EPSRC NHP-WEC Research Project
3rd Advisory Board Meeting

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Monday 7 November 2022

UNIVERSITY OF HULL | ENERGY AND ENVIRONMENT INSTITUTE

UKRI Engineering and Physical Sciences Research Council

Engineering | Lancaster University

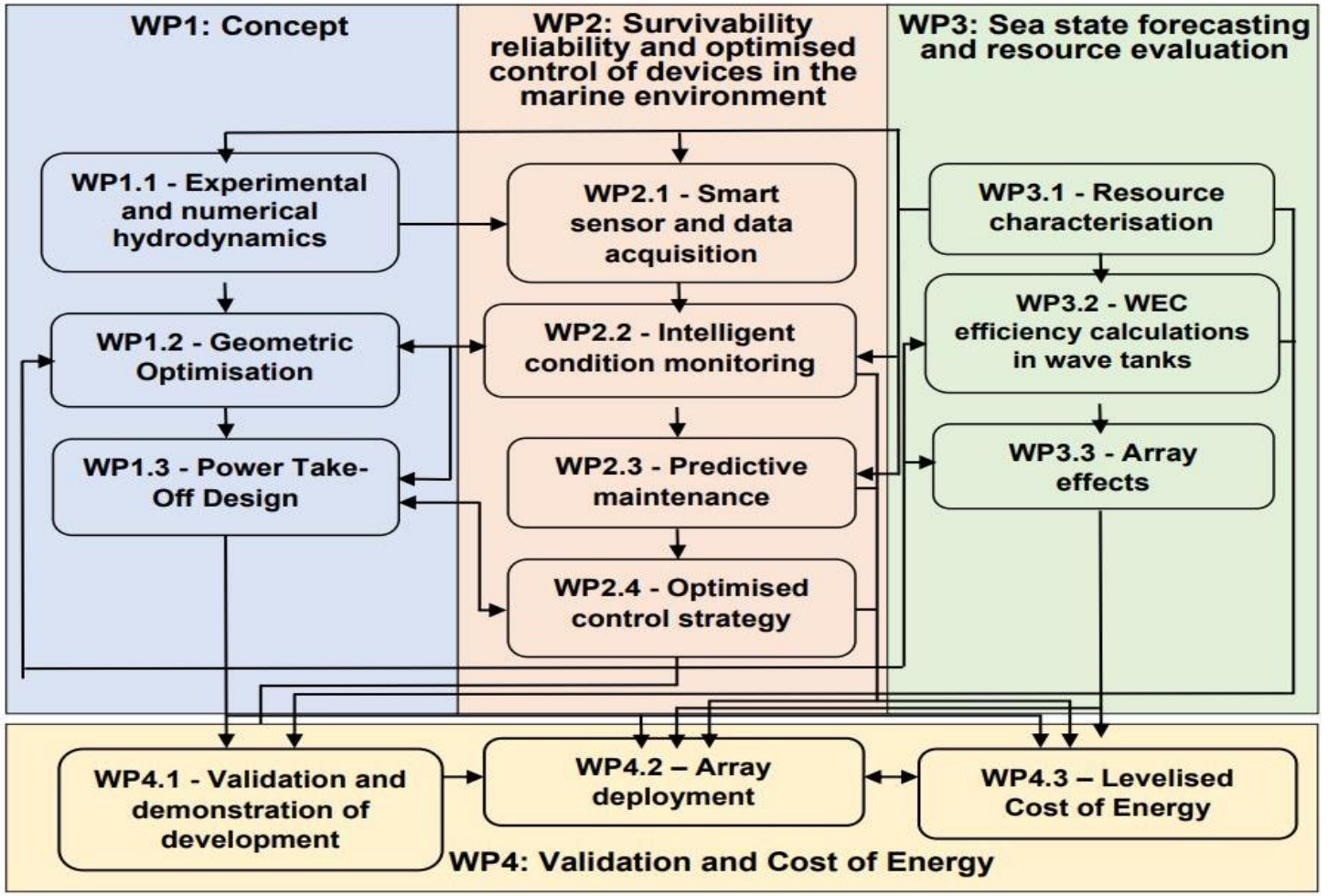
Project Team & WP Structure

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 – Dr Yueqi WU

UNIVERSITY OF HULL

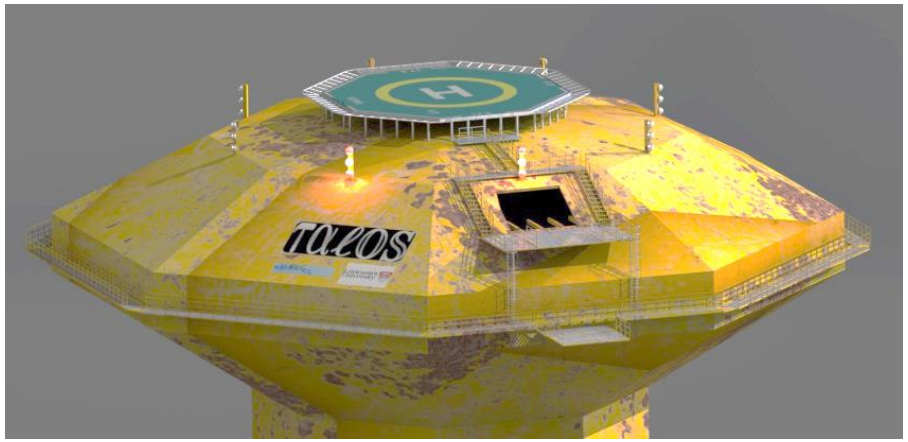
- Co-I - Dr Robert DORRELL
- Co-I - Professor Daniel PARSONS
- PDRA3–SRA – Dr Igor RIZAEV



Advisory Board

Chair of the Advisory Board:

