Development and demonstration of novel non-linear mooring solutions for floating offshore wind

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Outline

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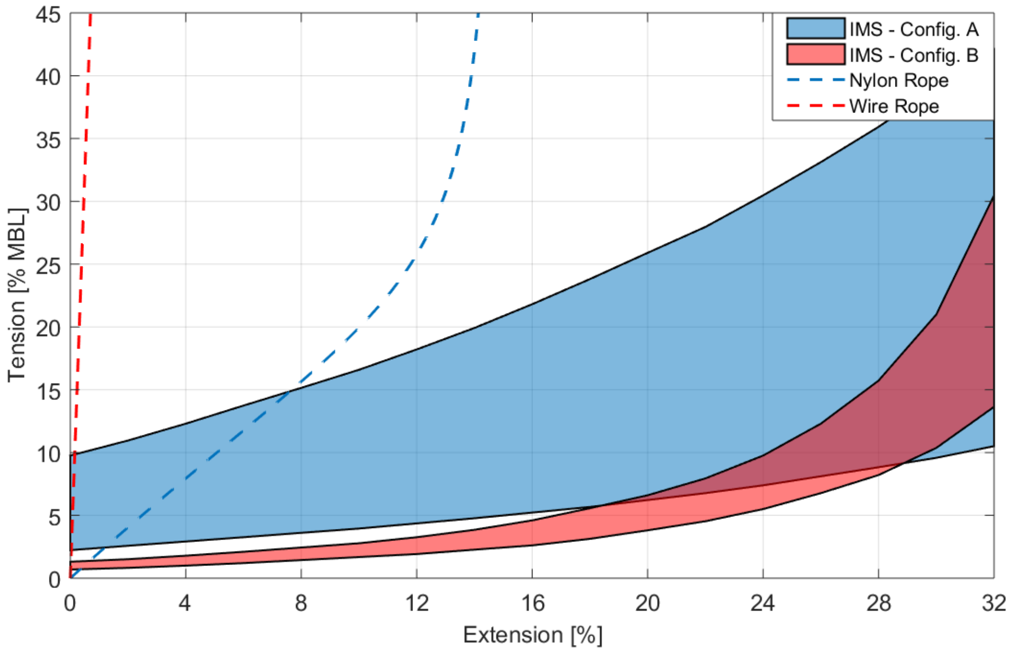
2. Exeter Tether – Passive Damper
   - Numerical Studies
   - Field Testing
3. Intelligent Mooring System (IMS) – Slow Varying Active Damper
   - Numerical Studies
   - Combined Numerical and Physical Modelling
4. Summary

Motivation

- Mooring system - A key technical barrier that could deliver considerable cost savings in floating wind.

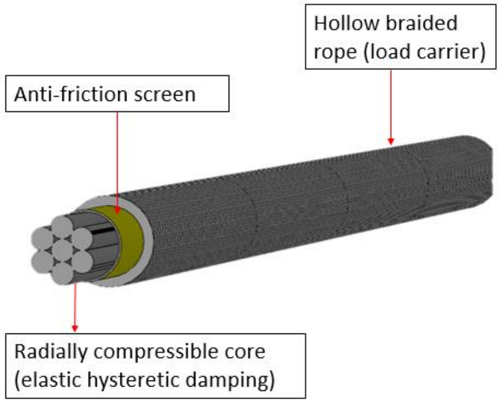
- Non-linear mooring systems have the desired load reduction characteristics.

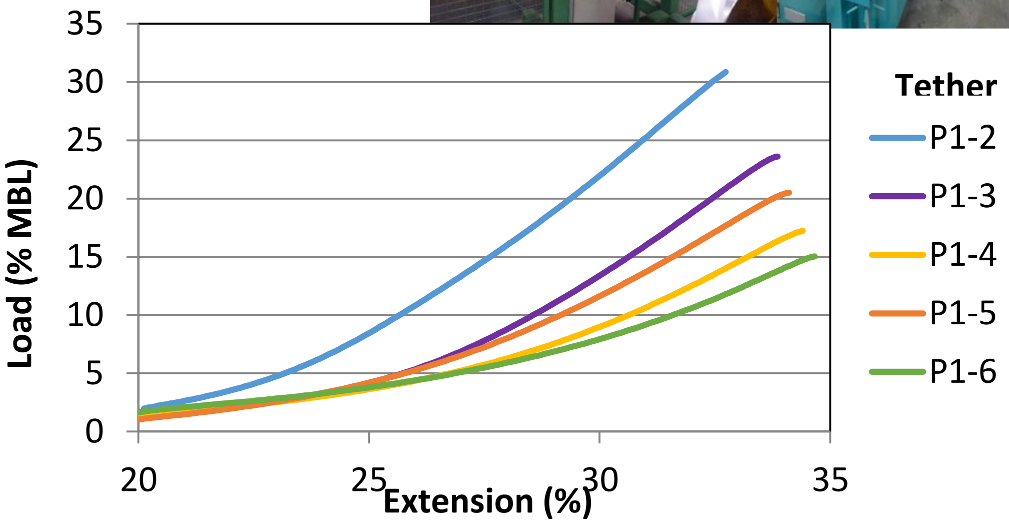
- Peak load reduction through the use of:
  - Passive damper – Exeter Tether
  - Active damper – IMS



