Supergen ORE Hub
Core Research Update

Supergen Offshore Renewable Energy

Engineering and Physical Sciences Research Council

Supergen Offshore Renewable Energy

CORE RESEARCH UPDATE 2

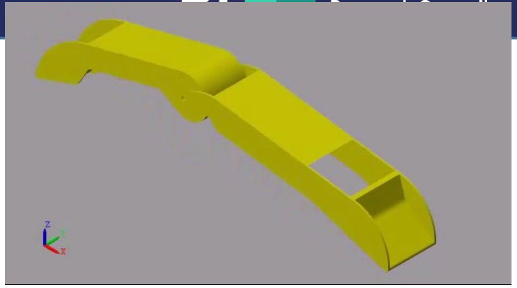
Deborah Greaves
Director of the Supergen ORE Hub

Professor of Ocean Engineering
University of Plymouth

UKRI Engineering and Physical Sciences Research Council

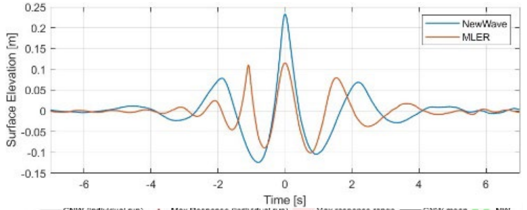
Supergen ORE Hub Phase 1 Design research at the University of Plymouth

Aim: Develop & validate design methods for floating ORE devices



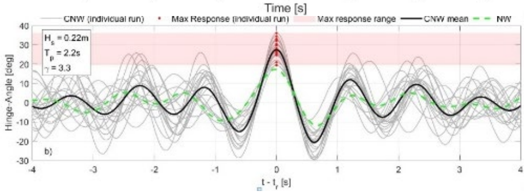
Existing Methods/Present Design Standards

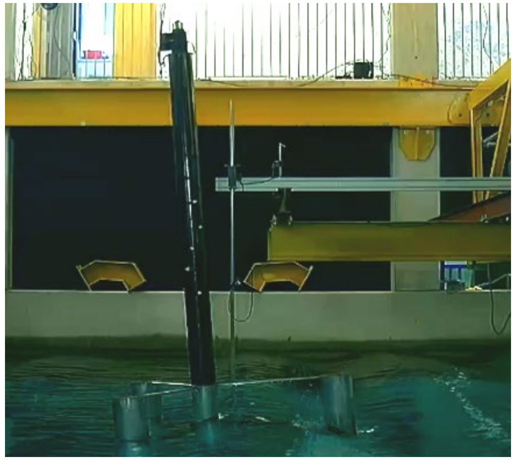
- Probabilistic approaches using large number of irregular sea states
- Robust but requires large quantities of simulated data



Short Design Waves (SDWs):

- More efficient method for characteristic load prediction in-line with design standards has been developed
- Single/embedded wave group to produce extreme responses
- Tested on a range of floating devices (WECs, FOWT)
- Promising results relative to present recommendations
- SDW procedures need refining for particular applications





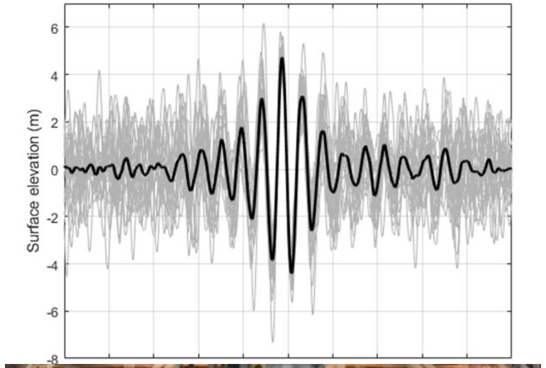
Impact:

- Wide range of device (TLPs, Spars, barges), response and mooring types
- Recommendations for floating ORE best practice/design standards
- Optimise SDW procedures (e.g. background wave selection)

