Supergen

Offshore Renewable Energy

Early Career Researcher Posters and Abstracts Booklet

2025 Annual Assembly

Surnames N - Z

Engineering and Physical Sciences Research Council

Supergen Offshore Renewable Energy

Early Career Researcher Posters 2025

Sebastian Neira Castillo, The University of Edinburgh Wide-Bandgap Power Electronics Topologies for Wave Energy Dielectric Elastomer/Fluid Generators
Duc Nguyen, University of Bristol Applied Bifurcation Methods For Efficient Airborne Wind Energy Generation
Charikleia Oikonomou, Hellenic Centre for Marine Research (HCMR), Institute of Oceanography **Multi-axis motion analysis of TALOS Wave Energy Converter under realistic sea states**
Claudio Alexis Rodriguez Castillo University of Strathclyde Assessing Operational Profiles for Offshore Renewable Energy: A Data-Driven Approach for Hydrogen Production Feasibility
Miad Saberi, University of Oxford Numerical Simulation of Laterally Loaded Monopiles for Offshore Wind Turbines using an Advanced Hyperplasticity Model
Isha Saxena, Durham University Reducing Uncertainty for Bayesian Analysis in Wind Energy Systems
Zhenyi Yan, University of Plymouth Enhancing Marine Concrete Performance: Fatigue Mechanics of Polymer-Modified Concrete
Markella Zormpa, University of Oxford Impact of support structure modelling methods in actuator line method large eddy simulations of wind turbine wakes

Sebastian Neira Castillo, The University of Edinburgh

Job Title: Research Associate

Academic Discipline: Electrical Engineering

I would like to present the advances on the research activities related to my project "Wide-Bandgap Power Electronics Topologies for Wave Energy Dielectric Elastomer Generators", funded through the Supergen ORE Hub ECR Research Fund.

The project explores the potential benefits and challenges of implementing wide-bandgap semiconductor-enabled power converters for wave energy dielectric elastomer generator (DEG) systems. The project analyses DC-DC converter topologies suitable for performing DEGs' priming and energy harvest processes with enhanced efficiency. Then, a small-scale 5 kW converter will be implemented and tested in the laboratory using a Hardware-in-the-loop strategy, where the DEG dynamics will be implemented in a real-time simulator.

The project is meant to be a first step in researching the potential benefits of using wide-bandgap semiconductor power electronics designed specifically for DEG wave energy applications. The main activities associated with the project are (i) Evaluation of DEG operational requirements for the power conversion system; (ii) Assessment of suitable topologies and most appropriate wide-bandgap semiconductor technology for the application; (iii) Implementation of laboratory scale prototype to test using a hardware-in-the-loop strategy, with the DEG dynamics implemented in a real-time simulator.

The proposed poster will focus on activities (i) and (ii) and will provide an update on the status of activity (iii).

THE UNIVERSITY of EDINBURGH

Wide-Bandgap Power Electronics Topologies for Wave Energy Dielectric Elastomer/Fluid Generators

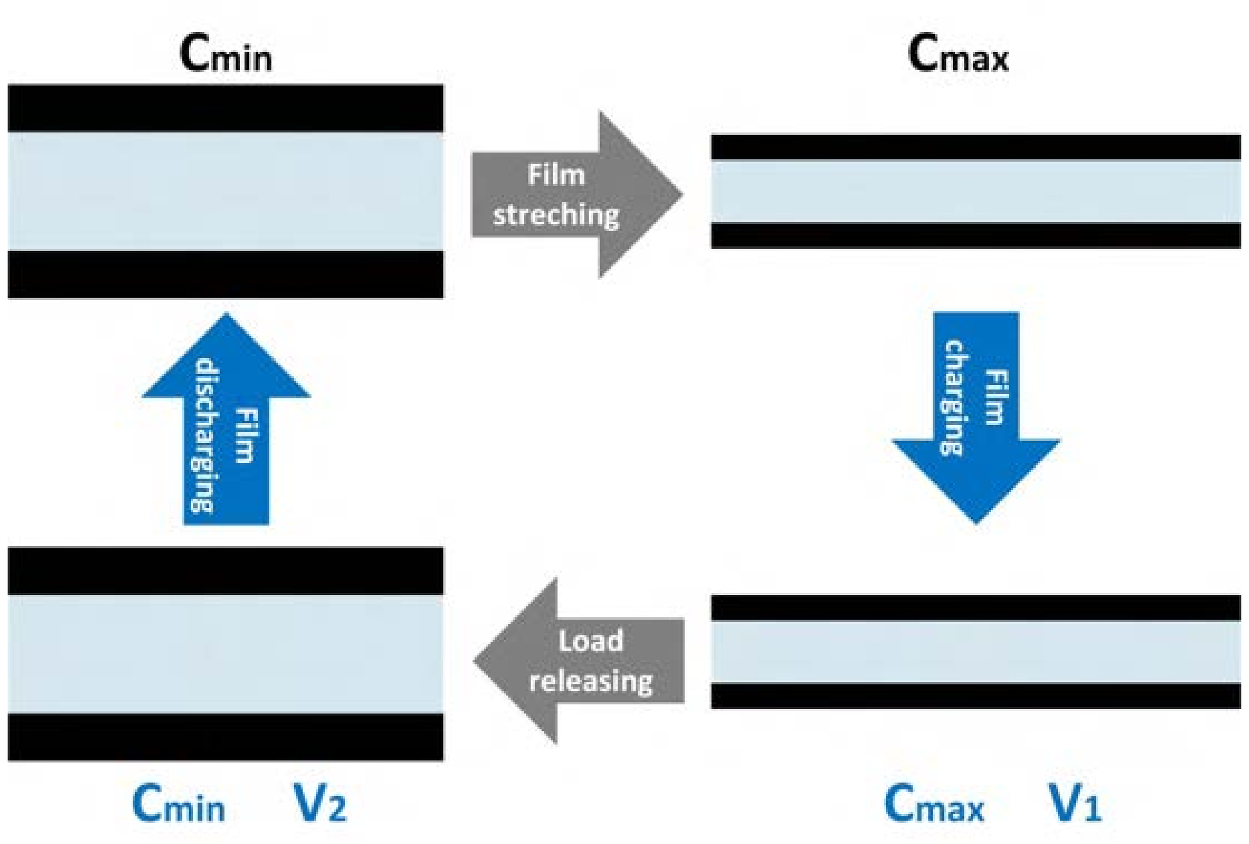
Sebastian Neira Castillo – s.neira@ed.ac.uk

Motivation: Advance the technology readiness level of Dielectric Elastomer Generator systems by developing wide-bandgap power converters

Dielectric Elastomer Generators (DEGs) and Dielectric Fluid Generators (DFGs) offer high energy densities and low mechanical complexity, particularly attractive for marine environments.

Power take-off systems require bidirectional power capabilities and to withstand efficiently high peak power levels (several kW), to perform the charge/discharge process, but low average output power

Gallium Nitride (GaN) power electronics offer significant advantages over traditional silicon-based devices, including higher efficiency, lower losses, and increased power density.



The project will result in the implementation of a 5-kW laboratory prototype of a wide-bandgap semiconductor-based DC-DC converter, designed for the studied DEG specifications.

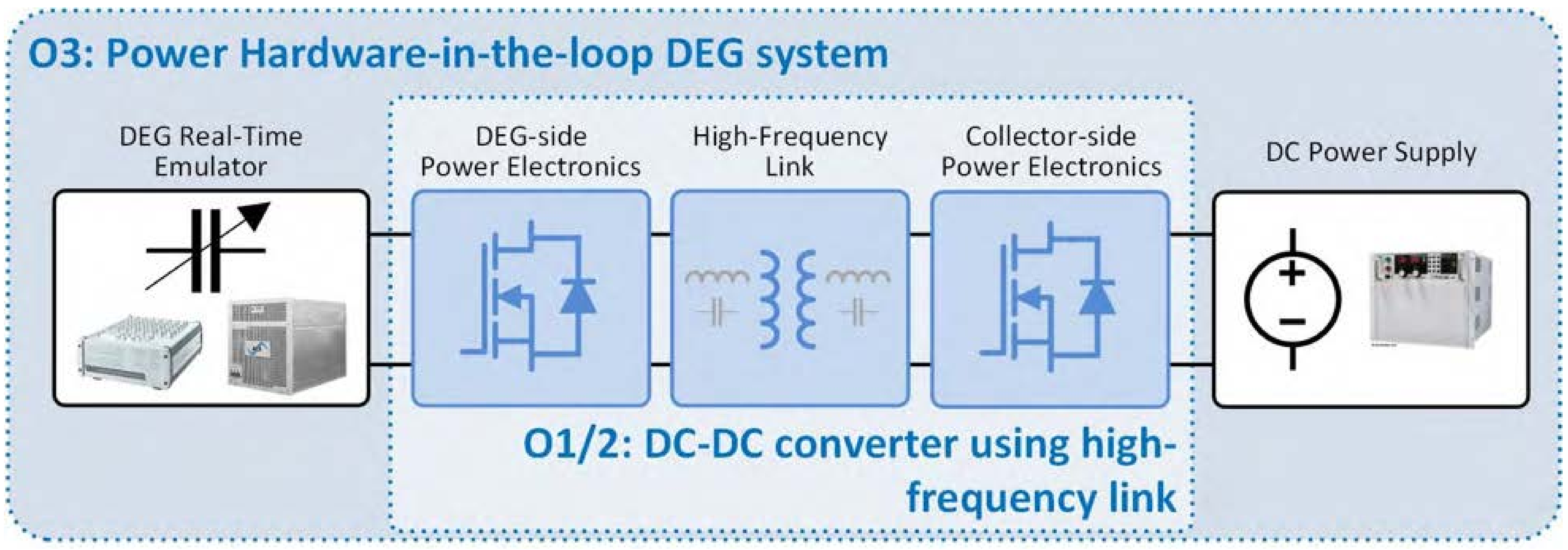
The main goal of the proposed research is to develop high-voltage high-frequency DC-DC power converter topologies using wide-bandgap semiconductors, such as GaN, capable of performing the power take off process in an efficient and reliable manner for future wave energy systems.

The specific objectives to achieve the outlined goal are defined as follows:

Objective 1: Conceptualisation and design of a 10 kV capable DC-DC converter using GaN devices, currently rated for 650 V, using modular strategies.

Objective 2: Analysis and construction of resonant links and their respective control and modulation strategies to maximise the efficiency of the charge/discharge process of the DEG given the high peak power levels.

Objective 3: Implementation of a Power Hardware-in-the-loop system emulating the dynamics of the DEG for validating the operation of the developed power converters.



Conclusions & Future Work

Resonant Isolated DC-DC converters based on GaN technology offer enhanced efficiency to perform priming and energy harvesting processes of DEGs and DFGs.

Power hardware in the loop strategy will allow validating a 5 kW prototype, with the DEG/DFG dynamic implemented in a real-time simulator.

The developed power converter will be validated at the University of Edinburgh Power Conversion laboratory with capability for testing devices up to 2000 V and 2000 A.

The author would like to acknowledge the support of Supergen ORE Hub ECR Research Funding

Duc Nguyen, University of Bristol

Job Title: Lecturer in flight dynamics and control

Academic Discipline: Aerospace engineering

Airborne wind is an emerging clean-energy technology with both onshore and offshore potential. Wind energy is extracted from tethered flying devices, which fly as high as 800 m to access higher wind speeds.

The key aspect for safe and efficient operation of airborne wind is flight control. Past research has identified the optimal flight paths. However, these trajectories have yet to be verified on high-fidelity simulations and test flights. This project focuses on the first half of the problem. We propose a two-layer cascaded control architecture to track the circular reel-out path in fixed-wing airborne wind systems. The novelty is in the inner layer, which uses a non-static reference frame to keep the tethered aircraft in circular orbits. This method maintains the kinetic-potential energy exchange, which prevents the loss-of-energy that would be encountered if the unpowered aircraft took a straight-line path to its desired destination. The proposed controller manages all three control surfaces (aileron, elevator, and rudder), enabling navigation in 3D space while tracking a desired angle of attack and zero sideslip. Furthermore, no way point or lookahead is used, giving a continuous controller suitable for classical closed-loop analysis. We tested the system in a variety of reel-out situations on an industrial, 6-degree-of-freedom simulation with full aerodynamic and tether dynamics. Performance was satisfactory in all cases despite the use of only proportional-integrator regulators, thereby highlighting the effectiveness and simplicity of our proposed architecture. This work provides a template for further developments that could incorporate more complex control algorithms, promising higher safety and efficiency of airborne wind. As an example, we proposed a minor modification to the pitch channel, which virtually eliminates the angle-of-attack oscillation during reel out.

APPLIED BIFURCATION METHODS FOR EFFICIENT AIRBORNE WIND ENERGY GENERATION

University of BRISTOL — Kitemill — Universidad Carlos III de Madrid

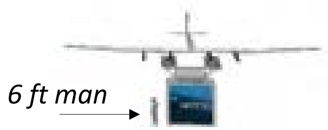
1. AIRBORNE WIND ENERGY

100 kW
16 m wingspan
5 tons

Operating altitude:
300-700 m

100 kW
26 m diameter
50 tons

Hub height:
30 m



Easy transport

Use in remote areas, low-wind regions, disaster relief, military deployment (in testing with Dutch army)

24h operation

Strong and consistent wind at high altitudes

Reduced life cycle carbon footprint

60% lower cumulative energy demand *(Hagen, 2023)*

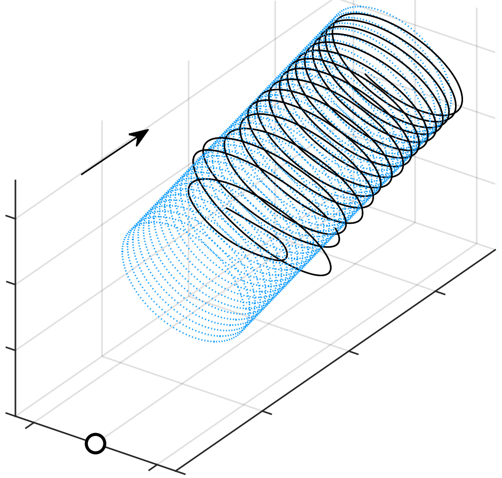
Similar energy cost to wind turbines *(Malz, 2020)*

2. THIS FELLOWSHIP

CHALLENGE: realising theoretical predictions

Optimal flight paths established.

How can the aircraft follow that path automatically?

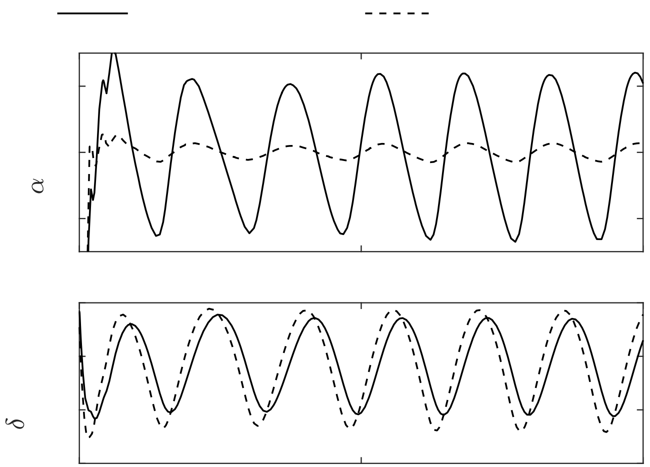


RESULTS

Derived a general control framework to guide the aircraft along a desired path.

