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Mooring Line Dynamics of a Semi-submersible Wind Energy Platform: Cross Validation of Two Commercial Numerical Codes with Experimental Data

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INTRODUCTION

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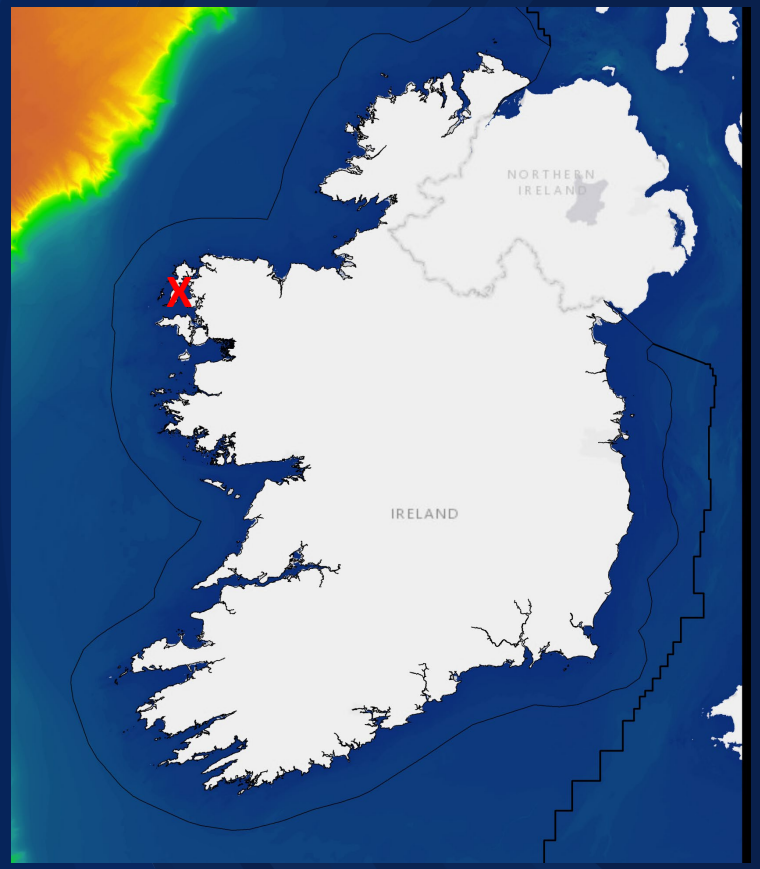
Mooring Line Dynamics of a Semi-submersible Wind Energy Platform: Cross Validation of Two Commercial Numerical Codes with Experimental Data

Content

- **Methodology**
- **Numerical Software**
- **Experimental Data & Tank Testing**
- **Validation Results**
- **Conclusions and Future Work**

METHODOLOGY



Location of the Atlantic Marine Energy Test Site in Belmullet, Ireland

Environment

- Dataset taken from Atlantic Marine Energy Test Site (AMETS) in Belmullet, Ireland
- Testing regular and irregular wave loads
- With and without a constant wind load

METHODOLOGY

Example semi-submersible platform [Source: DNV-GL]

Technology

- INNWIND Semi-submersible floating platform
- 5 MW Reference Turbine
- 3 Leg Catenary Mooring System

METHODOLOGY

Example semi-submersible platform [Source: DNV-GL]

Focus Points

- Response Amplitude Operators (RAOs)
- Fairlead Loads
- Acceleration at Hub Height

NUMERICAL SOFTWARE

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Flexcom

ORCAFLEX & FLEXCOM

NUMERICAL SOFTWARE

OrcaFlex

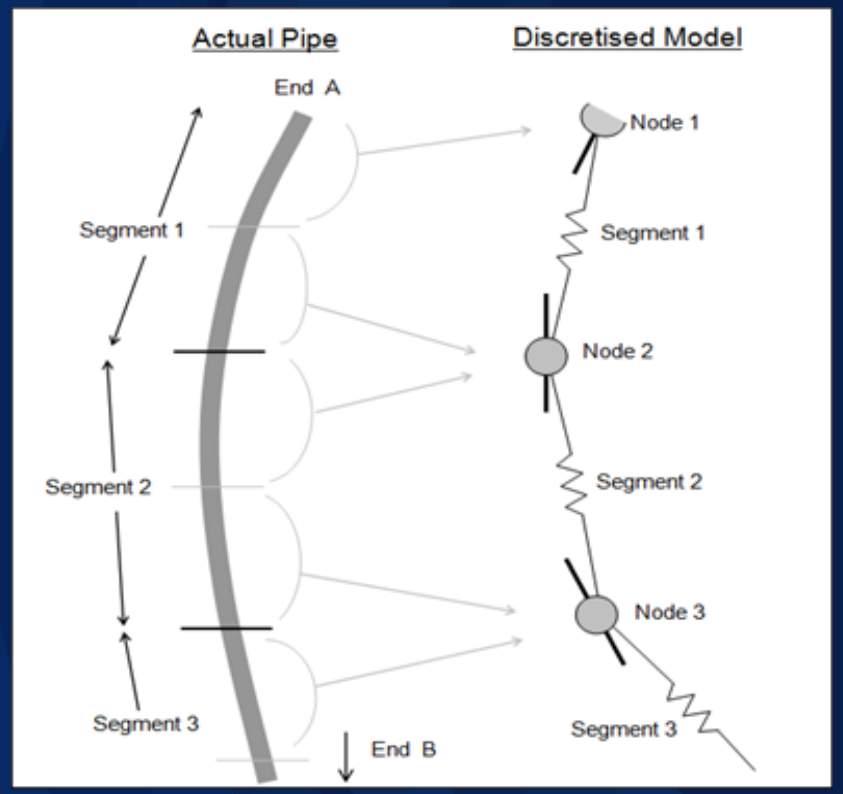


Illustration of lump mass and spring method [Source: OrcaFlex]