Neil Kermode EMEC Managing Director



EMEC ORKNEY
THE EUROPEAN MARINE ENERGY CENTRE LTD

NREL
Transforming ENERGY

DNV

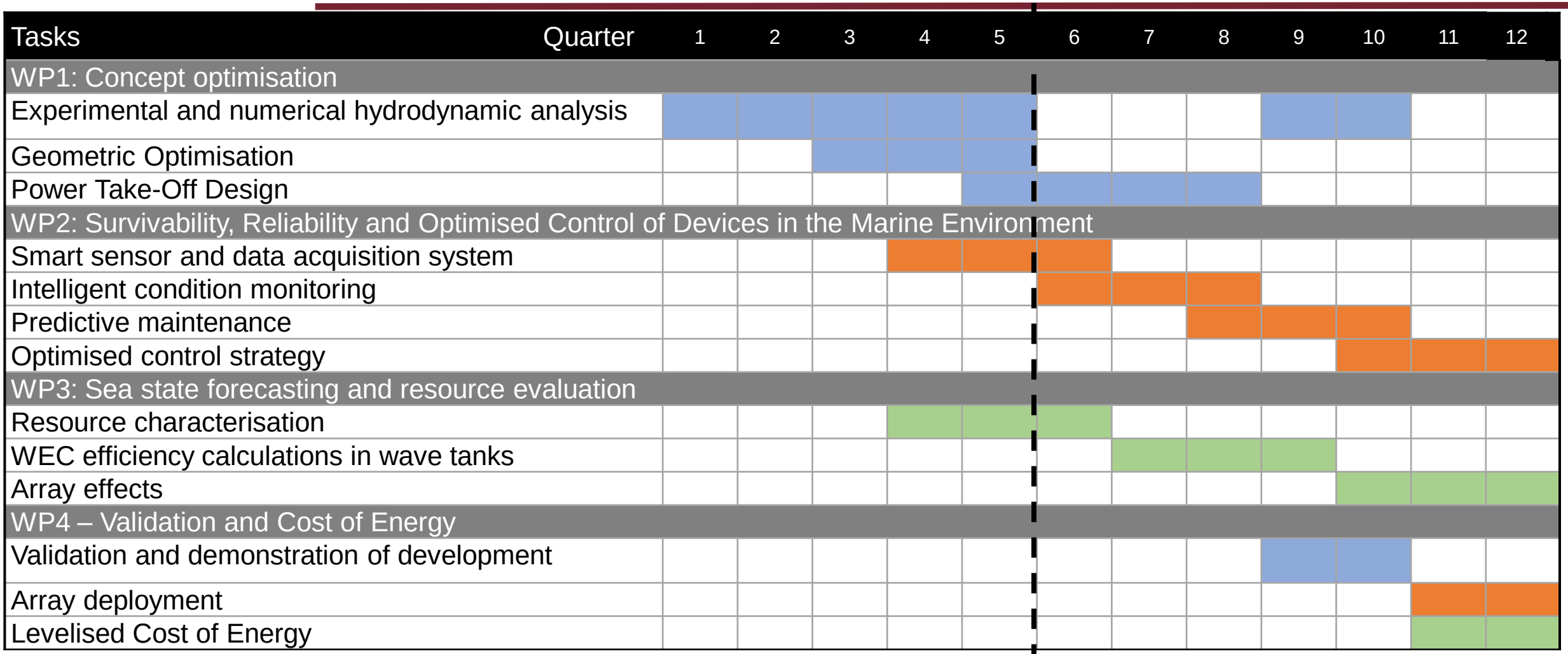
CATAPULT
Offshore Renewable Energy

aura