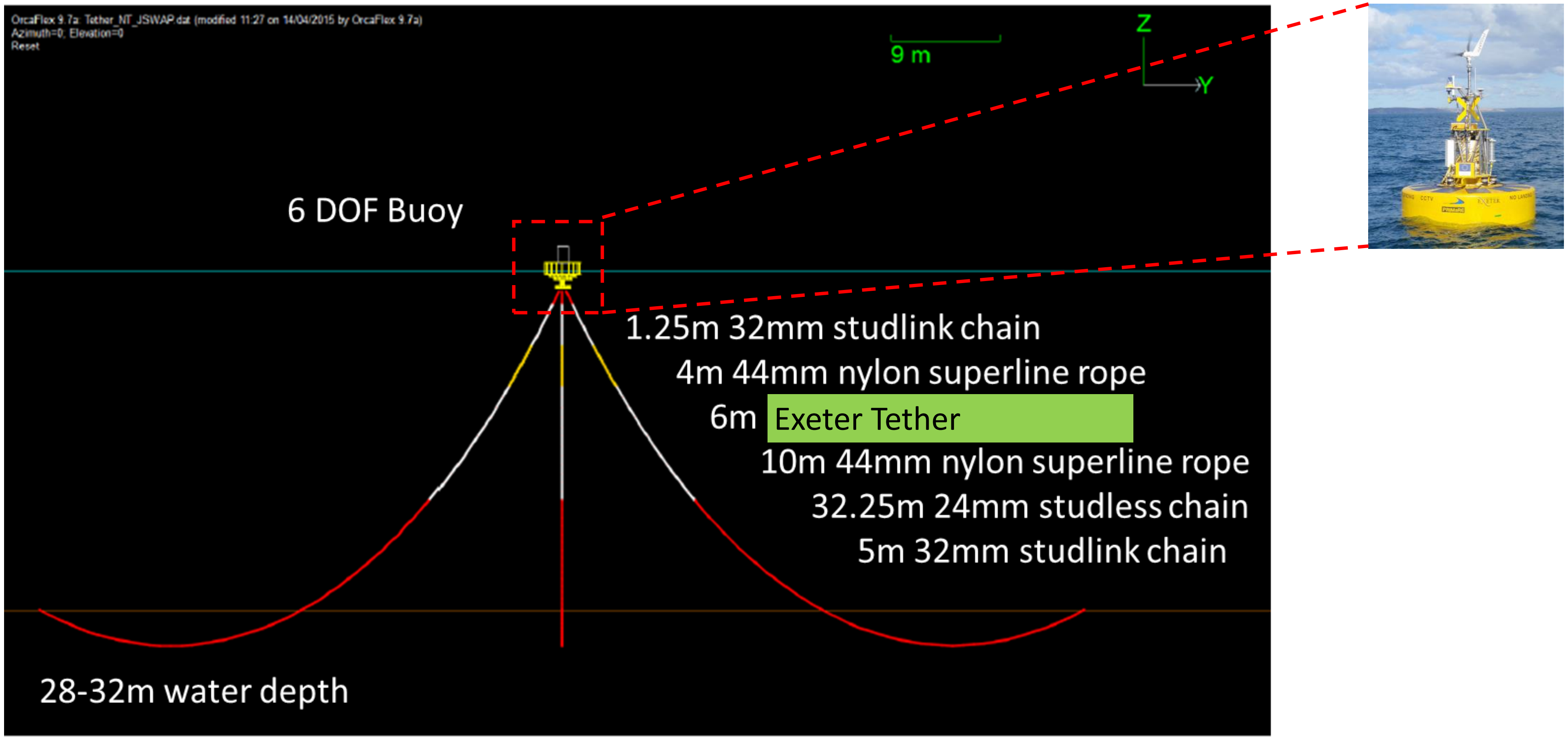
Exeter Tether – Passive Damper

- De-couples extension properties of the tether from the Minimum Breaking Load (MBL) of the rope.
- Allows selection of extension characteristics and damping.
- Offers proven load carrying via hollow rope and conventional splicing / connectors.