- 'Lump mass and spring method'
- Line is dicretised into series of elements connected by nodes
  - Nodes calculate effective tension, bending moments and shear forces
  - Elements deal with axial and torsional properties

NUMERICAL SOFTWARE

Flexcom

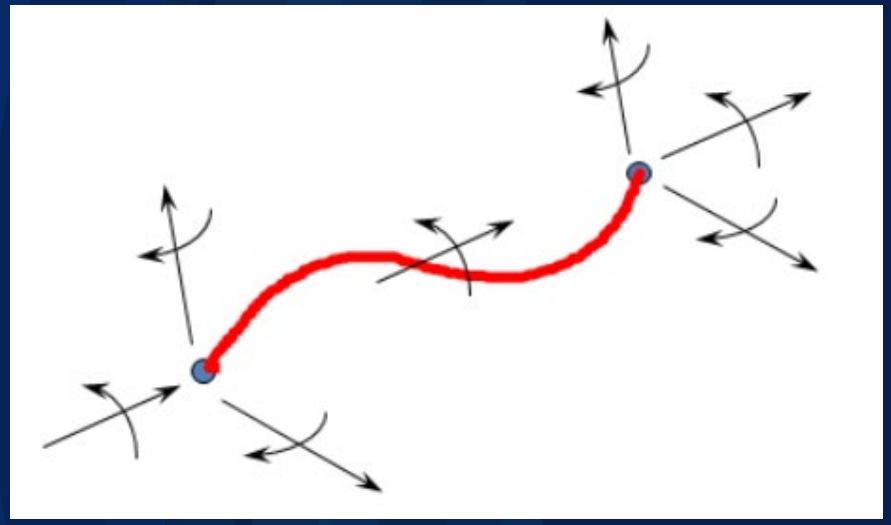
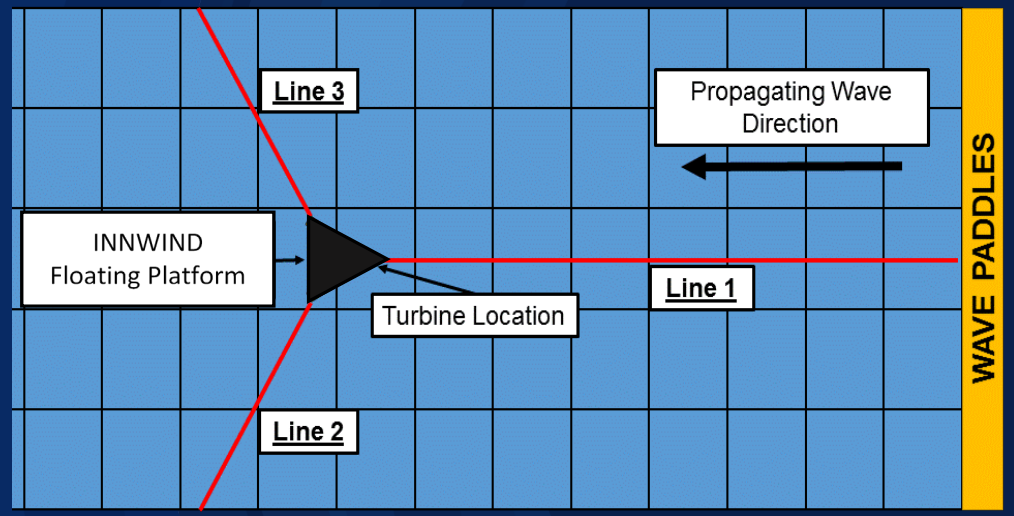


Illustration of 14 degrees hybrid finite element
[Source: Flexcom]

- Finite element formulation
- Utilises up to 10 integration points to distribute forces evenly across each element
- 14 degree of freedom hybrid beam-column allows fully coupled axial bending and torque

