

NHP-WEC WP1:

Concept optimisation

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**UNIVERSITY
OF HULL**

**ENERGY AND
ENVIRONMENT INSTITUTE**



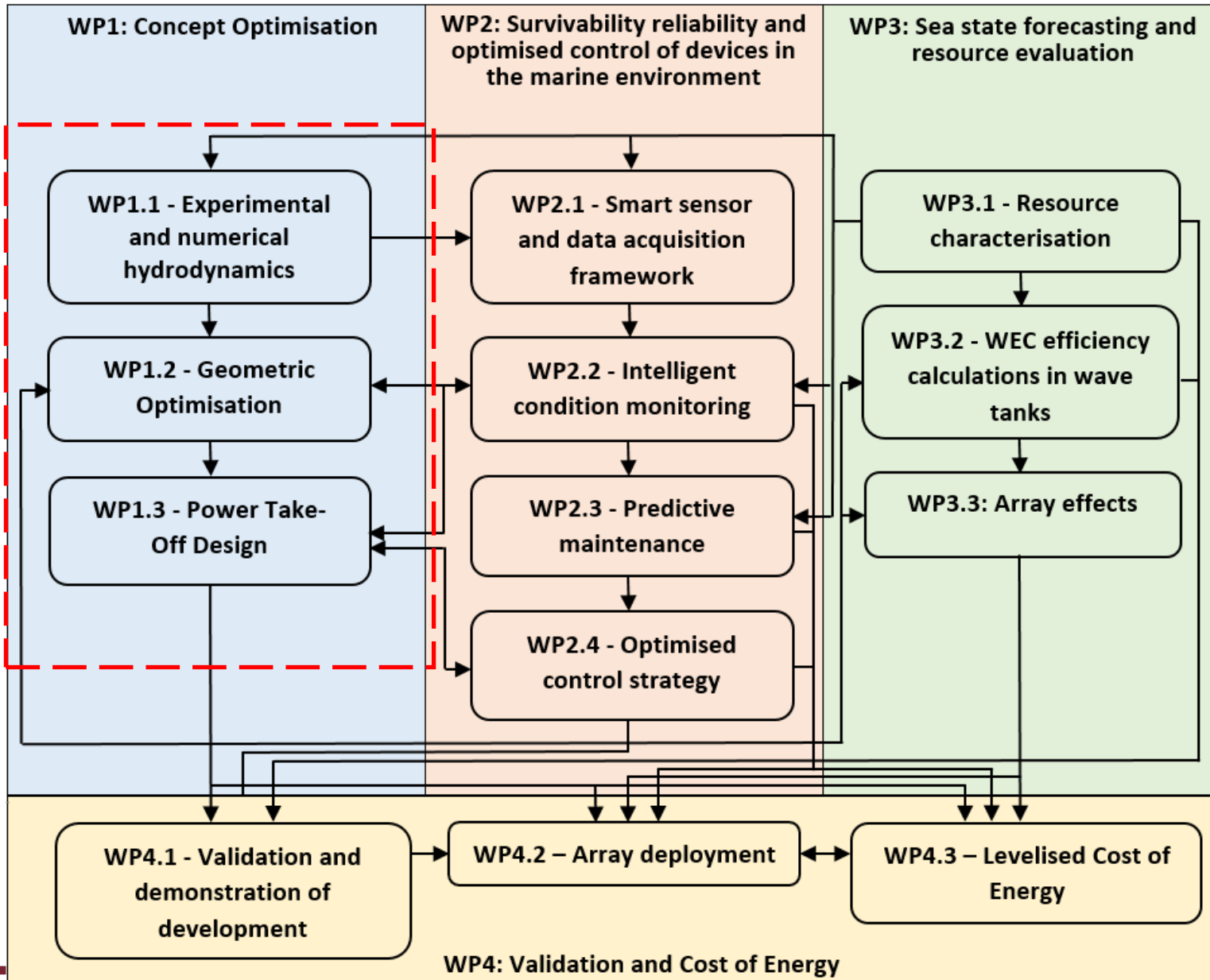
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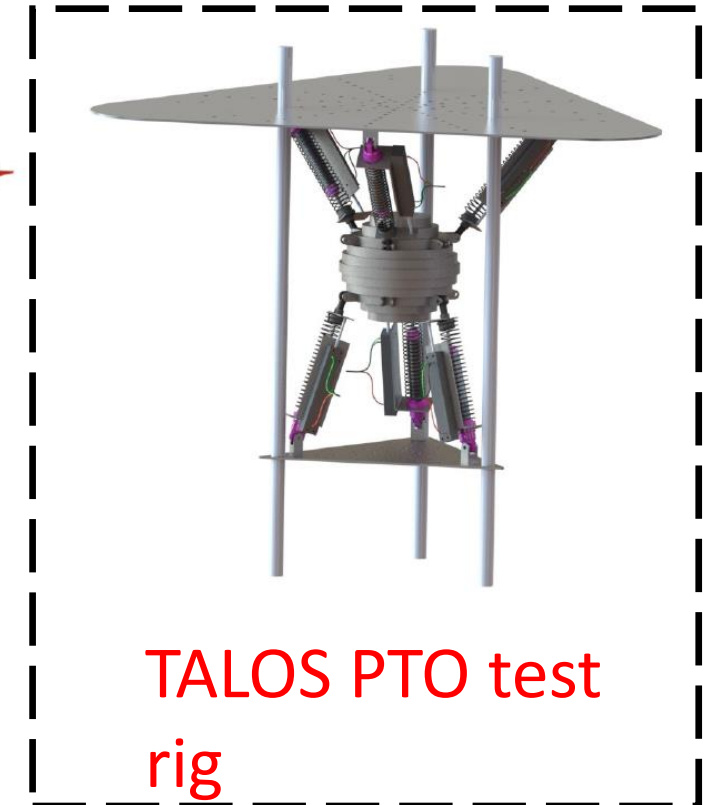