Exeter Tether – Numerical Studies



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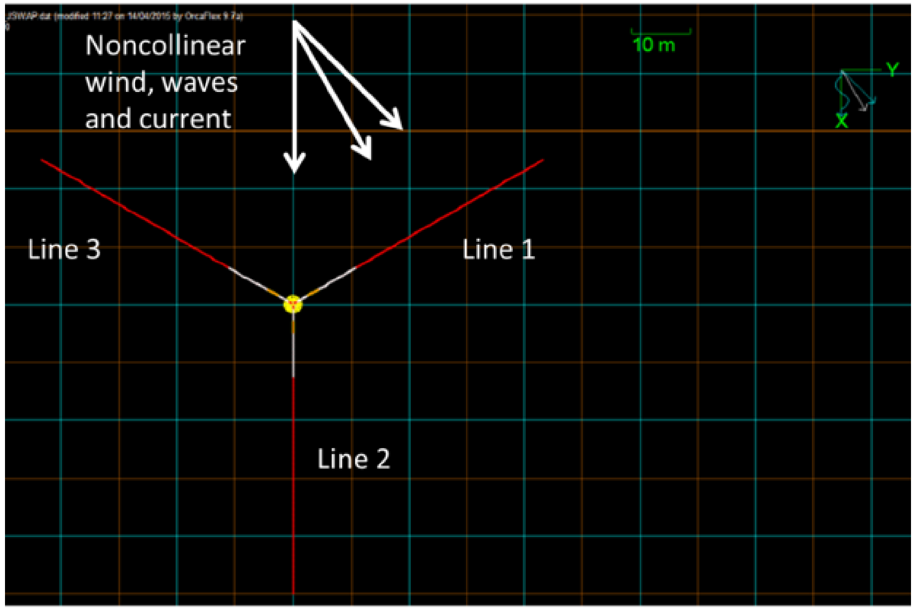
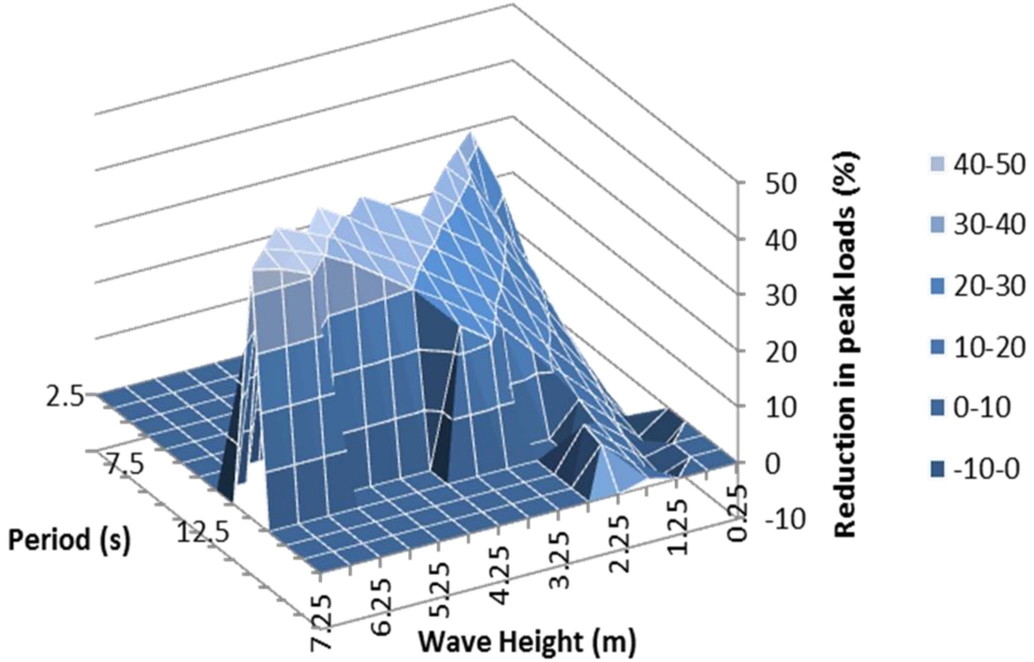
Exeter Tether – Numerical Studies



