Supergen Offshore Renewable Energy

ANNUAL ASSEMBLY

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University of Plymouth & online

#SupergenORE2022

NHP-WEC

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UNIVERSITY OF HULL | ENERGY AND ENVIRONMENT INSTITUTE

UKRI Engineering and Physical Sciences Research Council

Engineering | Lancaster University

Project Team

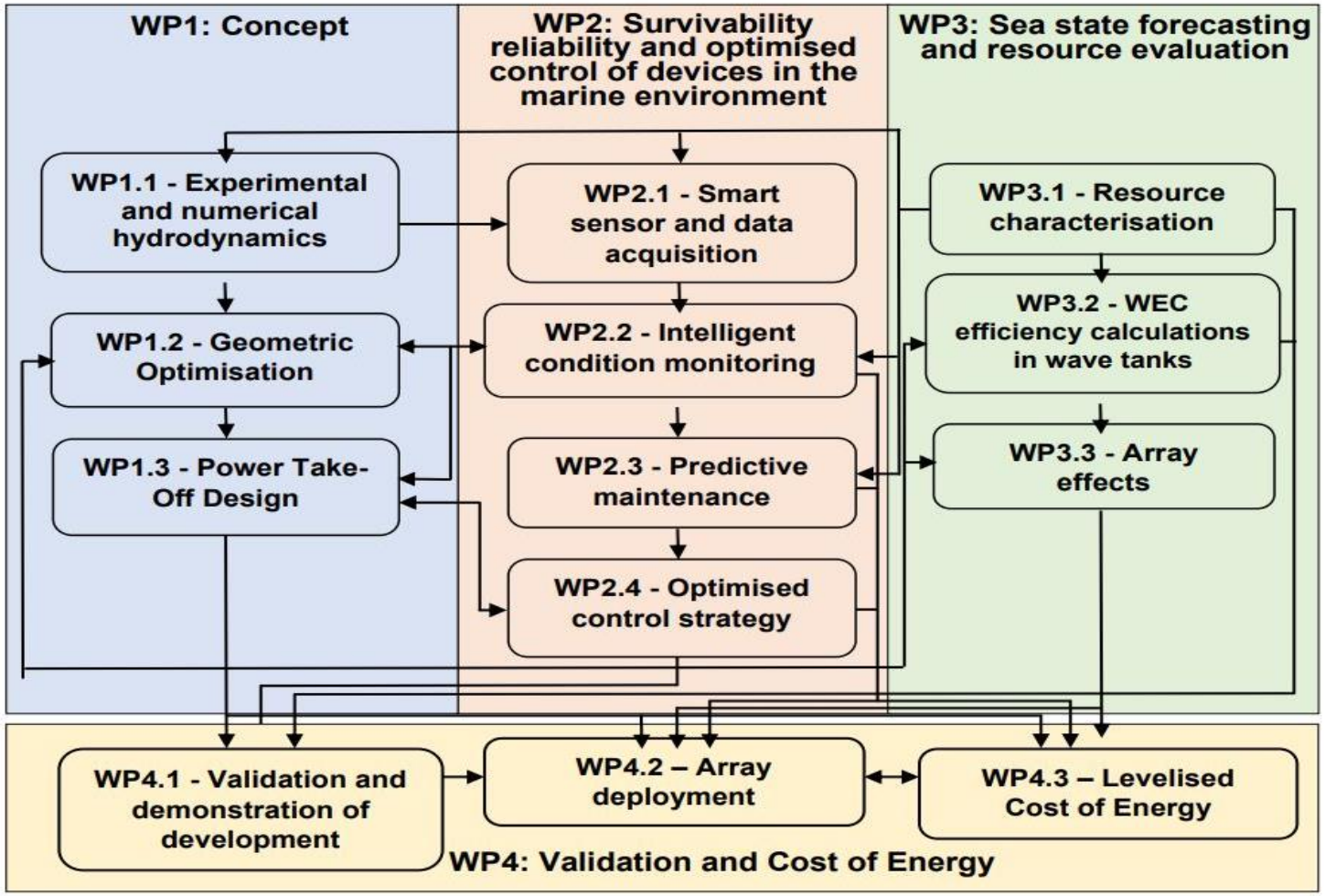
Lancaster University

- P-I - Professor George AGGIDIS
- Co-I - Dr Xiandong MA
- Co-I - Professor C. James TAYLOR
- PDRA1 - SRA - Dr Wanan SHENG
- PDRA2 – RA - Yueqi WU

