Flexible Funding Overview – Dr Ali Mehmanparast

- Research project: Structural Design and Integrity Enhancement of offshore Floating support structures (SDIEF)

- Partners involved: Cranfield University, Imperial College London, Strathclyde University

- Summary of research work, outputs and impact: This project aims to predict corrosion pitting fatigue damage evolution and crack growth at multiple critical locations in floating support structures, using a novel probabilistic fracture mechanics approach, and enhance the structural design and integrity of the floating substructures. The knowledge developed from this project will benefit diverse academic and industrial communities, in addition to offshore renewable energy sector engineers concerned with the design, manufacture, inspection, modelling, life-time assessment, safety and costs of wind turbines.

Flexible Funding Overview – Dr Mahmood Shafiee

- Research project: Stochastic Methods and Tools to Support ‘Real-Time’ Planning of Risk-based Inspection for Offshore Wind Structures

- Partners involved: Cranfield University (PI); University of Strathclyde (Co-I); Aalborg University (in-kind support)

- Summary of research work, outputs and impact:

With the development of advanced condition monitoring technologies in wind industry, information about the condition of wind farm assets and surrounding environment becomes available in real-time or near-real time. Nevertheless, incorporating such enormous amounts of “real-time data streams” into the assessment of instantaneous alterations of system condition and/or risk/reliability measures, and thereafter into cost-effective planning of O&M processes in the wind farm is a significant challenge in research and industry. To overcome this drawback, this research project proposes stochastic tools and methods (based on stochastic finite element simulation and dynamic Bayesian network) to support real-time planning of O&M activities in wind energy farms. The tools developed in this project will help wind farm operators gain benefit from real-time data and improve their O&M practices, and subsequently reduce OPEX and increase electricity production.

Publication Outputs:

- Development of a Bayesian Network Updating Model for O&M planning of Offshore Wind Structures (in preparation).
- New advances and developments in risk-based inspection (RBI) of marine structures. In: 38th International Conference on Ocean, Offshore & Arctic Engineering (OMAE), 11-14 June 2019, Glasgow, UK.
- 'Real-time' Risk-based Inspection Planning of Offshore Wind Support Structures. In: WindEurope Conferene, 25-28 September, Hamburg, Germany.
- Operation & Maintenance Planning of Floating Offshore Wind Turbines using Stochastic Petri Networks. In: EERA DeepWind Conference, 16 - 18 January 2019, Trondheim, Norway.
- Operation and Maintenance Planning Optimization of Wind Energy Farms: Under-Researched Areas. Reliability and Quality in Design (RQD) Conference, Log Angles, USA.

Flexible Funding Overview – Dr Christopher Crabtree

- Research project: Novel Data Integration Techniques for Enhanced Wind Turbine Condition Monitoring
- Partners involved: Durham University / Orsted / EDF

- Summary of research work, outputs and impact:

This project aimed to develop novel CMS and SCADA data integration techniques to automate data interpretation and improve the accuracy and the reliability of the diagnostic decisions, especially in the light of impending large-scale, offshore wind farm generation. This contrasts with the current situation where a vast volume of difficult to interpret data is generated from a variety of (often specialist) sources, which is unhelpful and overwhelming.

- Roger Cox made advances in using and analysing Work Orders, parts used in maintenance, and SCADA data (sensors and alarms) to improve the automated labelling of outages. He explored the use of Naive Bayes methods as a potential method for improving turbine outage classification, in close collaboration with Ørsted, using their data.
- Luke Payne developed novel Markov based approaches to monitor SCADA sensor movements for prognostics. He focused on the converter subsystem, testing his approaches across multiple farms. This work was undertaken as a one year secondment with Ørsted in Copenhagen.
- Diego López looked at maintenance data provided by EDF (under a new collaborative agreement). He developed a robust text data extraction and re-structuring method to transform the daily maintenance minutes into a structured format that can be used to support supervised machine learning.

Publications:

• Zappalá, D., Sarma, N., Djurović, S., Crabtree, C. J., Mohammad, A. & Tavner, P. J. (2019). Electrical & Mechanical Diagnostic Indicators of Wind Turbine Induction Generator Rotor Faults. Renewable Energy.

• Smith, C.J., Zappalá, D., Crabtree, C.J., Lapiedra, J. & Mulholland, B. (2018). Power Converter Junction Temperature Measurement using Infra-red Sensors. The Journal of Engineering.

Flexible Funding Overview – Dr Christopher Crabtree

- Research project: Solid State Transformers for Offshore Wind Turbines
- Partners involved: Durham University

- Summary of research work, outputs and impact:

This project will construct a SST demonstrator to enable fundamental experimental research into the challenges of implementing the novel SST electrical configuration in large offshore WTs and to identify the potential electrical benefits of this technology for future offshore farms with complex collection networks.

The main project deliverables include:

- An experimental SST demonstrator;
- Demonstration of SST capability under variable frequency operation (at WT generator frequencies);
- At least one high-quality journal publication drawing on Durham's expertise in wind and advanced power electronic devices, plus a conference paper;
- A feasibility study to support an EPSRC funding proposal and potential CDT projects.

Outputs:

A high-quality journal publication focused on the comparison of SST and conventional solutions for offshore wind (WP1 and WP2). A conference paper will be submitted based on WP3. A final report on the outputs and findings will also be produced.

Flexible Funding Overview – Dr Laith Danoon/Dr Francesco Fioranelli

- Research project: *Experimental Characterization and Modelling of Multistatic Multiband Radar Signatures of Large Offshore Wind Turbines*
- Partners involved: University of Manchester, Glasgow, UCL
- Summary of research work, outputs and impact:

Work summary:

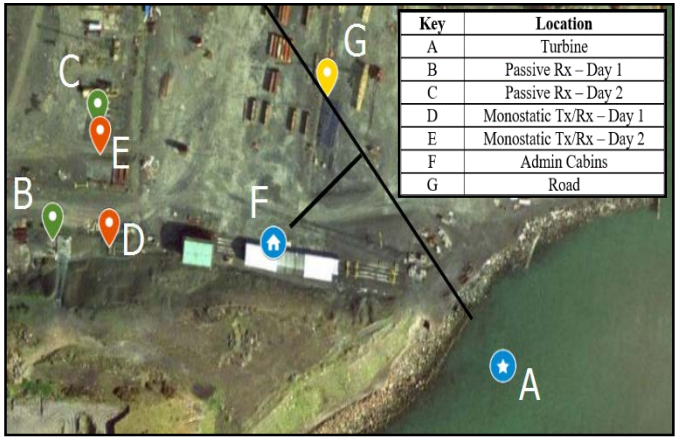
- Modified existing radar models to take into account nearfield calculations and bistatic radar scattering.
- Dataset of experimental polarimetric radar data was collected, using an active S-band radar and a passive DVB-T radar.
- The experimental data has been analysed providing a series of metrics, both in the time domain (amplitude statistics of the radar scattering of the turbines) and frequency domain (micro-Doppler signatures of the turbines). Preliminary analysis was done to match the experimental data with the modelled data, and work has been done at UCL regarding the simulations of synthetic targets and detection algorithms in the presence of wind turbine clutter.
- Additional flexible funding monies allowed us to develop a new dual-band radar for validation using the Levenmouth turbine as a target of opportunity. We completed the design of a core element of our own multi-frequency FMCW radar system, which is responsible for generating ultra-wide band waveforms (up to 1.4 GHz) necessary for resolving small targets against large measurement scenes, including wind turbines. The design of smaller accompanying elements, such as the RF mixing boards (transmit, receive, baseband) was also completed.

Publications:

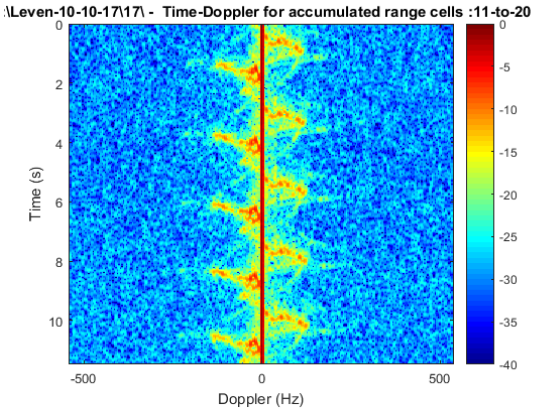
- Al-Mashhadani, W., Brown, A., Danoon, L., Horne, C., Palama', R., Griffiths, H., Patel, J., Fioranelli, F., 'Measurements and modelling of radar signatures of large wind turbine using multiple sensors', presented at *IEEE Radar Conference 2018,* Oklahoma City, USA, April 2018.
- Fioranelli, F., Patel, J., Horne, C., Palama', R., Griffiths, H., Danoon, L., Brown, A. 'Experimental measurements of radar signatures of large wind turbine', presented at *IET International Radar Conference 2018,* Nanjing, China, October 2018 – Best paper award

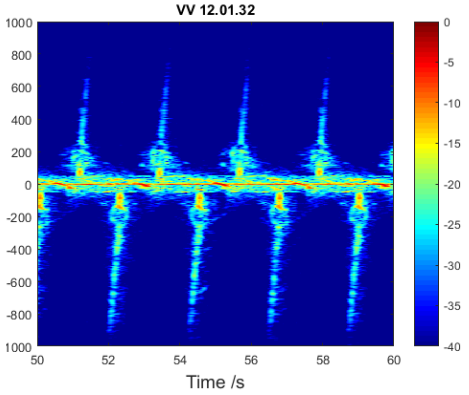
Invited talk:

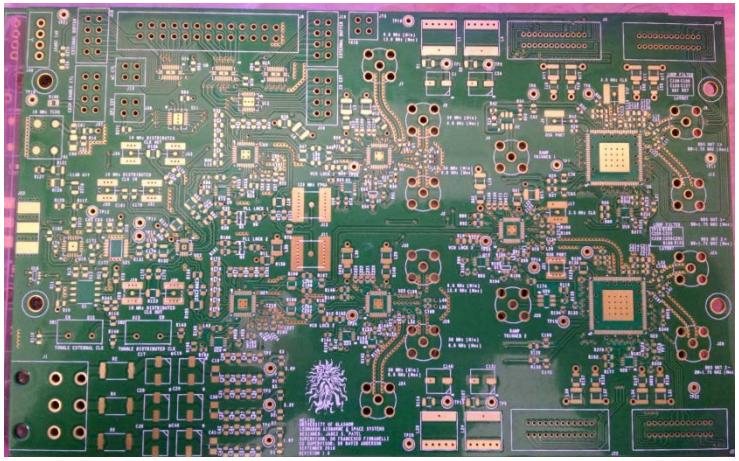
- Invited presentation while visiting Xidian University, Xian, China (April 2018, host Dr Jingwei Xu)

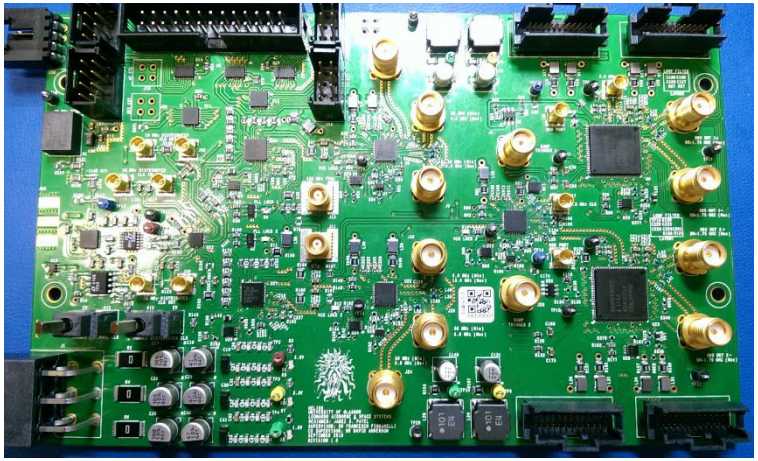


Key	Location
A	Turbine
B	Passive Rx – Day 1
C	Passive Rx – Day 2
D	Monostatic Tx/Rx – Day 1
E	Monostatic Tx/Rx – Day 2
F	Admin Cabins
G	Road









Flexible Funding Overview – Dr Marco Placidi

- Research project: Veers' method Extension to Stable Atmospheric Boundary Layers (VESABL)
- Partners involved: University of Surrey

- Summary of research work, outputs and impact:

The objectives of the project:
(i) to collect experimental data (i.e. PSD, two-point velocity correlations, hub current, temperature profiles) ahead of a single wind turbine in neutral and stable conditions;
(ii) to collect similar experimental data on multiple aligned wind turbines and similar stability conditions;
(iii) to assess the universality of the data statistics across single and multiple turbines.