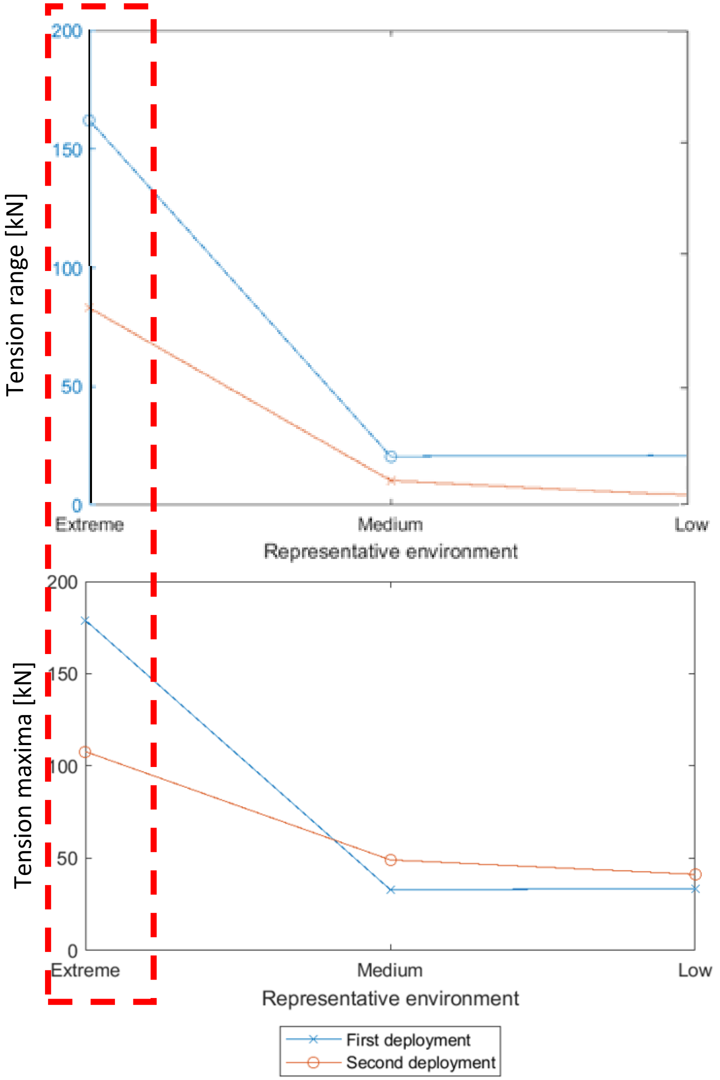


Expected fairlead peak load reduction by introducing a 6 m Exeter Tether section.

Exeter Tether – Field Testing

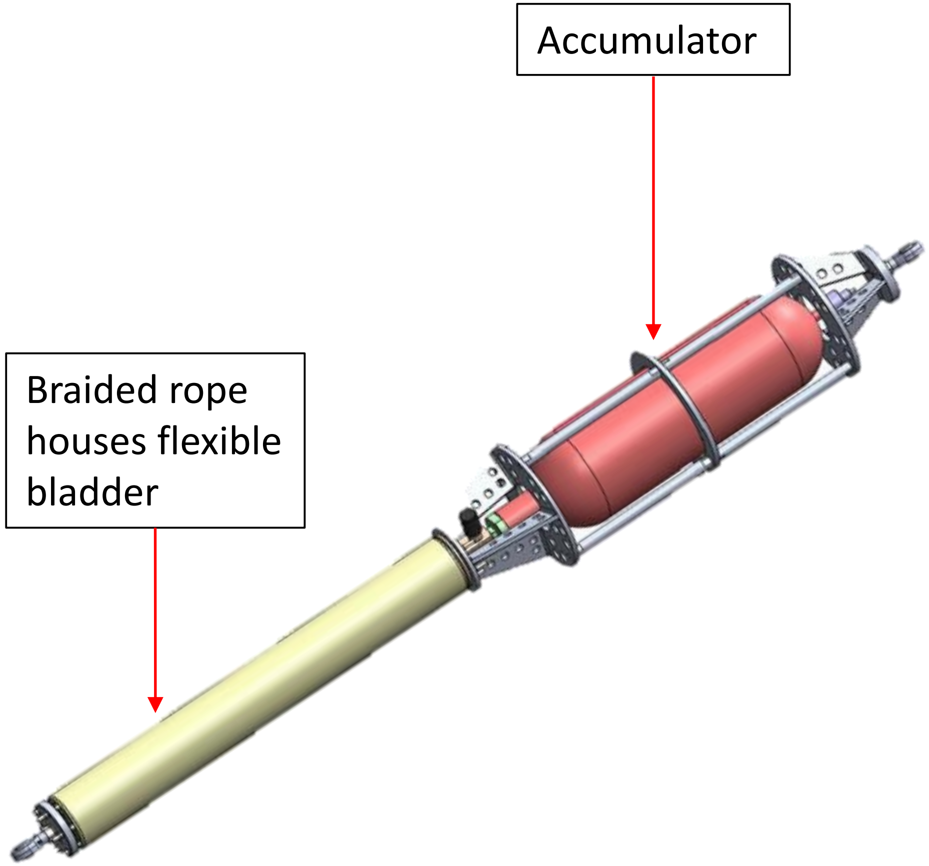
- Load reduction and component design integrity demonstrated at BiMEP by comparing:
  - 1st deployment: Conventional Polyester
  - 2nd deployment: Exeter Tether
- Tension range and maxima compared for sea states with similar, but not identical, environmental conditions.