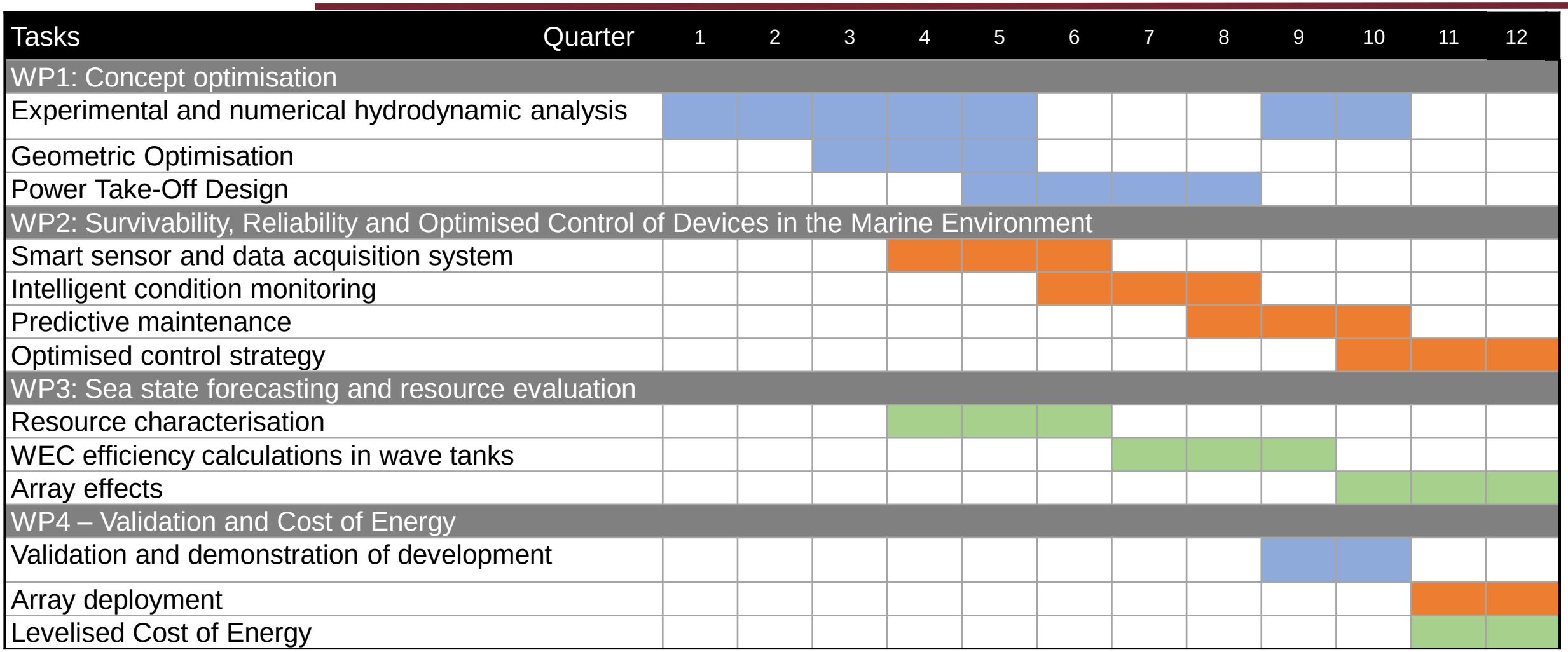
UNIVERSITY OF HULL

- Co-I - Dr Robert DORRELL
- Co-I - Professor Daniel PARSONS
- PDRA3–SRA–Co-I - Dr Evdokia TAPOGLOU