These data will ultimately allow us, via collaborations with different institutions within the Hub, to further investigate whether the Sandia method:
(ii) can be applied to weakly and moderately stable ABLs and if so, to what degree of accuracy;
(iii) can be useful to characterise wind performance of a wind turbine operating in the wake of an upstream turbine. In doing so we aim to disseminate the findings of this activity via high-calibre peer-reviewed international journals and conference participation and inform and influence the industrial partners within the Supergen Wind Hub.

Theme 2: Design, Manufacturing & Installation

- Research project: System Identification for Integrated Structural and Foundation Monitoring of Offshore Wind Turbines

- Partners involved:

  Academic: Department of Engineering Science, University of Oxford
  Byron Byrne (PI), Anela Bajric (PDRA), Ross Mcadam, Manolis Chatzis.
  Industrial: Parkwind NV

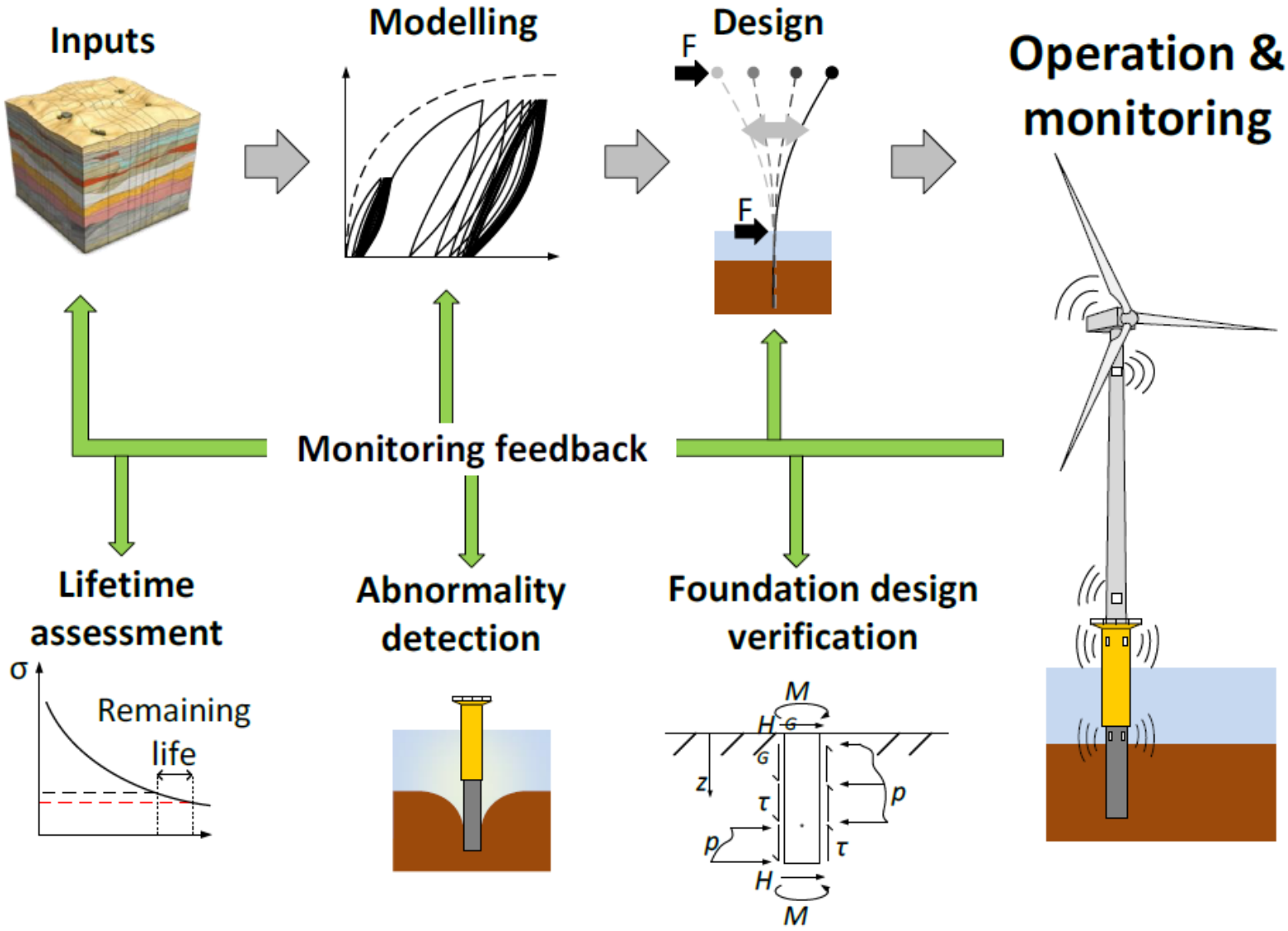
- Summary of research work, outputs and impact:

Assessment of the in-situ foundation stiffness for an offshore wind turbine enabled through novel mathematical formulation of a system identification algorithm for monitoring data. A comprehensive field data-set from Parkwind's Nobelwind wind farm development, allowed verification of the identification algorithm and a full assessment of the entire system performance, including the foundation.

Outputs: A system identification approach for analysis of offshore wind turbine monitoring data, accounting for the soil-structure interaction from the foundation.

Impact: Robust system identification techniques may provide evidence for operating wind farms for longer periods than initially designed. This will principally benefit offshore wind farm developers as well as the public generally.

Analysis of monitoring data, with the new system identification techniques, can provide evidence for supporting implementation of new less conservative foundation design methods into engineering design, lowering the cost of energy.


Inputs
Modelling
Design
F
F
Operation & monitoring
Monitoring feedback
Lifetime assessment
σ
Remaining life
Abnormality detection
Foundation design verification
M
H
G
z
τ
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H
M

Theme 2 Design, Manufacturing & Installation

- Research project: Fatigue prediction for non-conventional laminates application to wind turbine blades
- Partners involved: University of Bristol

- Summary of research work, outputs and impact:

• Develop a numerical fatigue prediction tool based on multi-continuum micro-mechanics theory and validate it against readily available experimental data.

• Design and build extension shear coupon samples that induce a bend-twist coupled response. These will be based on laminates that demonstrated promising BTC characteristics from the grand challenge research.

• Validate the MCT fatigue strength characteristics against the experimentally derived characteristics. Obtain the experimental data and compare against the numerical fatigue model predictions.

WP 1 - Identifying extension shear laminates:

• Successfully explored design space of laminates that exhibit extension shear coupling up to 30 plies

Conclusions

1. Whilst arbitrary angle plies can be included, laminates also need $0 \; - 90^{\circ}$ plies.

2. Coupling is quite tuneable

3. Can't get a laminate with A_f, B_0, D_s with less than 14 plies that includes "sensible" ply orientations for manufacturing

4. Lots of laying up is inevitable == time

WP 2 – Prediction Software

- Developed and numerically validated a MCT python code for fatigue predictions

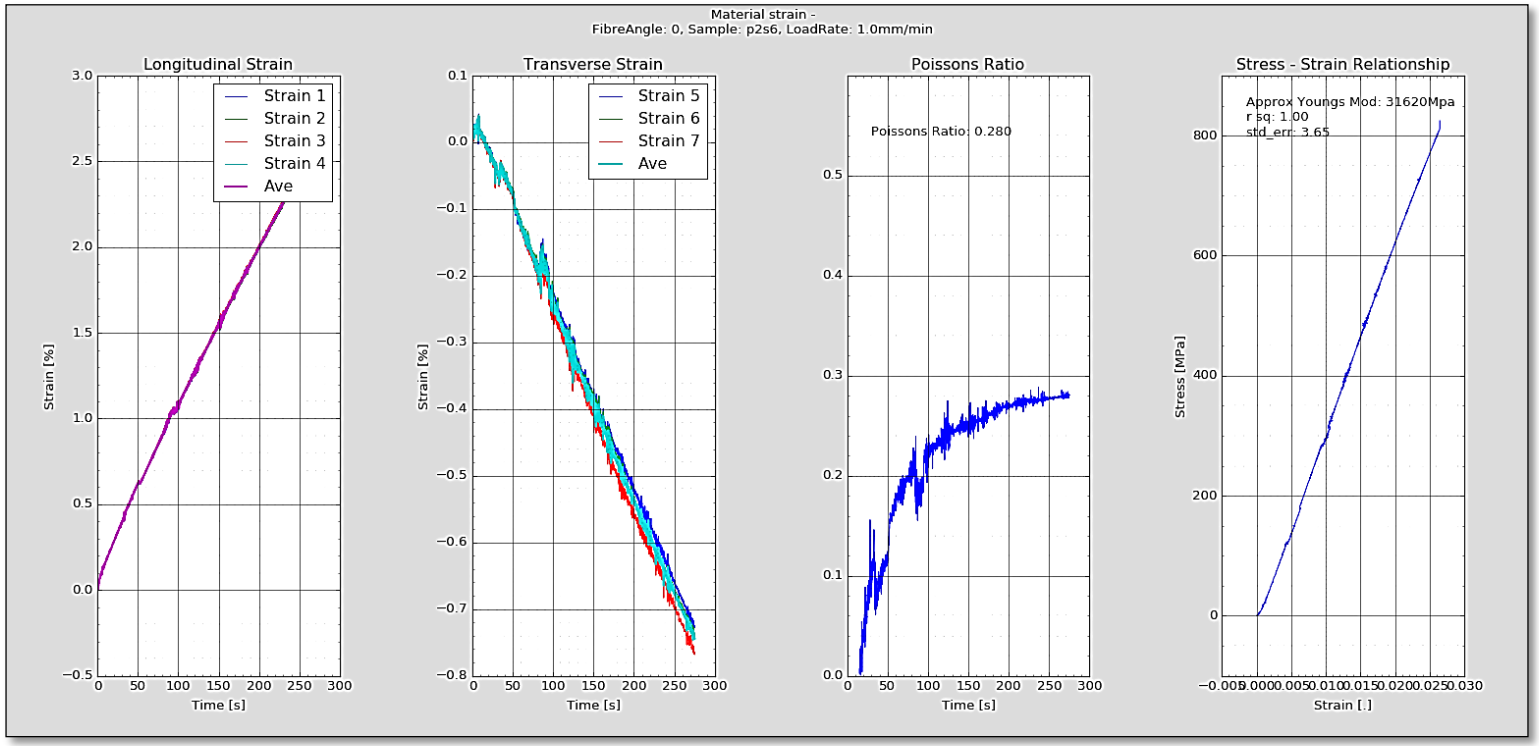
WP 3 – Coupons

- Tried realistic wind turbine approach of Infusion
  - Outcome laminate had high variability
  - It was more time consuming

