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Dynamic Loading on Tidal Turbine Arrays (DyLoTTA)

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Project Partners and Collaborators

Academic

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Strathclyde: Cameron Johnstone, Joe Clarke
University of South Wales: Daphne O'Doherty
Researchers: 2 Researchers plus 4 PhD students

Industrial

Airborne Composites, ANSYS, Arup, Bosch Rexroth, Intertek, Lloyds Register, National Instruments, Nautricity Ltd, ORE Catapult, SKF, Tidal Energy Ltd.

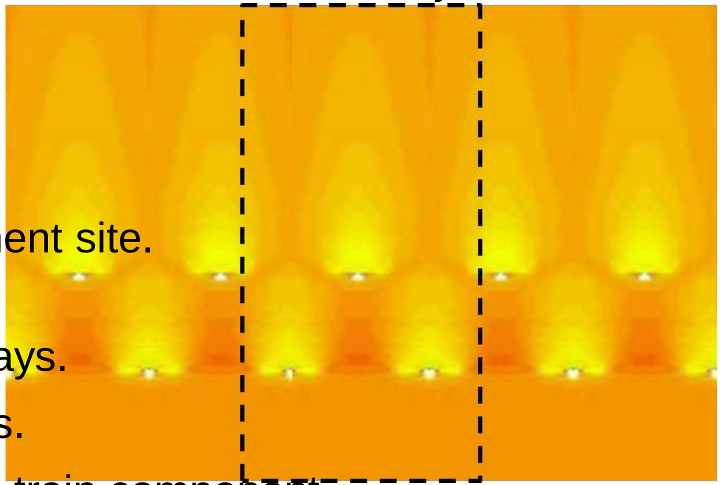
International

Dalhousie University – Canada [Material]
Inha University – South Korea [experimental/numerical]
Mississippi State University – USA [numerical]

Dynamic Loading on Tidal Turbine Arrays (DyLoTTA)

Aims

- Quantify the impact of wave-current interaction on the performance and integrity of TST devices when sited in an array.
- Develop operational procedures to mitigate the impacts of extreme loading patterns. Specifically the dynamic loading patterns on the blade, blade root and eccentricity induced within the drive train.
- Measure and mitigate such effects.



Objectives

- Assess the local hydrodynamics at a suitable UK deployment site.
- Produce a computer numerical analysis tool kit to support decision making for the configuration and operation of arrays.
- Deploy, test and optimise model scale array configurations.
- Produce an analysis loading mechanisms to support drive train component selection and establish operational maintenance requirements of an array.
- Develop operational procedures and maintenance scheduling applicable to open-sea arrays.

Background

Work by the investigators on previous RCUK programmes has independently recognised the magnitude of the loading problems that single TSTs are subjected to due to wave-current interaction, misaligned flows and structural interaction.

A series of tests were undertaken providing validation data for a number of scenarios: no-waves, waves, offset blades and misaligned flows.

Experiment Set-Up

- CNR-INSEAN Tow tank of 3.5 x 9 x 220m
- Rotor diameter 0.5m
- Blockage ratio of <1%
- Tow speeds of 0.5 to 1.5 m/s
- Wave heights of 0.4,0.3 and 0.2m
- Wave period of 2s

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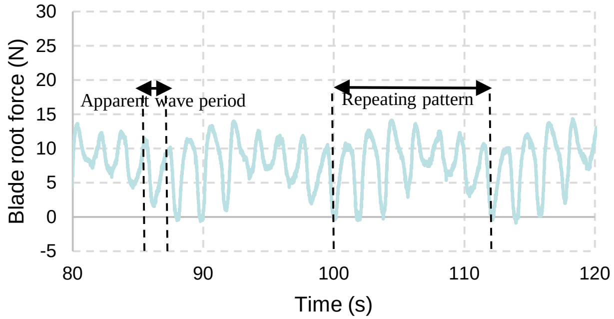
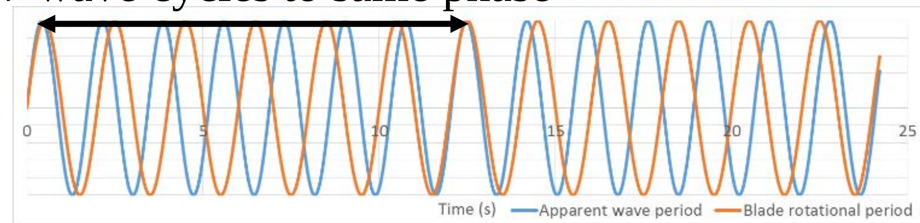
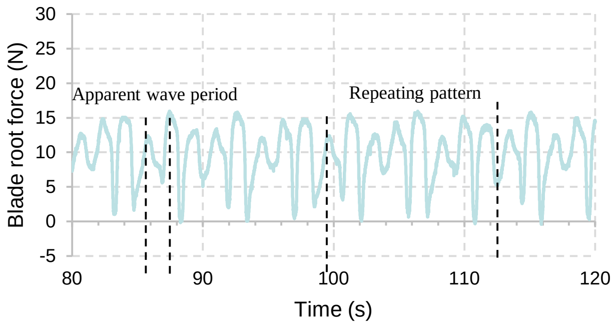
Blade Root Forces