Supergen ORE Hub Phase 2 Core Research at the University of Plymouth

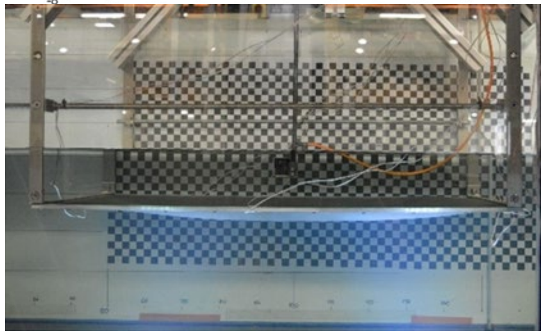
Probabilistic design approaches for ORE floating structures:

- Extend to include additional environmental conditions such as turbulent win currents and complex wind-wave-current misalignment scenarios
- Extend scale model experiments and numerical modelling to other FOWT platform types, multi-turbine platforms, floating tidal concepts and hybrid systems
- Comparison with blown wind simulations using the COAST Laboratory's new wind generation system
- FOWT fully coupled numerical model and representative design conditions the Celtic Sea, feeding into SRS3 and 5



Future ORE concepts:

- floating systems supporting multiple turbines/devices or hybrid platforms
- Flexible elastomer-based wave energy converters and direct embedded energy generation.
- Novel concepts and numerical tools feeding into SRS5



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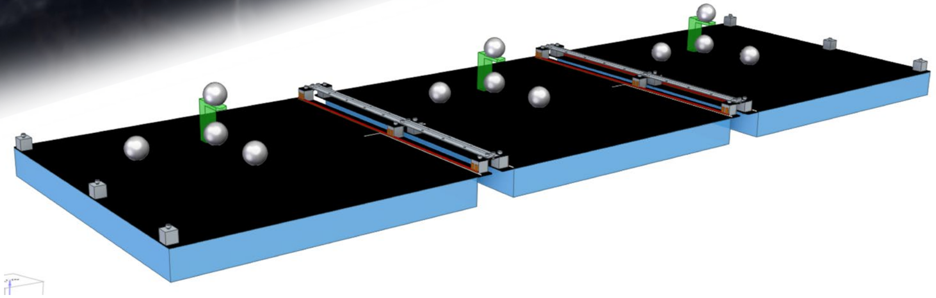
Co-Director of the Supergen ORE Hub

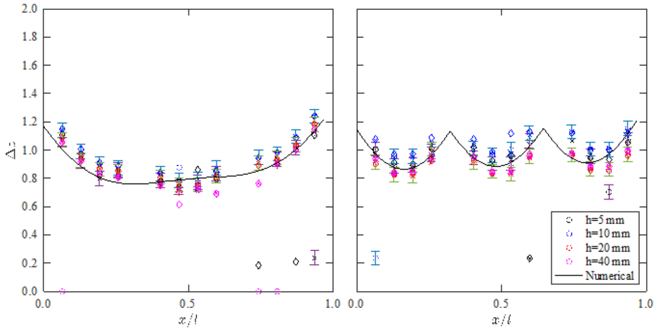
Professor Feargal Brennan
University of Strathclyde

UKRI Engineering and Physical Sciences Research Council

Phase 1: WS5 Floating Futures for ORE

- ❑ Understanding and developing models for ORE Floaters
  - Techno Economic Environmental Assessment
  - Very Large Floating Structures (VLFS)
  - Multirigid body dynamics
  - Elasticity modelling
  - Fluid-structure interaction
  - Structural design optimisation
  - Experimental test verification and validation





Arredondo-Galeana, A., Dai, S., Chen, Y., Zhang, X., Brennan F. (2023). "Very large hinged floating platforms for marine foundations and energy extraction." In the Proceedings of the 15th European Wave and Tidal Energy Conference (*abstract accepted*), Bilbao, Spain.