Work Package Structure



Work Package Tasks Timeline



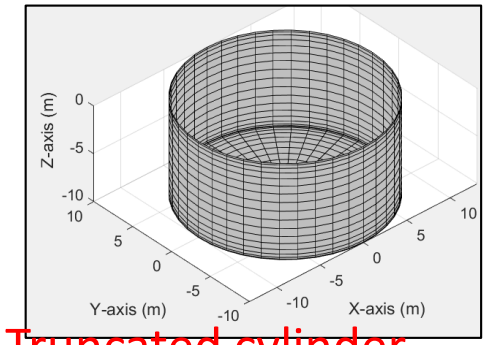
Tasks, Management

Tasks	1	2	3	4	5	6	7	8	9	10	11	12
Determined hydrodynamic characteristics												
Validation of numerical model/s												
Advanced optimisation of geometry												
Manufacturing of final model												
PTO design incorporation and model												
Established data acquisition framework												
Established condition monitoring method												
Predictive maintenance methods												
Optimised control method												
Machine learning model for wave evaluation from satellite images												
Model for the calculation of the efficiency of the device in tank tests												
Determination of array effects from tank tests												
Numerical data to validate development												
Experimental data to validate development												
Levelised cost of energy and potential												
Array deployment potential												

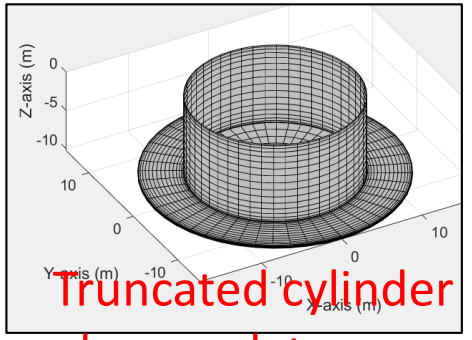
Project Management	1	2	3	4	5	6	7	8	9	10	11	12
Progress Meetings	Twice monthly											
Group face-to-face meetings	Quarterly											
Advisory Board meetings												
Workshops												

Paper 1: Code comparisons

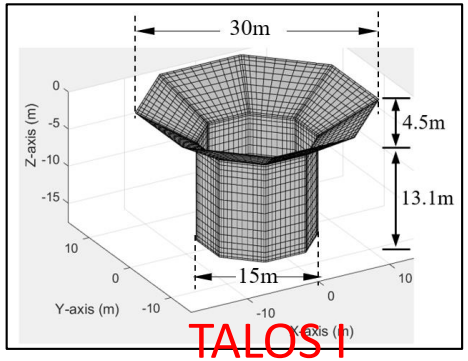
1) WAMIT (commercial): Wave Analysis MIT
2) Nemoh (open source, released by ECN, France)
3) HAMS (open source, Released by Dr. Yingyi Liu): Hydrodynamic Analysis of Marine Structures