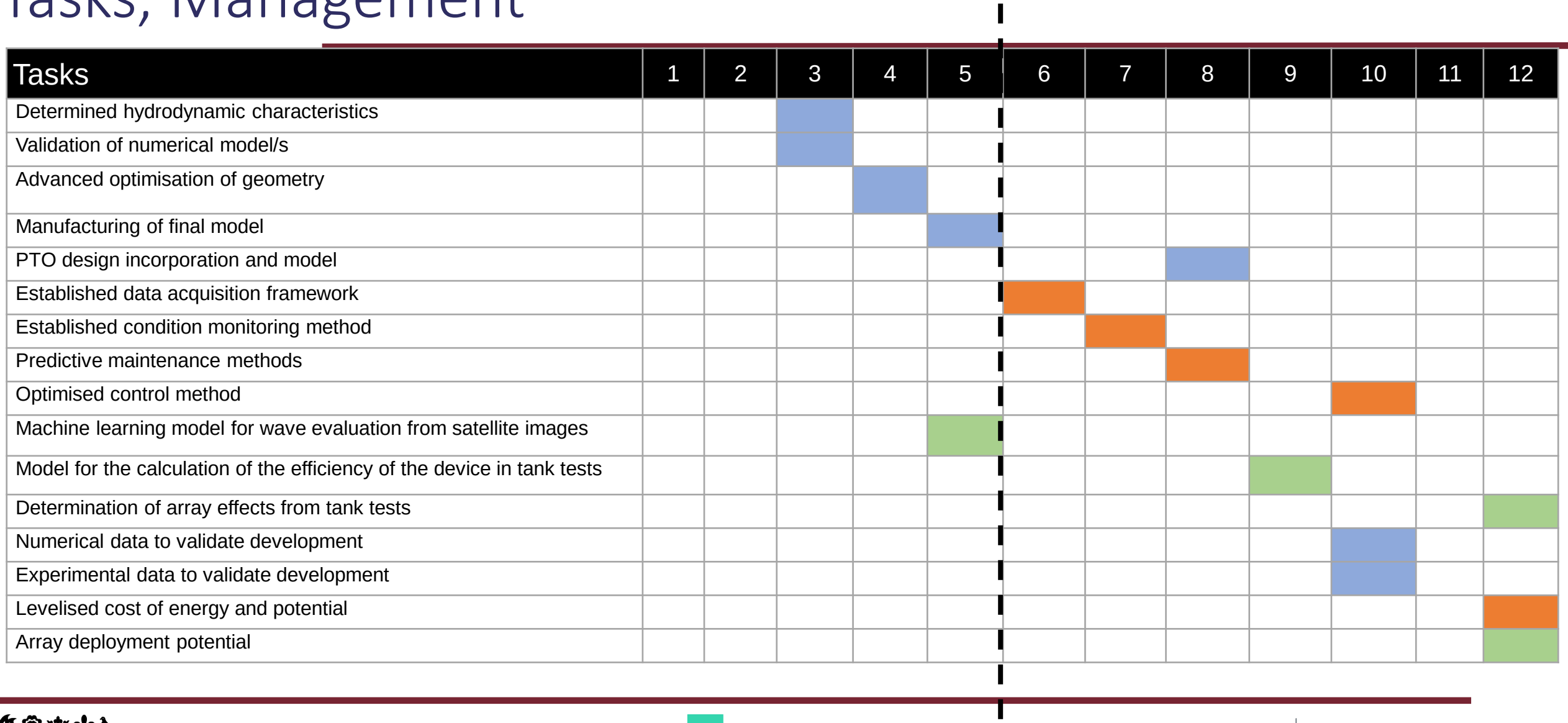
THE DEEP
For conservation, not profit

AMRC
ADVANCED MANUFACTURING RESEARCH CENTRE

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												