WP1



- **WP 1.1-** Experimental and numerical hydrodynamics
- **WP 1.2-** Geometric optimisation
- **WP 1.3-** Power take-off design

Introduction of TALOS WEC



- Multi-axis power take-off
- Fully enclosed system (PTOs...)

Paper 2: Time-domain implementation

An introduction of how to employ the open sources to implement time-domain modelling on multiple 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

- ***Paper 2 'Time-Domain Implementation and Analyses of Multi-Motion Modes of Floating Structures', *Journal of Marine Science and Engineering*, 2022, 10, 662.***
<https://doi.org/10.3390/jmse10050662> (open access, 13 May 2022)

'Fundamentals of Wave Energy Conversions'

*By Dr. Wanan Sheng and Prof. George Aggidis
published by Eliva Press*

Book publication

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NEW RELEASE



FUNDAMENTALS OF WAVE ENERGY CONVERSIONS

The Dynamics of the Wave-Structure Interactions
and Wave Energy Optimisation

WANAN SHENG GEORGE AGGIDIS

**ELIVA
PRESS**

Fundamentals of Wave Energy Conversions

Chapter 1 Introduction

Chapter 2 Fluid Dynamic equation: for fluid-structure interaction

Chapter 3 Potential Flow theory: fundamentals

Chapter 4 Potential Flow Theory: Wave Theory & Wave Energy

Chapter 5 Wind-Generated Waves & Wave Climates

Chapter 6 Potential Flow Theory & Fluid-Structure Interactions

Chapter 7 Potential Flow Theory: & Wave-Structure Interaction

Chapter 8 Potential Flow Theory: & Panel Method for Wave-Structure Interactions

Chapter 9 PTOs & Wave Energy Conversion with examples of wave energy conversions

Chapter 10 Optimisations of Power Take-off for Improving Wave Energy Conversions

Chapter 11 Wave Energy Conversion: Time-Domain Analyses

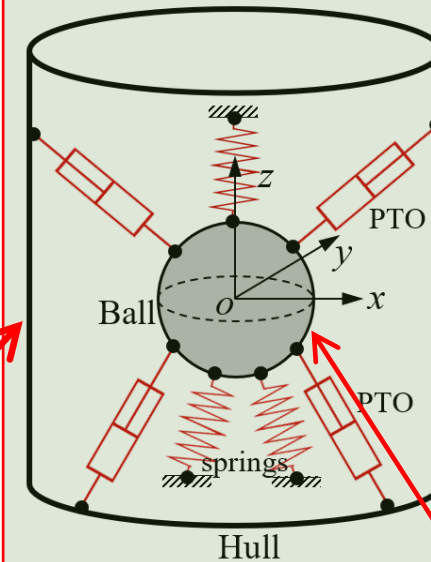
Chapter 12 Control Technologies for Improving Wave Energy Conversion

Chapter 13 Dimensional Analysis and Physical Modelling of Wave Energy Converters

Time-domain modelling of TALOS WEC (ongoing work)

Equations for hull motion

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



2-body system:
Hull + Ball

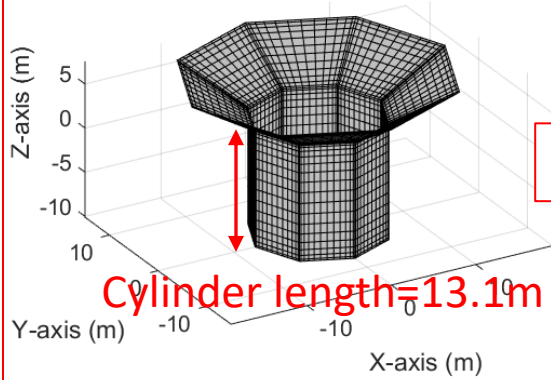
Equations for ball motion

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

Optimisations of TALOS WEC (initial studies)