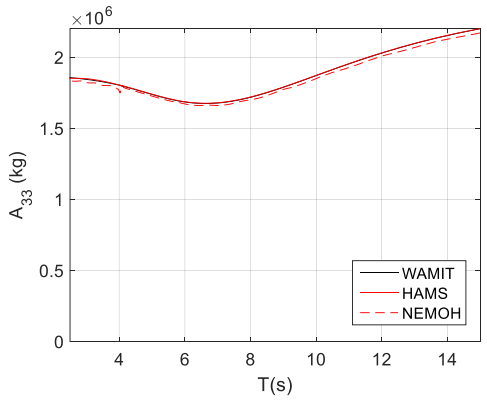
Truncated cylinder

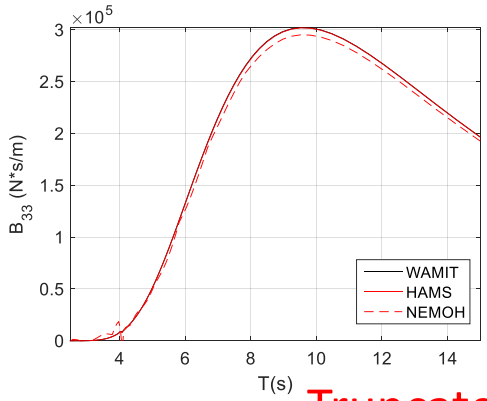


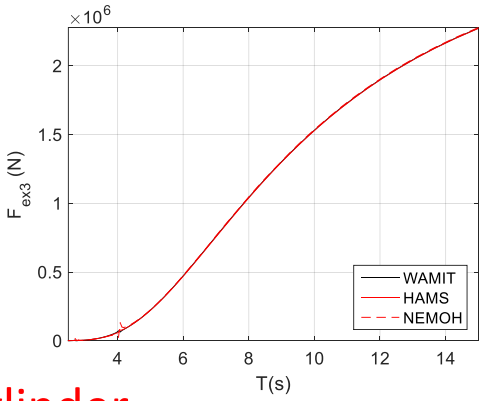
Truncated cylinder +heave plate

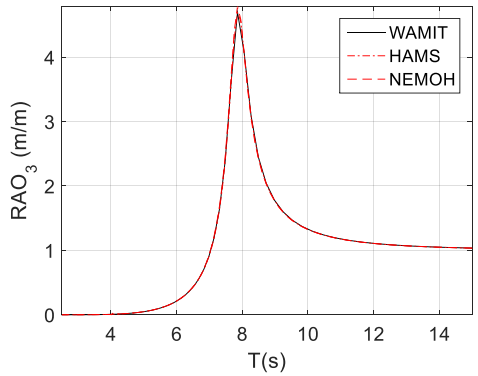


TALOS I



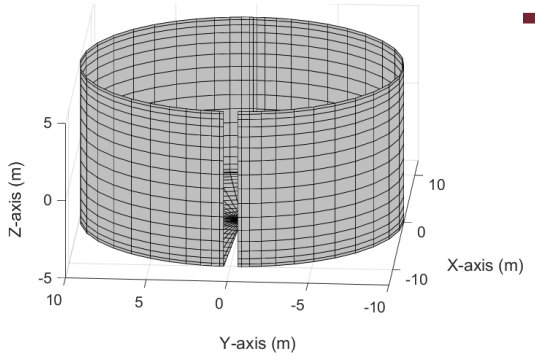




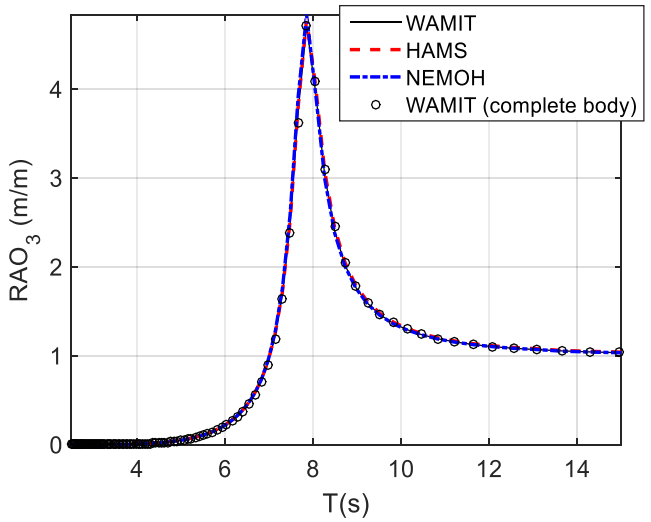


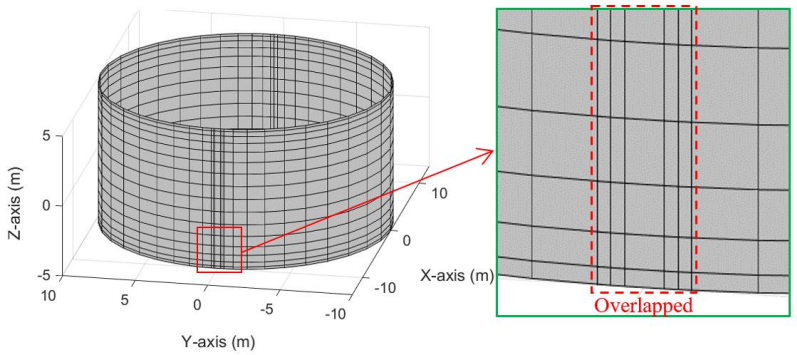
Truncated cylinder

Paper 1: Code comparisons…

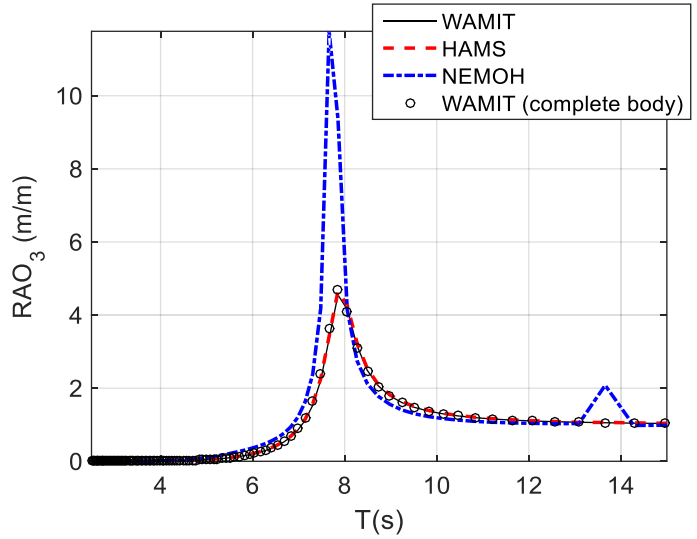


Incomplete cylinder





Cylinder with an overlap



Paper 1: Code comparisons, Status

- Revision has been submitted to Ocean Engineering for publication

- Following the suggestion from a reviewer, we are making the mesh files (used in the research) to public access for those who may be interested in the hydrodynamic analysis of marine structures.

Paper 2: Time-domain implementation

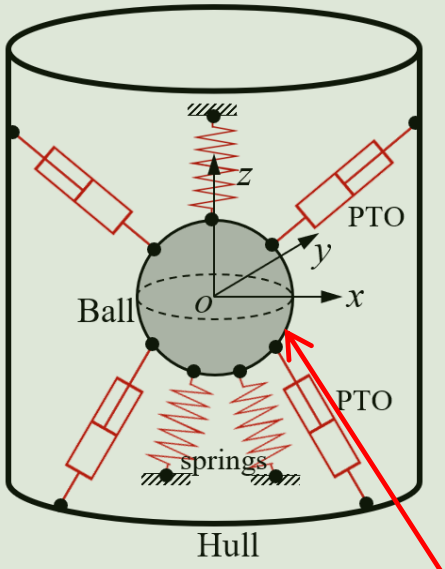
- Apply the open source 'HAMS' for the hydrodynamic analysis of TALOS, with the concentrations on the coupled motion modes
- Comparisons of the transformation from frequency domain and time domain (WAMIT vs. HAMS)
- the implementation of the time domain model of multiple motion modes, including:
  - ✓Approximations of impulse functions
  - ✓Approximation of the memory effects