EPSRC NHP-WEC Research Project 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.

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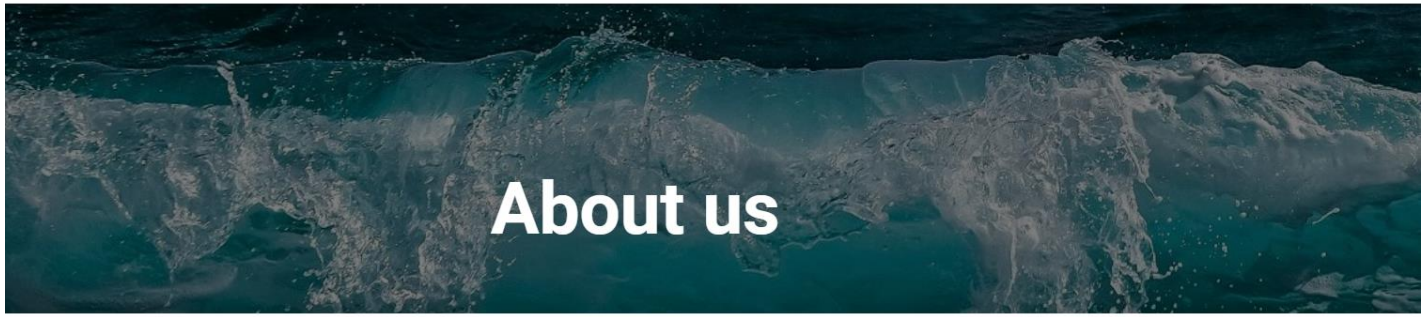
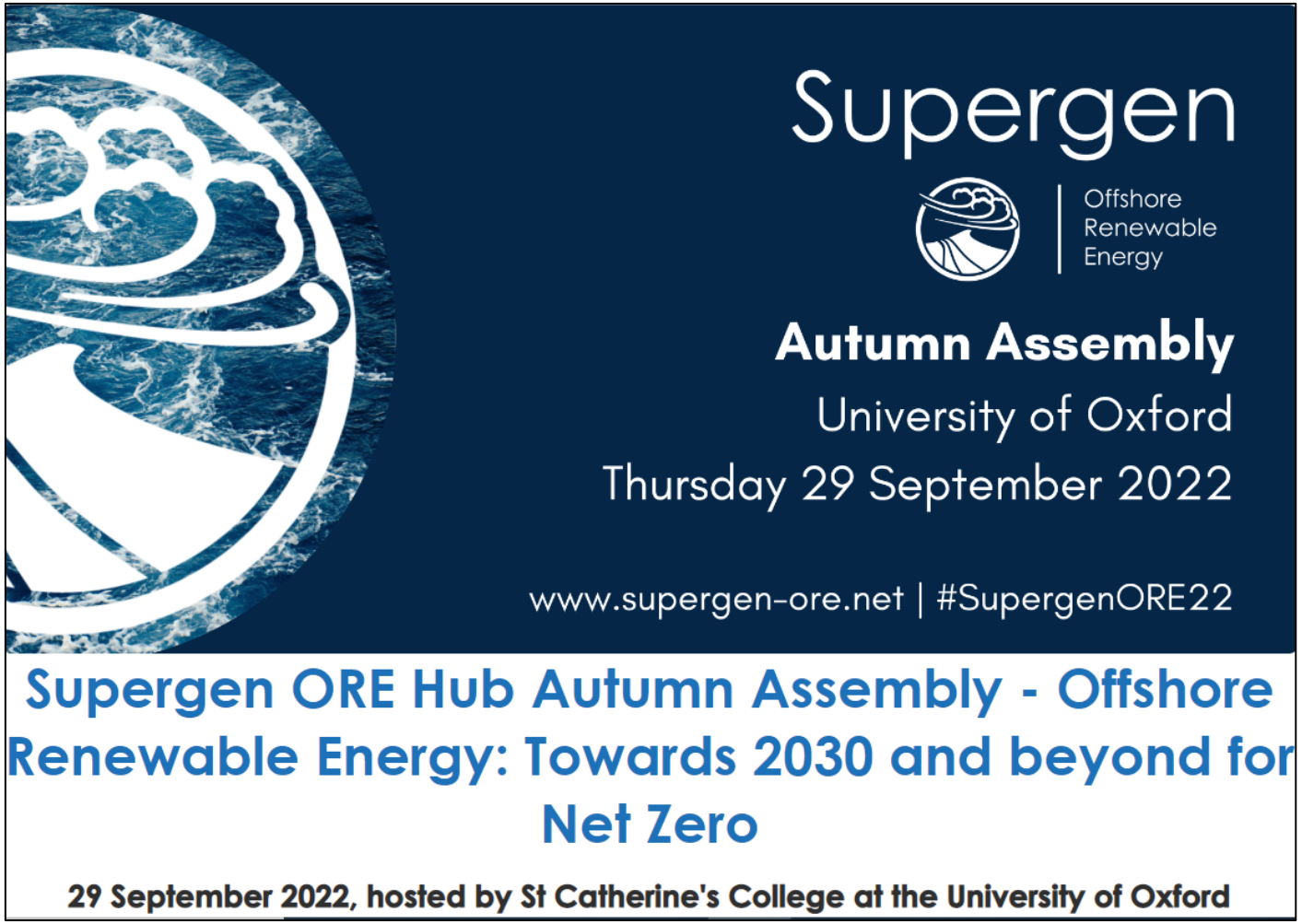