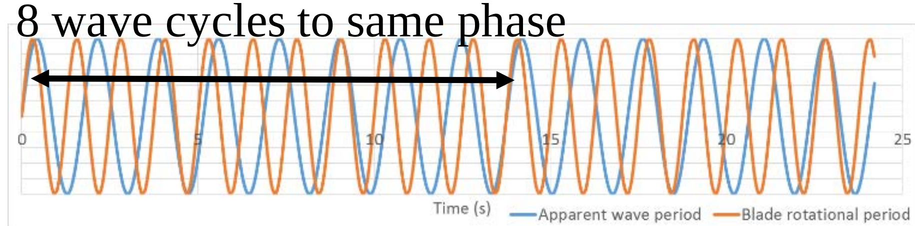
7 wave cycles to same phase



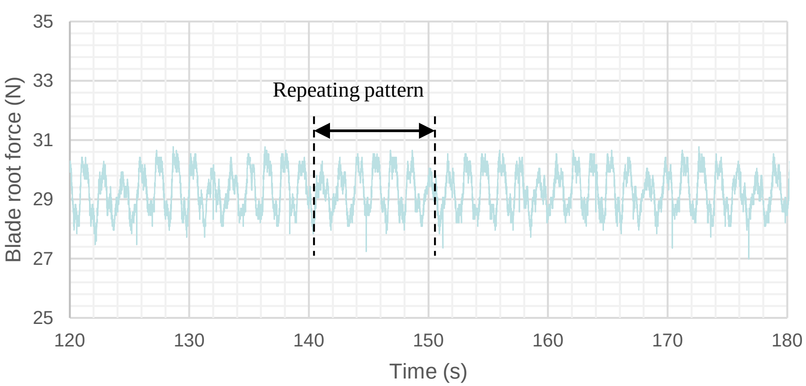
TSR = 1.6, 0.5m/s



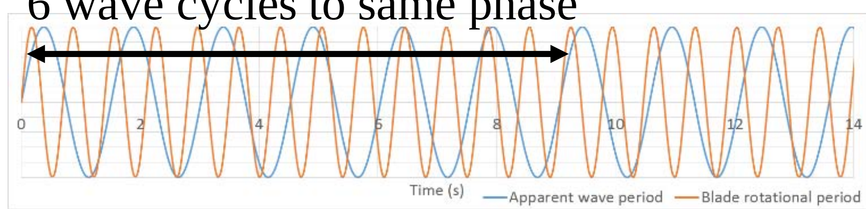
8 wave cycles to same phase



TSR = 2.5, 0.5m/s

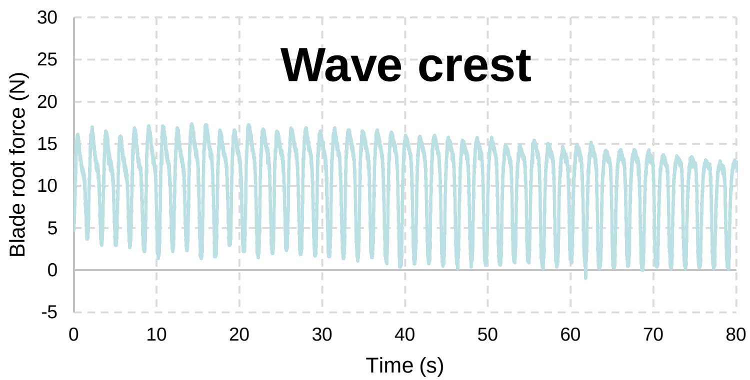


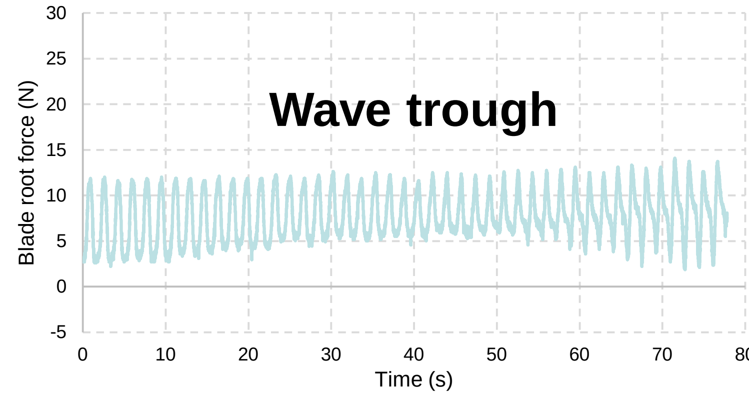
6 wave cycles to same phase



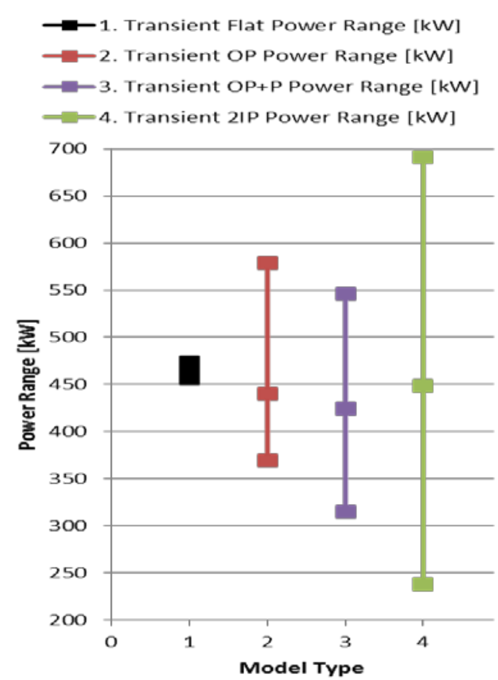
TSR = 2.25, 1m/s

Blade Root Forces
wave crest and trough

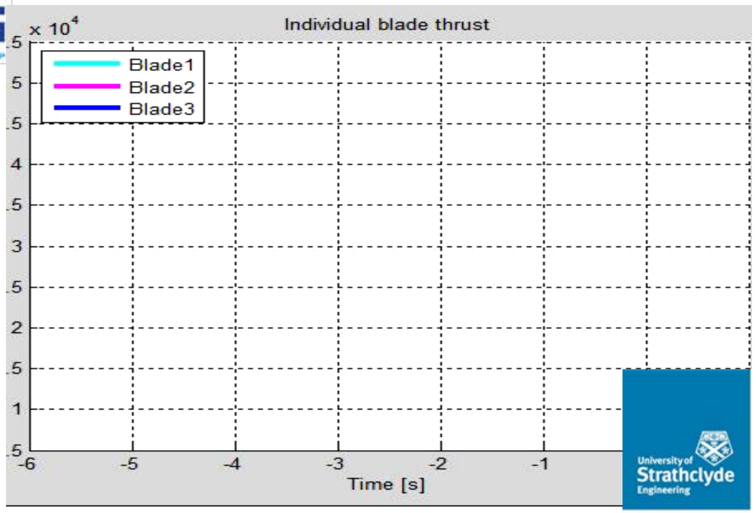