- Instead, we opted for oven cure UD glass prepreg
  - Made about 10 plates (including $0/\pm 45/90$ and extension shear) layups

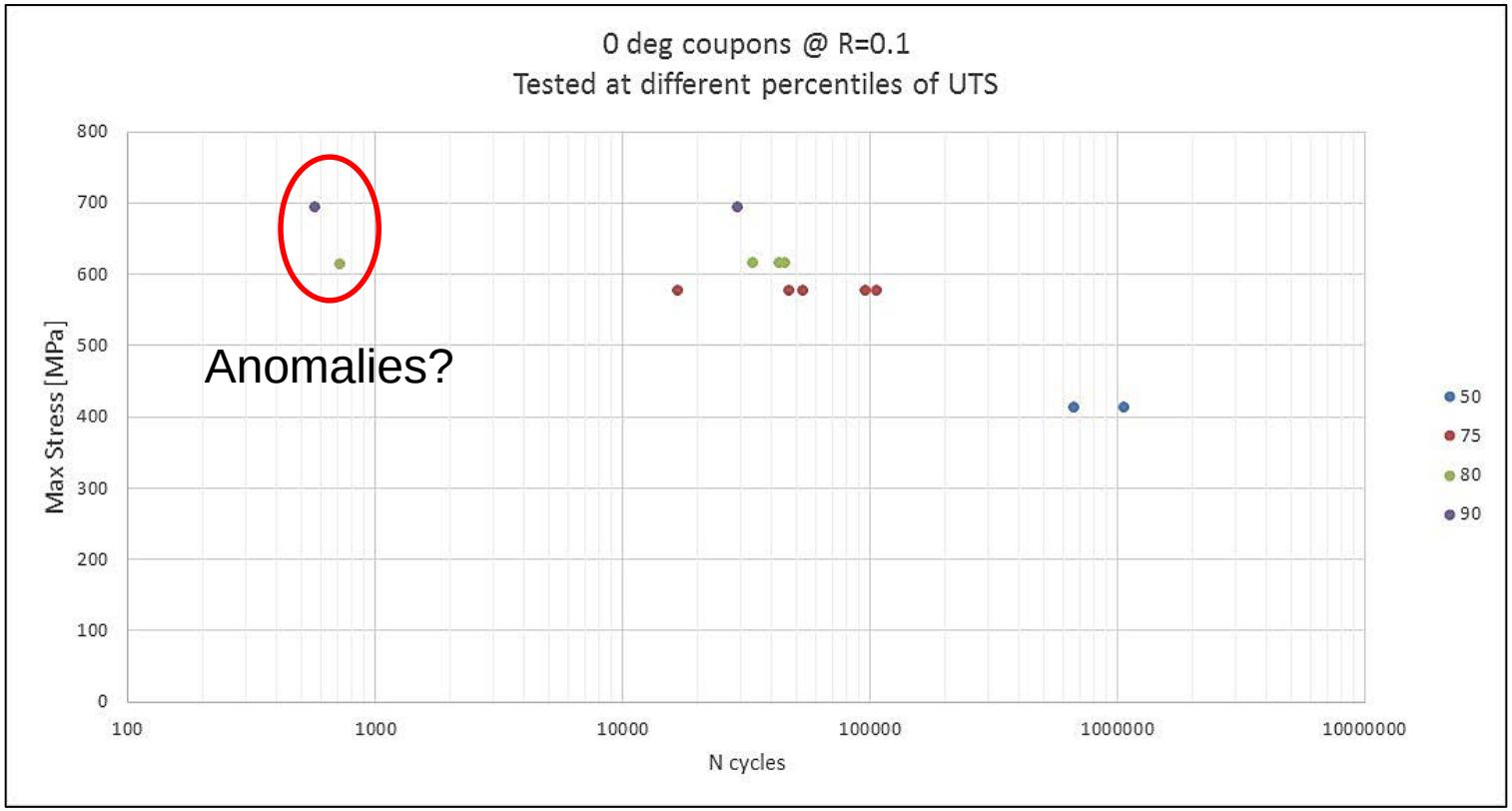
WP 4 – Static and Fatigue Testing

- Characterising (mostly through tensile testing for simplicity and sake of time)
  - $0/\pm45/90$ and shear laminates
  - Values generally in line with expectations



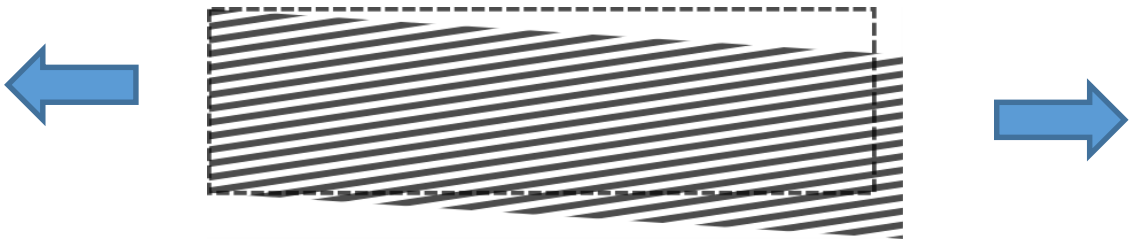
WP 4 – Static and Fatigue Testing

- Limited time left for fatigue test (unfortunately)
  - Mostly R=0.1 fatigue results



A couple of useful notes

- Raised many issues regarding testing of extension shear laminates
- How can we test the laminate and allow it to deform in the “natural” way it would in the blade?

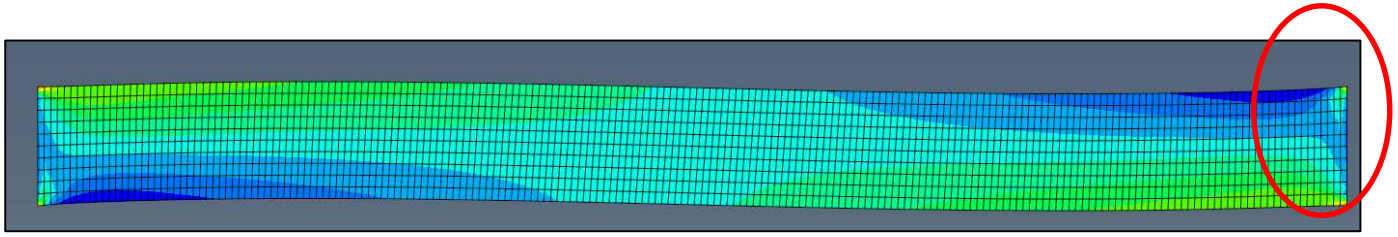


Grips of test machine constrain lateral deformation

A couple of useful notes

- Oblique tabs can help!

Extension shear laminate with conventional square end tabs

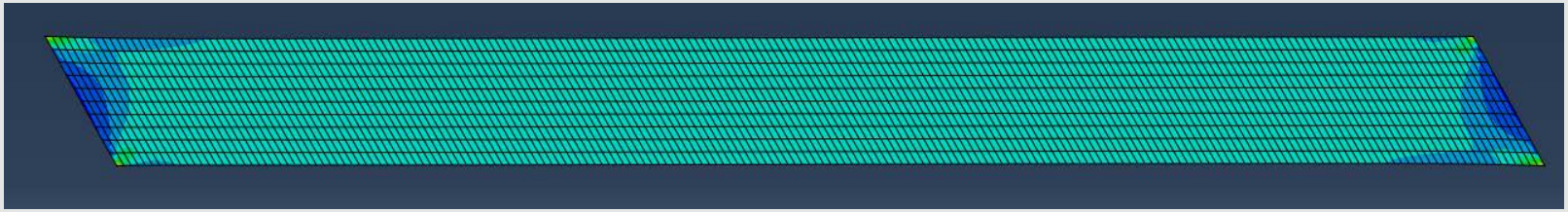


1. Laminate prone to buckle and suffer horrible stress state!
2. Stresses not uniform across the gauge.
3. Failure likely in the tabs rather than gauge section

A couple of useful notes

- Oblique tabs can help!

Extension shear laminate with oblique tabs



1. Much more uniform stress state.
2. Gauge section stress replicable with CLT
3. Tab alignment have to be strictly controlled!

Finally

Experimental results look promising but…

- Maybe worth studying prepreg quality a bit more
- More datapoints would be nice to get more confidence in fatigue
- Improving tabbing procedure to see if this reduces variability
- Remaining testing could probably done in a month as most of the plates are already made (will try to find some time to wrap it up)
- Candidate moving to EngD position on blade sub-component design and testing

Theme 1 Planning & Consenting

- Research project: The Economic Prospects of a Power Hub in the North Sea
- Partners involved: Imperial College London
- Summary of research work, outputs and impact:

The project will answer specific questions around how different stakeholders will benefit from the coordinated development of a ‘power island’ with enhanced connectivity to multiple countries. As a basis we use TenneT’s proposal to build 12+ GW of wind in the middle of the North Sea which are linked to multiple countries via an artificial island.

Research outcomes will be a broader understanding of the economic and energy-system impacts of deploying offshore wind, and will include one journal paper / conference presentation, and the open-access publication of the resulting DESSTINEE model implementation (to allow others to build off these scenarios).

Further details and image:

Connor Duffy was funded for 3 months, and we are now close to submitting a manuscript to Energy titled *"The prospects and impacts of an offshore wind power hub in the North Sea"*. The main highlights are:

- A cost analysis of building the power hub, finding that this will be cheaper than point-to-point connections if done on a large enough scale. 10 GW of wind is needed to justify spending €2bn building the island.
- An economic analysis of the power hub on neighbouring electricity markets, finding that it would bring major benefits for the UK's existing onshore and offshore wind farms (increasing their average selling price by €6-20 per MWh).

Off the back of this work, Iain Staffell was quoted in Wired magazine talking about the feasibility and economic impact of TenneT's power hub concept.

www.wired.co.uk/article/uk-electricity-wind-power-north-sea

Work Packages Overview

- Partners involved: University of Strathclyde
  - Flexible Funding project - Development of an integrated life-cycle cost assessment model of floating wind turbines.

The research links closely with the previous Flexible Funding project led by Professor Byrne, as well as further developing the theme of research on foundation and structural design methods, and health monitoring activities. The project builds on the wide range of research on offshore foundations developed by the research group at the University of Oxford (e.g. from the PISA project, the ALPACA project, the Ørsted-Oxford collaboration), which are reducing foundation design conservatisms.
This project further developed the mathematics behind the new identification technique, and tested the procedure with the data already obtained from Parkwind. The mathematical derivations ensured robust performance of the algorithms when applied to field data. The new technique was compared to the performance of techniques used in the original project.

Flexible Funding Overview – Sarah James

- Research project: Geographic and Economic Modelling of Floating Wind Potential in the UK Renewable Energy Zone
- Partners involved: STFC

- Summary of research work, outputs and impact:

The project aims to calculate the levelised cost of electricity (LCOE) of energy from offshore wind farms in the UK Renewable Energy Zone (REZ) for floating and fixed turbine technologies; to test the impact of floating turbine technology on predicted LCOE and energy capacity in the UK REZ; to test the impact of any future cost savings in floating turbine technologies on LCOE and UK offshore wind energy capacity.

The project will result in an updated GIS model for offshore wind LCOE in the UK REZ, which will then form the basis for an analysis of the potential economic impact of floating turbines on costs, and capacity in the UK REZ, to be delivered in a full report to Supergen.

- Collaboration with ORE Catapult

During the project we have formed a collaboration with the Offshore Renewable Energy Catapult, making use of their expertise on up to date costs for offshore wind installation and operation, and of work they have done to quantify weather related impacts in different sea conditions (using average wind speed as a proxy for mild, moderate and severe conditions).

