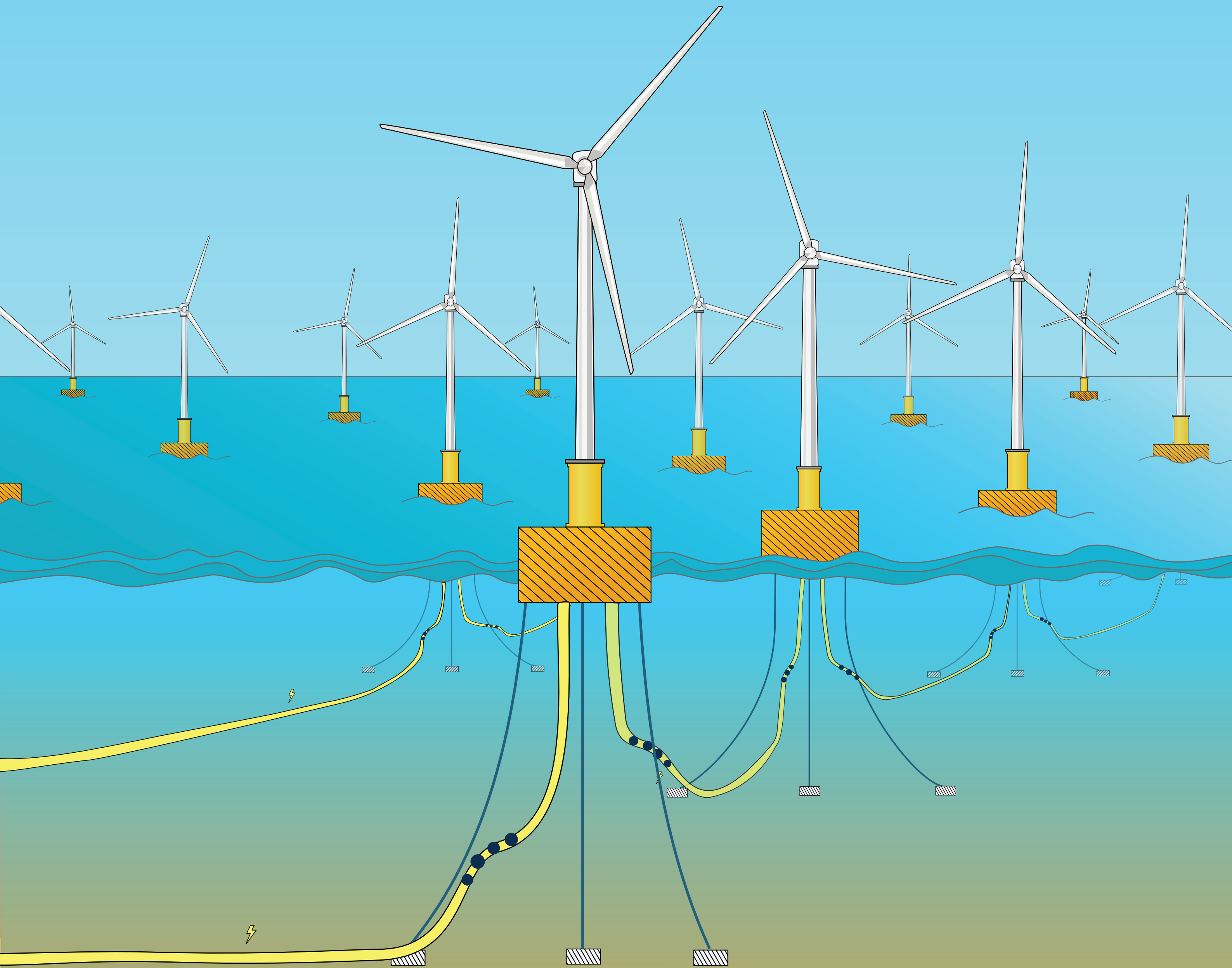
CARBON TRUST

Load Reduction Device

Floating Wind Technology Acceleration Competition

Executive summary



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Dublin Offshore

Acknowledgements

This project has been supported under the Floating Wind Technology Acceleration Competition (FLW TAC) which was funded by the Scottish Government and managed by the Carbon Trust's Floating Wind Joint Industry Project (FLW JIP).