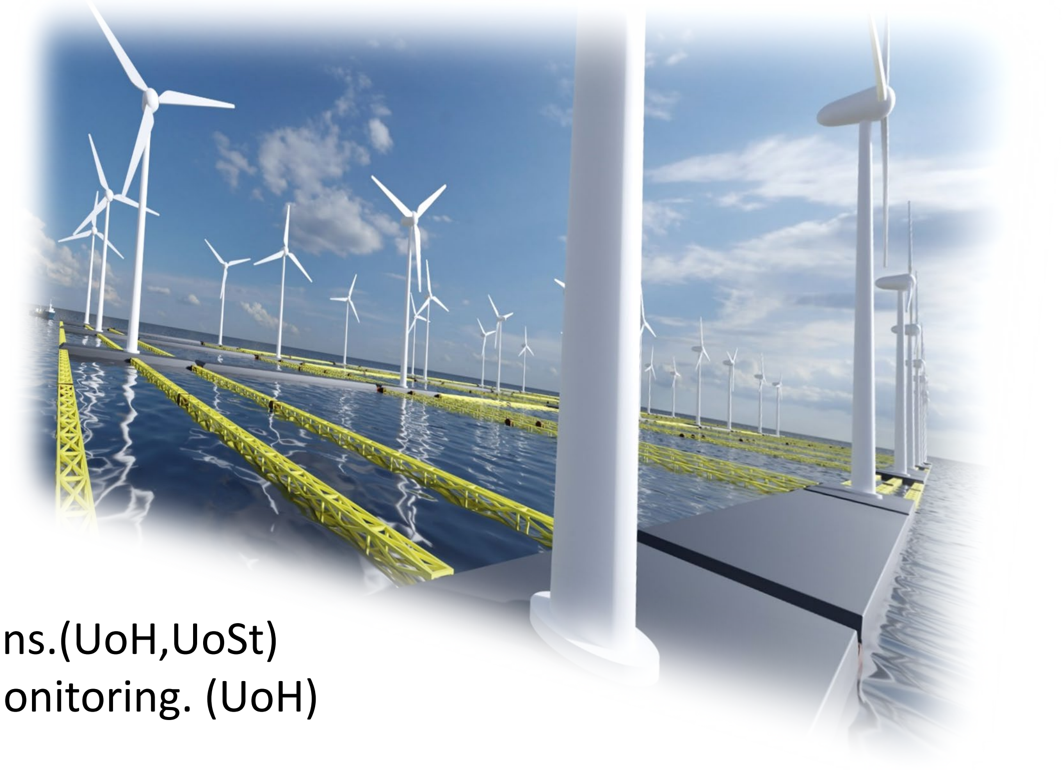
Phase 2: WS5 Future ORE systems and concepts

- Power density:
  - Recommendations for design of multi-turbine VLFS (UoSt)
  - Hybrid and co-location solutions (UoP, UoA)

- Longevity and Resilience Design Philosophies:
  - Innovative cable designs for current and future floating wind designs (UoEx)

- Resilient onshore and support infrastructure
  - Recommendations on circular economy supply chain considerations.(UoH,UoSt)
  - Manufacture and operation data and prognosis for through-life monitoring. (UoH)

- Power Integration:
  - Assessment of impact of increasing OWF penetration on short circuit levels (UoW)
  - Control strategies of OWFs enhancing short circuit level of the power grid (UoW)