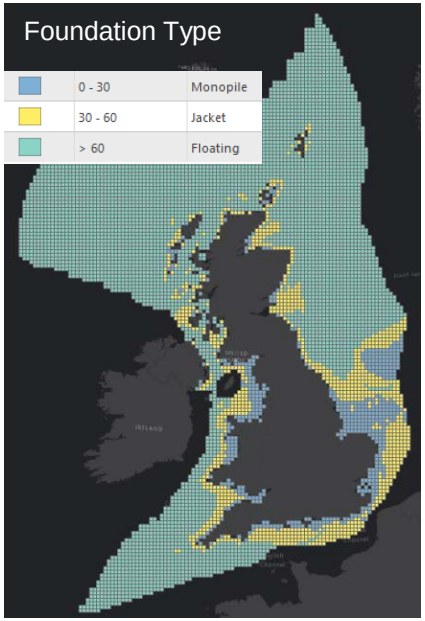
Flexible Funding Overview – Sarah James

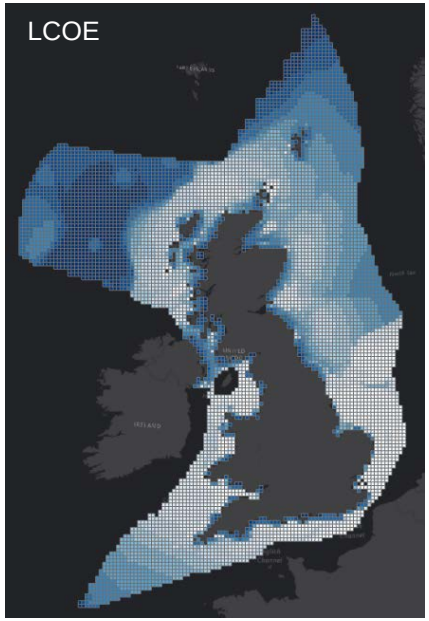
Updated Model – new features:

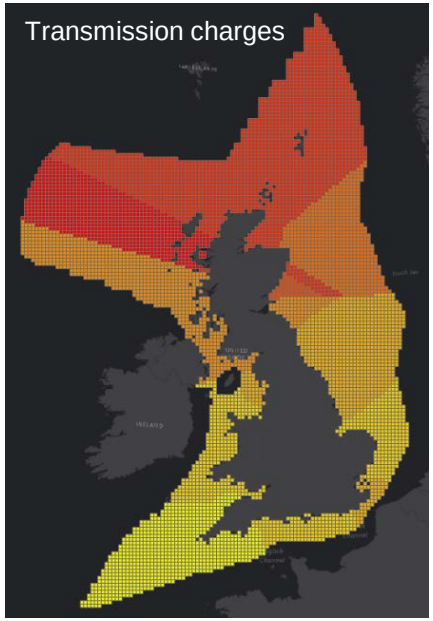
- Includes location dependent weather impacts and transmissions charges.
- Considers 1GW wind farm of 100 x 10MW turbines (previously using 5MW turbines)
- Refreshes economic and location constraints data

Results:

- Many Geographic Information System (GIS) layers that build the model allow us to see the ingredients that feed into LCOE by location (here are just a couple of examples)





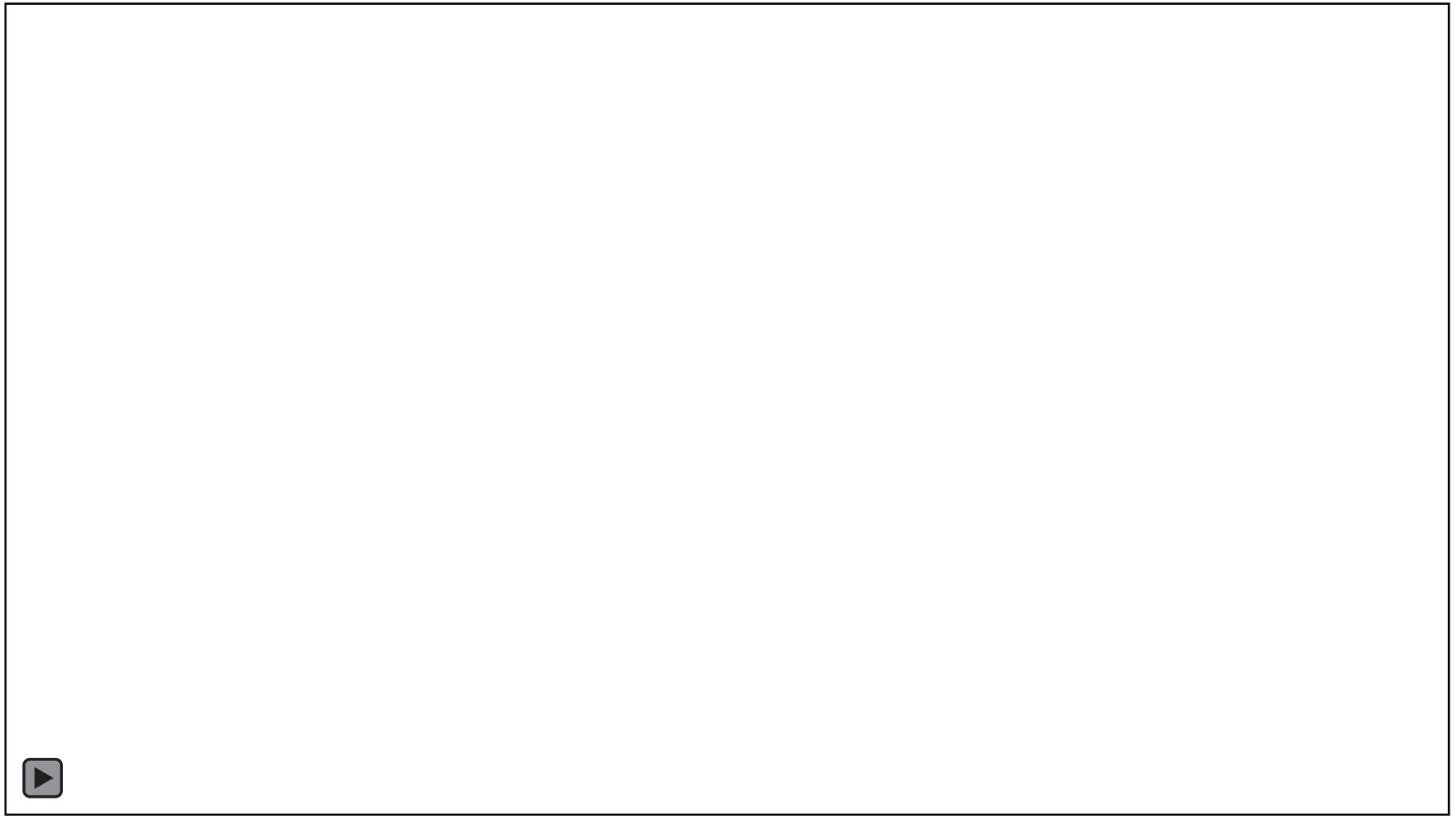


Wave Height Measurement using CCTV Cameras

Andrew Campbell, Paul Murray, David McMillan

CCTV Footage

- Provides an opportunity for turbine specify measurement at low cost



Ladder visibility

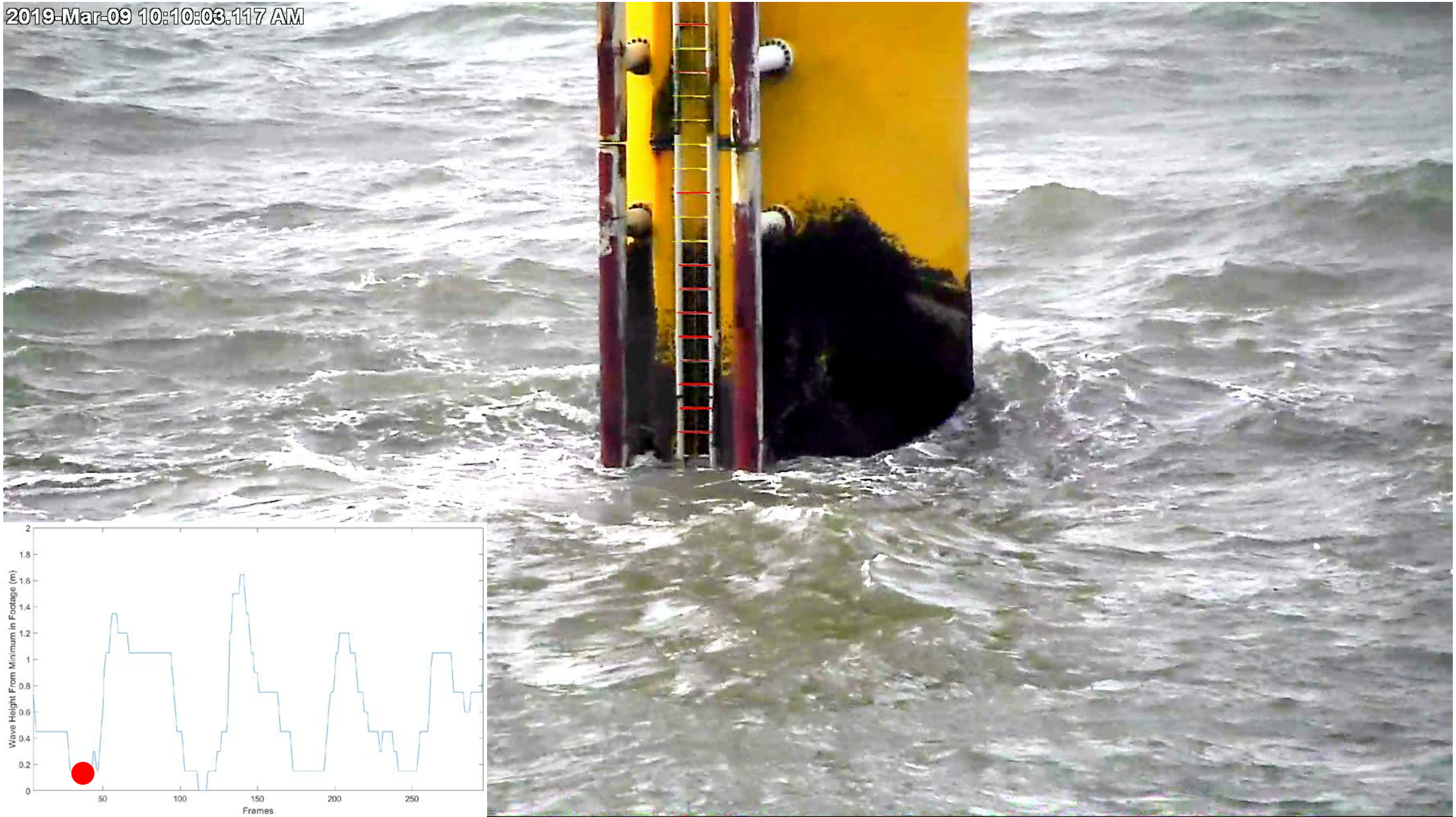
- The visibility of ladder rungs varies with wave height
- This provides a way to both track waves and infer scale

Original **5s later**

Example

- Wave height is inverse to the number of visible rungs in the image
- Assuming the maximum number of rungs gives a swell of 0 meters and the distance between rungs is 300mm wave height can be plotted against the CCTV footage
- This is shown in the following slides

Frame 39


2019-Mar-09 10:10:03.117 AM
Wave Height From Minimum in Footage (m)
Frames
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
50
100
150
200
250