Novelty: use of a non-static reference frame. Works with simple PI controller.

Eliminated the angle-of-attack during power production.



NEXT STEPS

Verify the theoretical predictions using simulations and potentially test flights.

DUC H. NGUYEN

ACADEMIC APPOINTMENTS

December 2023-present
Lecturer in Flight Dynamics and Control
University of Bristol

2022-2024
Lead Tutor in Control Engineering
University of Cambridge Online

2021-2023
Postdoctoral researcher
University of Bristol

EDUCATION

2019-2021
PhD Aerospace Engineering
University of Bristol

2015-2019
MEng Aerospace Engineering
University of Bristol

CURRENT PROJECTS (100% FTE)

Airborne wind energy
EPSRC postdoctoral fellowship
Collaboration with Norwegian startup Kitemill (see figure)
£375k, PI
2024-27

Folding wingtips
Innovate UK grant
£870k, co-I
2024-26

OTHERS

Private pilot license (2018)

Kitemill's KM1 airborne wind prototype

Charikleia Oikonomou, Hellenic Centre for Marine Research (HCMR), Institute of Oceanography

Job Title: Post-doctoral Research Associate

Academic Discipline: Wave energy

TALOS is a novel point-absorber Wave Energy Converter (WEC) developed at Lancaster University, designed to extract energy from multiple motion modes—surge, heave, and pitch—through a multi-axis omni-directional Power-Take-Off (PTO) system. Unlike traditional WECs that often operate in a single degree of freedom, TALOS maximises energy capture potential while maintaining structural integrity in a range of sea conditions. This study investigates the hydrodynamic performance of TALOS under four representative wave climates using a combination of frequency-domain and stochastic modelling. The analysis incorporates realistic irregular wave conditions via the Bretschneider spectrum, using significant wave height and energy period as key input parameters. Hydrodynamic coefficients were computed using panel methods, and the motion response was evaluated through Response Amplitude Operators (RAOs) and standard deviation calculations. Wave climate data were retrieved from the Copernicus Marine Service, allowing for site-specific analysis at four locations: the Isle of Islay, the southwest Irish coast, the Cantabrian Sea, and west of Sardinia. By identifying the most probable sea states at each site, the resonance characteristics of the WEC were tuned using Froude scaling to adjust the device's characteristic width. This optimisation aims to align the device's heave natural period with the dominant wave energy period at each location, thus improving energy conversion efficiency. Results show that surge and heave are the dominant energy-contributing modes for TALOS. Sites in the North Atlantic (Islay and Irish coast) offer strong alignment with the device's original design, while adjustments are recommended for deployment in lower-energy regions like the Mediterranean. This study represents an initial step toward performance-based scaling of TALOS for global deployment and provides insight into how multi-axis WECs can be adapted for diverse marine environments.

Multi-axis motion analysis of TALOS Wave Energy Converter under realistic sea states

Charikleia L.G. Oikonomou[1], Wanan Sheng[2], Gerasimos Korres[1], George Aggidis[2]

1. Hellenic Centre for Marine Research - HCMR, Greece

2. Renewable Energy Group, Energy Engineering, Lancaster University

Lancaster University

hcmr ΕΛΚΕΘΕ

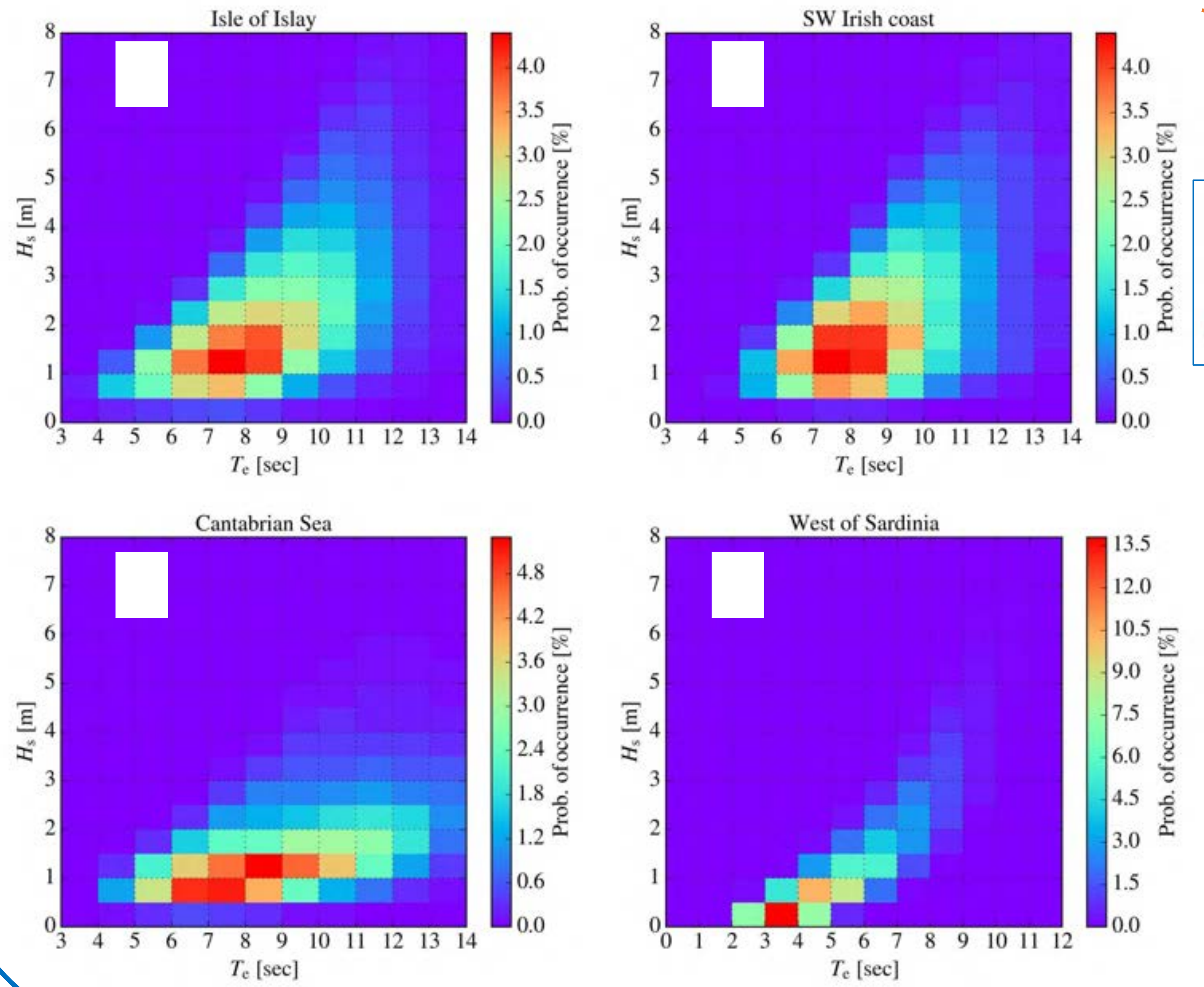
Introduction/Motivation

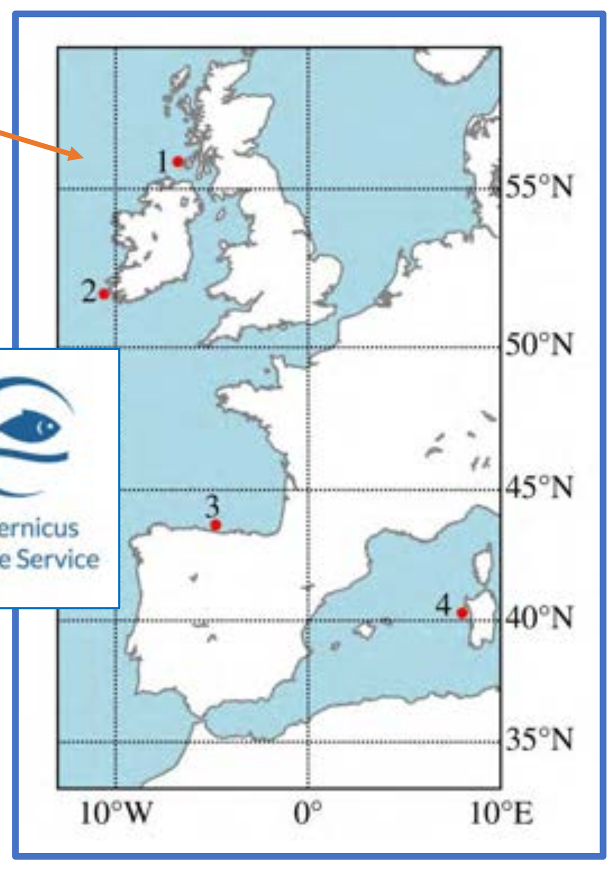
TALOS, developed at Lancaster University, is a novel wave energy converter (WEC) designed to extract power from multiple motion modes—surge, heave, and pitch—via a multi-axis omni-directional Power-Take-Off (PTO) system.
This study evaluates its performance under four representative wave climates using both frequency-domain and stochastic modeling, guiding device optimisation for deployment.

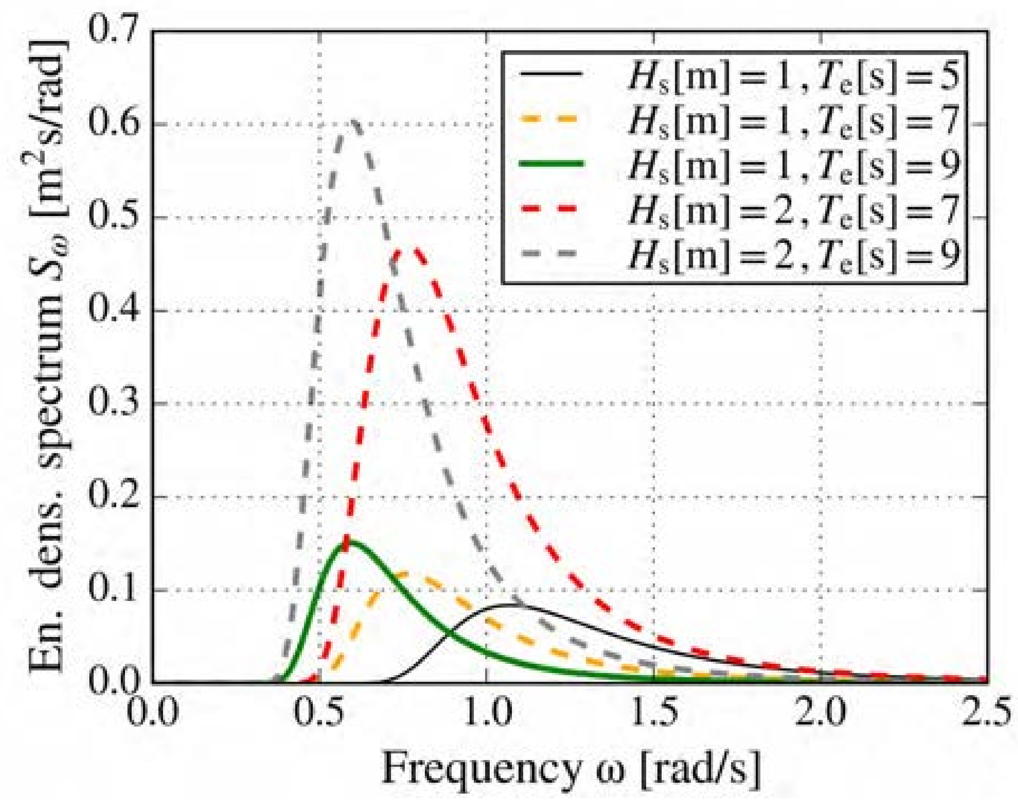
PTO test rig

Methodology

Wave climate locations analysed (1–4)



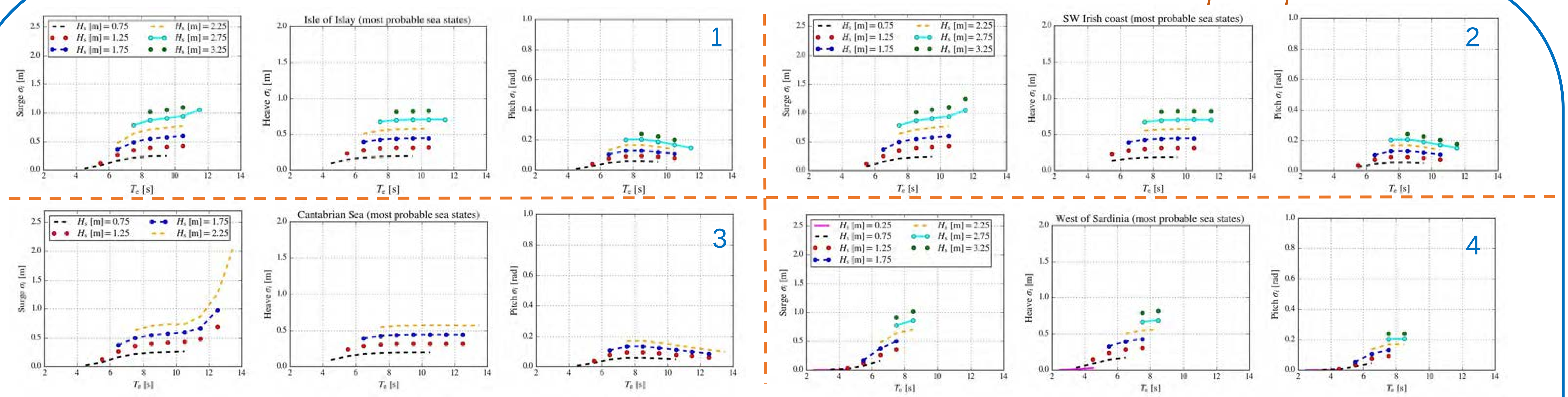




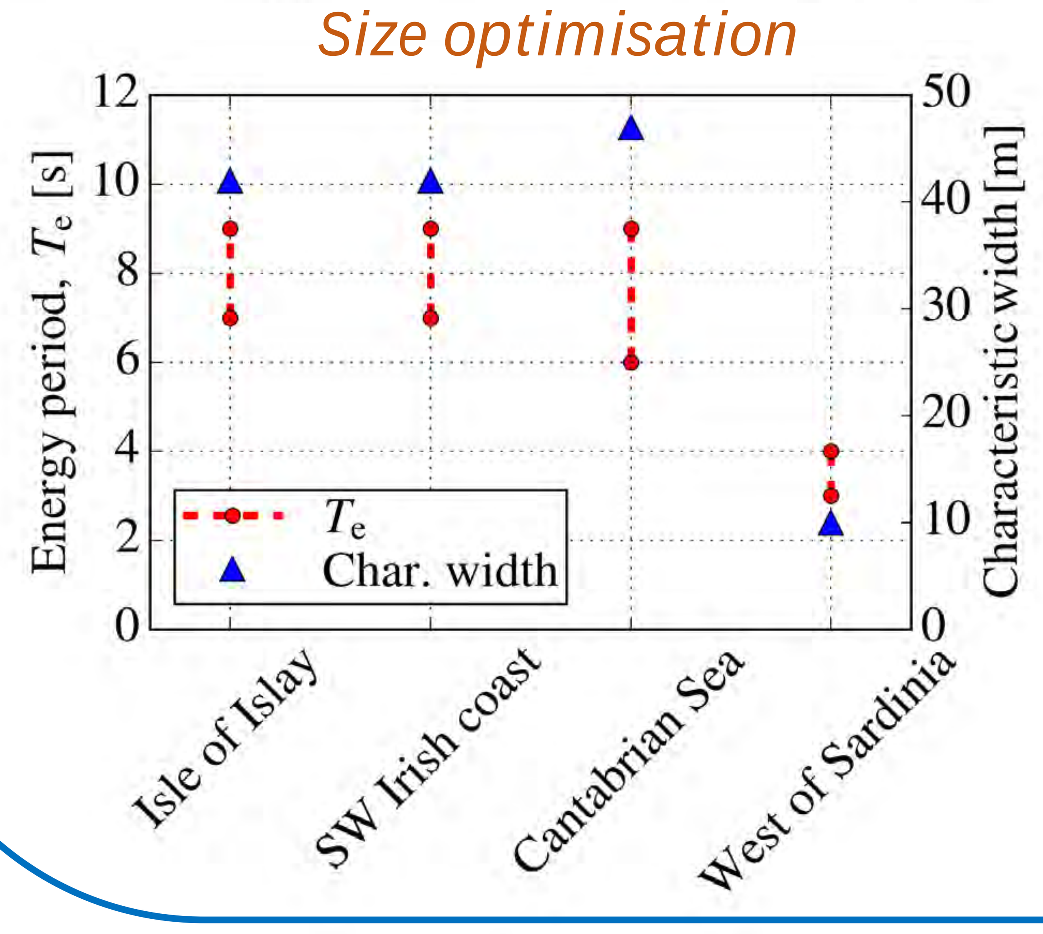
Hydrodynamic analysis was conducted using both frequency-domain and stochastic approaches. A semi-empirical Bretschneider wave spectrum was modelled to represent realistic sea states (wave data were retrieved from the Copernicus Marine Service). Key parameters included significant wave height and energy period. Response Amplitude Operators (RAOs) and standard deviations were computed using panel methods (WAMIT) and statistical estimations to assess TALOS motion.