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CORE RESEARCH UPDATE 2

Jim Gilbert

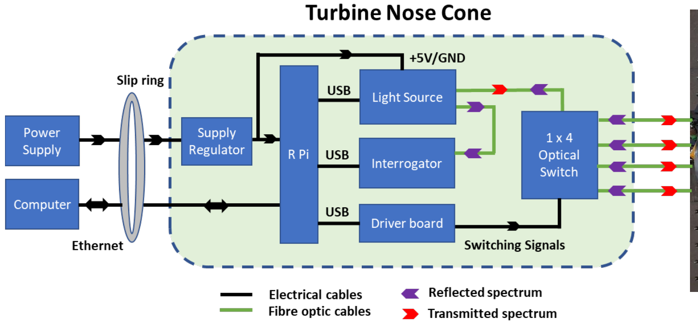
Co-Director of the Supergen ORE Hub

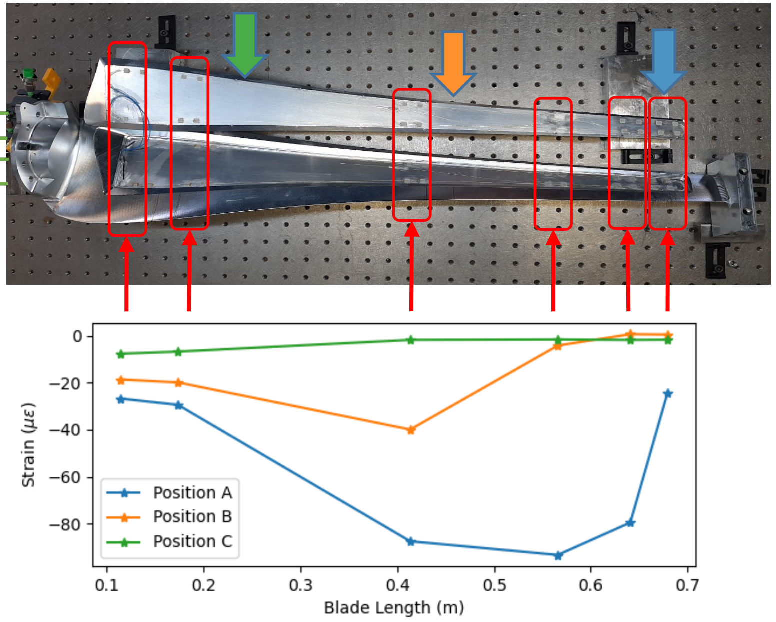
Professor of Engineering

University of Hull

Sensing in ORE structures

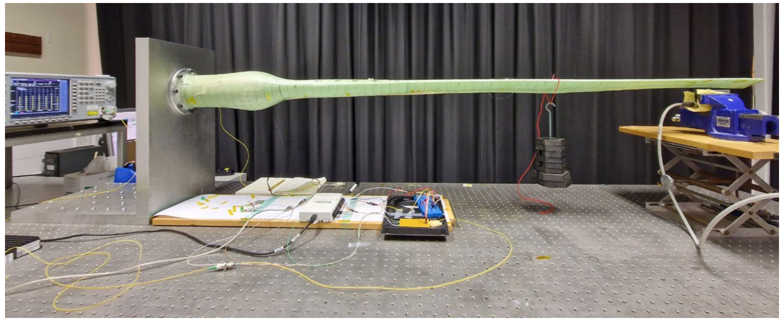
Distributed load estimation in tidal turbine benchmark



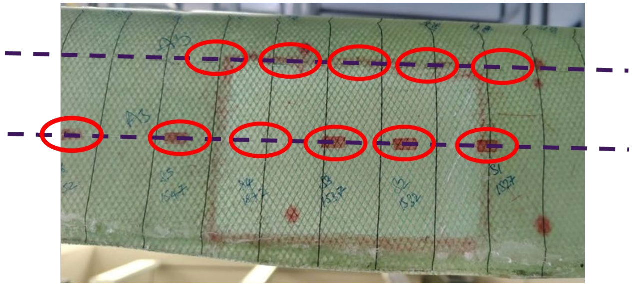


Using 24 fibre optic strain sensors and interrogation system built into the nose cone to estimate the distributed load along the blade.

Defect detection in composite structures



Heavily instrumented 1.8m scaled blade with artificial defect



How many sensors do we need to reliably detect small defect in ORE structures?