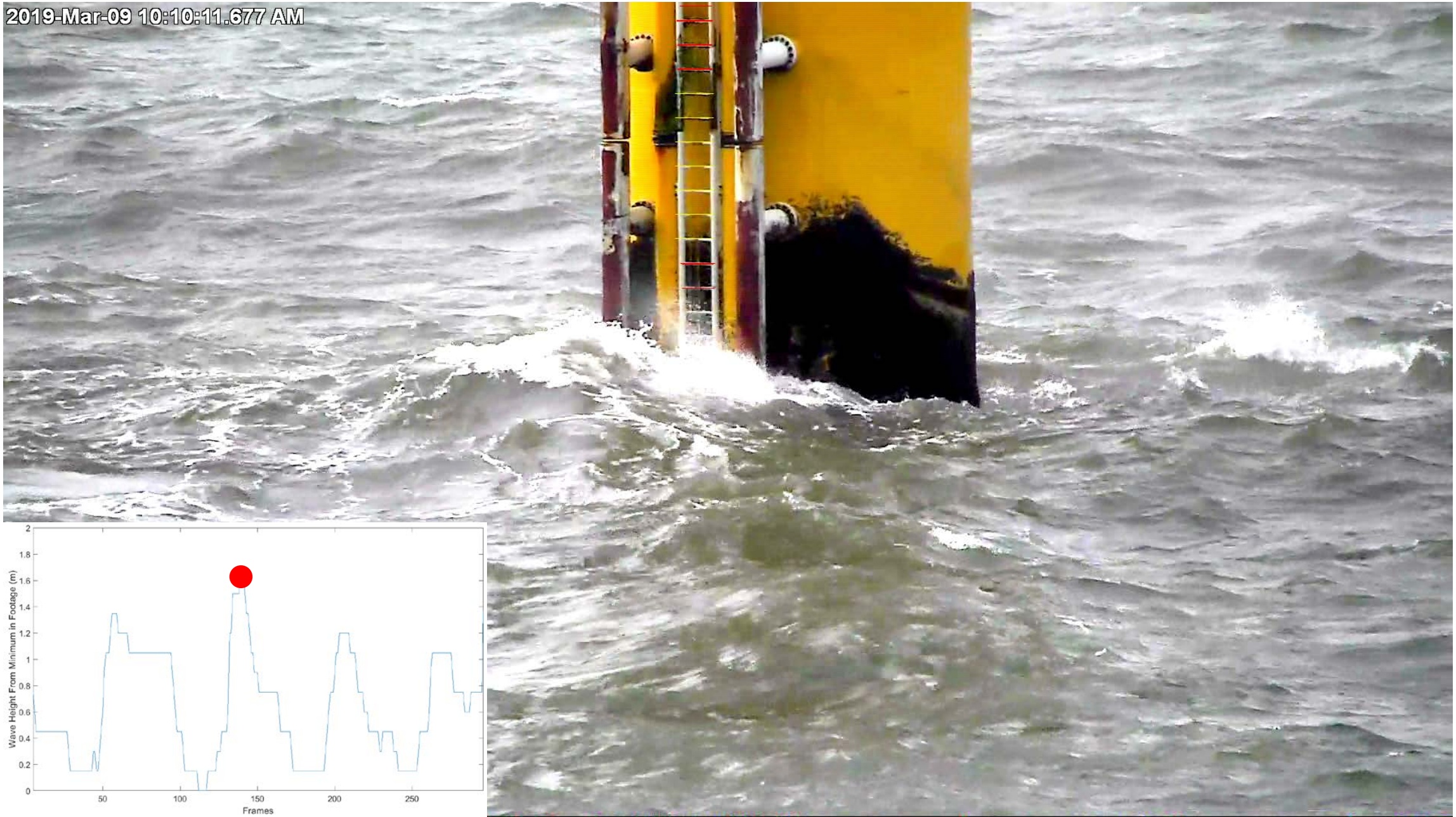
Frame 57


2019-Mar-09 10:10:04.477 AM
Wave Height From Minimum in Footage (m)
Frames
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
50
100
150
200
250

Frame 118


2019-Mar-09 10:10:09.877 AM
Wave Height From Minimum in Footage (m)
Frames
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
50
100
150
200
250

Frame 139


2019-Mar-09 10:10:11.677 AM
Wave Height From Minimum in Footage (m)
Frames
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
50
100
150
200
250

Frame 179


2019-Mar-09 10:10:15.116 AM
Wave Height From Minimum in Footage (m)
Frames
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
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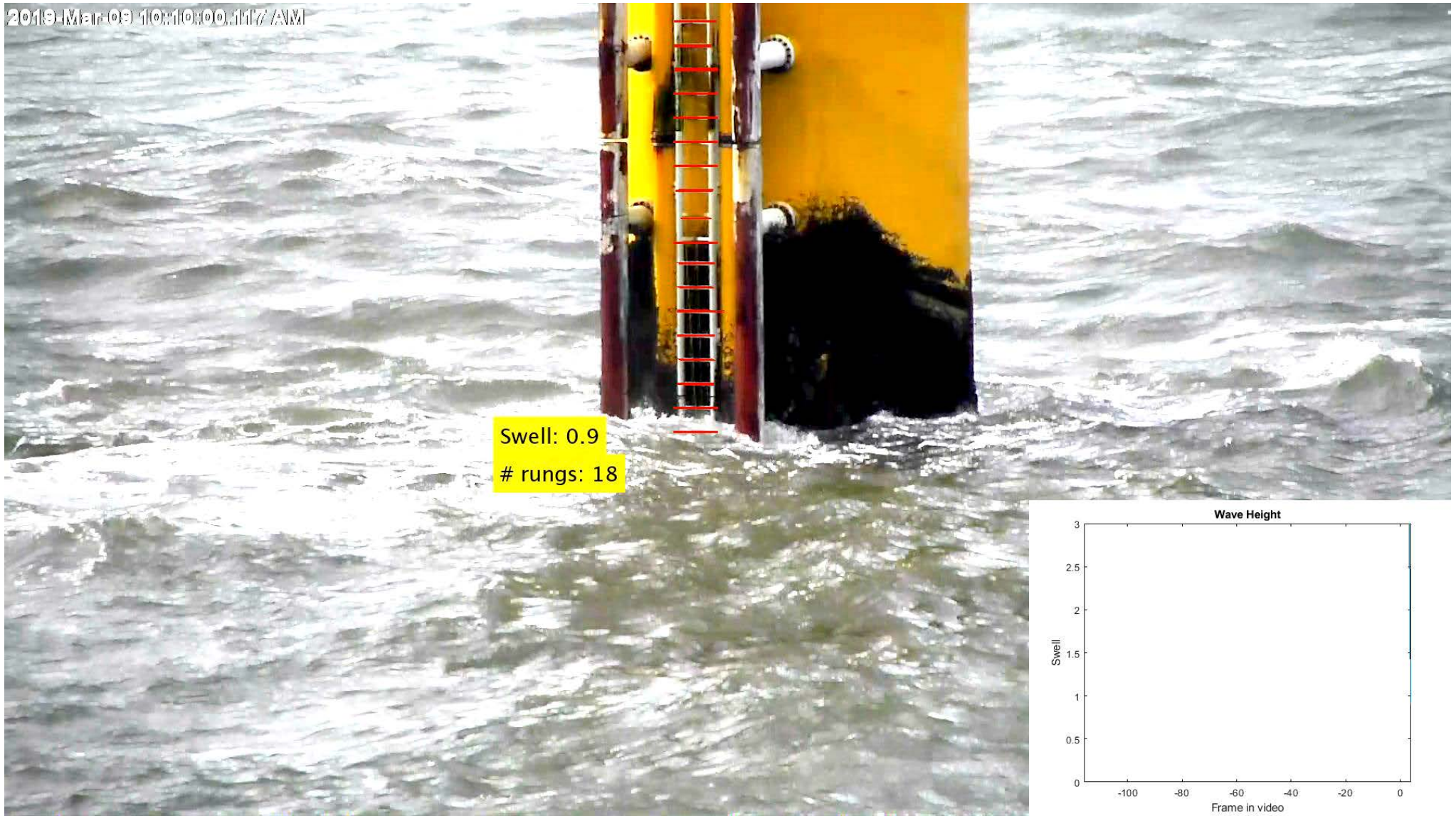
250

Processed Video



Theme 3: O&M and Decommissioning

- Research project: Automated Video Analysis for Accurate Wave Height Measurements in Offshore Wind Farms
- Partners involved: e.on

- Summary of research work, outputs and impact:

WP1 Data labelling and ground truth (W1 – W3)

- Gathered a dataset of video files showing sea conditions at offshore wind turbines
- Obtained further data from wave radars active on site describing conditions nearby
- Observed individual turbines experiencing conditions that differed from the site average, hence the need for this work

WP2 Algorithm development (W3 – W12)

- Automated video processing algorithm developed to identify ladder rungs in each frame
- Additional algorithm developed to interpolate potential missing rungs due to image distortions
- Algorithm designed to count all visible ladder rungs (above sea level) and map this to the instantaneous wave height
- Industry standard averaged measures such as significant wave height (Hs) were automatically computed from data

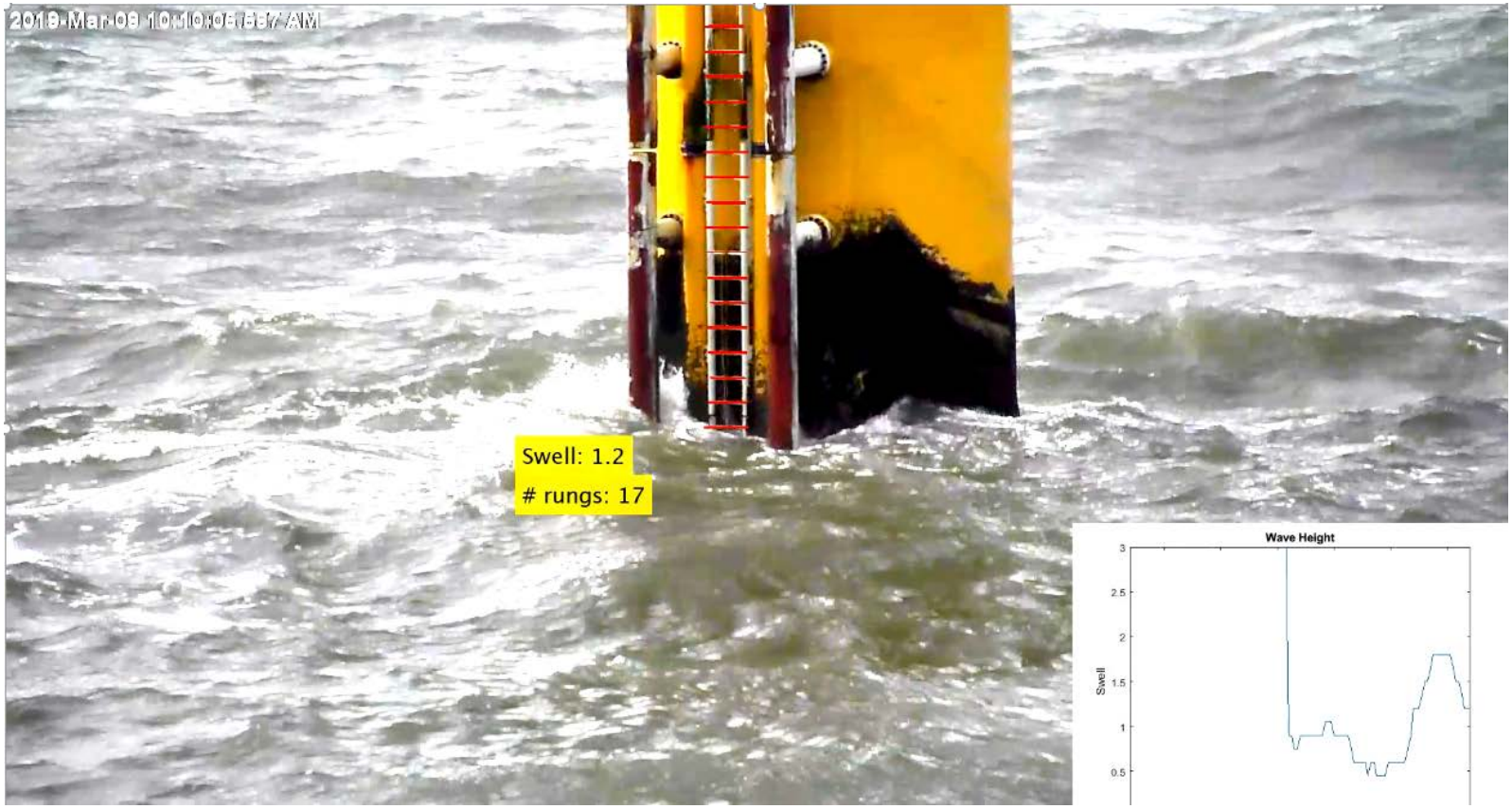
WP3 Algorithm evaluation (W12 – W15)