FLW JIP, formed in 2016, is a collaborative research and development initiative between the Carbon Trust, and fifteen leading international offshore wind developers: EDF Renouvelables, EnBW, Equinor, Kyuden Mirai Energy, Ocean Winds, Ørsted, Parkwind, RWE, ScottishPower Renewables, Shell, SSE Renewables, TEPCO, TotalEnergies, Vattenfall, and Wpd.

Authors

Darren Hayes darren.hayes@dublinoffshore.ie
Danny Golden danny.golden@dublinoffshore.ie
Tom Doyle tom.doyle@dublinoffshore.ie

Disclaimer

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LOAD REDUCTION DEVICE

EXECUTIVE SUMMARY

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INTRODUCTION

THE CHALLENGE

"The Carbon Trust expects up to 10.7GW of floating wind is feasible by 2030 and 70GW by 2040.

Floating wind is a proven technology and promises to be the next renewable power success story, but to meet the scale of ambition we need to accelerate cost reduction.

The competition is seeking methods, materials or technologies that allow easier and safe installation, reduce maintenance requirements and therefore reduce overall cost of mooring systems"

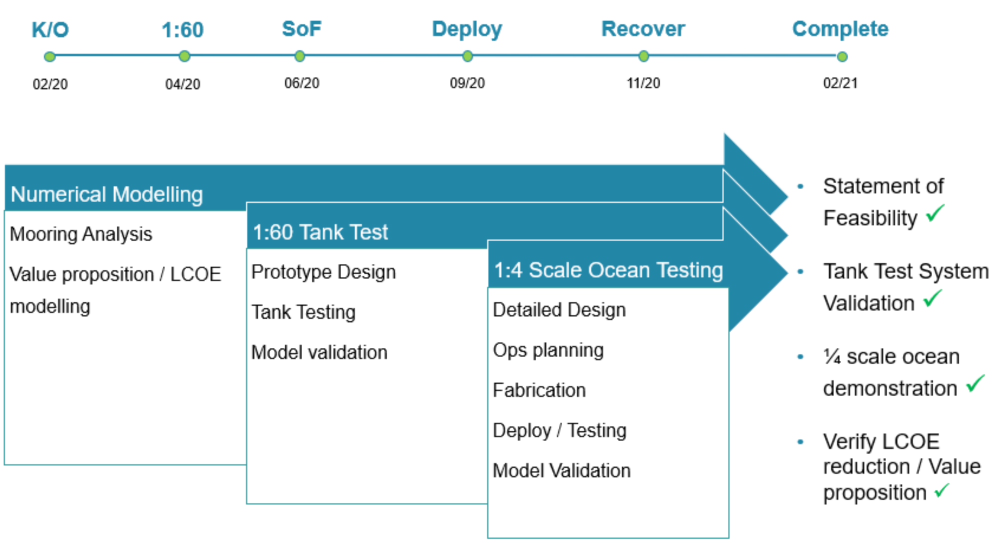
Carbon Trust 2019

BACKGROUND

The Floating Wind Technology Acceleration Competition (FLW TAC) was designed to address key industry challenge areas that need to be overcome to commercialise floating wind. The four areas were identified in Phase 1 of the Floating Wind JIP were: monitoring and inspection, mooring systems, heavy lift maintenance and tow to port maintenance.

PROJECT OVERVIEW

The project commenced in February 2020 with a schedule of 12 months. At the outset of the project the Load Reduction Device (LRD) was at TRL4 following numerical model development and component level validation testing. The completion of the ¼ scale pilot project in relevant conditions progressed the technology to TRL 7.