The NHP-WEC project aims to advance data-driven monitoring and control in connection to both device technology and sea state predictions for WEC arrays, combining the TALOS technologies of Lancaster University (LU) and the SmarWave technologies of University of Hull (UoH). The NHP-WEC project aims to 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)]

Supergen ORE – Sept 2022

- Supergen ORE Autumn Assembly September 2022
  - University of Oxford
- Offshore Renewable Energy: Towards 2030 and beyond for Net Zero
  - St. Catherine's College
- Invited Presentations Included:
  - NHP-WEC TALOS Project



Outputs & DNV SESAM Software

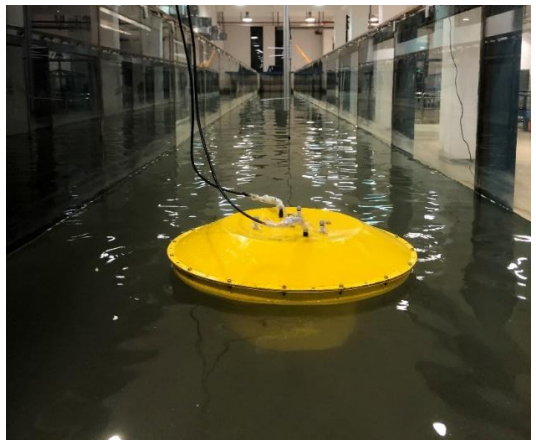
- PAPERS
  - Hydrodynamic studies of floating structures: Comparison of wave-structure interaction modelling, Ocean Engineering, Vol. 249, 110878.
  - Time-domain implementation and analyses of multi-motion modes of floating structures, Journal of Marine Science and Engineering, Vol. 10, 662. https://doi.org/10.3390/jmse10050662
  - A Preliminary Study on Identifying Biomimetic Entities for Generating Novel Wave Energy Converters. Energies, 15(7), p.2485.