- Evaluation of our algorithm was performed by comparing measurements of Hs existing wave radars
- Automated algorithm gave measurements in expected range
- Measurements were typically most similar to measurements from the wave radar positioned geographically closest to the turbine
- With this algorithm low cost CCTV cameras could be deployed to measure the entire site, while more expensive wave radars would only ever be deployed sparsely

WP4 Next steps (W9 – W15)

- Larger datasets have been acquired to further test this work in different times of day and lighting conditions
- Further opportunity to develop this into a service that can be deployed on vessels has be identified
- Further funding has been secured from the IAA to advance this work in the short term with a larger IUK grant under development with an industrial partner, Reygar.

The image below shows a screenshot of a processed video file. For each frame of video captured rungs are detected and the number of visible rungs is mapped to the instantaneous wave height (swell). This is recorded to the time series in the bottom right which can be used to analyse the wave conditions, or mapped to significant wave height (Hs) measurements.

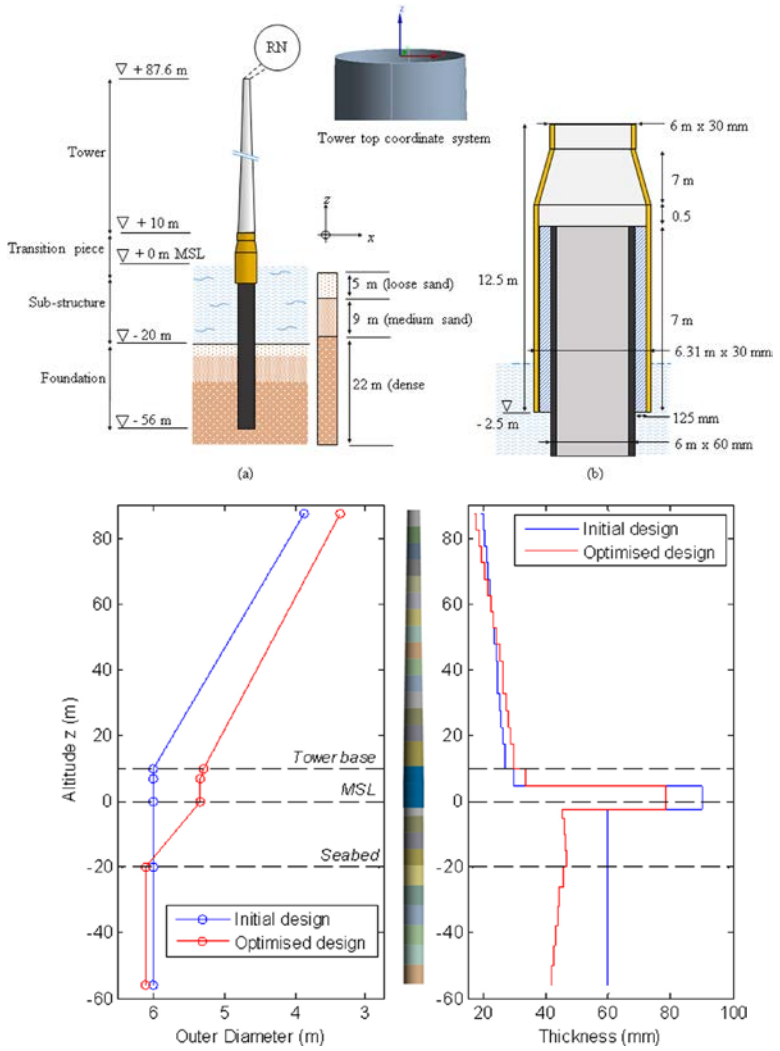


Flexible Funding Overview – Professor Athanasios Kolios

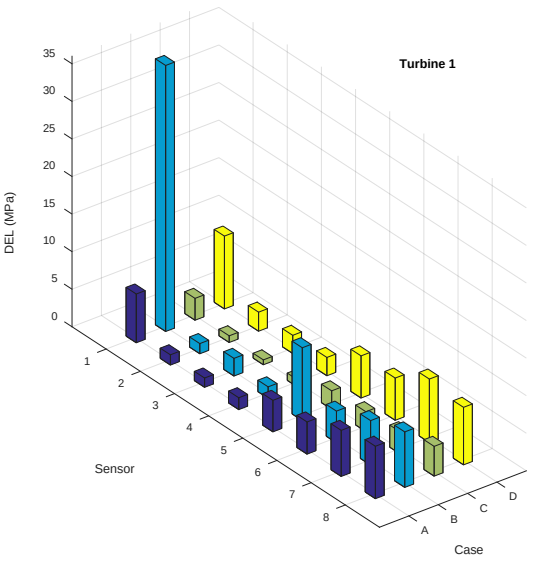
- Research project: Evaluation of wind farm support structures' performance based on extrapolation of Structural Health Monitoring (SHM) data from selected instrumented units

- Partners involved: University of Strathclyde

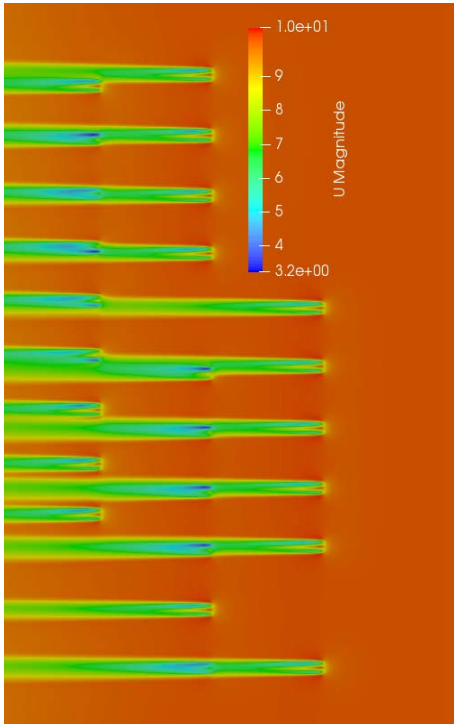
- Summary of research work, outputs and impact:
  - Aim of the project:
    - To deliver a framework for the evaluation of wind farm support structures' performance based on extrapolation of SHM data from selected instrumented units.
  - Outputs:
    - Development of data processing methods, focusing on treatment of incomplete datasets.
    - Development, validation and derivation of an optimization framework for offshore wind monopiles using GAs.
    - High fidelity CFD analysis of wind farm and validation using data from an operational wind farm.
  - Impact:
    - Current practice suggests that less than 10% of units are instrumented, but decisions for operational management concern every unit individually.
    - This project provides a framework for optimum placement of sensors and extrapolation of measurements to non instrumented units, reducing cost and increasing value of collected data.



Design optimisation using GAs



Fatigue assessment based on different scenarios of data processing



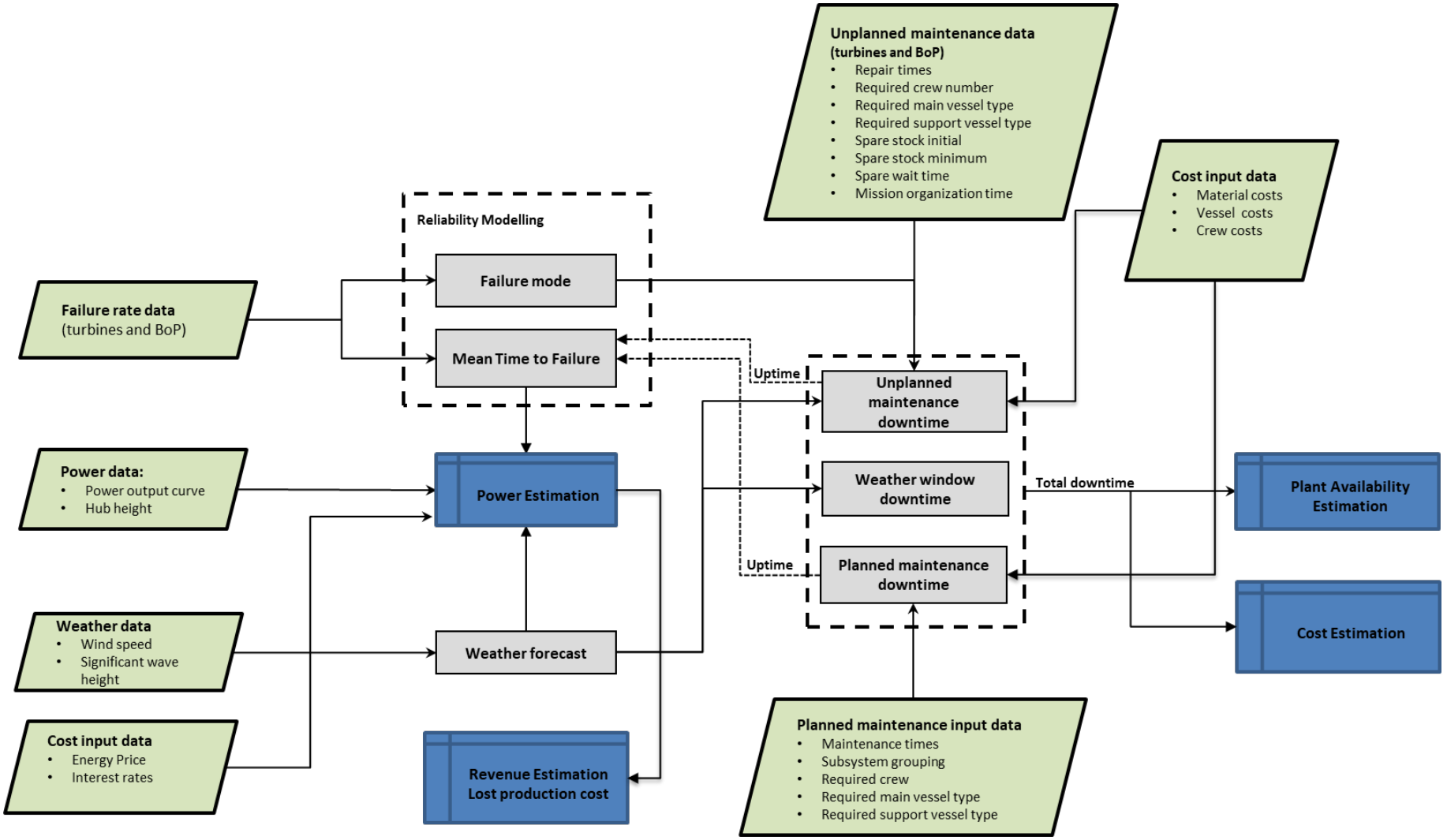
CFD analysis of an operational wind farm (velocity profiles)