TECHNICAL OBJECTIVES

- Validation of mooring load reduction through tank testing
- Technology Assessment / Statement of Feasibility from DNVGL
- Complete 1000 hours ocean testing of the ¼ scale prototype without incident
- Verify LCOE reduction and value proposition

TECHNOLOGY

REDUCED MOORING LOADS

REDUCED FATIGUE CYCLES

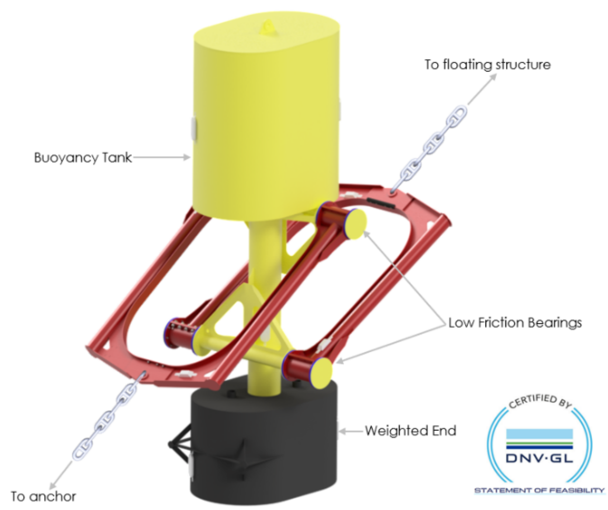
STORM PROTECTION

TAILORED RESPONSE

REDUCED LCOE

>20 YEAR DESIGN LIFE

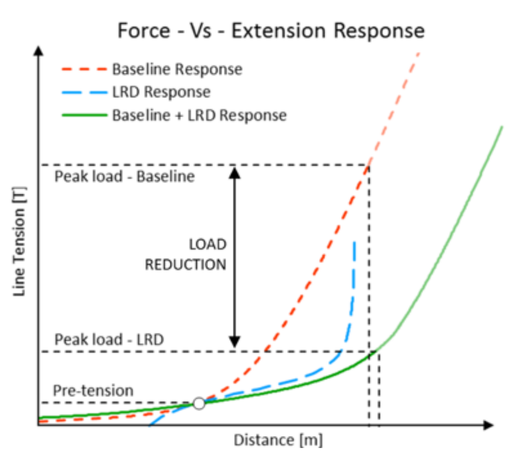
LOAD REDUCTION DEVICE (LRD)

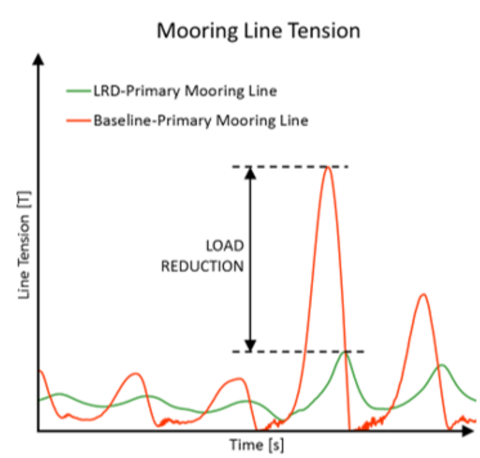


The LRD is a subsea component of an offshore mooring system targeted at the floating wind market. It is fully scalable and tuneable to deliver the customer's specific mooring response requirement.

The LRD is manufactured using basic low-cost materials such as steel and concrete which have a demonstrated track record in the marine environment.

HOW IT WORKS





The LRD comprises a rigid shaft with a buoyant end and a weighted end, and two attachment arms to connect the device within an existing mooring line. In the nominal, unloaded state the device maintains a vertical orientation and subsequently rotates in response to movement of the floating platform and increased mooring line loads. Rotation of the device provides extension of the mooring line overall length and the combination of weight and buoyancy creates a restoring force to return the device to the nominal vertical position. The result is a bespoke non-linear mooring response.

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ANALYSIS

TANK TESTING

CERTIFICATION

COMPONENT DESIGN

PROTOTYPE BUILD

OFFSHORE TESTING

PROJECT ACTIVITIES

MOORING ANALYSIS

Analysis and design of the mooring system and LRD was undertaken using hydrodynamic software, Orcaflex. The platform used for comparative modelling was the MaRINET2 V3 semi-submersible platform coupled with the NREL 15MW reference wind turbine. The LRD was modelled in Orcaflex using connected 6-dimensional buoy elements to represent the buoyancy, weight, and hydrodynamic performance.