EXPERIMENTAL DATA

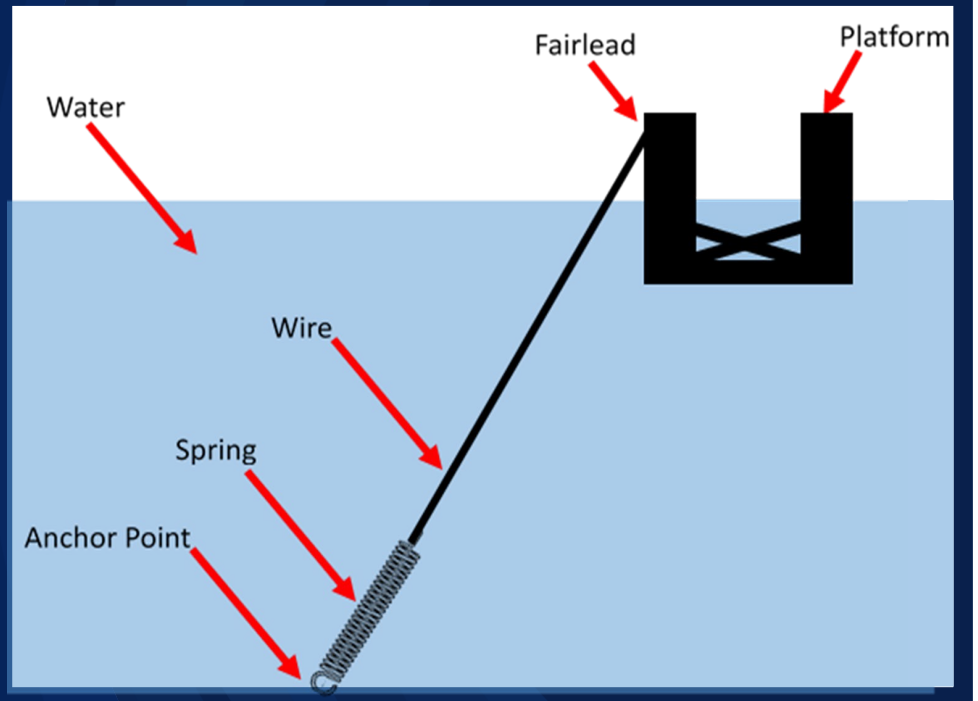
Tank Testing



- Tank testing conducted at Lir National Ocean Testing Facility, Cork
- 1:36 Froude scale
- Equivalent of 100m water depth
- Instrumentation:
  - Load cells at fairlead interface
  - Wave elevation probes
  - Qualisys motion capture system