(MBL = 130tonnes)

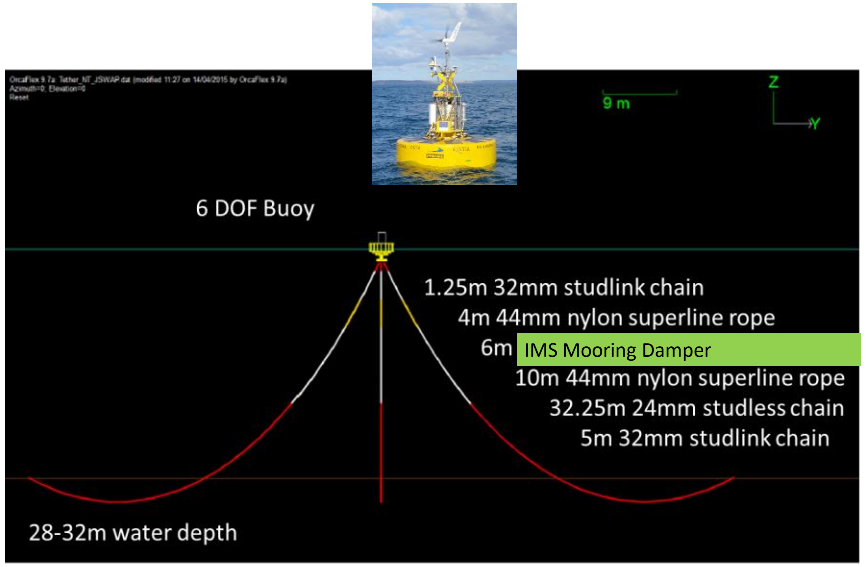


IMS – Slow Varying Active Damper

- Developed by Intelligent Mooring Ltd.
- Provides functionality akin to a shock absorber.
- Internal pressure increase from IMS extension leads to non-linear stiffness.
- Control over internal pressure can tune the system to suit the prevailing metocean conditions.