Flexible Funding Overview – Professor Athanasios Kolios

- Research project: OpenO&M: Optimising availability of floating wind turbines for increased safety

- Partners involved: University of Strathclyde

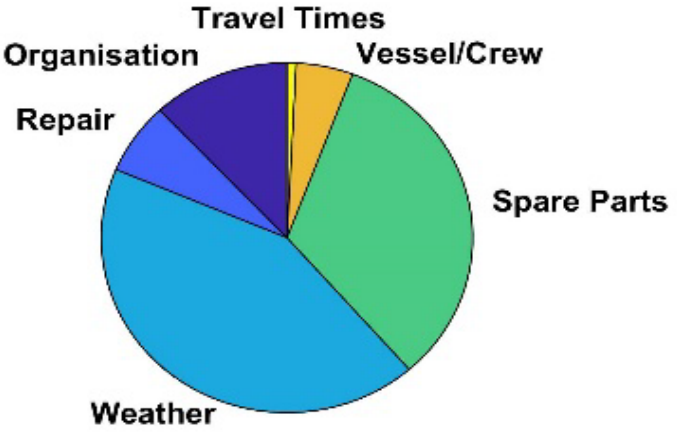
- Summary of research work, outputs and impact:
  - Aim of the project:
    - To develop an open access O&M tool for the evaluation of the availability of floating wind farms, taking into account relevant serviceability safety constraints.
  - Outputs:
    - Developed an efficient algorithm for weather time series simulations applicable for wind and wave data.
    - Developed an O&M simulation tool to analyse passive downtime and account stochastically for uncertainty in inputs.
    - Run case studies for a floating support structure and perform a sensitivity analysis to define the impact of safety limits to the availability of the asset.
  - Impact:
    - Transition in deeper waters deployments, further offshore, has shifted operational boundaries of fixed support structures, so operators are now investigating floating support structure options.
    - This project develops an open access tool and investigates the impact of additional considerations for floating support structures to the availability of these assets.

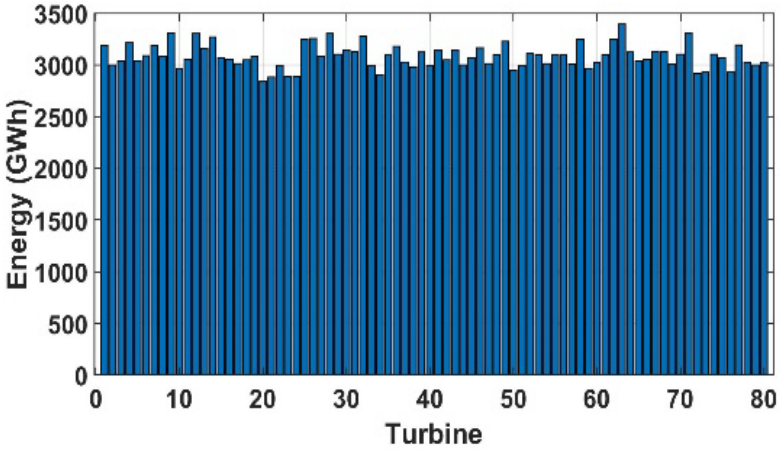


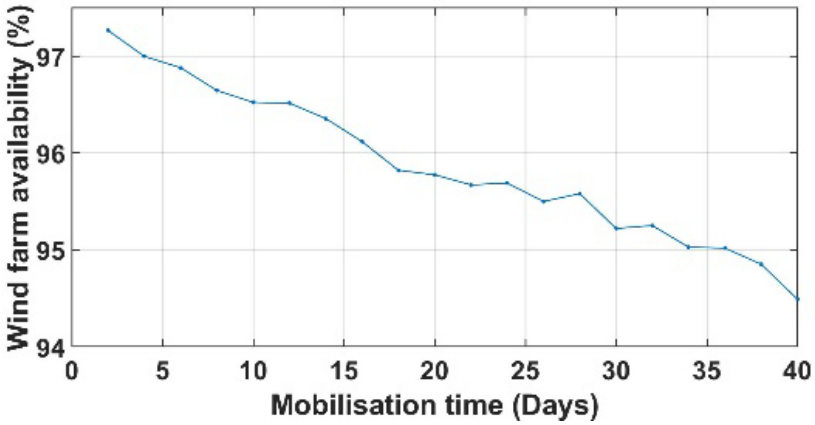
Modelling algorithm

Key outcomes

Availability (%)	Energy Production (GWh)
94.49	246,852







Flexible Funding Overview – Dr Alasdair McDonald

- Research project: Comparison of turbine powertrain models and measurements for maximum energy capture

- Partners involved: University of Strathclyde, University of Edinburgh, ORE Catapult

- Summary of research work, outputs and impact:

Operation and maintenance companies, as well as operators are seeking for models that can help them understand the properties and way of operation of their assets. Companies such as Enel and Ingeteam, have already expressed interest in the development of this tool.

Work has established gearbox models (at Strathclyde) and generator and power converter models have been developed (at Edinburgh) for the Levenmouth Development Turbine.

SCADA data will compare the results predicted by powertrain design models with field measurements, capture the uncertainty in the models, and improve them in turbine design processes.

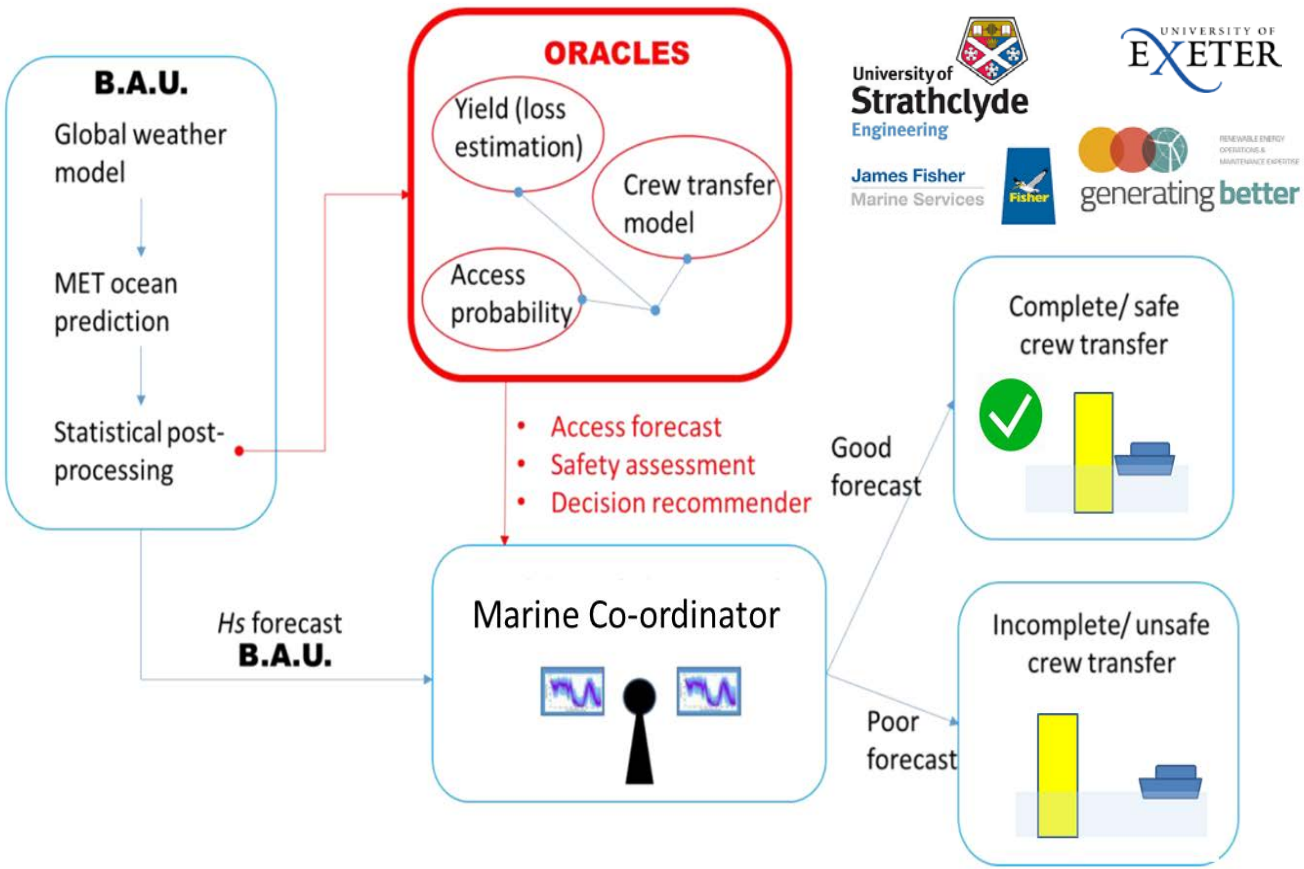
The thermal model development of the LDT gearbox will help understand the system losses. By considering the thermal behaviour of the powertrain mechanical components, the turbine control strategy can be adapted in order to maximize the energy capture.
In addition, with the creation of the equivalent electrical circuit of the gearbox the overall complexity of the system is considerably reduced and full wind turbine studies could be carried out by introducing a simplified generator and converter equivalent electrical circuits.

Flexible Funding Overview – Dr David McMillan

Project: Offshore Renewables Accessibility for Crew Transfer, Loss Estimation and Safety (ORACLES)

The pressure to achieve increased access to turbines implies a greater number of marginal-weather transfers, which carry a greater safety risk.