Results and discussion

Stochastic model results: Standard deviation of motion response per location



Size optimisation



By analysing the most probable sea states from wave reanalysis data, we determined ideal adjustments to TALOS's width for resonance-based tuning using the Froude scaling law.
These recommendations aim to align the device's heave resonance with the most common incoming wave periods at each location

Scan to learn more about the TALOS WEC Project Lancaster University

Access to wave climate Copernicus Marine Service data

Original paper:
Oikonomou, C. L. G., Sheng, W., Korres, G., & Aggidis, G. (2023). *Operating of TALOS wave energy converter in different wave climates.* Paper presented at the ISOPE International Ocean and Polar Engineering Conference. (Paper No. ISOPE-I-23-094)

Assessing Operational Profiles for Offshore Renewable Energy: A Data-Driven Approach for Hydrogen Production Feasibility

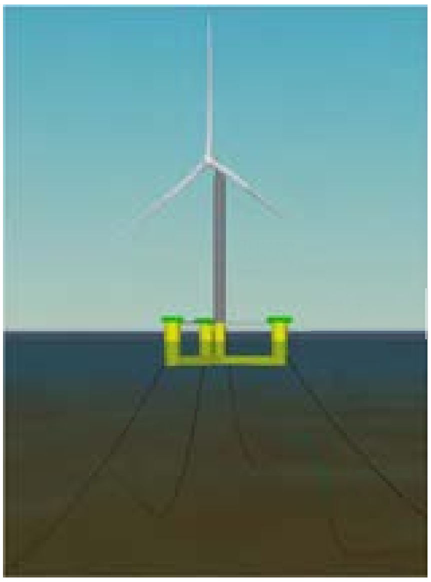
Claudio A. Rodríguez, Maurizio Collu, Feargal Brennan

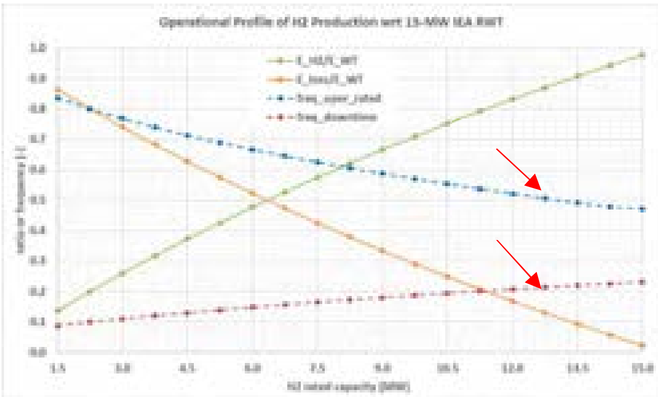
Department of Naval Architecture, Ocean & Marine Engineering, University of Strathclyde, Glasgow

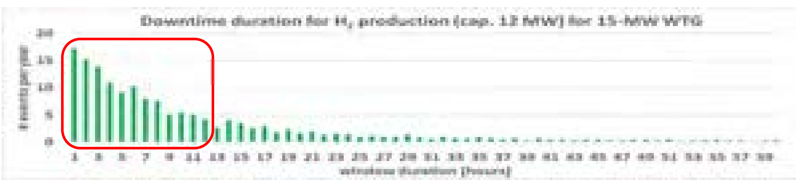
The integration of offshore renewable energy with hydrogen production presents a promising pathway for decarbonization. However, the variability of metocean conditions introduces challenges in determining reliable operational windows for energy conversion processes. This study presents a systematic approach to analysing historical wind and wave records to assess operational and downtime periods for floating wind-hydrogen systems (FWHS).

Using the IEA 15-MW reference wind turbine power curve, we estimate power generation and energy production at the ScotWind NE8 site based on several years of hindcast metocean data. By evaluating wind speed, wind turbine (WT) power output, and typical operating requirements for various alkaline electrolyser (AEK) rated capacities, we compute performance profiles for both the WT and the hydrogen facility. This analysis includes estimations of electrolyser energy consumption, curtailed WT energy, capacity factors and operational/downtime frequencies.

Through persistence and exceedance/non-exceedance analyses, we characterise operational and downtime events relative to offshore hydrogen production thresholds. Preliminary results indicate that while the 15-MW WT achieves a good capacity factor, wind resource variability still impacts hydrogen production. However, integrating other offshore energy (ORE) resources, such as wave energy, could significantly mitigate these effects. Indeed, an initial assessment of wave conditions suggest that sustained suitable wave conditions at the installation site could substantially reduce operational downtime and under-rated hydrogen production. These insights contribute to optimising offshore renewable energy utilization and enhancing the economic viability of offshore hydrogen production through ORE resource complementarity.







Assessing Operational Profiles for Offshore Renewable Energy: A Data-Driven Approach for Hydrogen Production Feasibility

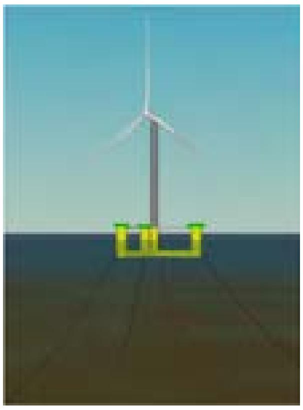
Claudio A. Rodríguez, Maurizio Collu, Feargal Brennan

Department of Naval Architecture, Ocean & Marine Engineering

Background

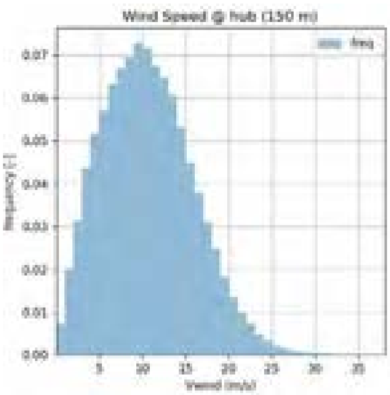
Ref: Buchan Offshore Wind @ LinkedIn.com

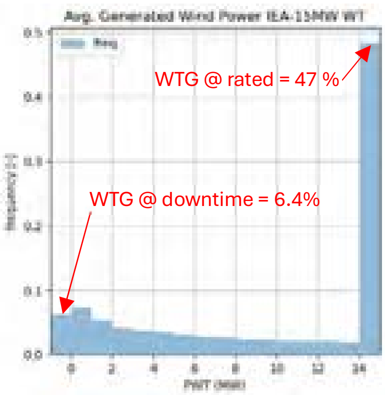
Decentralised Floating Wind-H_2 System



- 15-MW IEA RWT
- Integrated H_2 facilities
- ERA5 hindcast metocean data (2002 – 2021)
- AEKs typical operational requirements: rated capacity at 80% of rated WT power, minimum load of 20% rated capacity.

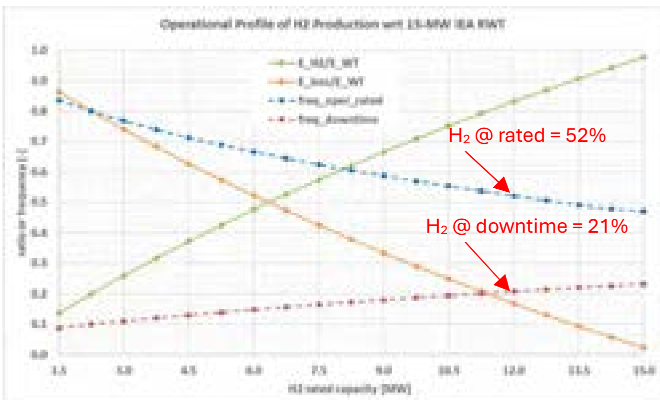
Wind Energy Resource





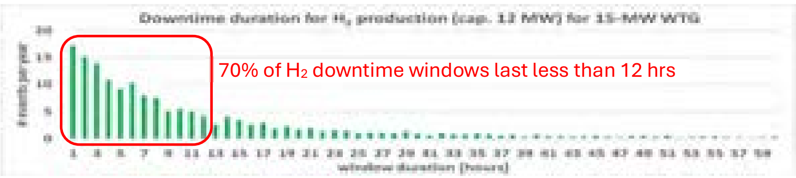
15-MW WTG capacity factor = 64.5%

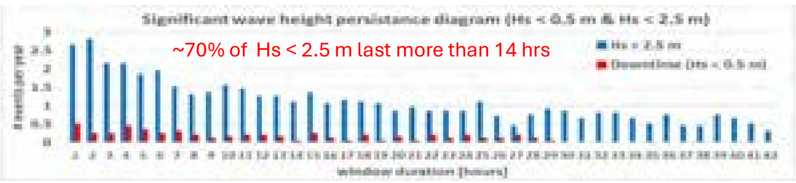
Operational Profile of H_2 facility



12-MW AEK oper. factor = 83.1% (wrt WT gen. power)

Persistence downtime: AEK & Hs





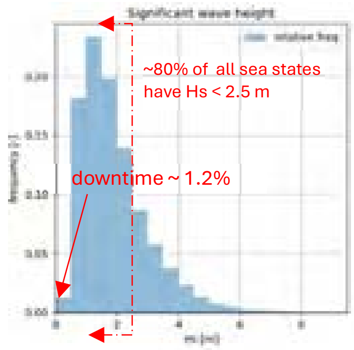
Complementary ORE potential

- Required complementary power (15-MW WTG & 12-MW AEK):

  0.20 * 12.0 = 2.4 MW

Thus:

- 10 WECs (~250 kW), or
- 02 tidal devices (~1.2 MW)
- Fuel cells?



Conclusions & Future work

- ✓ Number of shutdown/start-up events are critical for H_2 production feasibility assessment;
- ✓ Downtime wind energy persistence diagrams evidence the need to complementary energy resources;
- ✓ Wave energy seems to be a promising complementary resource: power and persistence;
- ○ Investigate wind–wave joint occurrences and correlation;
- ○ Investigate WECs and other ORE devices suitable for WTG & AEK downtime windows.

Ocean REFuel

Supergen ORE Hub Early Career Researcher Forum

Supergen

Miad Saberi, University of Oxford

Job Title: Postdoctoral Researcher

Academic Discipline: Civil and Geotechnical Engineering

Numerical Simulation of Laterally Loaded Monopiles for Offshore Wind Turbines using an Advanced Hyperplasticity Model

Miad Saberi, Luc E.J. Simonin, Guy T. Houlsby, Byron W. Byrne

Department of Engineering Science, University of Oxford, UK

Abstract

Monopiles are the widely used foundation system for offshore wind turbines (OWTs), with three-dimensional (3D) finite element (FE) analysis commonly used for their design and assessment. However, reliable predictions from 3D FE simulations require an advanced soil constitutive model capable of accurately capturing complex soil-structure interactions under both monotonic and cyclic loading. This study explores the application of the HySand model, a multi-yield surface effective stress constitutive model formulated within the hyperplasticity framework and consistent with thermodynamic principles, to simulate monopile behaviour in OWT foundations. HySand effectively represents both dilative and contractive sand behaviour across varying densities and confinement pressures under different loading conditions. In this study, the model parameters are first calibrated using laboratory soil test data, followed by 3D FE simulations of a laterally loaded monopile. The force-displacement response is analysed for different soil densities and loading paths, including unload-reload loops.

Numerical Simulation of Laterally Loaded Monopiles for Offshore Wind Turbines using an Advanced Hyperplasticity Model

Miad Saberi*, Luc E.J. Simonin, Guy T. Houlsby, Byron W. Byrne
Department of Engineering Science, University of Oxford, UK
*Email: miad.saberi @eng.ox.ac.uk

UNIVERSITY OF OXFORD

Introduction & Problem Statement

Monopiles, large-diameter open-ended steel piles (6–10 m) with L/D ratios of 3–8, are the preferred foundations for offshore wind turbines (OWTs) in shallow waters (Byrne et al. 2020). As foundation costs significantly impact OWT costs, optimizing the design and understanding of the monopile behaviour under lateral loads is crucial. While 0D and 1D methods are common, 3D FE modelling with advanced constitutive models offers more realistic predictions. The main challenge is developing an efficient and sophisticated model to capture complex soil–pile interaction and sandy soil behaviour under varied loading.