TANK TESTING

Validation of numerical modelling for the Floating Offshore Wind (FOW) system was delivered through physical prototype testing in the deep ocean basin at Lir, Ireland's National Ocean Test Facility.

STATEMENT OF FEASIBILITY

Third Party Certification of the LRD was undertaken by DNVGL in accordance with DNVGL-SE-0160. The first step toward product certification was to achieve a 'Statement of Feasibility' following assessment of the Design Basis.

OCEAN TESTING

A quarter scale LRD was designed and built for the purpose of ocean testing. The chosen test site was situated off the west coast of Ireland. The site was subject to a wave climate which approximates a ¼ scale climate of an exposed Atlantic site in 24.5m water depth Mean Sea Level (MSL). The LRD accumulated 1200 hours of continuous operation, thereby exceeding the target 1000 hours required to demonstrate the suitability of the mechanical systems. The deployment period coincided with Hurricane Epsilon and Storm Aiden, yielding high quality data across all phases of the LRD response curve.

ANALYSIS

A rich collection of high-definition data such as line tension, LRD acceleration and environmental conditions were collected during the offshore test period. This data set was analysed and compared to LRD performance as predicted by the numerical model. A levelised cost of energy (LCOE) model was developed in order to provide a bottom-up assessment of the impact of the LRD in a reference floating wind project.

PROJECT RESULTS

REDUCED MOORING LOADS UP TO 70%

LOAD REDUCTION

The outputs of the numerical modelling, scaled tank test, and ocean test all demonstrate the LRD will result in a large reduction in mooring line tension. This reduction is as high as 70% when compared to traditional steel catenary moorings, and up to 50% when compared to higher performance semi-taut systems.

NUMERICAL MODEL VALIDATION

RESPONSE CURVE VALIDATION

A high degree of predictive accuracy is demonstrated. Correlation between the predicted numerical model outputs and actual results measured during tank and ocean testing show excellent agreement, making LRD system integrated performance highly predictable. The data gathered during ocean testing and subsequent analysis was certified as compliant with the IEC TS 62600-10.

LOW TECHNICAL NOVELTY

CERTIFICATION

The LRD has been awarded a Statement of Feasibility, and no technology qualification activities were deemed necessary. All components of the LRD are assessed by DNVGL as being Technology Class 1 (no new technical challenges).

ROBUST & SIMPLE DESIGN

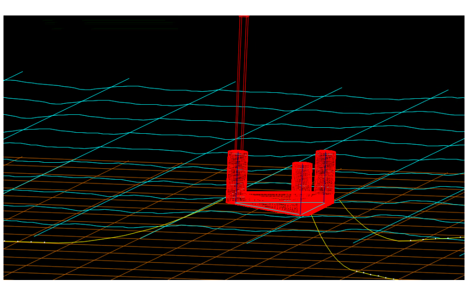
MECHANICAL DESIGN

Visual inspection of the ¼ scale LRD prototype was carried out following the ocean test period. The results of the inspection indicate that the LRD has behaved as intended. No degradation of performance is evident over the test duration.

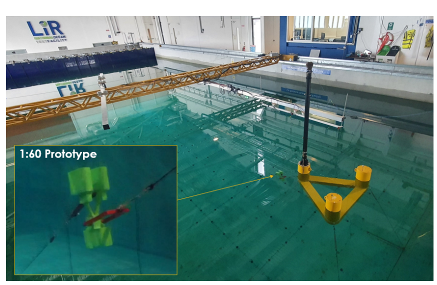
LCOE REDUCTION OF UP TO 8%

LCOE ANALYSIS

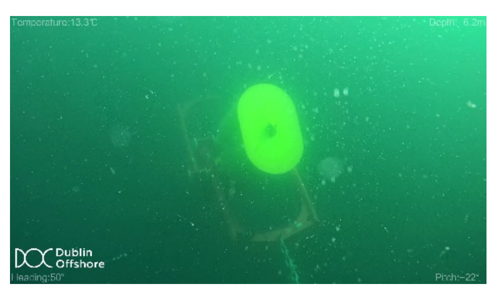
When compared against semi-taut mooring systems the LRD can conservatively deliver a reduction in LCOE between 5 – 8%. This will increase when considered against chain catenary systems, and allow for overall project savings. The cost savings are driven by CAPEX reductions in the mooring system and platform.