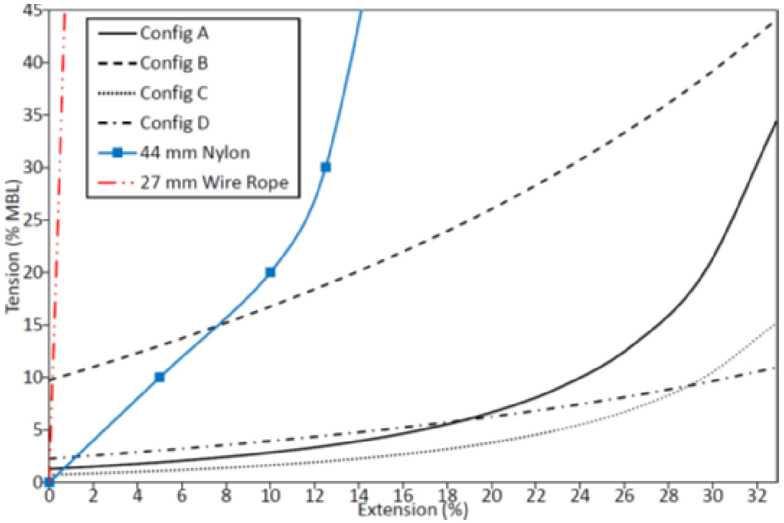


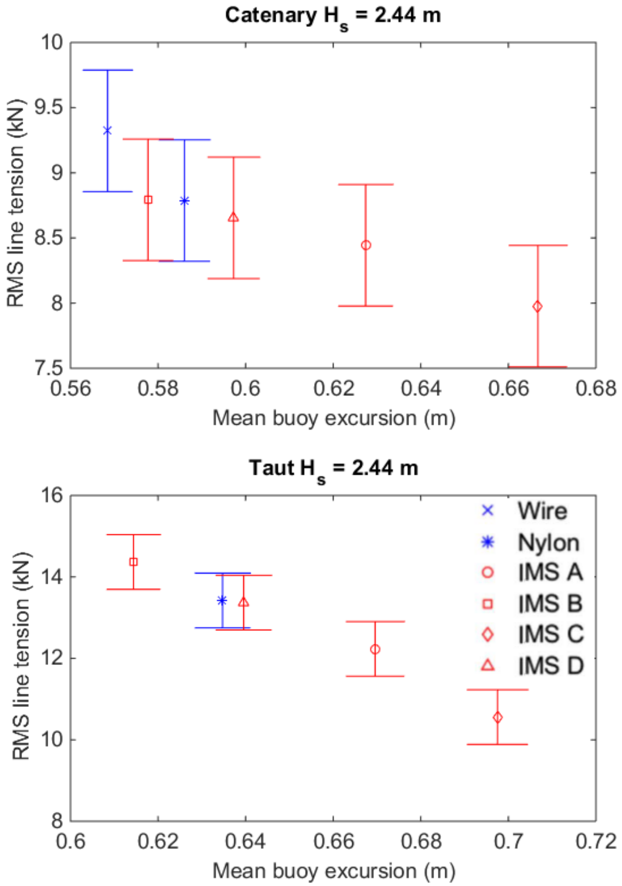
IMS – Numerical Studies



Accumulator air volumes and initial pressures for configurations A–D.

Configuration	Air volume (m^3)	Pressure (kPa)
A	0.72	158
B	2.62	1198
C	0.85	89
D	2.62	278



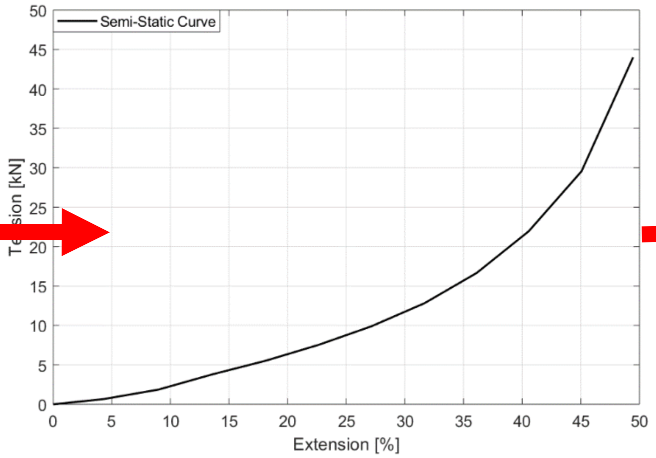


IMS – Combined Physical and Numerical Modelling

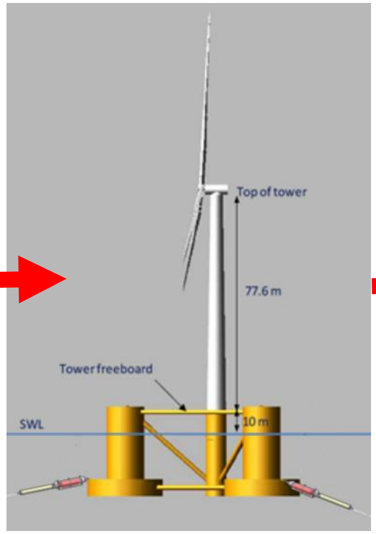
- IMS performance characterised via combined physical testing at Dynamic Marine Component Test Facility (DMaC) at University of Exeter and OrcaFlex modelling.