EXPERIMENTAL DATA

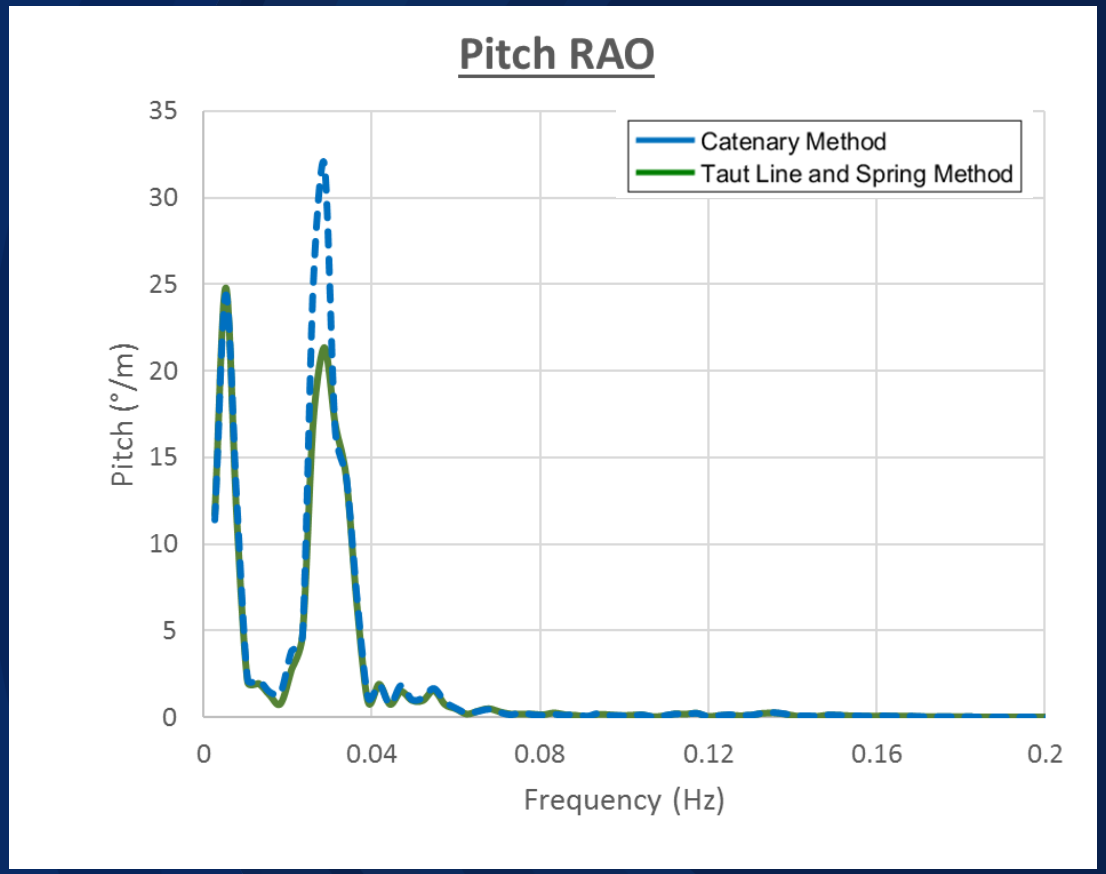
Taut Line & Spring Method

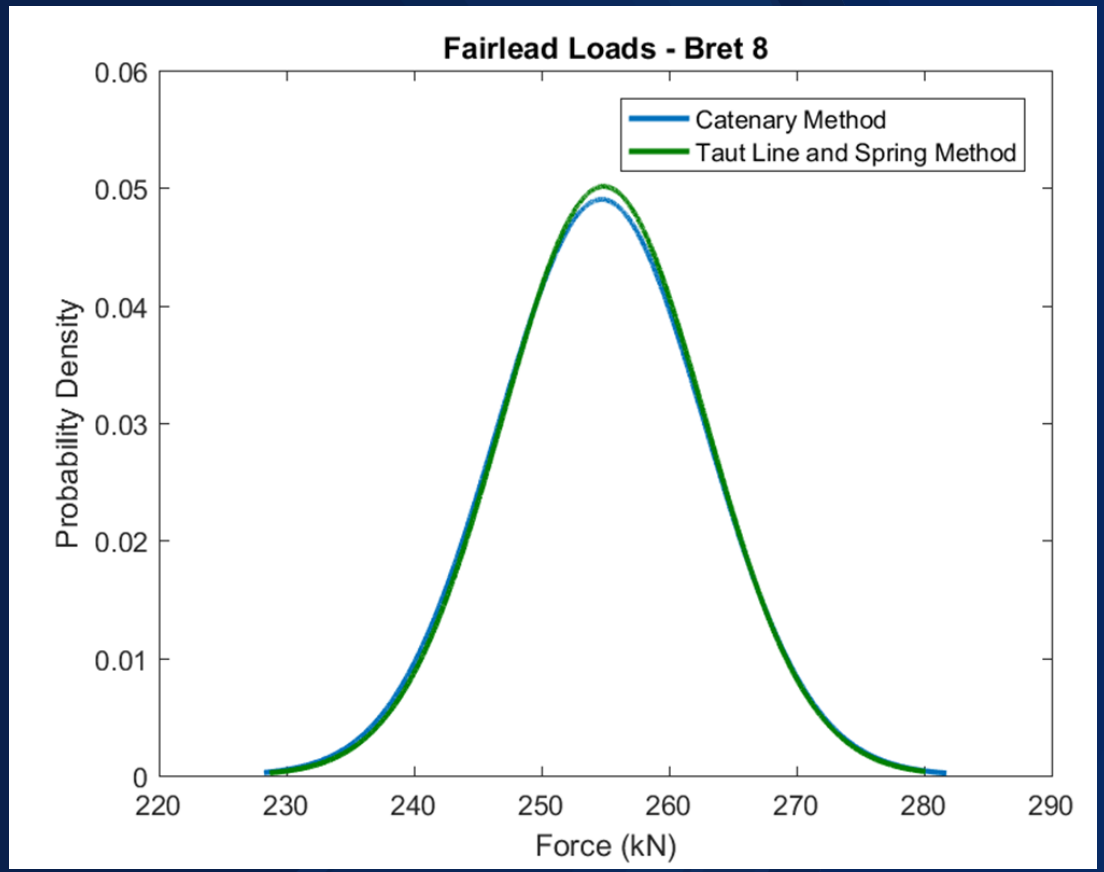


- Spring attached at interface between taut line and anchor
- Springs used to replicate load-displacement curve
- Method unrestricted by basin size.