Phase 1 : Numerical Model



Phase 2 : Tank Testing



Phase 3 : Ocean Testing

WHAT'S NEXT

FULL SCALE DEPLOYMENT

The next step for the LRD development is to undertake a suitably sized demonstration deployment in the mooring system of a full scale Floating Offshore Wind Platform. Specifically, the target scale is on a floating wind platform of >2MW. The LRD will be optimised for a demonstration scale deployment based on specific site, platform, and project owner requirements.

WANT TO KNOW MORE? GET IN TOUCH

www.dublinoffshore.ie

hello@dublinoffshore.ie

57 Fitzwilliam Square,

Dublin 2, Ireland

ACKNOWLEDGEMENTS

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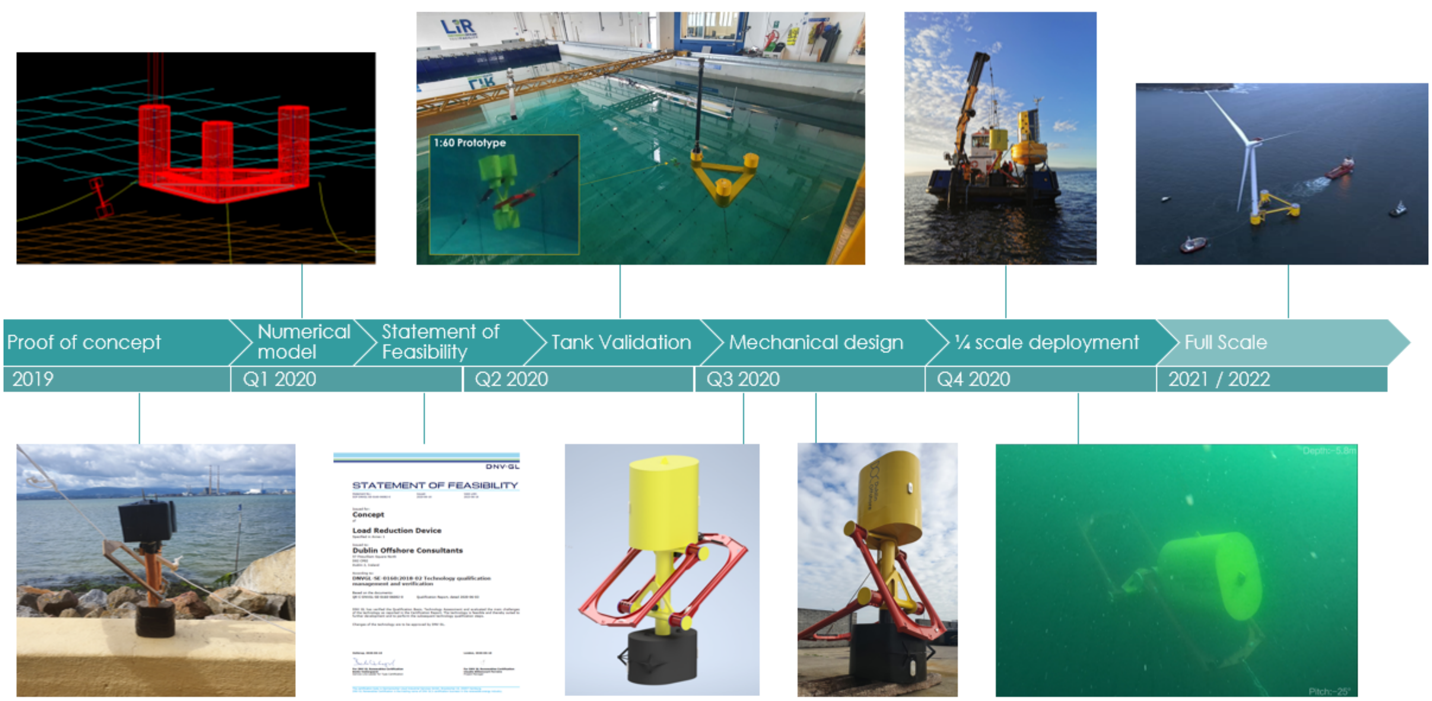