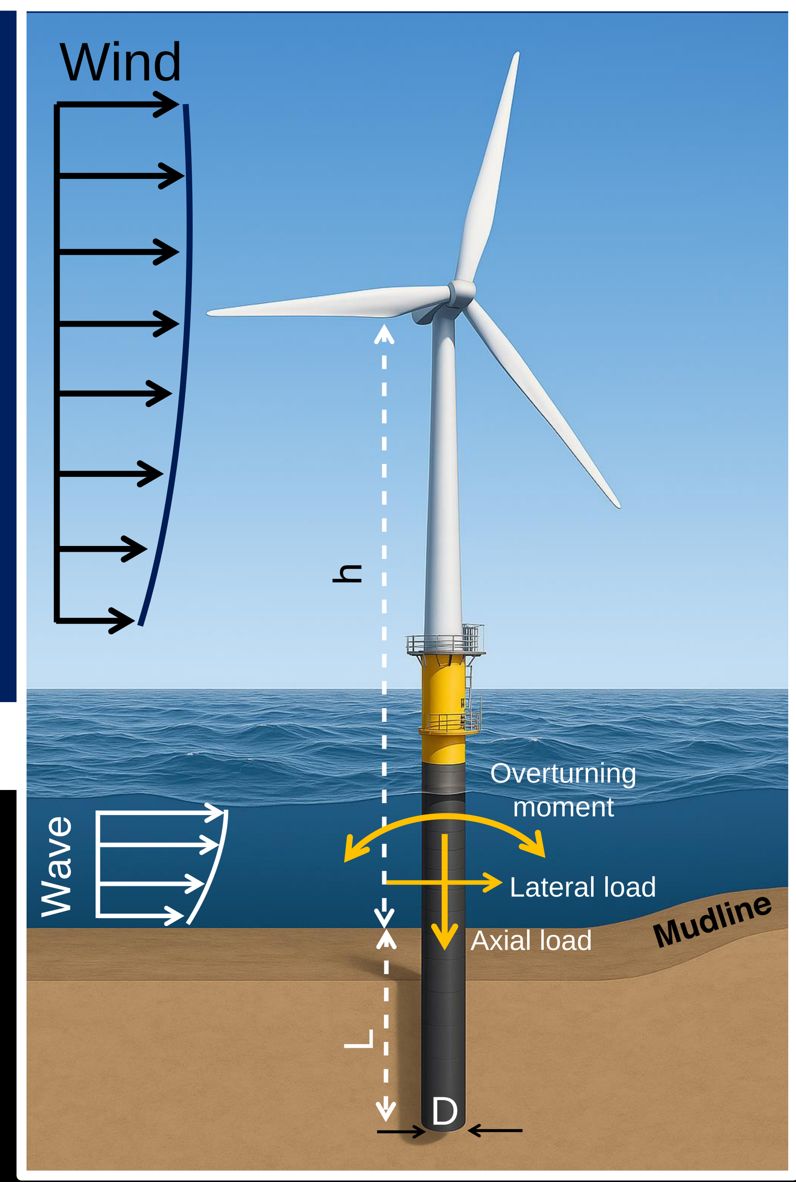


Fig.1: Monopile foundation for OWT

Objective

1. Develop an advanced sand constitutive model for monotonic and cyclic loading
2. Calibrate the model with laboratory element tests
3. Implement the model into FE code and apply to laterally loaded monopiles

1 HySand Model Development

HySand is a hyperplasticity-based effective stress model with multiple yield surfaces (Simonin, 2023), based on thermodynamic principles.

Gibbs energy function (g):

$$g=-\frac{p_r}{k_r(1-m)(2-m)}\left(\frac{p_0}{p_r}\right)^{2-m}-q\frac{1}{N}\sum_{n=1}^{N}\alpha_q^{(n)}-p\frac{1}{N}\sum_{n=1}^{N}\left(\alpha_p^{(n)}+\alpha_{pc}^{(n)}\right)$$

$$p_0^2=p^2+\frac{k_r(1-m)}{3g_r}q^2$$

Yield functions (y):

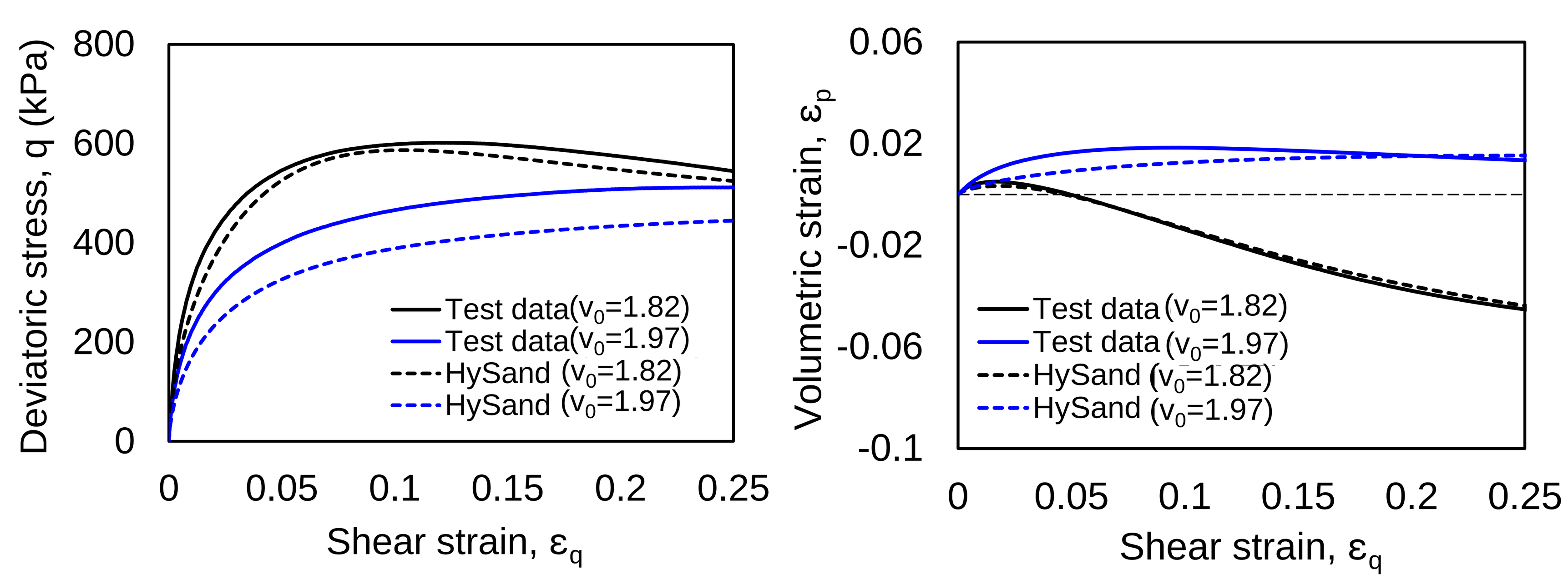
$$y^{(n)}=\frac{\left(N\chi_q^{(n)}-h_n\left(p,q,\alpha_q^{(n)}\right)-a\beta^{(n)}N\chi_p^{(n)}+A(1-|a|)\chi_a\right)^2}{4\left(\frac{n}{N}\mu\right)^2\left(p+\frac{2}{3}q\right)\left(p-\frac{q}{3}\right)}+\left(\frac{N\chi_{pc}^{(n)}}{p_c^{(n)}}\right)^r-1$$

Model parameters:

Elastic bulk stiffness	k_r	Min. specific volume	Δ
Elastic shear stiffness	g_r	Critical state line slope	λ_B
Stiffness exponent	m	Consolidation line slope at max. Density	λ_Δ
Critical state stress ratio	μ	Max. anisotropy rate factor	A_{max}
Max. dilation rate	β_{max}	Max. hardening factor	h_0
Max. specific volume	B	Hardening factor exponent	b
Critical state specific volume	Γ	Consolidation exponent	r

2 Model Calibration

The model was calibrated using Karlsruhe sand triaxial data from Wichtmann and Triantafyllidis (2016).



3 Implementation & Application

3D FE Model:

The model was implemented as a user subroutine in the FE code and applied to simulate a monopile behaviour in different sand densities under lateral load.

Pile diameter, D	Loading height, h	Embedment depth, L	L/D
8 m	32 m	24 m	3

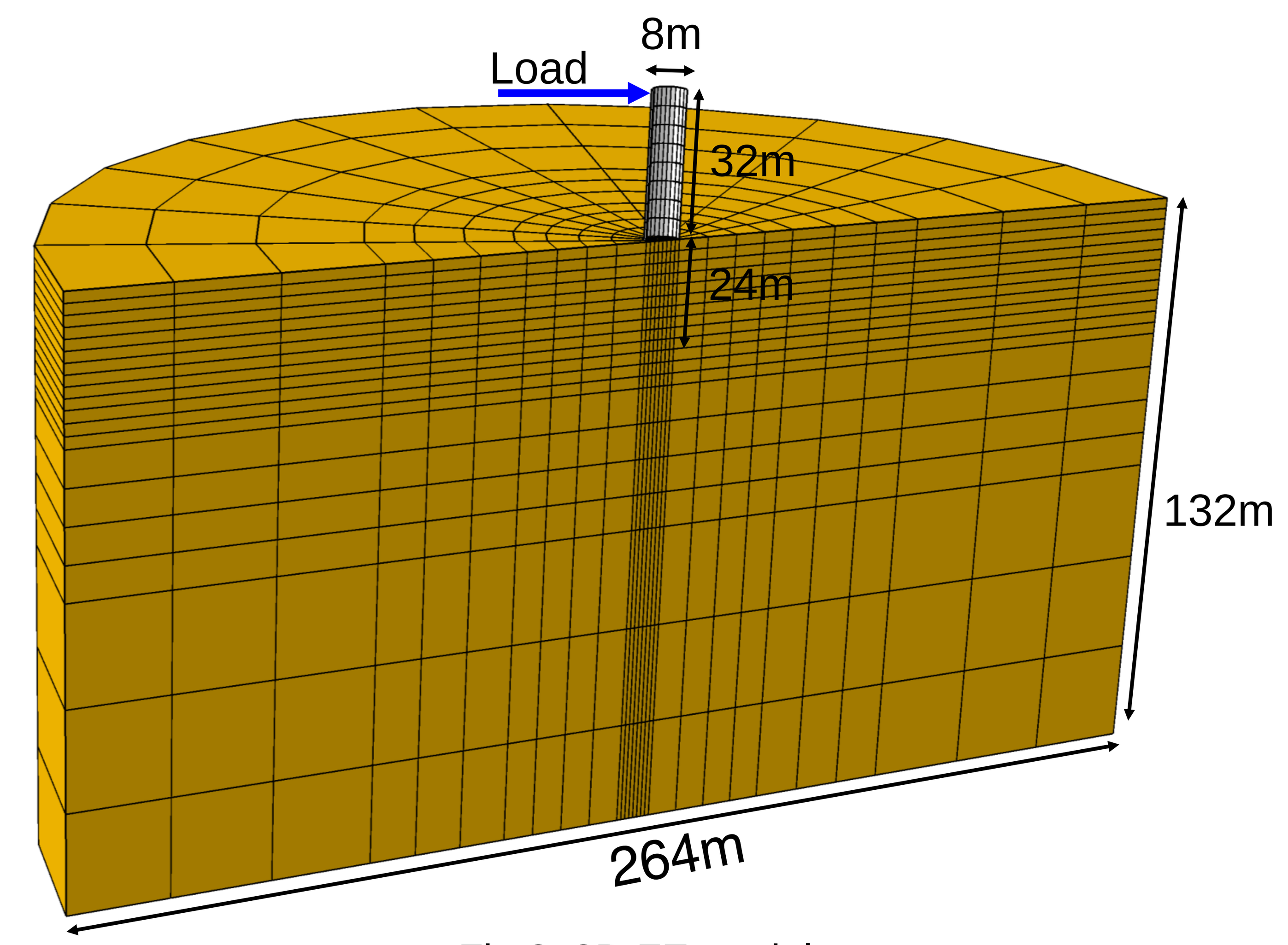
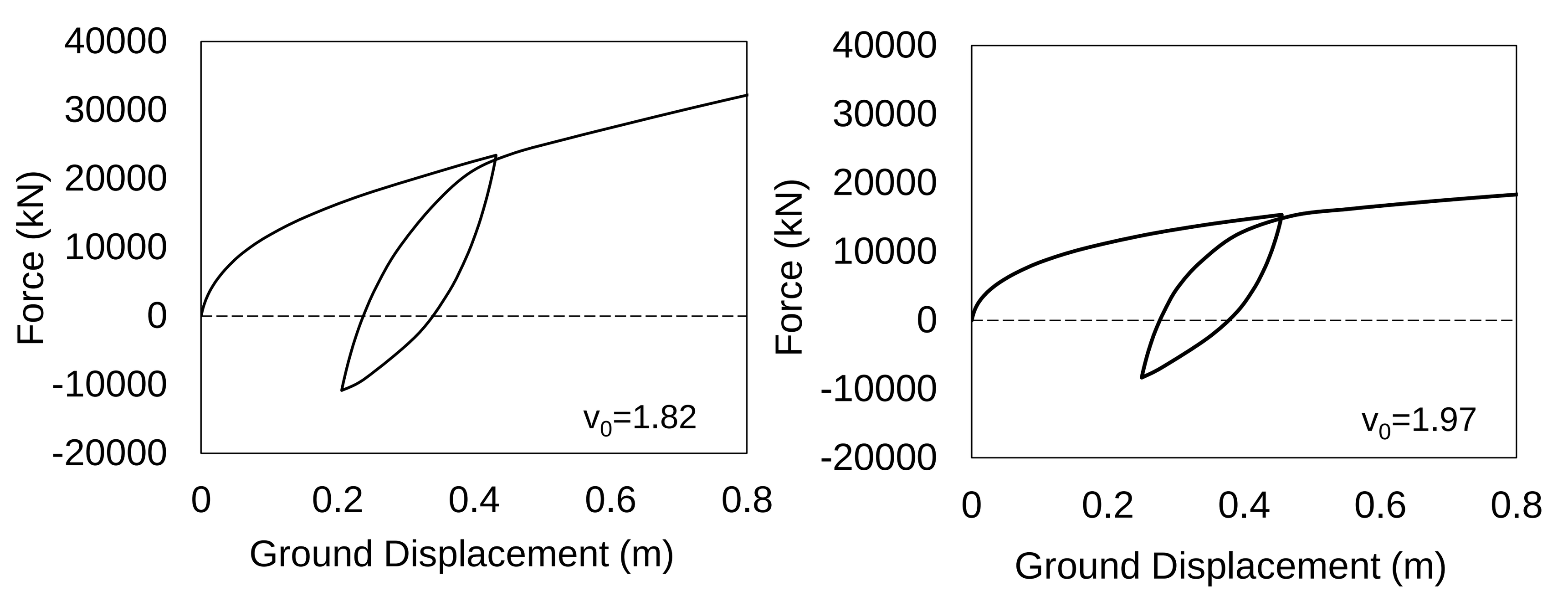


Fig.2: 3D FE model

Numerical results:



References:

- Byrne, B.W., Houlsby, G.T., Burd, H.J., et al. (2020). PISA design model for monopiles for offshore wind turbines: Application to a stiff glacial clay till. Géotechnique, 70(11): 1030–1047.
- Simonin, L. (2023). Development of an effective stress model for sand under cyclic loading in the hyperplastic framework. DPhil thesis, University of Oxford, UK.
- Wichtmann, T., and Triantafyllidis, T. (2016). An experimental database for the development, calibration and verification of constitutive models for sand with focus to cyclic loading: part II—tests with strain cycles and combined loading. Acta Geotechnica, 11(4), pp. 763–774.