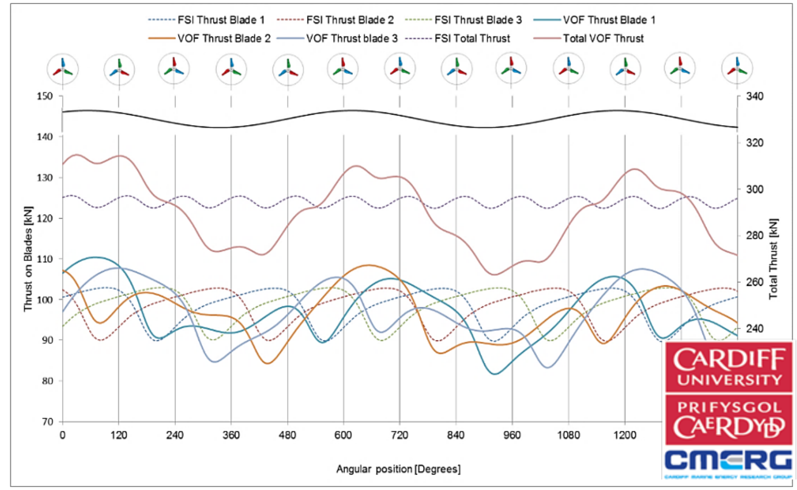


- Two experiments were carried out when either the wave crest or trough approximately coincided with the instrumented blade passing the upright position.
- Rotational velocity was set to match the apparent period of the wave.
- The loading fluctuations are noticeably reduced in the test where the wave trough coincides with the upright blade.
- These variations in load fluctuations have also been numerically modelled with CFD and BEMT.