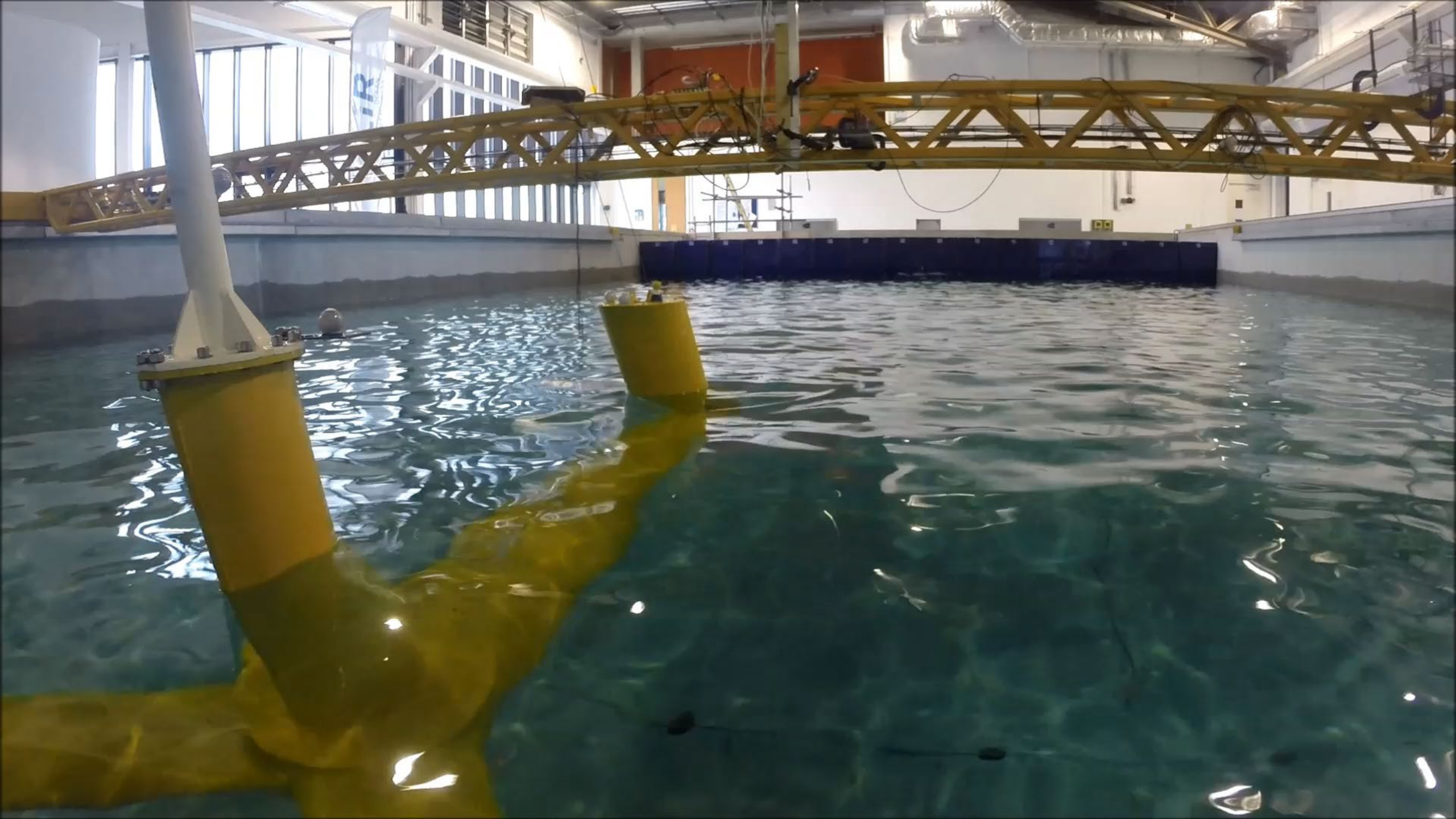
EXPERIMENTAL DATA

Taut Line & Spring Method



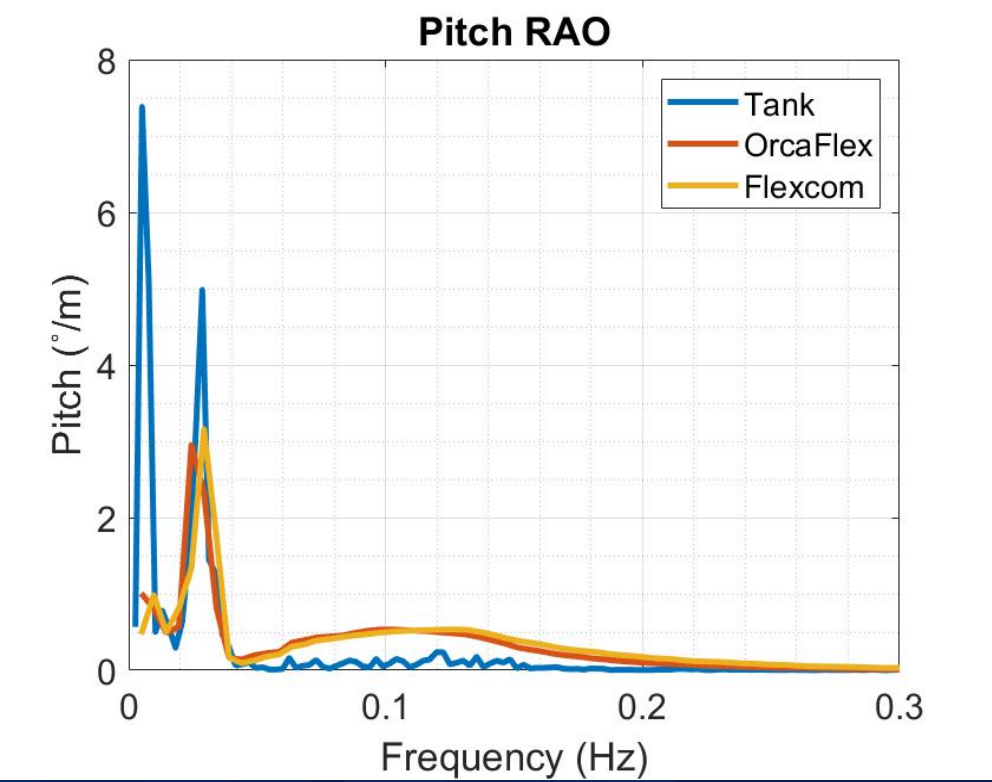


Catenary Method
Taut Line and Spring Method



RESULTS

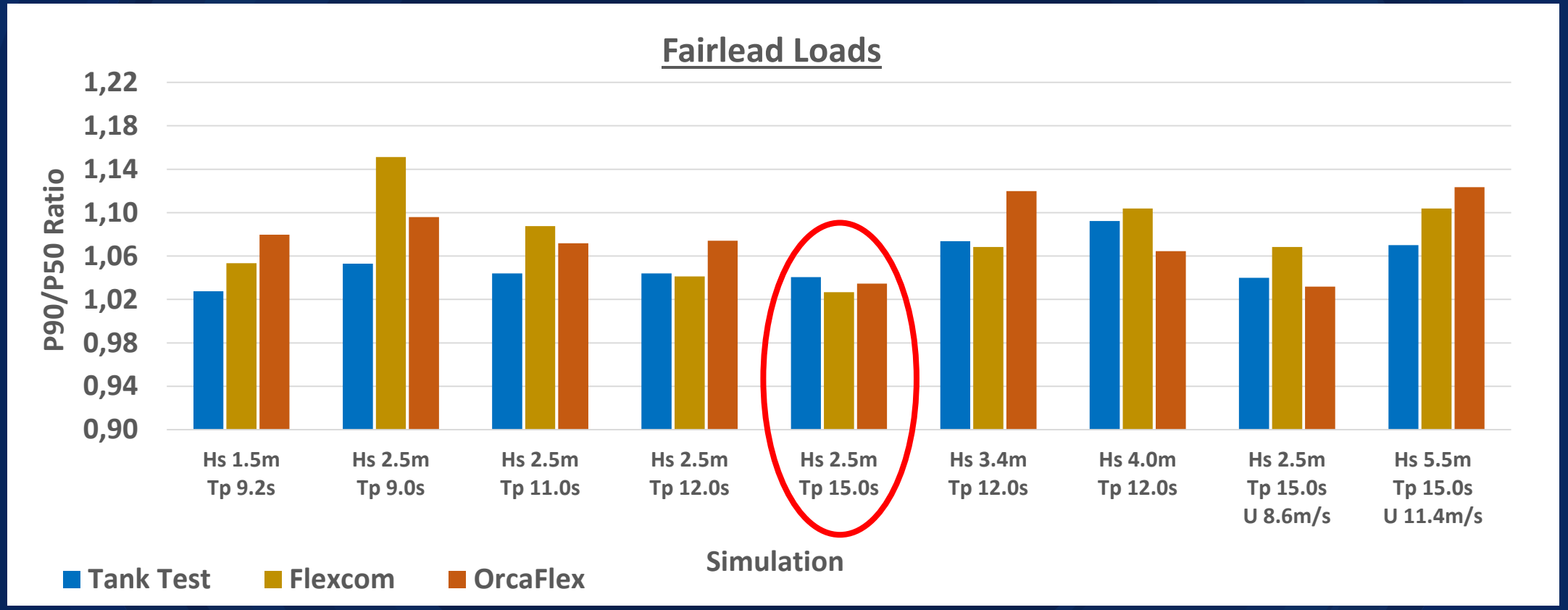
RAOs



- Reasonable agreement between all 6 degrees of freedom
- Resonance responses all in agreement
- Numerical models produce lower resonance displacement