Ørsted
Supergen Offshore Renewable Energy

Isha Saxena, Durham University

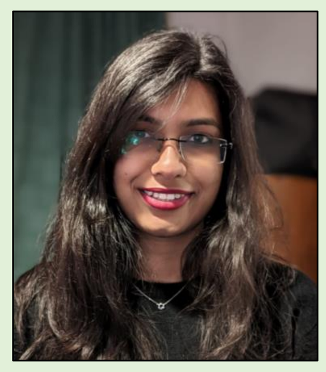
Job Title: PhD Student

Academic Discipline: Engineering

This poster presents a Bayesian framework for wind turbine reliability analysis, focusing on the integration of expert knowledge through prior elicitation to improve parameter estimation under uncertainty. Wind turbine failures are modelled using both homogeneous (HPP) and non-homogeneous Poisson processes (NHPP), with the latter incorporating time-varying failure rates via a Weibull intensity function. Bayesian inference is employed to update prior distributions with observed data, yielding posterior distributions that refine reliability predictions. The study highlights the critical role of informed priors, particularly in data-scarce scenarios, and demonstrates how expert opinions can be systematically incorporated to enhance model accuracy. Using failure data from onshore wind turbines, the methodology is applied to derive hyperparameters for the HPP analytically and for the NHPP using Monte Carlo simulation. Results show that integrating expert knowledge with Bayesian methods significantly improves reliability estimates, supporting optimized maintenance strategies and sustainable energy deployment. This approach provides a robust, flexible framework for wind turbine reliability analysis, offering valuable insights for decision-making in wind energy systems.

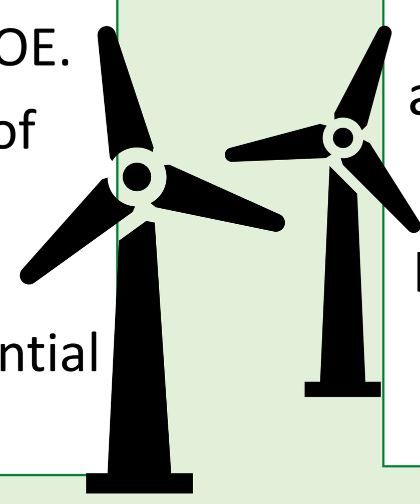
REDUCING UNCERTAINTY FOR BAYESIAN ANALYSIS IN WIND ENERGY SYSTEMS

Isha Saxena, University of Durham, isha.saxena@durham.ac.uk
Supervised by:
Dr. Behzad Kazemtabrizi, Prof. Matthias Troffaes, Prof. Christopher J Crabtree



MOTIVATION 1

- About 25-35% of the Levelised Cost of Electricity(LCOE) of modern wind farms is incurred in the operation and maintenance (OPEX) of the wind farms. A more data-driven approach can be useful in more precise costs estimation and decreasing LCOE.
- Lack of data for wind turbine failures and repairs gives rise to uncertainty in case of wind turbines makes it harder to calculate the hyperparameters for the prior.
- Bayesian parameter estimation, utilizing prior knowledge and observed data, provides a robust framework for modelling the failure rates of wind turbines, essential for optimizing performance and reducing costs.

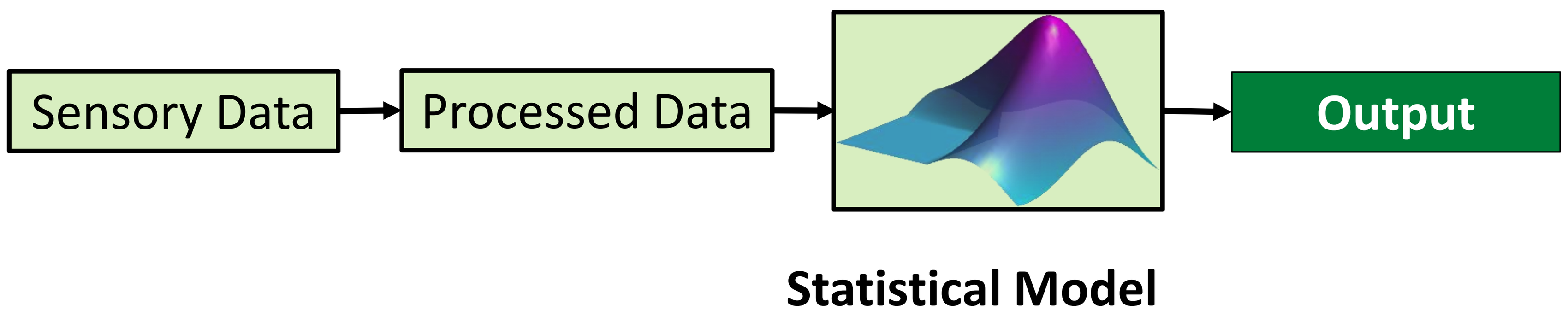


QUESTION 2

How can sensory data be used to optimise installation and operation and maintenance procedures of a wind farm using statistical analysis?

How can uncertainties be addressed in case of a Bayesian estimation utilisation?

METHODOLOGY 3



- SCADA data, and turbine logs are used for this project. The SCADA data consists of the SCADA signals like generator RPM, total active power, etc. This data needs to be converted into times to failure and times to repair for modelling.
- The power production from real time SCADA Data and wind turbine's wind vs power curve are used to determine times to failure and repair of the wind turbines at this stage.
- A new statistical model characterising the times to failure or number of failures per year for each turbine is prepared to understand the impact of the environment on the wind turbines' failures. The parameter estimation for the model is carried out by using Bayesian inference and the results are compared with maximum likelihood estimation.

PRIOR ELICITATION 4

{Using Historical data} For a homogeneous process, let N(t) ~ Po(tλ) be the number of wind turbine failures in the time t, with failure rate λ ~ *Gamma*(α, β). The prior predictive distribution is:

$$N(t) \mid \alpha, \beta \sim NB\left(\alpha, \frac{\beta}{t+\beta}\right)$$

The expectation and variance of N(t) given α, β, and t are:

$$E(N(t)) = \frac{t\alpha}{\beta} \text{ and } Var(N(t)) = \frac{t+\beta}{\beta} E(N(t)).$$

Prior elicitation can be done if the expectation and variance are known. The data below is obtained from [2].

Years t	Number Failures per turbine	Number of failures (N(t))
1	10.75	2375.75
2	10.18	2249.78
3	11.01	2433.21
4	9.41	2079.61
5	7.44	1644.24
6	13.32	2943.72
7	9.91	2190.11
8	7.94	1754.74

Based on the failure data for offshore wind turbines over 8 years for 1,768 turbine hours, as shown in Table 1, the hyperparameters α and β of the prior Gamma distribution were estimated for the failure rate (λ). Using the sample variance of 165,993.8 and the total number of failures 17,671.16 for N(t = 1768 turbine years) and the values for N(t =221), we obtain α = 29.8 and β = 2.98. The value of variance can also be inflated if the sample variance does not fully represent the uncertainty of the data. These values are used to visualize the prior predictive distribution (Negative Binomial) and the Gamma prior distribution. This analysis applies only to wind farms in similar situations as the data.

POSTERIOR INFERENCE 5

{Using Current Data} Let $T_1,\dots,T_n$ be i.i.d. random variables representing wind turbine failure times, with density P(t_i |θ). Here, model 1 assumes a Weibull distribution:

$$T_i \mid \lambda, k \sim Weibull(\lambda, k)$$

Model 2 assumes an exponential distribution (Weibull with *k*=1):

$$T_i \mid \lambda \sim Weibull(\lambda, 1)$$

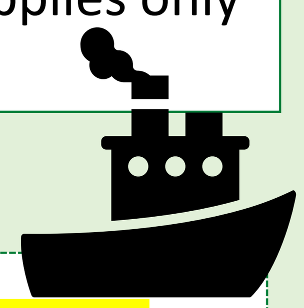
Where, *λ ~ InverseGamma*(α, β), and for *k ~ Uniform*(*ķ, ķ**).

Hyperparameter Selection: We assume that k and λ are a priori independent. Once initial hyperparameters are chosen according to the values obtained from Ref [2], they are iteratively adjusted until a reasonable prior predictive distribution is achieved.

Dataset for analysis for this section is sourced from EDP Renewables [3], encompassing SCADA and log data from a wind farm of 16 turbines, each rated at 2MW, with a focus on a subset of 5 turbines. Here, within Bayesian framework, Markov Chain Monte Carlo algorithms are used for sampling data from posterior distribution effectively.

	k (Expo)	λ (Expo)	k (Weibull)	λ (Weibull)
MLE	1	21.03	0.87	19.71
Bayesian Estimation	1	21.7	0.84	20.31

Model Validation: The data can be divided into two parts: test data and training data. The training data is used to train the statistical model and to obtain parameters for the curve. The test data, which represents around 20% of the total dataset, is used to test the performance of the model based on parameters obtained from the training dataset.



TAKE AWAYS

This research focuses on determining a more generalised statistical model pertaining to times to failure (and repair) in offshore wind turbines, leading to better estimations of impacts of failure/repairs on key performance indicators.

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[2] Carroll, J., McDonald, A., and McMillan, D. (2016) Failure rate, repair time and unscheduled O&M cost analysis of offshore wind turbines. Wind Energ., 19: 1107–1119. doi: 10.1002/we.1887

[3] Data. en. https : / / opendata . edp . com / open - data / en / data . html. Accessed: 2023-6-2

Durham University

aura

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Job Title: PhD candidate

Academic Discipline: Civil engineering

Marine concrete structures face unique challenges, such as wet/dry cycles and fatigue loads. This research investigates polymer-modified concrete (PMC) as a solution to these challenges. The study focuses on optimising PMC's mix design to enhance properties particularly under marine conditions.

Experimental testing will be used to examine the mechanical properties of PMC, including compressive, tensile, flexural strengths and fatigue performance. The modified Gurson-Tvergaard-Needleman (GTN) model will be developed and used to simulate PMC's behaviour under fatigue load in the marine environment numerically.

This research not only aims to improve the performance of PMC in marine environments but also seeks to deepen the understanding of its meso-structural changes under fatigue loading. By bridging experimental data and numerical modelling, the study provides a foundation for more resilient and durable marine concrete designs, enabling safer and more cost-effective applications in critical infrastructures.

Enhancing Marine Concrete Performance: Fatigue Mechanics of Polymer-Modified Concrete

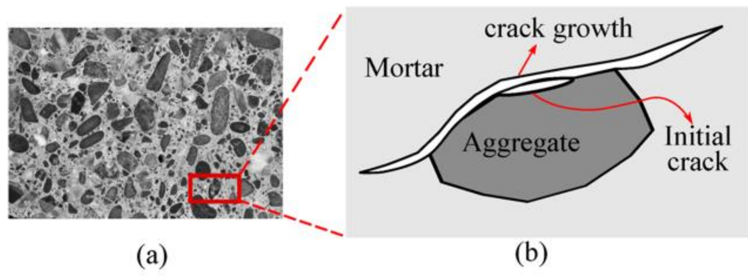
Zhenyi Yan

Concrete challenges in the marine environment

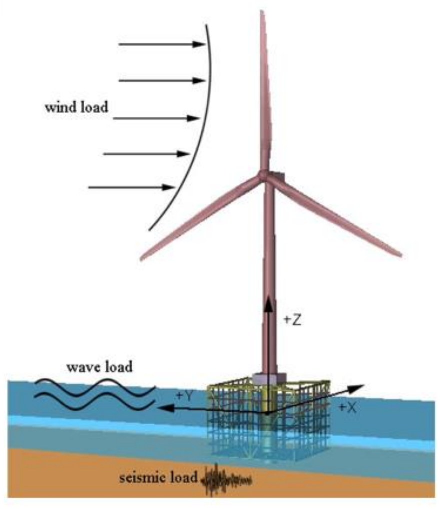

Chloride ion penetration


Dry-wet cycles

Difficult maintenance



Fatigue (cyclic) load



What is polymer modified concrete (PMC)

PMC is a cement-based composite where polymers (e.g., latex, epoxy) are added to improve mechanical properties, durability, or workability compared to conventional concrete.