Sensing in ORE structures – Phase 2 plans

Developing cost effective techniques to increase density of sensing point

Using sophisticated signal processing techniques to maximise use of optical bandwidth and increase number of sensors

Investigating loop and mesh structures to make sensing systems more robust to damage

Use of low cost, robust interrogation systems for high resolution, high speed measurement

Application areas

Continue distributed blade load monitoring – feeding into SRS 1

Dynamic cable monitoring for floating ORE systems – feeding into SRS2

Investigating loop and mesh structures to make sensing systems more robust to damage

Lifetime monitoring of composite structures - from manufacture to end of life

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CORE RESEARCH UPDATE 2

Xiaowei Zhao

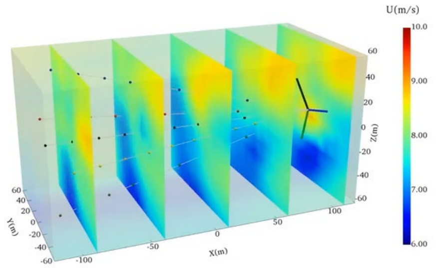
Co-Director of the Supergen ORE Hub

Professor of Control Engineering
University of Warwick

UKRI Engineering and Physical Sciences Research Council

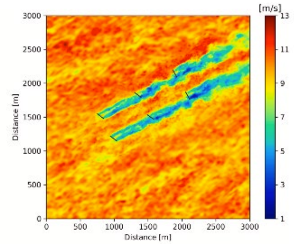
Supergen ORE Hub Phase 1: Modeling & Control Research at University of Warwick

Aim: Develop & validate novel AI methods for wind and wave applications



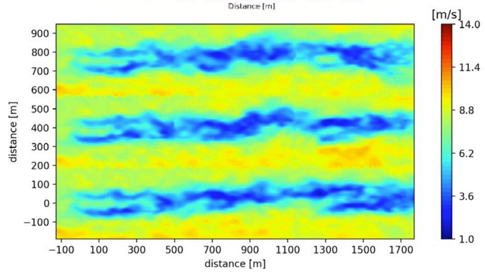
Digital twin of the wind turbine flow system via physics-informed deep learning

- Lack of flow digital twin: analytical, numerical, purely data-driven methods
- Data-physics-fusion method: the first digital twin of wind turbine flow system
- Impact: supporting the whole lifecycle of wind turbines



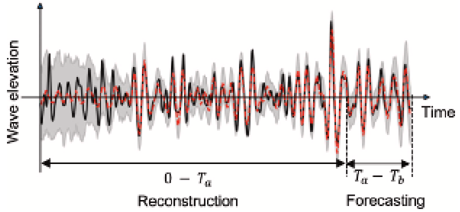
Intelligent wind farm control via deep reinforcement learning (DRL)

- Control barriers: system complexities, wake interactions, stochastic conditions
- A series of DRL-based wind farm control methods
- Impact: push the boundary of wind farm operation technologies



Accurate and efficient wind farm wake modelling via deep learning

- Current models: low-fidelity analytical models; high-fidelity numerical models
- A series of wind farm wake modelling approaches via GAN, CNN, multi-fidelity
- Impact: control-oriented real-time models capturing high-fidelity flow features



Phase-resolved real-time ocean wave prediction via DL (with Plymouth))

- Current methods: linear wave theory; HOS method; deterministic ML
- Phase-resolved real-time nonlinear wave prediction with quantified uncertainty
- Impact: the safe and optimal operation of WECs via risk-aware wave prediction

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Deep learning based modelling of wave-structure interactions

- Design new deep learning models to handle the complex scenarios of wave-structure interactions, based on the state-of-the-art diffusion model
- Target at optimised performance of DL models for generating high-dimensional content (e.g. flow field and wave field generation) and multi-model learning
- A large-scale wave-structure interaction dataset will be generated by numerical simulations, which will include different incoming wave conditions
- Validations will be carried out via comparison with the measurements from wave tank experiments
- The DL model will achieve real-time simulations of the WEC dynamics

Grid integration

- DRL Based control strategies of offshore wind farms enhancing short circuit level of the power grid