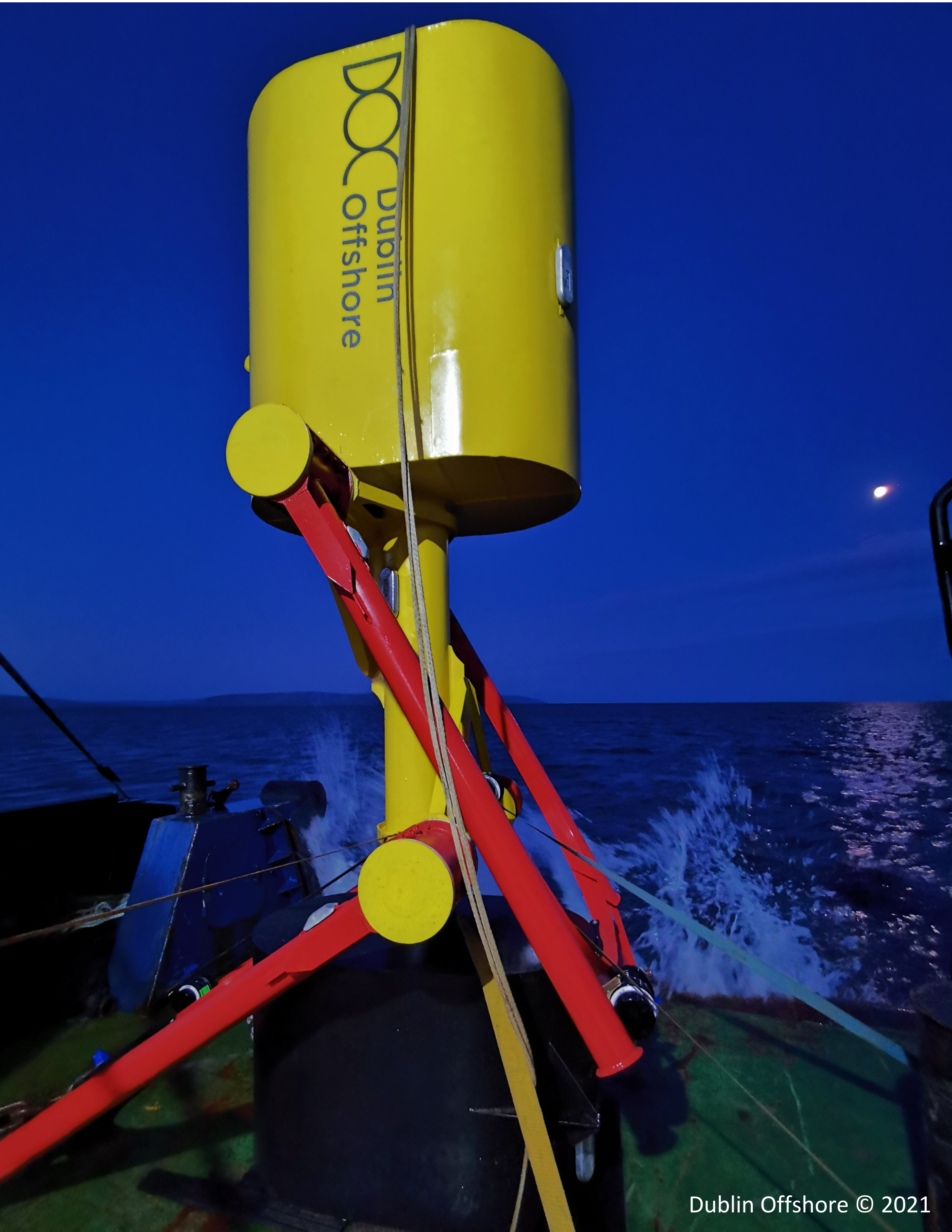
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