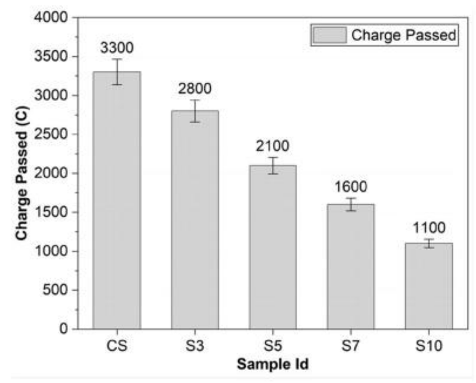
Polymers added to the concrete

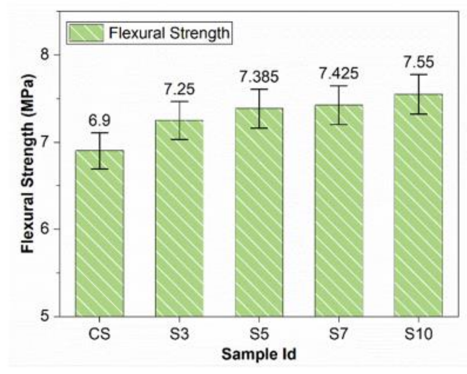
SBR(Styrene-Butadiene Rubber) latex

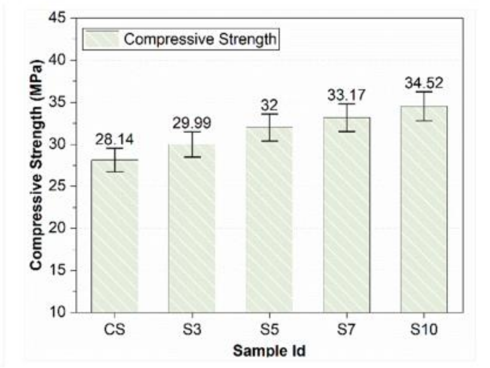
Epoxy resin

Epoxy resin emulsion

Enhancement of PMC in current state of research

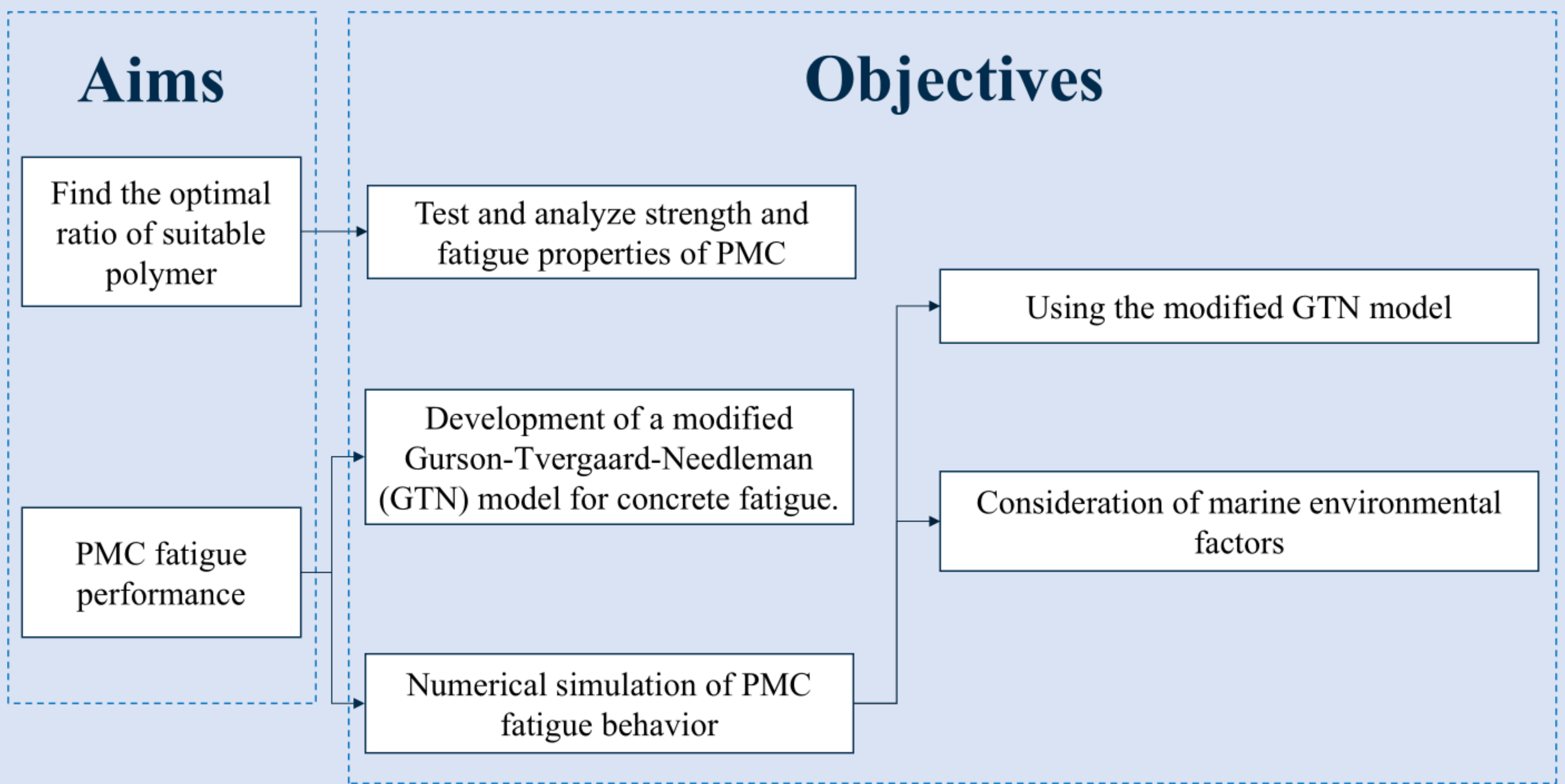




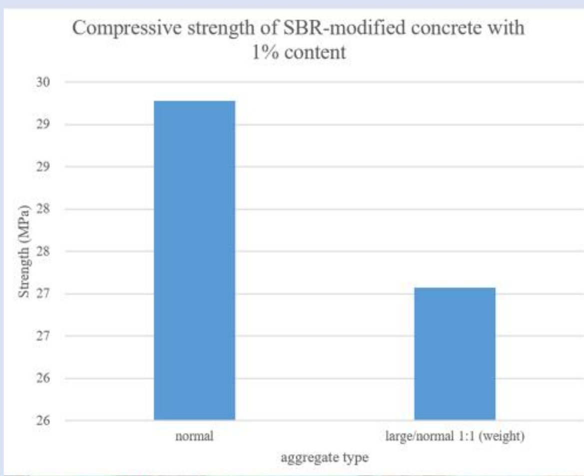


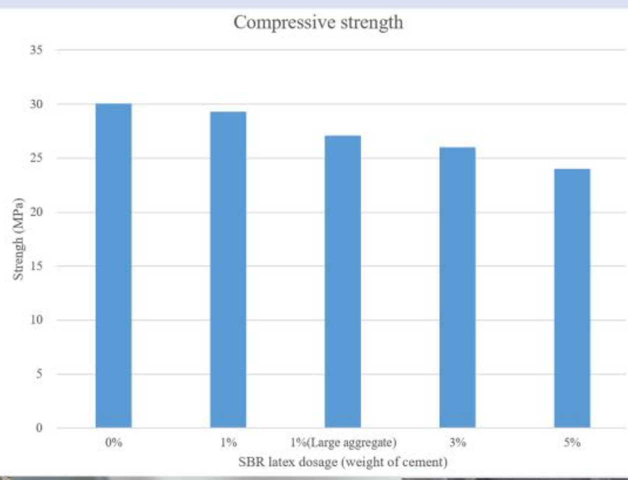
0%, 3%, 5%, 7%, and 10% SBR modification

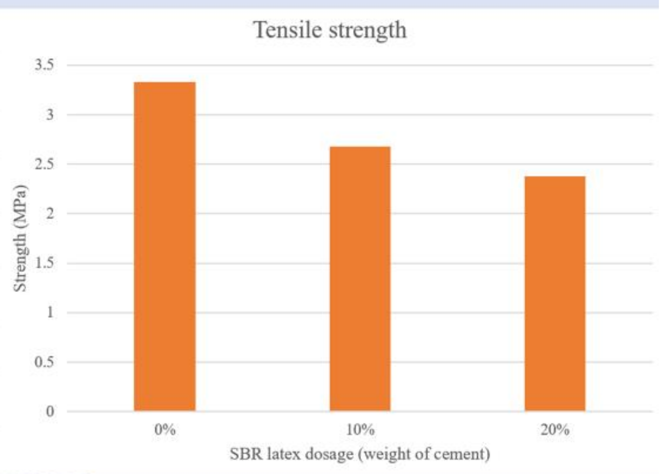
Aims and objectives



Current test result (7 days)



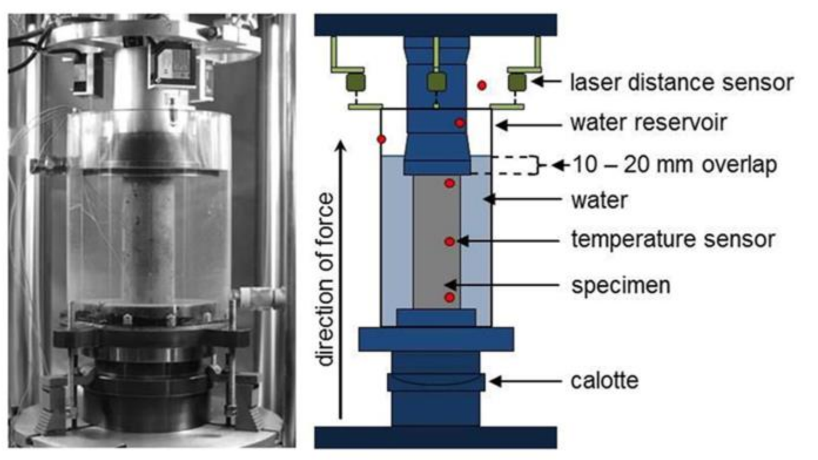




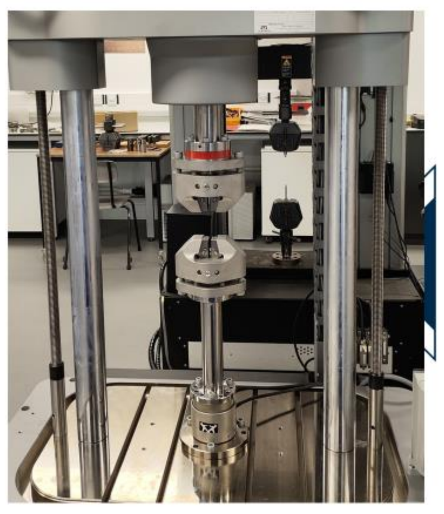


The results do not match some of the literature and more experiments are needed

Future fatigue test with wet/dry circle

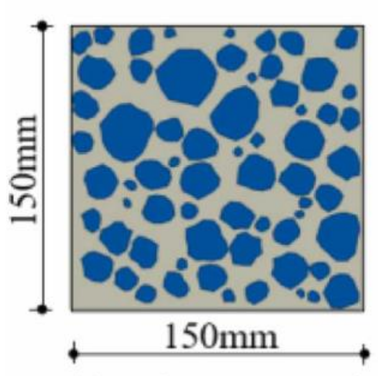


	Wetting	Drying
Time	8 hours	4 hours
Equipment	Water tank	Fan (AD) (8.5knots)

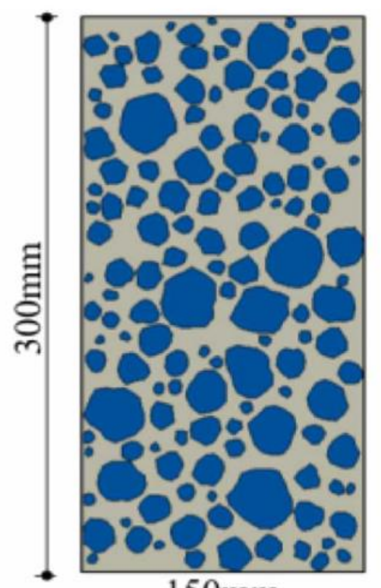



Numerical simulations on meso-structure of PMC under fatigue

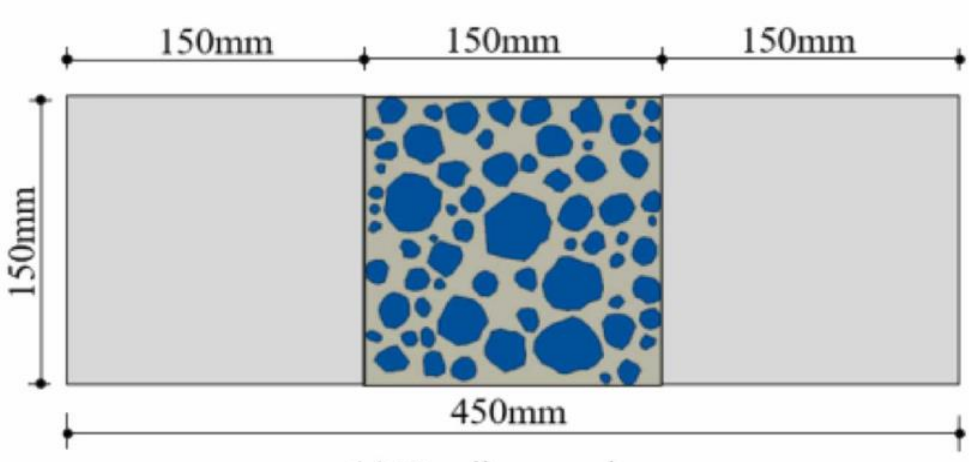
Random Aggregate Modeling based on Monte Carlo method



(a) Cube compression specimen



(b) Prismatic compression specimen



(c) Bending specimen

Numerical simulations on meso-structure of PMC

Gurson-Tvergaard-Needleman (GTN) model

Yield function of the GTN model

- $\Phi = \frac{q^2}{\sigma_m^2} + 2q_1 f^* \cosh\left(\frac{-3q_2\sigma_h}{2\sigma_m}\right) - (1 + q_3 f^{*2}) = 0$
- q –Macroscopic von Mises equivalent stresses
- σ_m – Equivalent stress
- q_1, q_2, q_3 –Calibration coefficients, usually q_1=1.5, $q_2 = 1.0$, $q_3 = q_1^2$
- f^* – Equivalent pore porosity
- σ_h –Macroscopic hydrostatic stress

Equivalent pore porosity

$$f^* = \begin{cases} f, & f \le f_c \\ f_c + \frac{f_u^* - f_c}{f_F - f_c}(f - f_c), & f_c < f < f_F \\ f_u^*, & f \ge f_F \end{cases}$$

f – The porosity obtained from the pore evolution model

f_c – The porosity of the material at the time of the start of pore aggregation

f_u^* – Equivalent porosity at the time of occurrence of fracture

f_F – The porosity of the material at the time of occurrence of fracture

Pore nucleation and pore growth

$$\dot{f} = \dot{f}_{growth} + \dot{f}_{nucleation}$$

$$\dot{f}_{growth} = (1 - f)\dot{\varepsilon}_m^p$$

$$\dot{f}_{nucleation} = A\dot{\varepsilon}_m^p$$

$$A = \frac{f_N}{s_N\sqrt{2\pi}} exp\left[-\frac{1}{2}\left(\frac{\varepsilon_m^p - \varepsilon_N}{s_N}\right)^2\right]$$

f_{growth} – The porosity increment due to pore growth

$f_{nucleaton}$ – The porosity increment due to pore nucleation

$\dot{\varepsilon}_m^p = (\dot{\varepsilon}_{11}^p + \dot{\varepsilon}_{22}^p + \dot{\varepsilon}_{33}^p)/3$ The mean plastic strain increment of the material

A – The rate of pore nucleation

f_N – The volume fraction of the nucleated particle

s_N – Nucleation strain standard deviation

ε_N – The average strain of the pore nucleation

Damage factor calculation with asymptotic homogenization method

Lemaitre model

$$\tilde{\sigma} = \frac{\sigma}{1-D}$$

$$\varepsilon = \frac{\sigma}{\tilde{E}} = \frac{\tilde{\sigma}}{E} = \frac{\sigma}{(1-D)E}$$

$\tilde{\sigma}$ – The effective stress tensor

σ– The non-destructive stress tensor

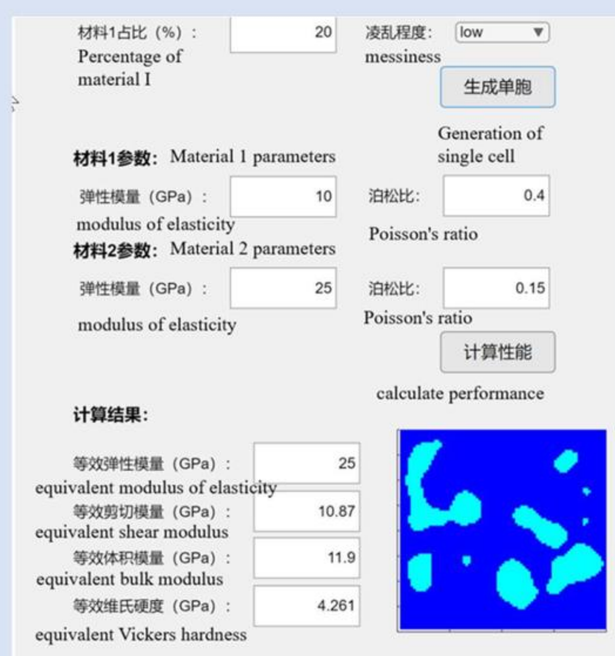
D – The damage factor

$$D = 1 - \frac{\tilde{E}}{E}$$

$$\tilde{E} = (1 - D)E$$

E – The damage-free elastic modulus

$\tilde{E}$ – The effective elastic modulus



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(2) Aggarwal, L. K., Thapliyal, P. C., & Karade, S. R. (2007). Properties of polymer-modified mortars using epoxy and acrylic emulsions. Construction and Building Materials, 21(2), 379-383.
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(4) A.Demayo. (1985).Elements in sea water. CRC handbook of chemistry and physics.
(5) Numerical analysis of mesoscale fatigue cracking behavior in concrete based on cohesive zone model

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Academic Discipline: Environmental Engineering

Cross-flow turbines have technical benefits that may contribute to accessing untapped tidal energy potential in the UK coast and around the world. At the same time the blades of these rotors undergo complex hydrodynamic loading, making it difficult to predict hydrodynamic efficiency and therefore creating a bottleneck in optimising and commercialising the device concept.