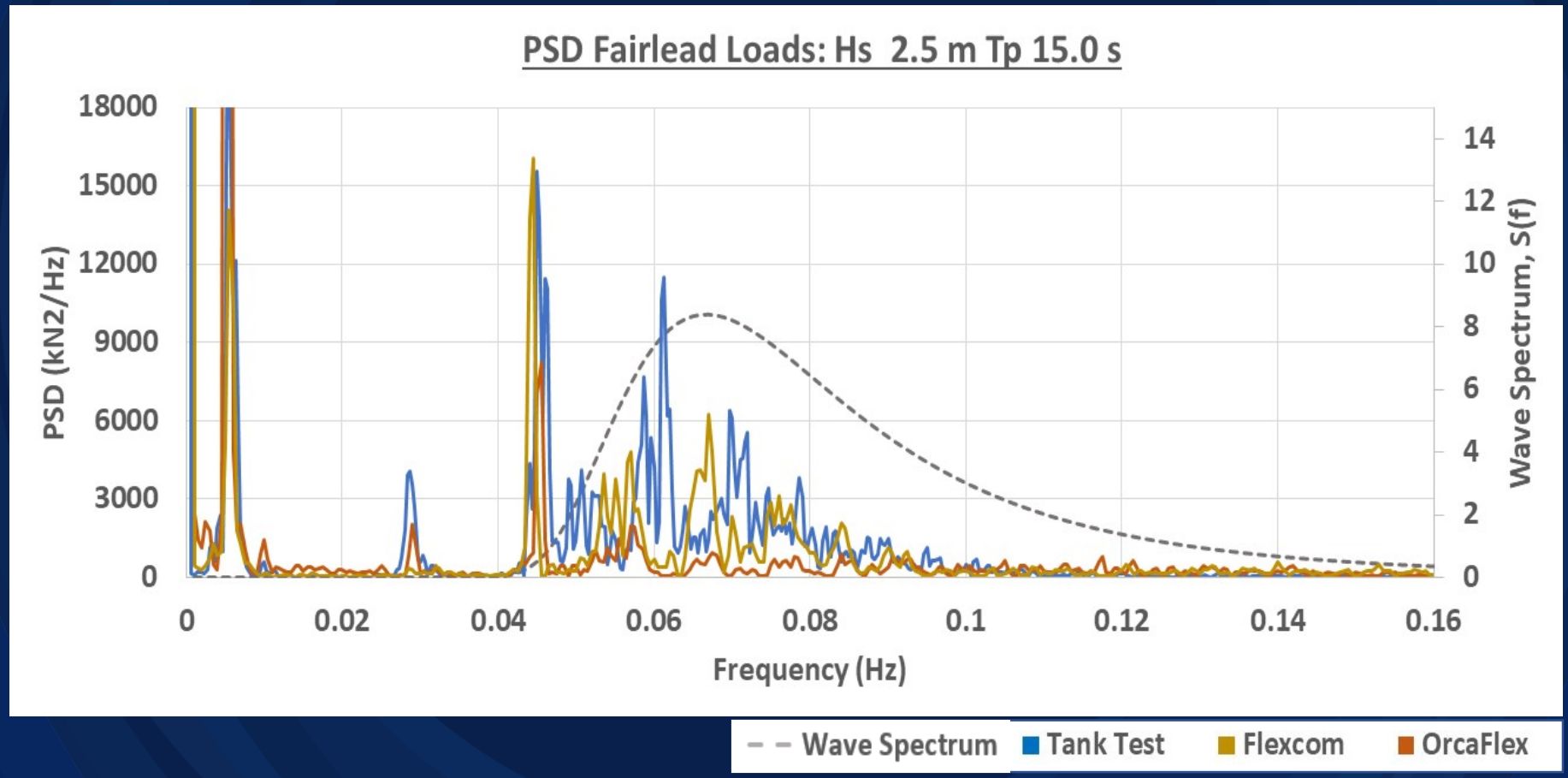
RESULTS

Fairlead Loads



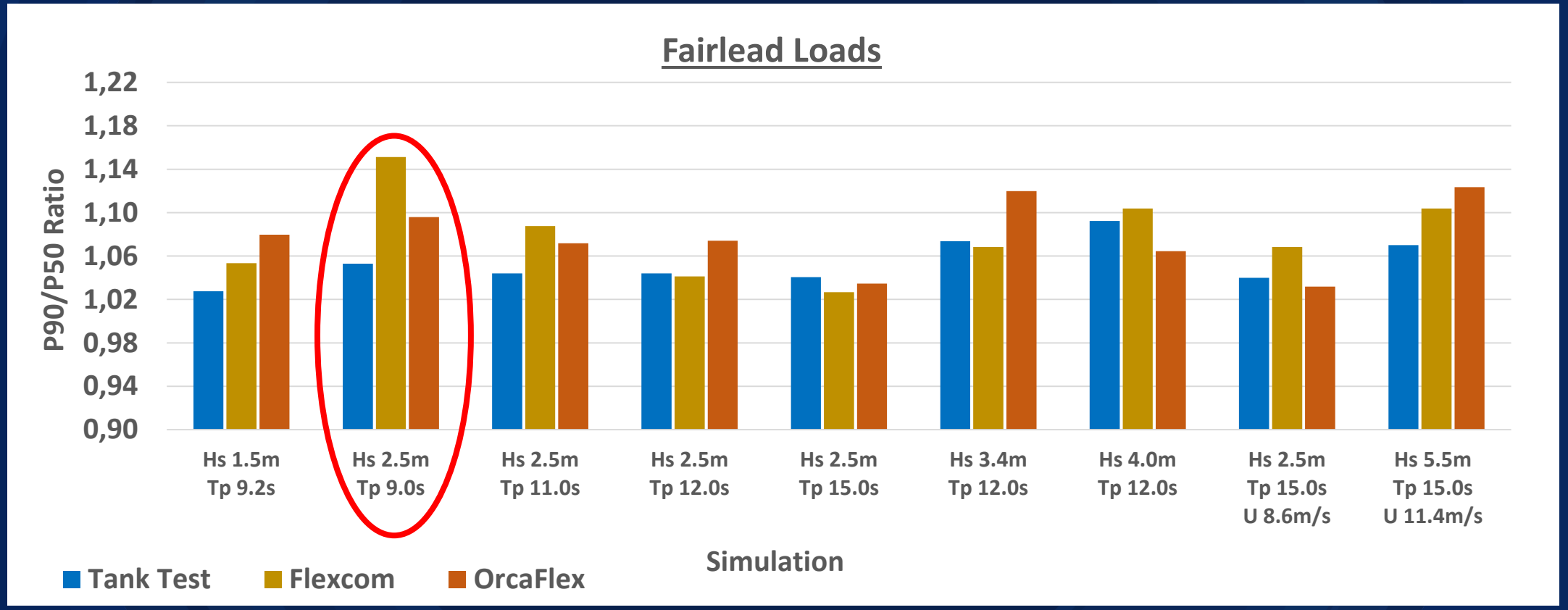
RESULTS

Fairlead Loads



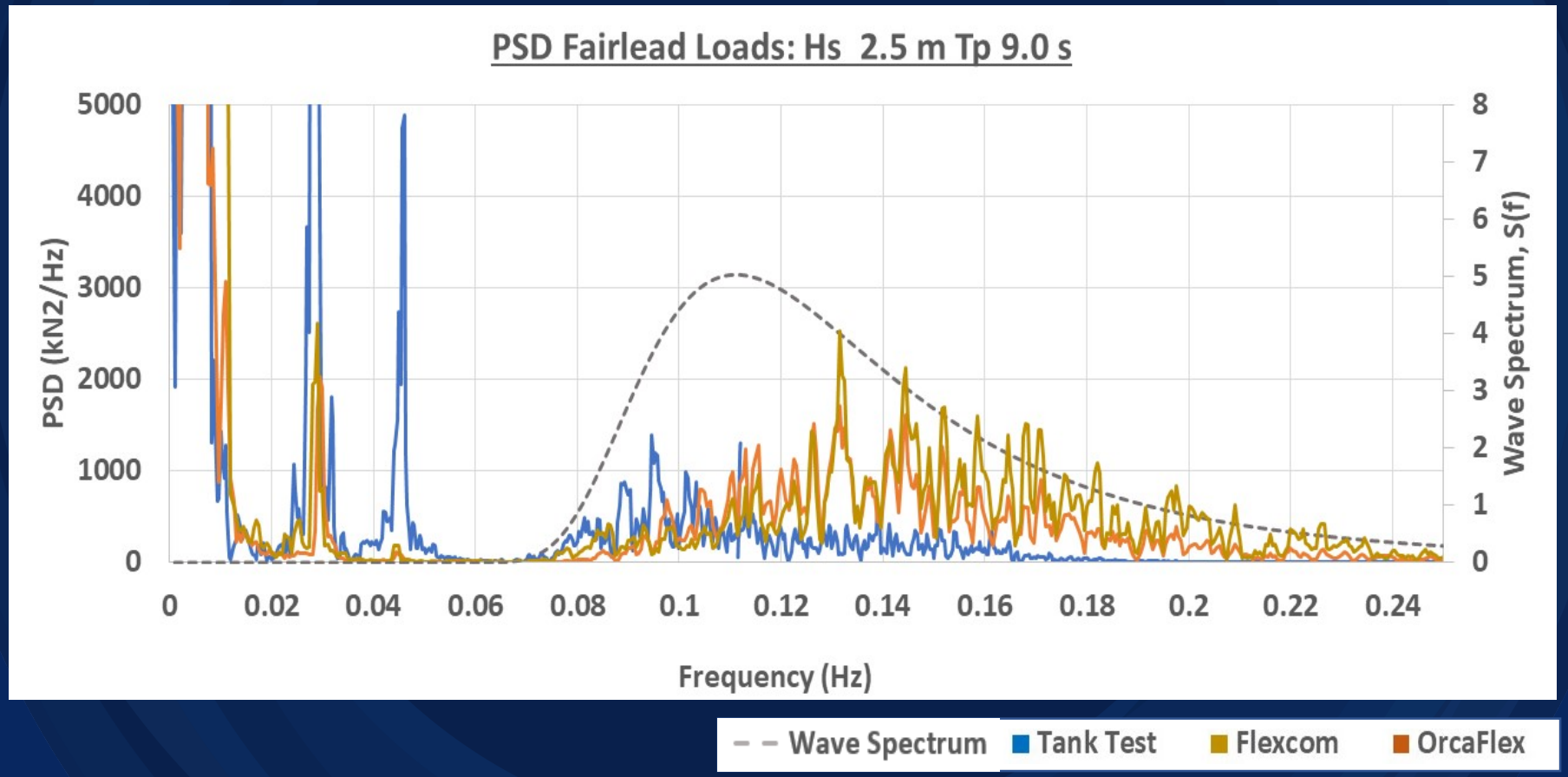
RESULTS

Fairlead Loads



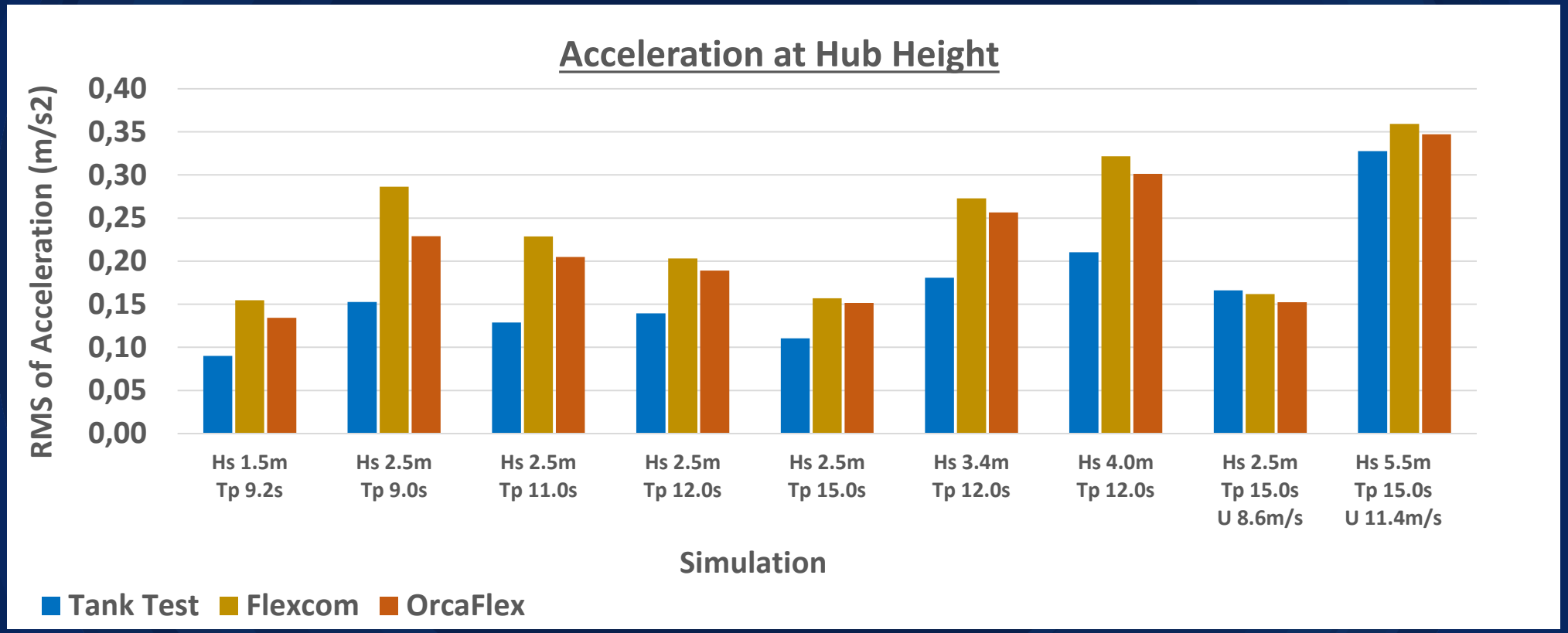
RESULTS

Fairlead Loads



RESULTS

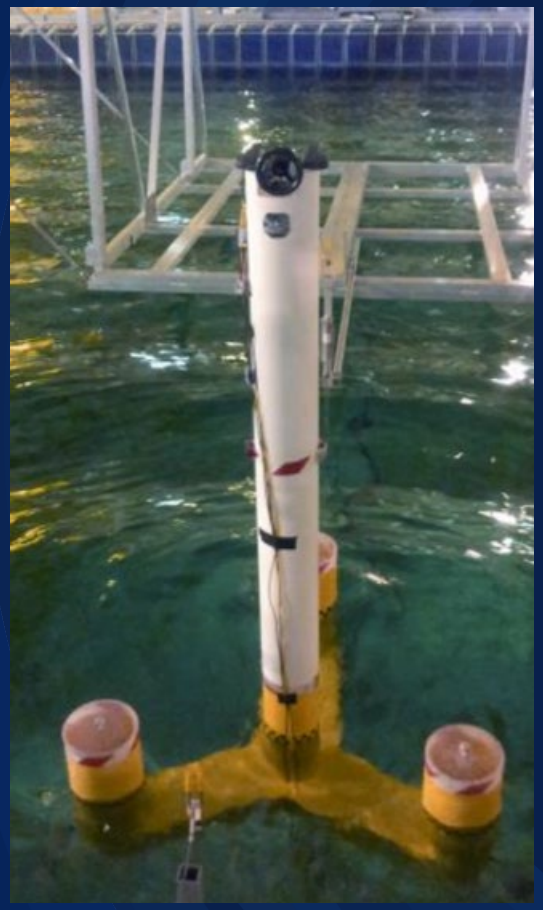
Acceleration at Hub Height



CONCLUSIONS

- Two scaled mooring systems displayed very similar results;
- OrcaFlex and Flexcom showed broadly similar behavior throughout;
- Some discrepancies between numerical and physical models for wave loading scenarios:
  - Discrepancies are minimized when dominant wind loading is considered;
  - Discrepancies can be attributed to the absence of mid-frequency responses in irregular wave loading.

FUTURE WORK



Tank testing with SIL fan
[Source: INNWind]

Incorporation of variable wind loading:

- SIL fan in tank testing
- Incorporation of FAST
- Using wind turbine updates in numerical software

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THANK YOU FOR LISTENING

QUESTIONS?

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