Tested at DMaC

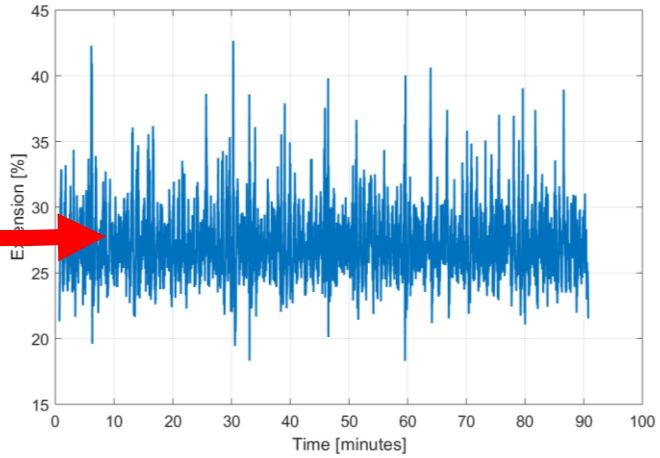
Measured IMS Curve



Numerical Model



Time-Series of Extension/Tension



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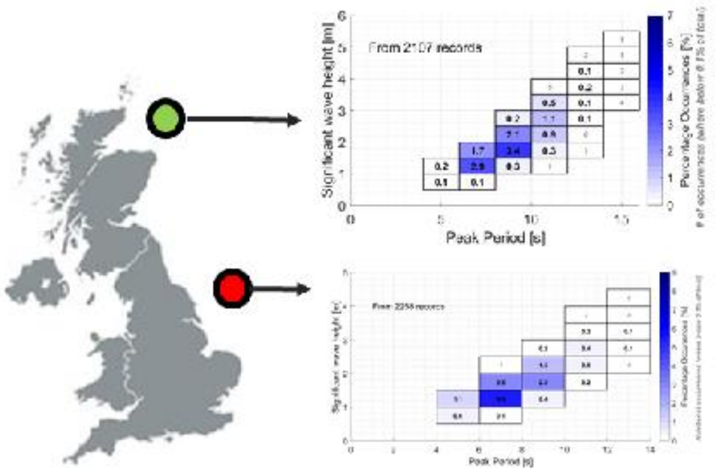
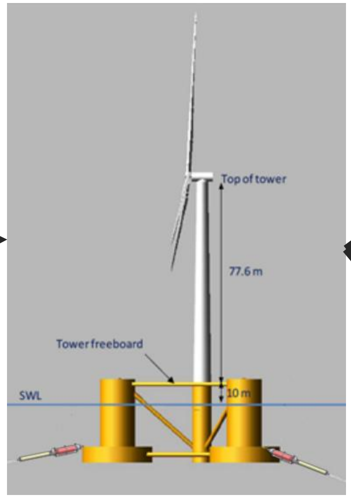
IMS – Influence of water depth on load reduction

- Site specific environmental data and NREL 5 MW semi-submersible model for 2 sites with and without the IMS.
- Deepwater site (200 m) and shallow water site (100 m) for rated wind speed