The blades of a cross-flow turbine are subject to a range of complex aerofoil hydrodynamic phenomena such as separation and reattachment, dynamic stall, and blade-vortex interaction. For this reason, 2D Unsteady Reynolds Averaged Navier-Stokes (URANS) simulations have been widely used for the study of these rotors as a viable compromise between accuracy and numerical cost.

At the same time, 3D flow effects may lead to a 33.3% drop in power when comparing 2D and 3D URANS blade-resolved simulations, suggesting that it is important to model 3D effects in such devices. A viable model that resolves three-dimensional features but overcomes the computationally expensive task of meshing and resolving the aerofoil boundary layer, are 3D actuator line method (ALM) simulations of cross-flow and vertical axis turbines.

It is currently unclear if the ALM can adequately model the cross-flow turbine blade interactions emerging from 2D URANS simulations. In this work we perform a fair comparison between the two methods: the flow emerging from 2D URANS simulations of cross-flow turbines is compared to that emerging from 2D ALM simulations. We further hypothesize that the ALM will agree best with the blade-resolved methods for utility scale rotors (where the relative distance between the blades is larger) while for lab-scale rotors the blade turbulence will dominate the device hydrodynamics.

Impact of support structure modelling methods in actuator line method large eddy simulations of wind turbine wakes

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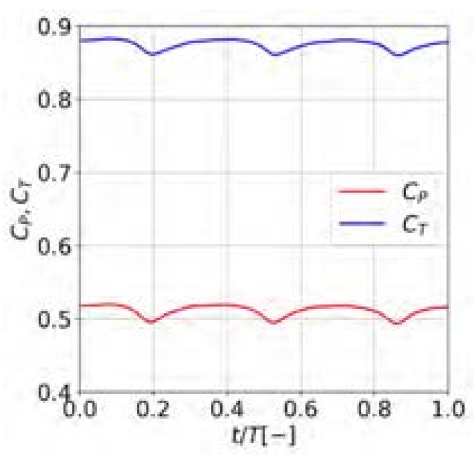
RWE

UNIVERSITY OF OXFORD

Influence of nacelle and tower on wind energy aerodynamics

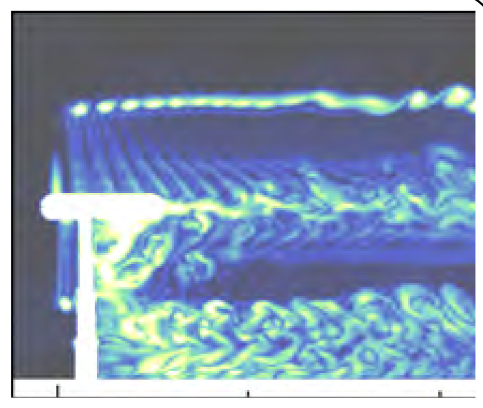
Rotor Loads

Tower shadow;
Instantaneous decrease in aerofoil performance.



Near wake

Coherent structures;
Breakdown of tip vortices;
Hub vortex [2].



Far wake

Far wake asymmetry [1];
Increased turbulence.

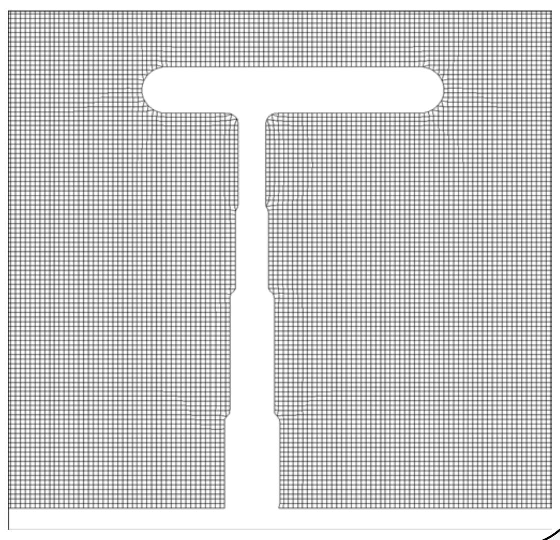
Farm Scale

Wake meandering [2];
Influence on the farm resistance [3].

? *How should we numerically model the support structure in actuator line method large eddy simulations?*

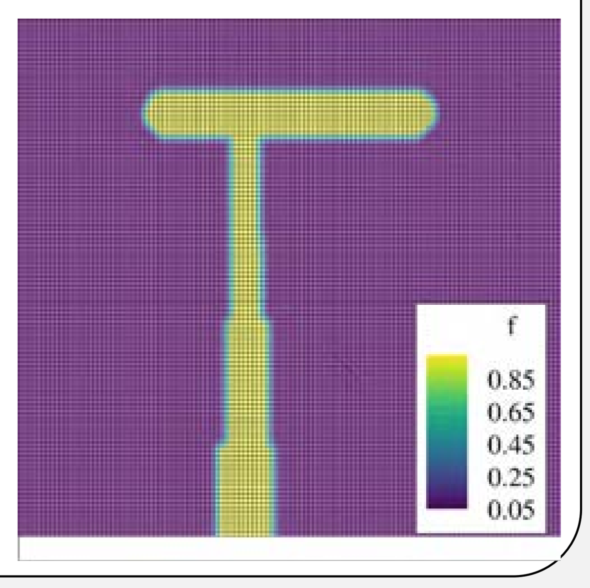
Meshed representation

20<y+<300;
Analytical wall function



Cell blocking method

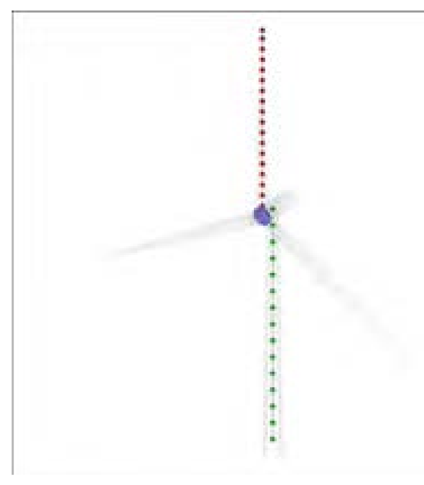
Momentum source;
No penetration condition;
Meshless method;
[4].



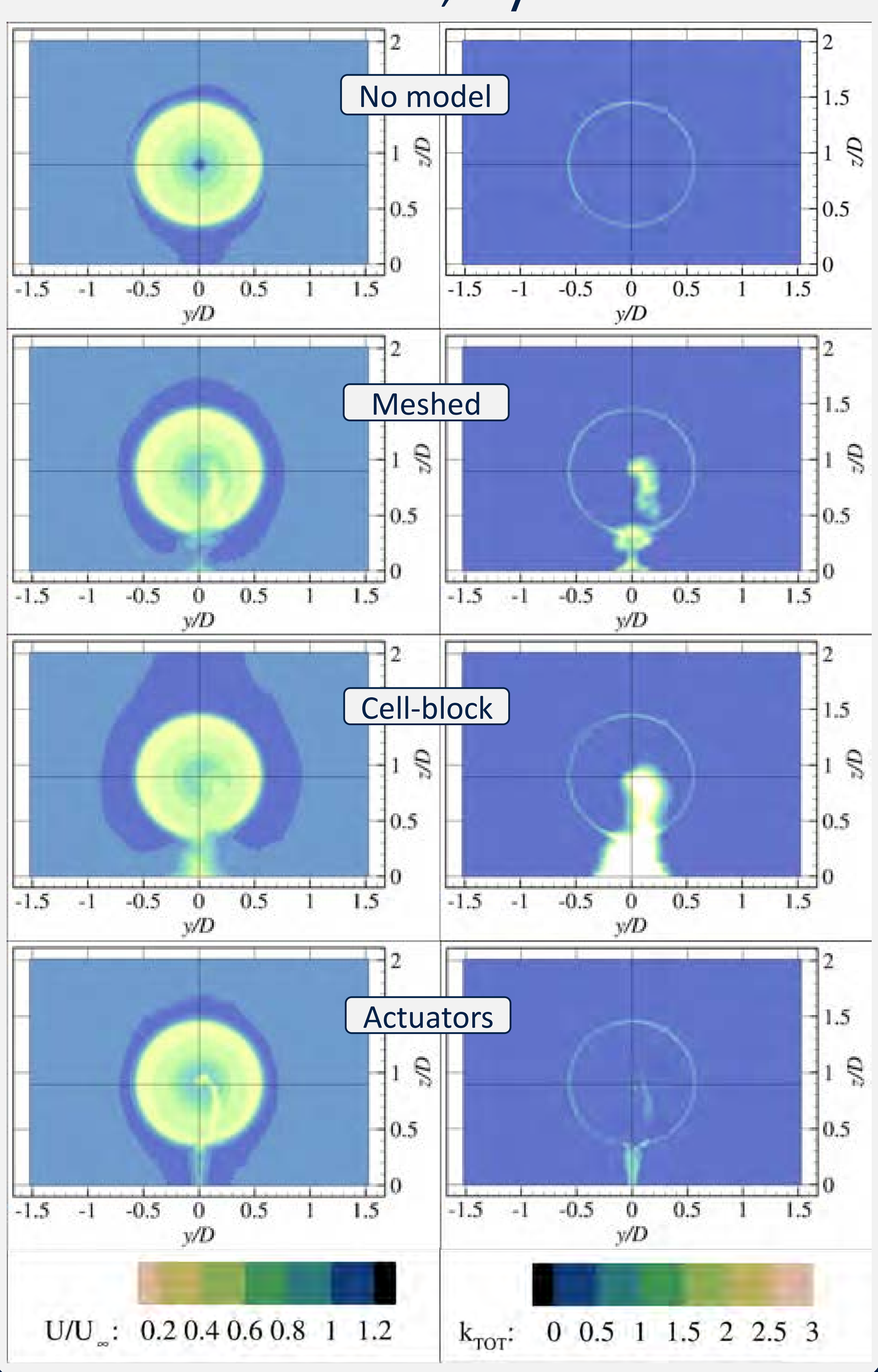
Actuator Line/Disc Method

Actuator disc nacelle,
$Cd = 0.3$;

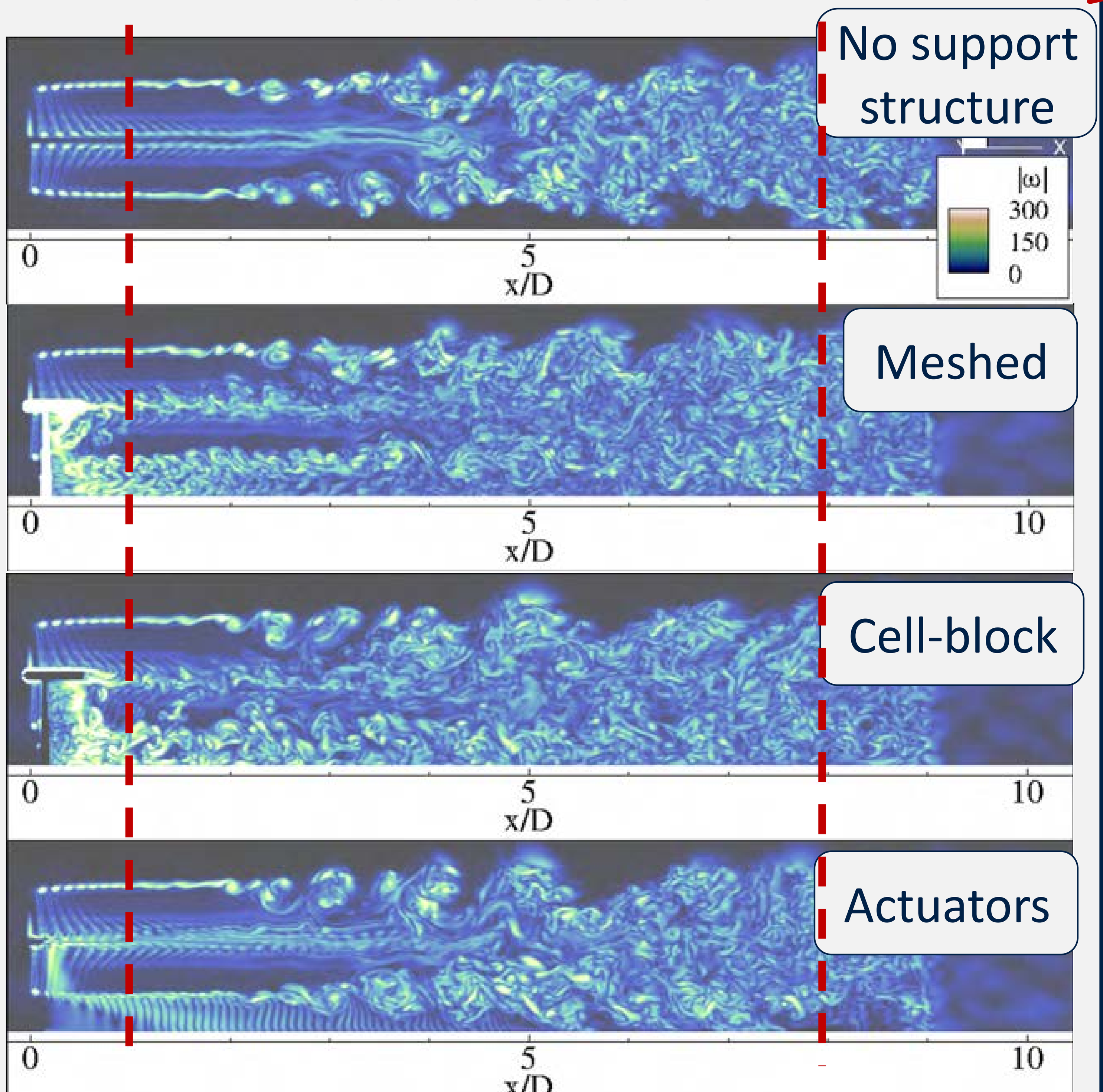
Actuator line tower,
$Cd = 1.2$;
$St = 0.2$. [5]



