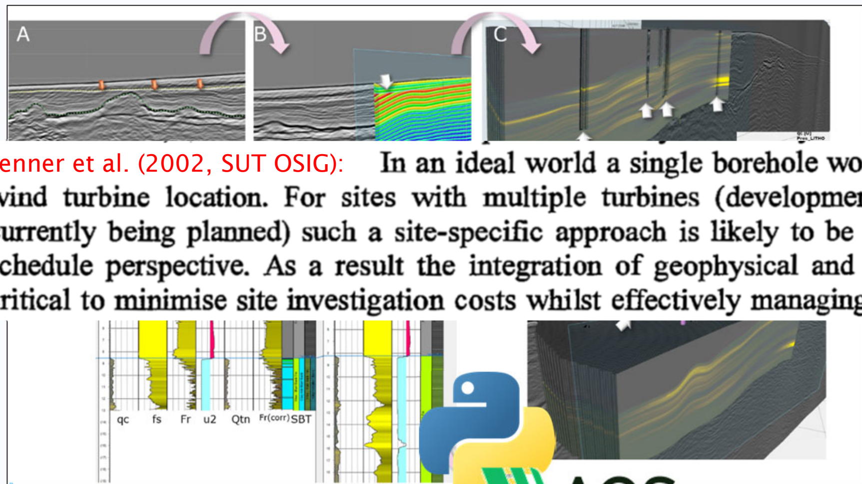


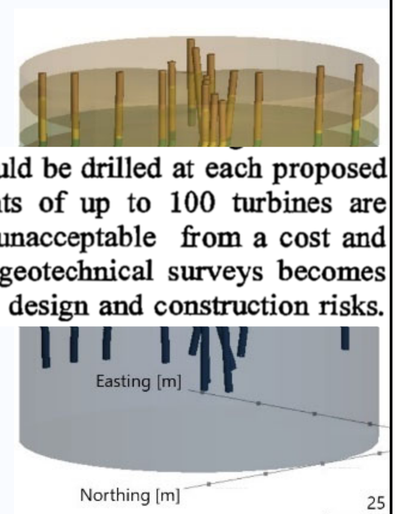


Jenner et al. (2002, SUT OSIG): In an ideal world a single borehole would be drilled at each proposed wind turbine location. For sites with multiple turbines (developments of up to 100 turbines are currently being planned) such a site-specific approach is likely to be unacceptable from a cost and schedule perspective. As a result the integration of geophysical and geotechnical surveys becomes critical to minimise site investigation costs whilst effectively managing design and construction risks.

AGS

Patel et al. (2023), Senanayake et al. (2023)

Peuchen et al. (2023)

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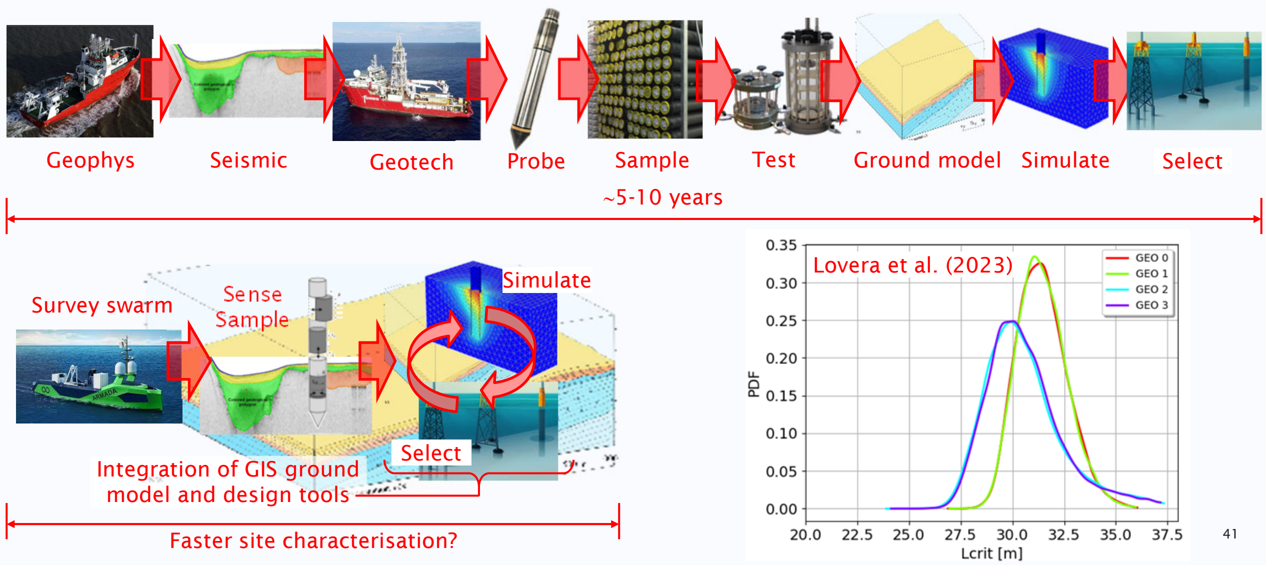
## OFFSHORE WIND SITE CHARACTERISATION OF THE FUTURE?

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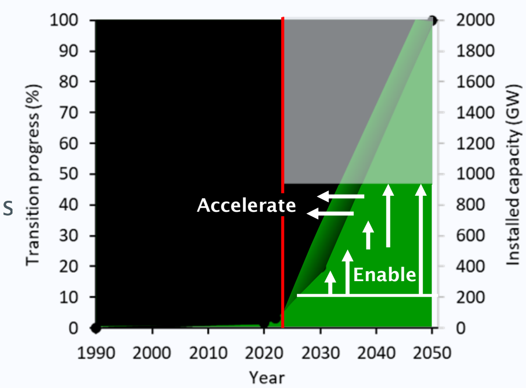
## CLOSING COMMENTS

Presentation structure

- We've built ~ 5% of the global wind for net zero
- The UK is at ~10%, but needs to get 6× faster
- A 1GW wind farm saves 40M tCO2e & 10,000 lives
- Speeding up OW by 3 months saves 400,000
- Offshore site investigation is on the critical path
- Now is the time for a rethink, and to innovate, with both a commercial and societal imperative




- The OSIG / Oceanology communities are key contributors in this race to save humanity
- Many new technologies exist... ...but adoption can be slow...
- ...yet the risk and cost of slow progress will eventually outweigh our usual project risks

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# Offshore wind site characterization
# Time for new ideas?

Professor Dave White
University of Southampton
Co-Director, UK Offshore Renewable Energy Supergen Hub

Oceanology, London
13 March 2024

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University of Southampton

# YOUR QUESTIONS

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