ORACLES – CONCEPT & TEAM

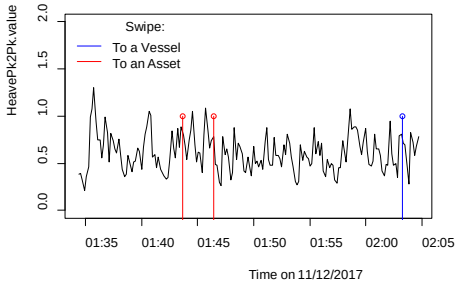


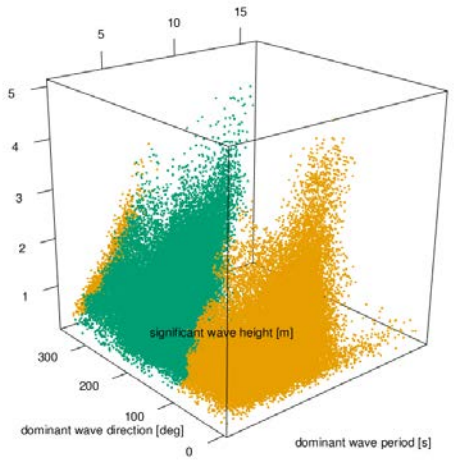
University of Strathclyde Engineering

James Fisher Marine Services

University of Exeter

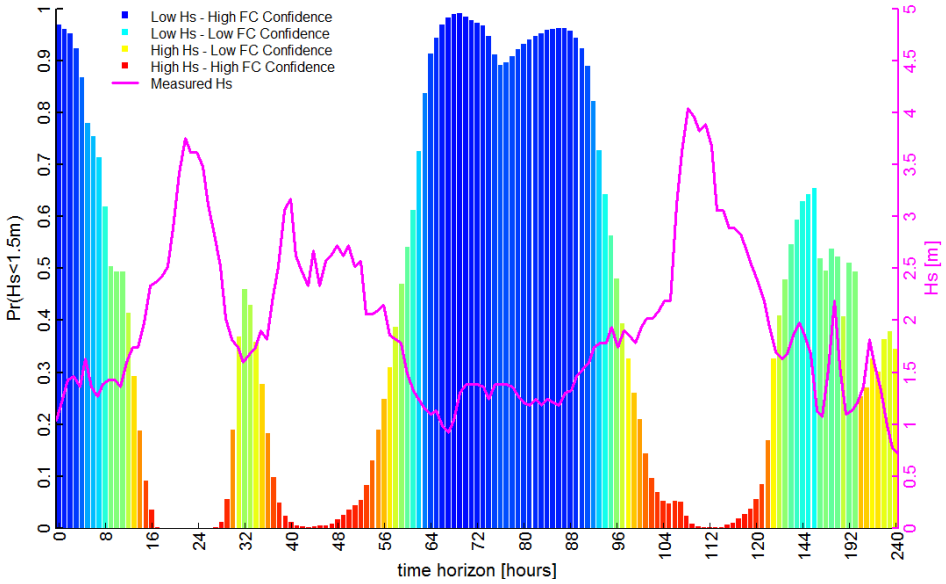
generating better

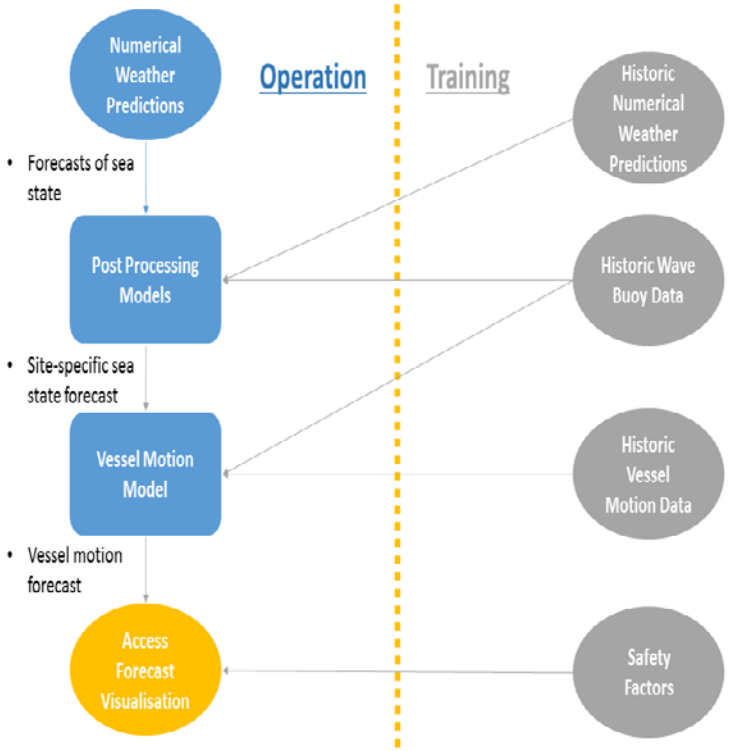




Develop a novel methodology to produce access forecasts:

1. The upside of a marginal-weather crew transfers in terms of cost and other KPIs
2. Safety/risk factors of the crew transfer itself
3. Develop the methodology in a way which better connects across site interfaces & KPIs





ORACLES - ENGAGEMENT

https://oracles.eee.strath.ac.uk/

ORACLES – Closeout Update

Outputs

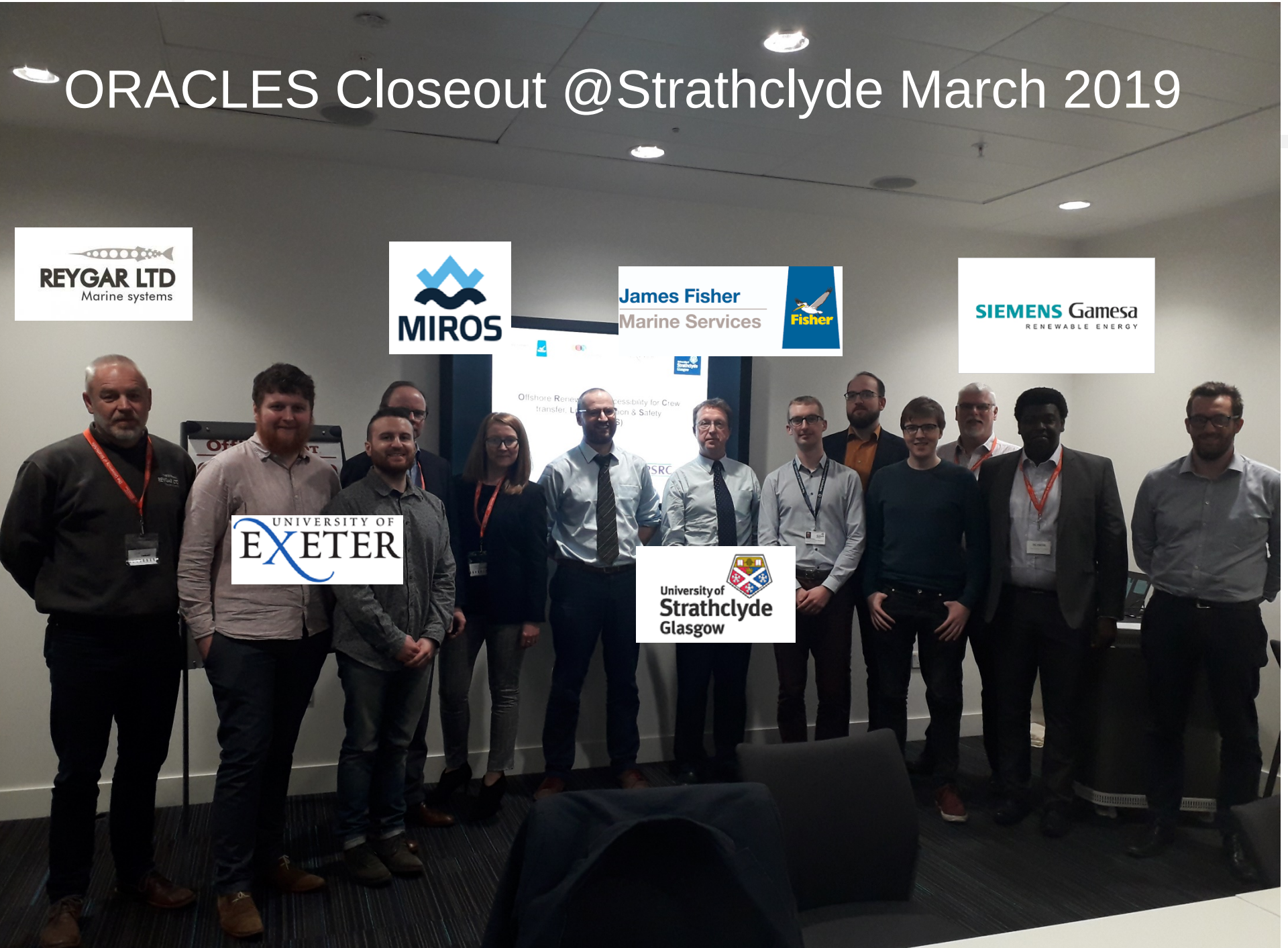
- WindEurope 2019
- RUK Offshore 2019
- IEEE Oceans 2019
- Journal paper under review (J Forecasting)

Follow-on Projects

- SCORE – ORE Supergen with UoEd 100k (confirmed, Oct start)
- KTP on ocean measurement with Miros 200k (confirmed, Sept start)
- IAA/ Innovate Smart Award with Reygar 300k (in draft)
- Ciaran Gilberts Innovation placement with EdF Offshore (in draft)
- ‘ORACLES+’ with Miros, StormGeo, Iceni (in draft)
- Ongoing talks with JFMS re possible porting of ORACLES code

https://oracles.eee.strath.ac.uk/

ORACLES Closeout @Strathclyde March 2019



Flexible Funding Overview – Prof Olimpo Anaya-Lara

- Research project: Dynamic Wind Power Plant Control for System Integration

- Partners involved: University of Strathclyde

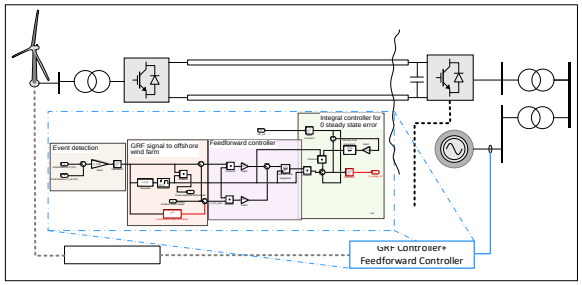
- Summary of research work
- This project presents a holistic wind farm control approach that enables wind power plant to provide the full range of ancillary services including synthetic inertia at the wind farm level rather than single turbine level.

  - In order to detect a power system event and select the magnitude of the service provision from the wind farm, a fully instrumented small/medium generator is used.
  - The wind farm is enslaved to the of the small/medium generator natural response during power system events. In this way, the wind farm is able to provide a stable scaled-up range of ancillary services without relying in delayed or noisy grid frequency measurements.
  - Transmission delays in communications with offshore wind farm farms are compensated with feedforward controllers in the onshore HVDC stations for immediate output power provision.

Outputs and impact:

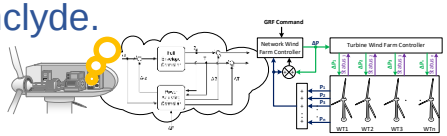
- One IEEE Transaction on Industrial Electronics Paper (2018).
- Best poster Award from the Global offshore wind conference 2018.
- A Functional Model of a multi-machine network for testing and validation of the "Generator Response Following" (GRF) concept.
- A Functional Controller for the GRF concept that takes into account commands transmission delays and feedforward to provide a stable GRF output.
- An enhanced model of a DFIG wind turbine for faster simulation and extra compatibility in Simulink models.
- One ETP-Funded visit to Canada for 1 month to work in prototypes of a DFIG wind turbine developed during core research of the project.
- Development of a Functional 0.5kW Prototype of a DFIG wind turbine at UBC (Canada)
- An enhanced model of the PMSG wind turbine for faster simulation and extra compatibility in Simulink models.
- A patent proposal currently under evaluation by the University of Strathclyde.

Further details and image:

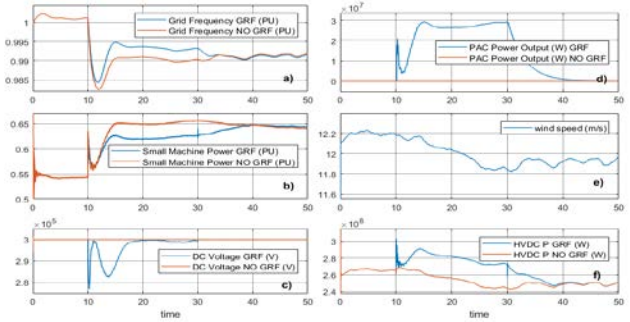


The GRF concept

Best poster award 2018 Global offshore wind



The PAC controller



Simulation results of the GRF concept

Flexible Funding Overview

➢ Partners involved: University of Strathclyde

- Flexible Funding project - Development of an integrated life-cycle cost assessment model of floating wind turbines.

This project involved the development of an integrated lifecycle techno-economic assessment tool to allow researchers and developers benchmark their floating concepts in a fair way.
The objectives of the work:

- Identify the key cost components for the development of floating wind farms;
- Develop parametric equations for cost component specific to floating wind farms;
- Integrate an O&M module taking into account latest reliability data, weather conditions and serviceability safety constraints;

The project outputs:

- An open access cost assessment tool for fixed and floating wind turbine support structures available to researchers and developers, which will allow for the benchmarking and cost analysis of an investment;
- Scholarly papers in high impact academic journals, including source dissemination of generic results and guidelines for design and application.