  - ✓The implementation and solution of the time-domain equation
- Provision of a method for checking the time-domain analysis

The manuscript (Paper 2) has been submitted to Ocean Engineering for publication

Paper 3: Implementation of TALOS WEC, ongoing work

Equations for hull motion

$$
\begin{cases}
(m_s + A_{11})\ddot{x}_{s1}(t) + \sum_{j=1}^{6}\int_0^t K_{1j}(t-\tau)\dot{x}_{sj}(\tau)d\tau + C_{s1}x_{s1}(t) = F_1^{exc}(t) - F_{pto1}(t) - F_{spr1}(t) \\
(m_s + A_{22})\ddot{x}_{s2}(t) + \sum_{j=1}^{6}\int_0^t K_{2j}(t-\tau)\dot{x}_{sj}(\tau)d\tau + C_{s2}x_{s2}(t) = F_2^{exc}(t) - F_{pto2}(t) - F_{spr2}(t) \\
(m_s + A_{33})\ddot{x}_{s3}(t) + \sum_{j=1}^{6}\int_0^t K_{3j}(t-\tau)\dot{x}_{sj}(\tau)d\tau + C_{s3}x_{s3}(t) = F_3^{exc}(t) - F_{pto3}(t) - F_{spr3}(t) \\
(I_{s44} + A_{44})\ddot{x}_{s4}(t) + \sum_{j=1}^{6}\int_0^t K_{4j}(t-\tau)\dot{x}_{sj}(\tau)d\tau + C_{s4}x_{s4}(t) = F_4^{exc}(t) - M_{pto1}(t) - M_{spr1}(t) \\
(I_{s55} + A_{55})\ddot{x}_{s5}(t) + \sum_{j=1}^{6}\int_0^t K_{5j}(t-\tau)\dot{x}_{sj}(\tau)d\tau + C_{s5}x_{s5}(t) = F_5^{exc}(t) - M_{pto2}(t) - M_{spr2}(t) \\
(I_{s66} + A_{66})\ddot{x}_{s6}(t) + \sum_{j=1}^{6}\int_0^t K_{6j}(t-\tau)\dot{x}_{sj}(\tau)d\tau + C_{s6}x_{s6}(t) = F_6^{exc}(t) - M_{pto3}(t) - M_{spr3}(t)
\end{cases}
$$