Environmental Data



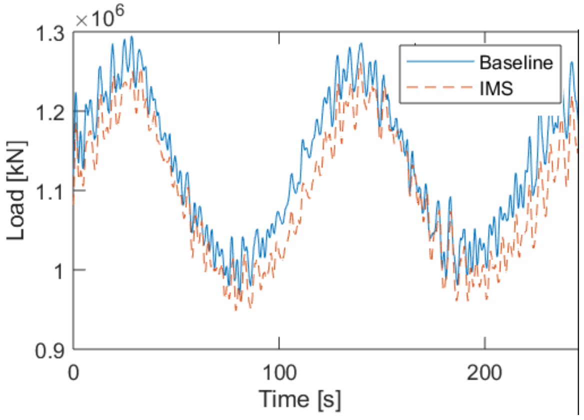
System Model



Case

- Without IMS 200 m
- With IMS 200 m
- Without IMS 100 m
- With IMS 100 m

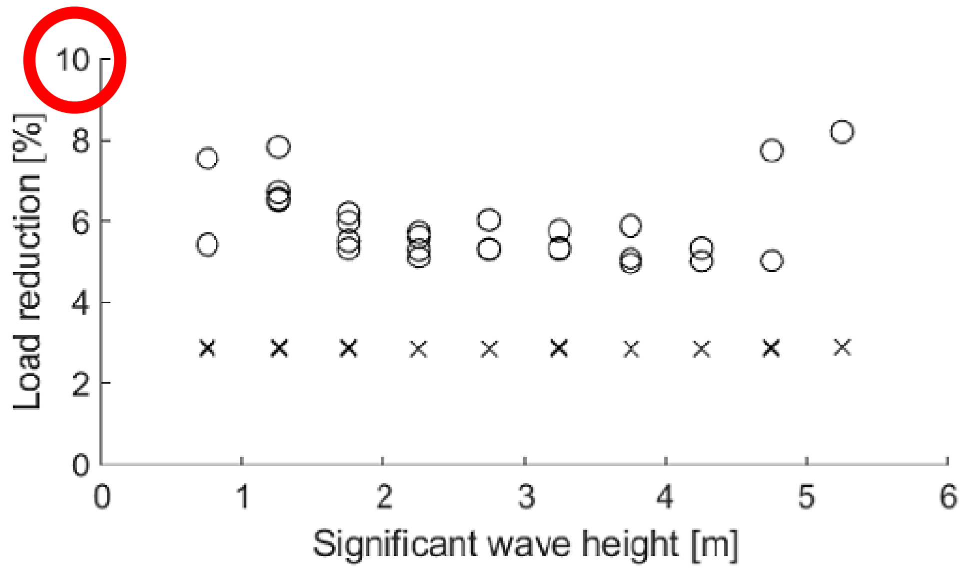
Mooring line tension



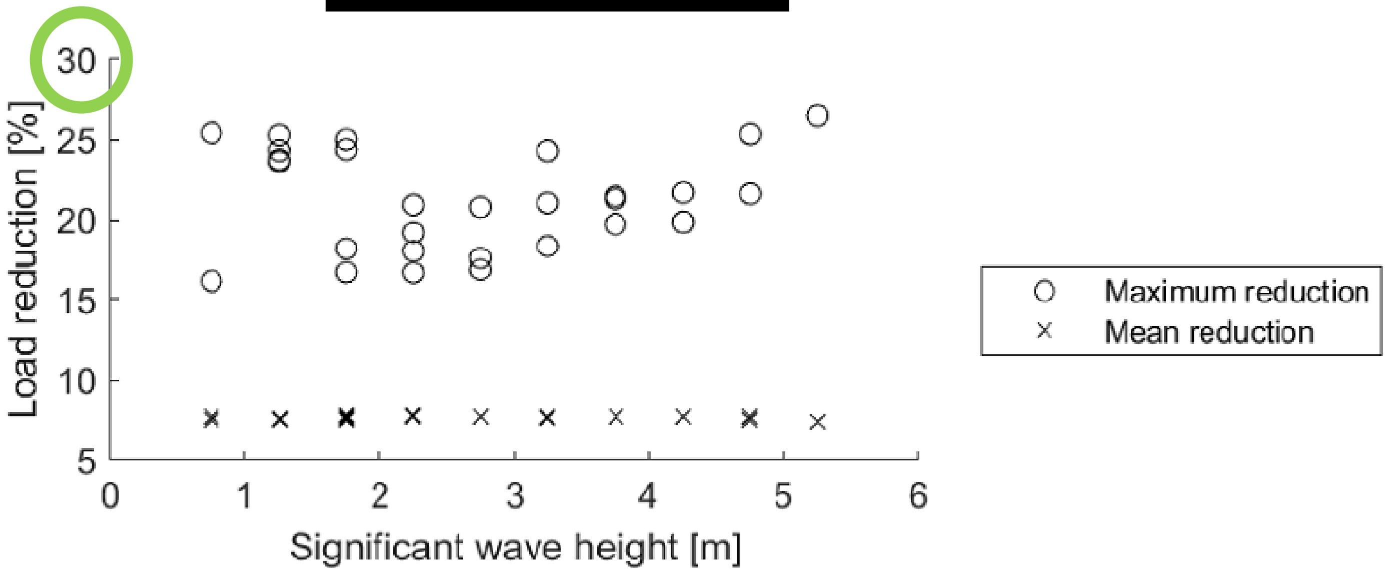
IMS – Influence of water depth on load reduction

- Peak load reduction: 10% at deep water site vs 30% at shallow water site.
- Load reduction potential varies for different wave conditions within the same wind speed bin.

Deep water



Shallow water



Summary

- Innovative nonlinear mooring systems offer peak load (up to 50%) and cost reduction for floating wind systems
- Working principles of active and passive mooring load dampers have been demonstrated at prototype stage
- Technology development through combined numerical modelling & physical (field) testing approach
- Future work involves:
  - Field testing of the IMS at East Pickard Bay, Wales
  - Component integration into Floating Offshore Wind platforms

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Thank you for your time

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