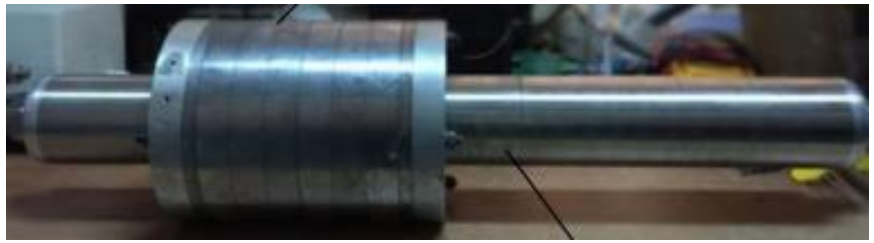
- BOOK
  - Environmental Fundamentals of Wave Energy Conversions: The Dynamics of the Wave-Structure Interactions and Wave Energy Optimisation, Eliva Press.

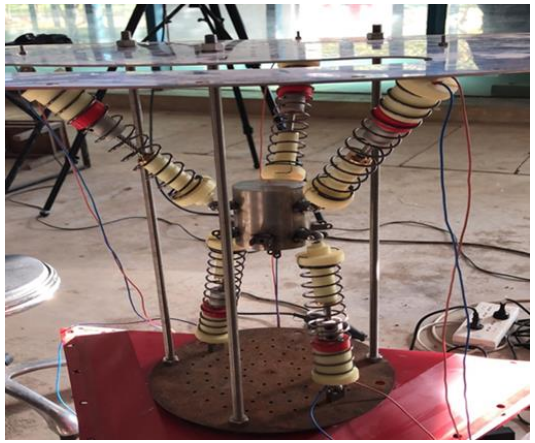
- DNV SESAM SOFTWARE
  - Collaboration with AUTH & IHU Universities (Greece)
  - Building time-domain model using DNV SESAM code
  - For comparisons with in-house time-domain model

Zhejiang University - China International collaboration

- Experimental Testing
- Computational time-domain modelling of TALOS WEC
- Experimental Modelling and Validation of the Computational Modelling for TALOS WEC







TEAMER - US DoE - Collaboration

- TEAMER – WP1
  - "Numerical Modeling of the TALOS Wave Energy Converter"
  - NREL & Sandia NL (USA) - a TEAMER funding award of $150,000 approved to build time-domain modelling for TALOS WEC using WEC-SIM facility

- TEAMER – WP2
  - "Advanced data acquisition and fault diagnosis system for wave energy converter"
  - NREL (USA) - a TEAMER funding application 11/10/2022 for $150,000 waiting approval

- TEAMER – WP3
  - "A test bed for the TALOS wave energy converter"
  - NREL (USA) - a TEAMER funding application 12/10/2022 for $150,000 waiting approval

ISOPE 2023 - Canada

- Renewable Energy and Environment Symposium of ISOPE 2023 Ottawa, Canada, June 19–23, 2023.
- ISOPE 2023 includes a specific focus session with title: "Recent developments on TALOS WEC project".
- There are 14 TALOS related paper abstract submissions to date including:

- 2 from USA (WP1 and WP4)
- 2 from China (WP1 and WP4)
- 2 from Greece (WP1 and WP3)
- 1 from Turkey (WP2)
- 2 from the UK (both on WP2)
- 1 from US/UK Fulbright Scholar on WP2, and
- 4 from our NPH-WEC Project - 1 on WP1, 1 on WP2, 1 on WP3 and 1 on WP4.