Mean flow, near wake, $x/D = 1$

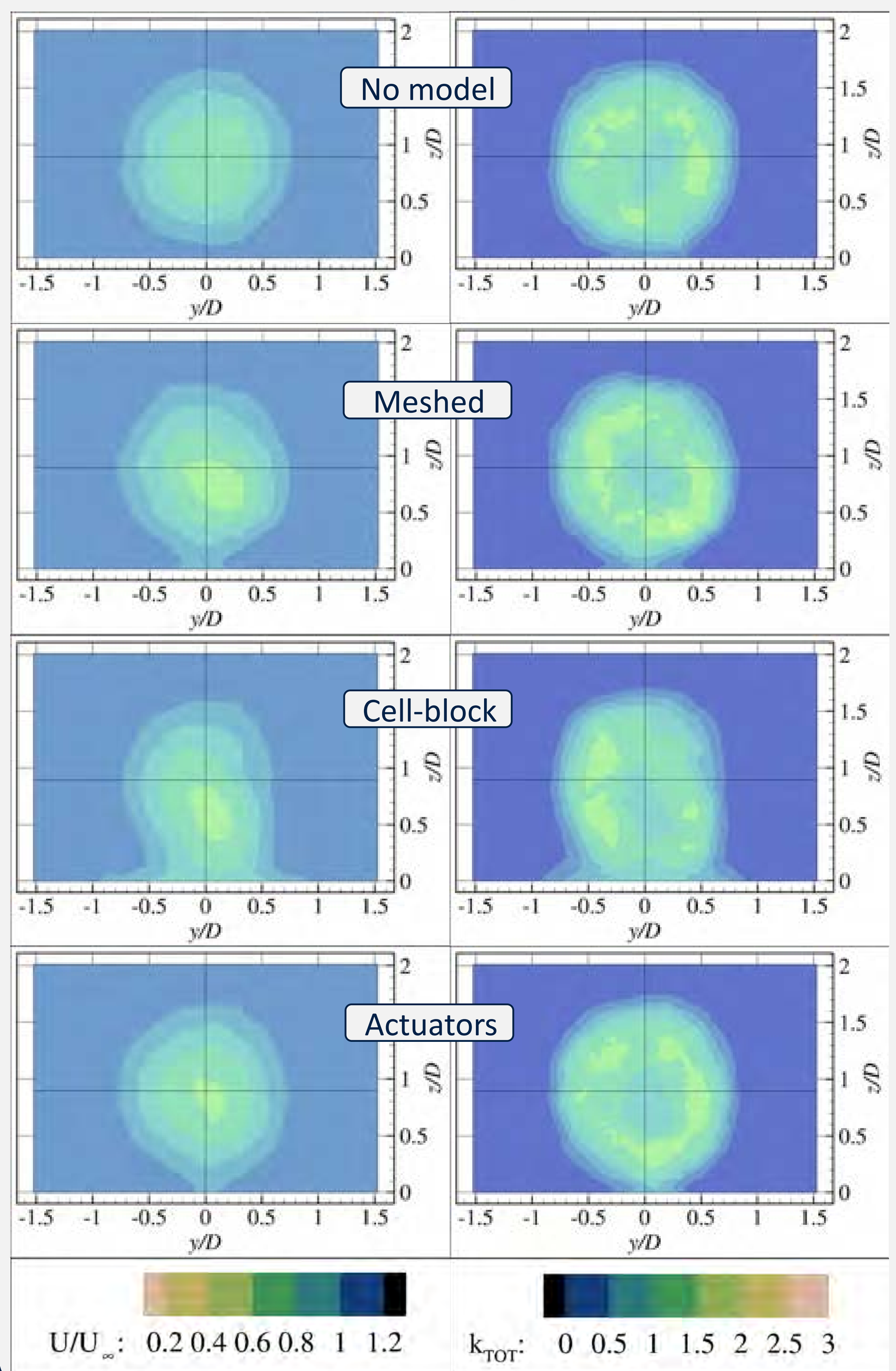


Instantaneous Flow

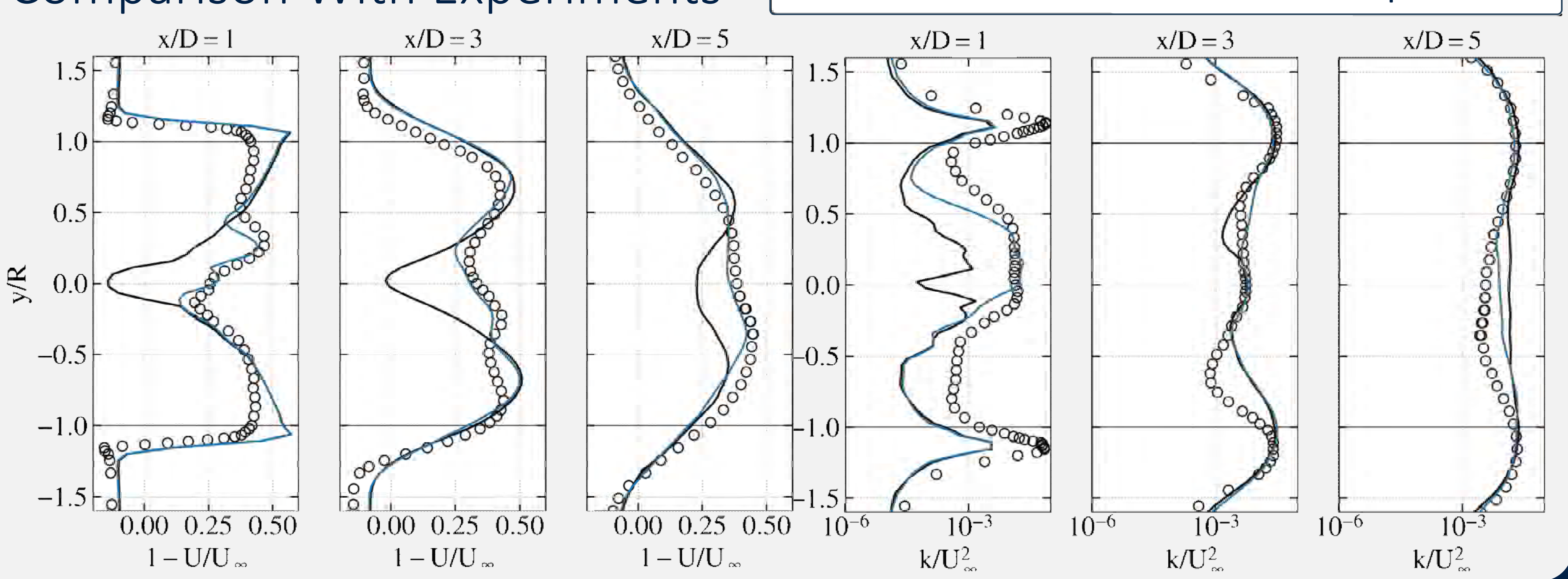


Method	Rotor Thrust [N]	Support Structure Drag [N]
No support structure	33.59	0
Mesh	33.59	1.59
Cell-block	33.43	3.45
Actuators	33.55	1.19

Mean flow, far wake, $x/D = 8$



Comparison With Experiments



Conclusion

Three support structure modelling methods were tested for the NTNU lab-scale rotor [1] with diameter $D = 1\,m$ using actuator line method large eddy simulations.

The **meshed representation** provides the best **agreement with experiments**, capturing both flow behaviour and magnitude.

The **cell-blocking** method **reproduces asymmetric behaviour** but **overstates TKE production** at the near wake.

The **actuator method understates** the effect of the support structure and therefore does not induce far wake asymmetries.

Having tested the methods for a lab-scale rotor for which experimental data are available, **future work** will aim to assess the impact of the support structure in the **utility scale**.

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Autonomous Biomimetic Robot-Fish for Offshore Wind Farm Inspection

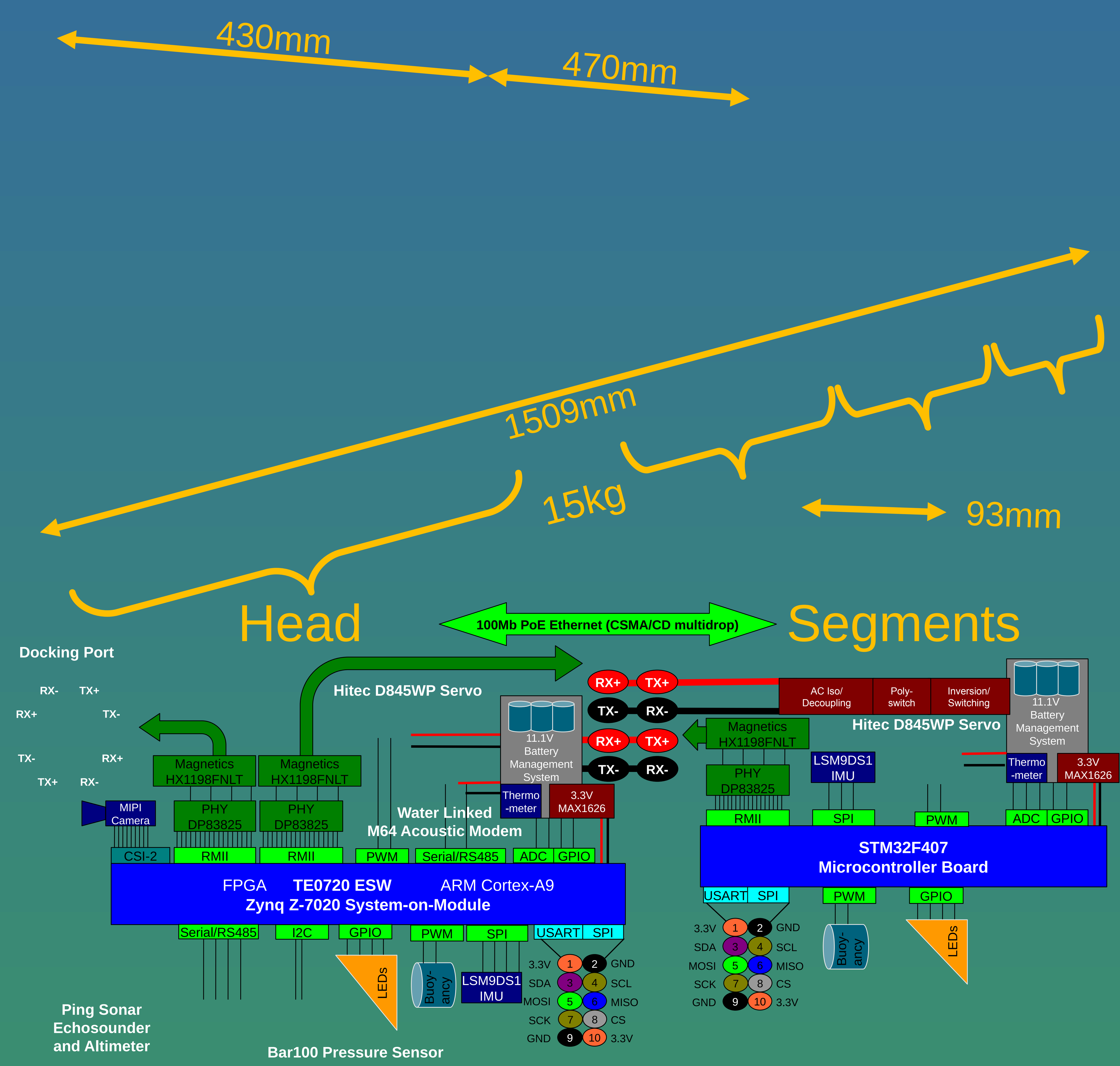
"RoboFish"

Mark Post[1]; Wael Gorma[1]; Zhihao Ma[1]; Marvin Wright[2]; Qing Xiao[2]; Yang Luo[2]; Andrew Durrant[3]; Bodhi Sarkar[4]; Alex Louden[5].

1: University of York School of Physics, Engineering, and Technology. 2: University of Strathclyde Dept. of Naval Architecture, Ocean and Marine Engineering. 3: PicSea Ltd. 4: Verlume Ltd. 5: Offshore Renewable Energy Catapult.

Introduction

- Offshore wind farms provide clean, reliable and commercially viable energy.
- Regular Inspection Maintenance and Repair (IMR) tasks must be performed at up to 100m depth
- Autonomous Underwater Vehicles (AUVs) can provide IMR in a **cost effective** and **safe** manner.
- The AUV needs to be **efficient, adaptable** and **environmentally unintrusive** in long-term operation.
- A biomimetic AUV can provide higher **specific thrust efficiency** at low velocities and higher **manoeuvrability in confined spaces**.
- **RoboFish** is a biomimetic AUV with an adaptable modular design for autonomous monitoring.



Flexible Design

- Articulated, fully actuated body can perform many different swimming gaits and operate as a manipulator.
- Modular software and hardware design, with flexible configuration for multiple payloads and missions.
- Communications and power shared between modules using a novel implementation of Power-over-Ethernet.
- Head includes acoustic modem, echosounder, and camera with a Xilinx Zynq visual odometry processor.
- High-pressure watertight joints 3D printed in ASA using magnetic clutch drive between segments.

Servo-Driven Magnetic Clutch Actuator:

Bio-Inspired Control

- Central Pattern Generators (CPGs) are neural networks that produce coordinated oscillatory signals for gaits.
- RoboFish uses the Amphibot II CPG model to produce efficient swimming gaits that is defined by:

$$\left\{ \begin{array}{c} \dot{\theta}_i = 2\pi v_i + \sum_j r_j w_{ij} \sin(\theta_j - \theta_i - \phi_{ij}) \\ \ddot{r}_i = a_i \left(\frac{a_i}{4}(R_i - r_i) - \dot{r}_i \right) \\ x_i = r_i(1 + \cos(\theta_i)) \end{array} \right\}$$

From: A. Crespi and A.J. Ijspeert, "AmphiBot II: An amphibious snake robot that crawls and swims using a central pattern generator." Proceedings of CLAWAR 2006 pp. 19-27.

- The *i'th* oscillator produces a phase θ_i and amplitude r_i
- Intrinsic frequency and amplitude are set by v_i and R_i
- Positive constant a_{ij} =100 is commonly used.
- Coupling defined by weights w_{ij} and phase biases Φ_{ij}
- Ensures stable gait convergence, smooth transition compared to a sinusoid, and ability to learn new gaits.

Frequency Variation (gait speed) CPG vs. sinusoid

Angle offset (turning angle) CPG vs. sinusoid

Amplitude Variation (gait stride) CPG vs. sinusoid

Phase Changes CPG2/CPG3 vs. sinusoid2/sinusoid3

Fluid Dynamics and Modelling

- An in-house CFD solver modelled swimming gaits.
- Effects of control inputs on mobility can be estimated.
- Trade-offs between segment size and gait efficiency.

Simulation of Z-vorticity for connected 5-element RoboFish composed of NACA0012 foils in water

Future Work

- RoboFish has also received interest for use in aquaculture, water utility piping, and pollution monitoring in rivers.
- A smaller, more autonomous, easy to use AUV is desired in these applications.
- "RoboFish 2" is hydraulically-actuated with SLA printed Elastic 50A joints to be modular, smaller and more efficient.
- Acoustic mesh networking and multi-agent underwater SLAM are among the technologies currently being researched and developed in our group for RoboFish and other underwater biomimetic robots.

Related Publications:

- Marvin Wright, Wael Gorma, Yang Luo, M. A.Post, Qing Xiao, Andrew Durrant. "Multi-actuated AUV Body for Windfarm Inspection: Lessons from the Bio-inspired RoboFish Field Trials", 2020 IEEE/OES Autonomous Underwater Vehicles Symposium (AUV), September 30-October 2, 2020, St John's, Canada.
- Marvin Wright, Yang Luo, Qing Xiao, M. A. Post, Wael Gorma, Andrew Durrant, Hong Yue, "CFD-FSI" Analysis on Motion Control of Bio-inspired Underwater AUV System Utilizing PID Control, 2020 IEEE OES Autonomous Underwater Vehicle Symposium (AUV), September 30-October 2, 2020, St John's, Canada.
- Wael Gorma, M. A. Post, J. White, J. Gardner, Y. Luo, J. Kim, P. D. Mitchell, N. Morozs, M. Wright, Q. Xiao. Development of Modular Bio-Inspired Autonomous Underwater Vehicle for Close Subsea Asset Inspection. Appl. Sci. 2021, 11, 5401. https://doi.org/10.3390/app11125401.
- Marvin Wright, Qing Xiao, Saishuai Dai, Mark Post, Hong Yue, and Bodhi Sarkar. "Design and development of modular magnetic bio-inspired autonomous underwater robot–MMBAUV." Ocean Engineering 273 (2023): p113968.

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