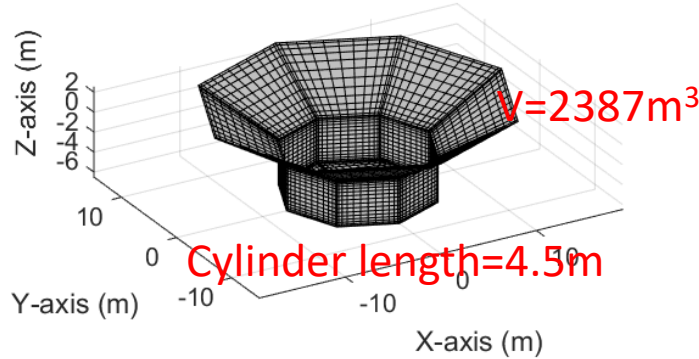
$V=3755\text{m}^3$

3D Visualization of the Wamit file: TALOS_{G₁_h}.alf.gd



$P=132\text{kW}$

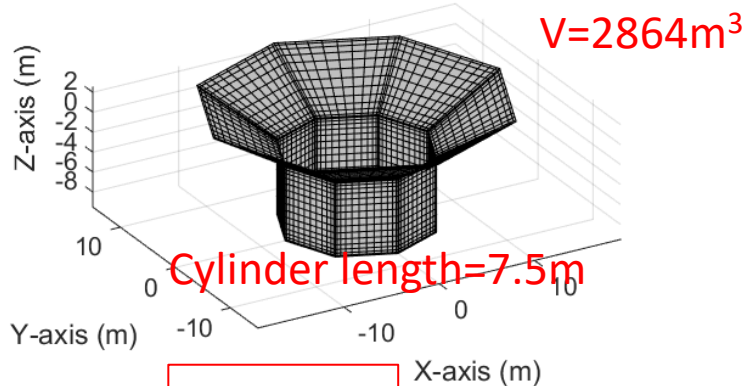
3D Visualization of the Wamit file: TALOS_{G₁_h}.alf.gd



$P=155\text{kW}$

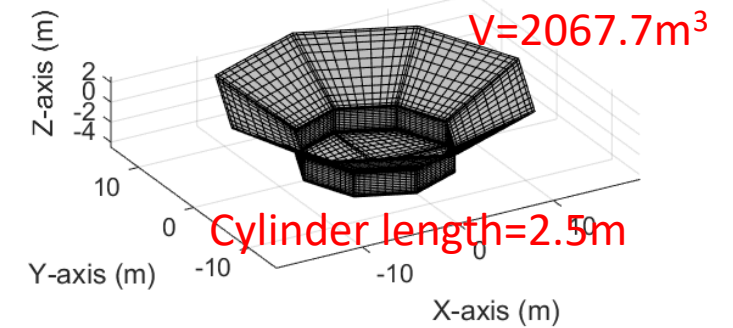


3D Visualization of the Wamit file: TALOS_{G₁_h}.alf.gd



$P=133\text{kW}$

3D Visualization of the Wamit file: TALOS_{G₁_h}.alf.gd



$P=175\text{kW}$



ISOPE 2023 paper and collaborations

ISOPE 2023 paper:

Title: 'Hydrodynamic studies of TALOS WEC using different open source panel methods'

Wanan Sheng & George Aggidis

Collaborations:

- Time-domain model for TALOS optimisations (Hakan)
- TALOS hydrodynamic models for different wave climates
- TALOS hydrodynamics for control purposes
- And others

International collaborations

- National Renewable Energy Laboratory (NREL): a funding of \$150,000 has been granted to support to use WEC-SIM to model TALOS wave energy converter.
- TALOS model testing in Zhejiang University (China): data sharing and comparison; proposed joint publications
- Hydrodynamics modelling (time-domain model using DNV SESAME software):
 - Dr. **Constantine Michailides** (International Hellenic University)
 - Dr. **Eva Loukogeorgaki** (Aristotle University of Thessaloniki)
- And others



Future work

- Optimisations of the TALOS structure; of the PTOs (and springs)
- **TALOS Model design and manufacture**
- **PTO consideration and design for model testing**
- Work with **WP2**: to provide information for control studies
- Work with **WP3**: to examine the yearly outputs of energy extraction by TALOS
- Work with **WP4**: to validate and study the cost of energy...
- Paper preparations: (hydrodynamics studies; implementation of TALOS WEC, joint papers etc)
- And more...