ISOPE 2023 – TALOS Papers

- WP1
  - NPH-WEC Project - *Hydrodynamic studies of TALOS WEC using different open source panel methods*
  - USA - *Time-Domain Modelling of the TALOS WEC using WEC-Sim*
  - Turkey - *An initial study on power capture performance analysis of TALOS based on power take-off system parameters*
  - China - *Numerical and experimental study on a scaled TALOS wave energy converter*
  - Greece - *Time-Domain Analysis of the TALOS WEC using different computational tools*
- WP2
  - NPH-WEC Project - *Machine learning based TALOS wave energy converter power output prediction*
  - UK - *Fully probabilistic control design application on TALOS wave energy converters (WEC) Array*
  - UK - *Medium-Voltage Modular Power Converter for Wave Energy Conversion Systems*
  - US/UK - Fulbright Scholar - *The Impact of Constraints on the Control of a Wave Energy Conversion with a Hydraulic PTO System*

ISOPE 2023 – TALOS Papers

- WP3
  - NPH-WEC Project - *Wave power resource dynamics for the period 1980-2021 in Atlantic Europe's Northwest seas*
  - Greece - *Operation of TALOS wave energy converter in different wave climates*
- WP4
  - NPH-WEC Project - *An overview of the levelized cost of wave energy*
  - USA - *Characterizing the use of Wireless Communication for Subsea Data Transmission*
  - China - *A Method of Obtaining Biological Inspiration to Improve the Performance of TALOS WEC*

TALOS International Collaboration

LUREG Lancaster University Renewable Energy Group

Lancaster University

Professor Spyros Mavrakos
Professor John Anagnostopoulos

Dr Jochem Weber
Dr Robert Thresher
Dr Aidan Bharath
Dr David Ogden
Dr Matthieu Ancellin