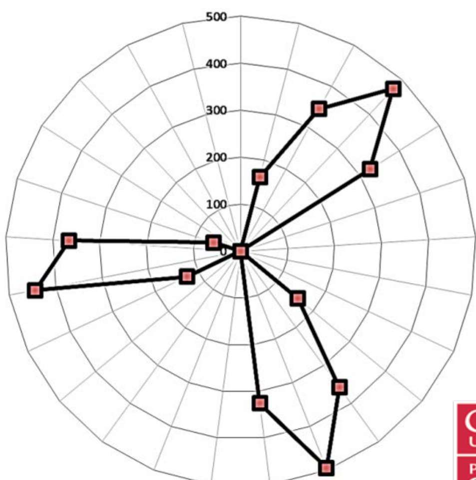


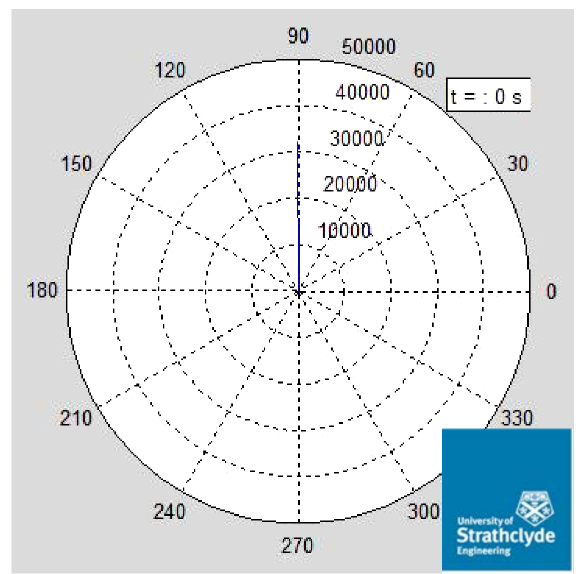
Transient thrust curves



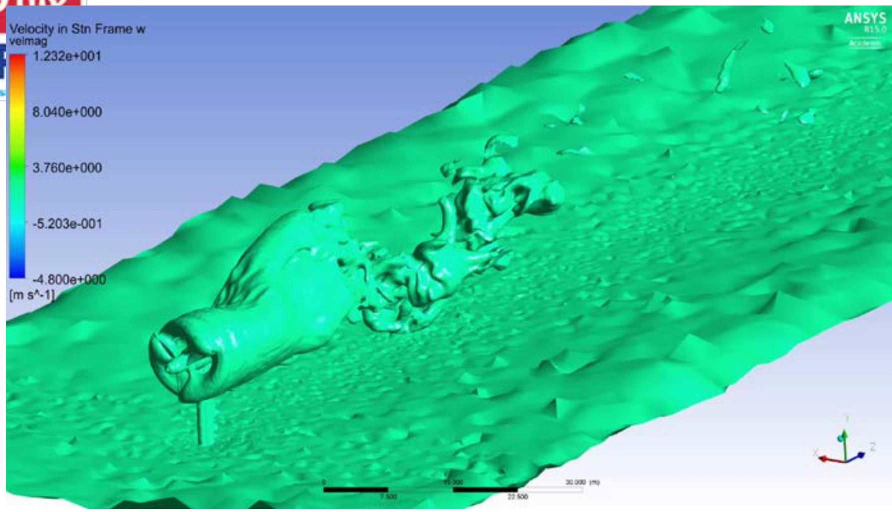


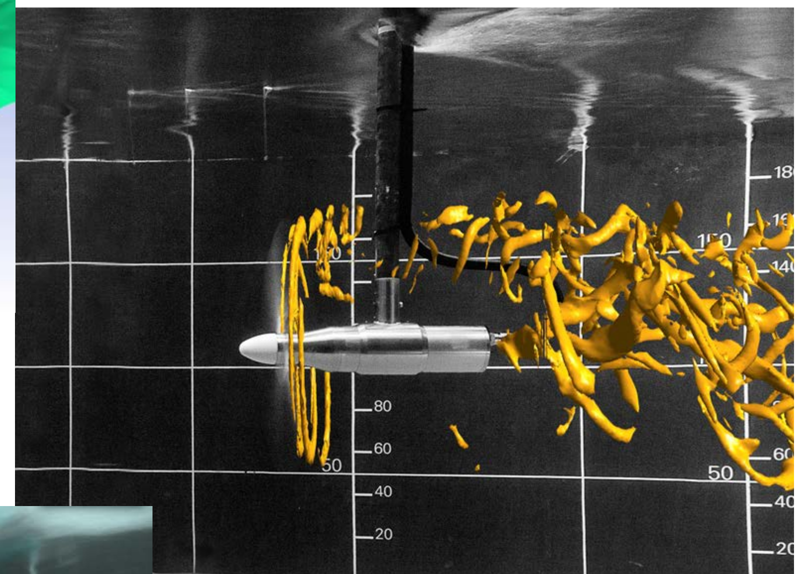
Transient shaft bending moments





Wakes





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