2-body system:
Hull + Ball

Equations for ball motion

$$
\begin{cases}
m_b\ddot{x}_{b1}(t) = F_{pto1}(t) + F_{spr1}(t) \\
m_b\ddot{x}_{b2}(t) = F_{pto2}(t) + F_{spr2}(t) \\
m_b\ddot{x}_{b3}(t) = F_{pto3}(t) + F_{spr3}(t) \\
I_{bxx}\ddot{x}_{b4}(t) = M_{pto1}(t) + M_{spr1}(t) \\
I_{byy}\ddot{x}_{b5}(t) = M_{pto2}(t) + M_{spr2}(t) \\
I_{bzz}\ddot{x}_{b6}(t) = M_{pto3}(t) + M_{spr3}(t)
\end{cases}
$$

1st Workshop

Supergen Offshore Renewable Energy

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EPSRC Project Workshop: NHP-WEC Marine Energy Project

Online, 25 October 2021 at 2:00pm - 3:30pm

UNIVERSITY OF HULL | UKRI Engineering and Physical Sciences Research Council | Lancaster University

EPSRC Marine Wave Programme 2020 - Novel High Performance Wave Energy Converter Research Project (NHP-WEC)

The NHP-WEC team would like to invite you to the 1st workshop of their EPSRC funded project: 'Novel High Performance Wave Energy Converters with advanced control, reliability and survivability systems through machine-learning forecasting (NHP-WEC)' project. Find out more about the project in this PDF.

Workshop details

- Date: 25 October 2021
- Time: 14:00 - 15:30 BST
- Location: Virtually (via Microsoft Teams) Please find the link to join the meeting in the PDF here

Agenda

14:00 Welcome & Introduction to NHP-WEC - George Aggidis (Lancaster University - LU)

14:05 TALOS & WP4 - George Aggidis (LU)

14:10 SmartWave - Robert Dorrell (University of Hull - UoH)

14:15 WP2: Survivability, reliability and optimized control of devices in the marine environment - Xiandong Ma (LU)

14:20 WP1: Concept Wanan Sheng (LU)

14:35 WP3: Sea state forecasting and resource evaluation - Evdokia Tapoglou (UoH)

14:50 Q&A Panel Discussion - All

15:30 Close

LancasterEngineering
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Prof George Aggidis is holding the EPSRC Wave Energy NHP-WEC Project Workshop on TALOS Wave Energy Converter and SmartWave online (Mon 25 Oct 2021 at 14:00 UK Time). To book click👉

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We provide research leadership to connect academia, industry, policy and public stakeholders, inspire innovation and maximise societal value in offshore wind, ...