NREL Transforming ENERGY

Dr Sal Husain
Dr Stein Housner
Dr Matthew Hall

Sandia National Laboratories

Dr Jorge AndresLeon Quiroga

Renewable Energy Technologies https://energy.sandia.gov

Dr Budi Gunawan

INTERNATIONAL HELLENIC UNIVERSITY

Ass Professor Constantine Michaelides

Copernicus Europe's eyes on Earth

Copernicus Marine Service

POSEIDON SYSTEM

Dr Charikleia 'Lily' Oikonomou

國立陽明交通大學 NATIONAL YANG MING CHIAO TUNG UNIVERSITY

Ass Professor Yi-Hsiang Yu

University of Victoria

Professor Brad Buckham
Professor Curran Crawford

南京林業大學 NANJING FORESTRY UNIVERSITY

Ass Professor Chenglong Guo
Professor Dakshina De Silva

ARISTOTLE UNIVERSITY OF THESSALONIKI

Ass Professor Eva Loukogeorgaki

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Professor John Ringwood

CENTRALE NANTES

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Ass Professor Guillaume Ducrozet
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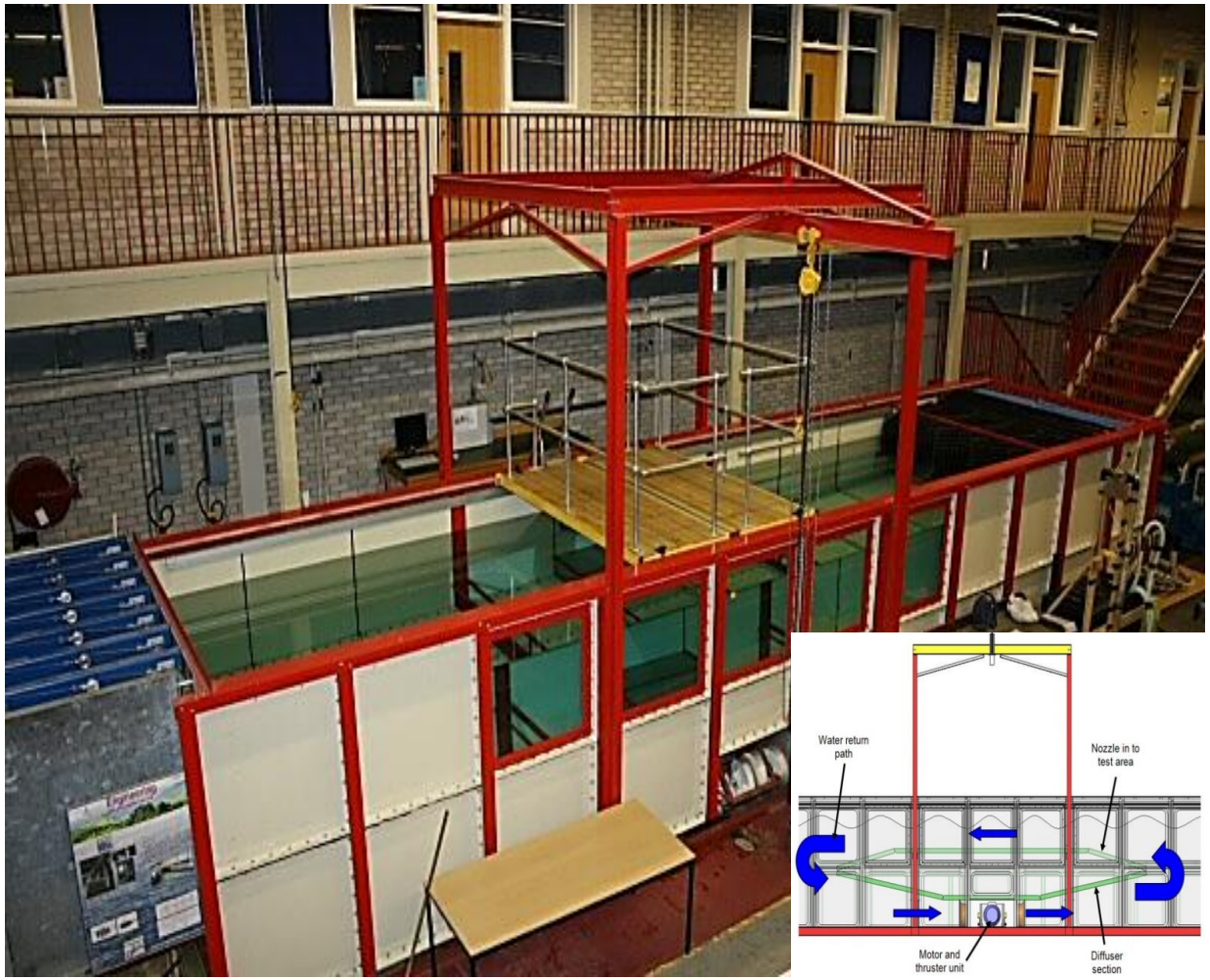

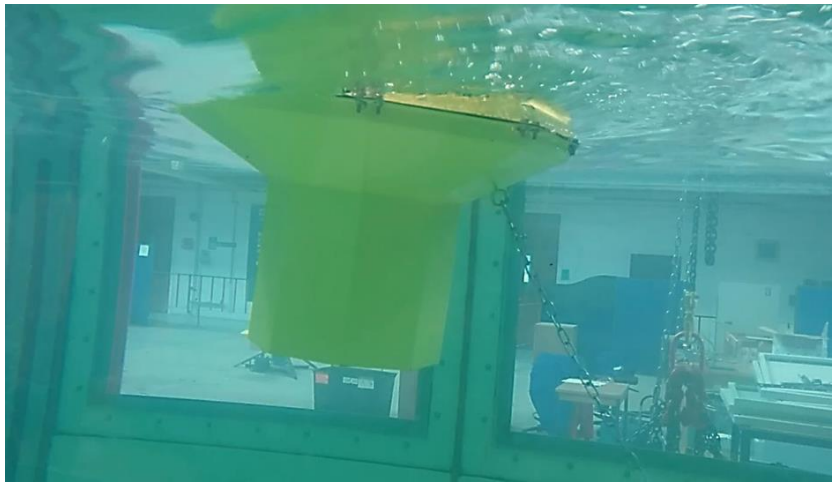

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