10:27 AM · Oct 20, 2021 · Twitter Web App

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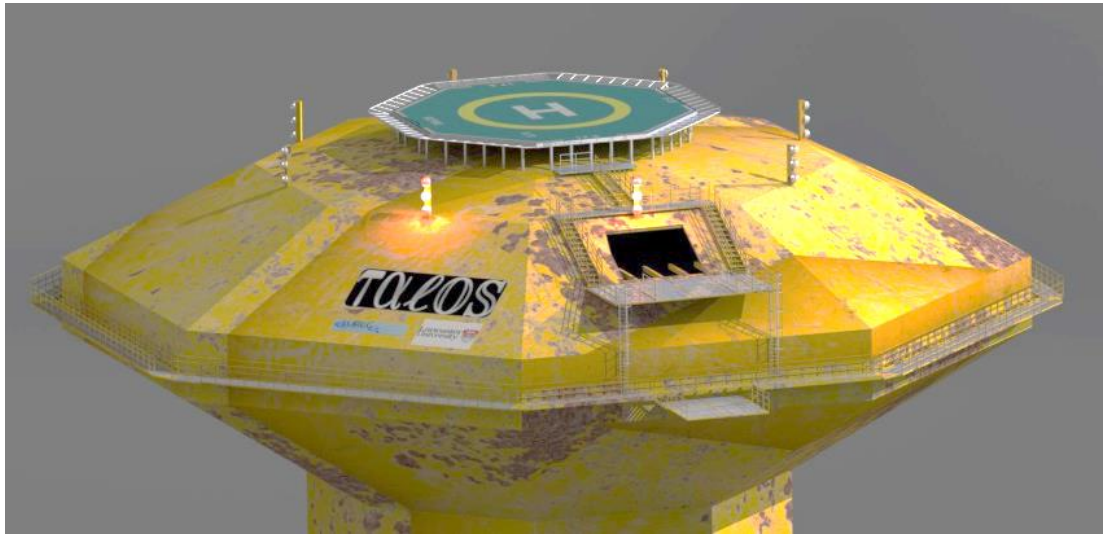
Advisory Board Meeting, 25/10/2021



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THE EUROPEAN MARINE ENERGY CENTRE LTD

CATAPULT
Offshore Renewable Energy

DNV

aura

THE DEEP
For conservation, not profit

AMRC
ADVANCED MANUFACTURING RESEARCH CENTRE

NHP-WEC Website

TALOS wave energy converter (LU):

The research proposed is simultaneously generic while significantly contributing to the development of a concept device that has shown potential, namely the multi-axis TALOS that has been developed and tank tested at Lancaster University.

TALOS is a novel multi-axis moving parts, and the internal PTO system is made up of an inertial mass (a ball) with hydraulic cylinders that attach it to the hull. The motion of the ball moves the hydraulic cylinders causing them to pump hydraulic fluid through a circuit, thus to generate electricity i.e. an inertial mass PTO approach.

Key strengths of TALOS device include:

- Fully enclosed wave energy converter, so to avoid the harsh sea environments on the energy conversion system;
- The arrangement of the rams allows for the ball to move in multiple directions, allowing energy to be captured from multiple degrees of freedom;
- The flow of hydraulic fluid will change as the ball's motion changes, so an internal hydraulic smoothing circuit is utilised to regulate the output.

SmartWave (UoH):

SmartWave is a tool capable of deriving high resolution sea state conditions from satellite images using machine learning. It integrates recent advances in all-weather satellite monitoring to map and study the temporal and spatial distribution of sea surface wave characteristics.

Key strengths:

- based on a novel forecasting methodology;
- capable of resolving sea state within offshore windfarms for sector O&M logistics.

The NHP-WEC project aims to advance data-driven monitoring and control in connection to both device technology and sea state predictions for WEC arrays, combining the TALOS technologies of Lancaster University (LU) and the SmarWave technologies of University of Hull (UoH). The NHP-WEC project aims to optimise the design of the wave energy converter and the PTO system (TALOS) in response to time-varying inputs from waves (SmartWave). as such, the operational conditions, including wave characteristics, must be quantified to estimate dynamic loads, constraining manufacturing techniques and materials, so to improve wave energy production as well as the survivability of the wave energy system.

[EPSRC NHP-WEC project: A TALOS and SmartWave Project (lancs.ac.uk)]

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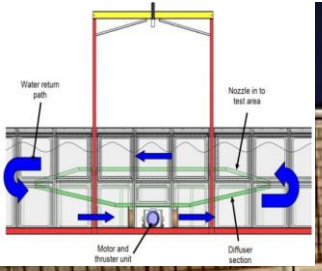

Thank you

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