Multibody dynamic assessment of vessel-floater accessibility for floating wind

C. Perez Moreno, J. Lange,
T. Snedker, and I. Bayati

Confidentiality classification

Classification level	How to handle information sharing
NON-BUSINESS	Not corporate related information.
PUBLIC	The information carries no confidentiality risk and can be shared.
RESTRICTED	The information should only be shared on a need-to-know basis. No NDA is required.
CONFIDENTIAL	The information should only be shared on an organizational or team need-to-know basis. An NDA is required.
STRICTLY CONFIDENTIAL	The information should only be shared on a personal need-to-know basis. An NDA is required.

Disclaimer

Agenda

Accessibility of floating wind platforms

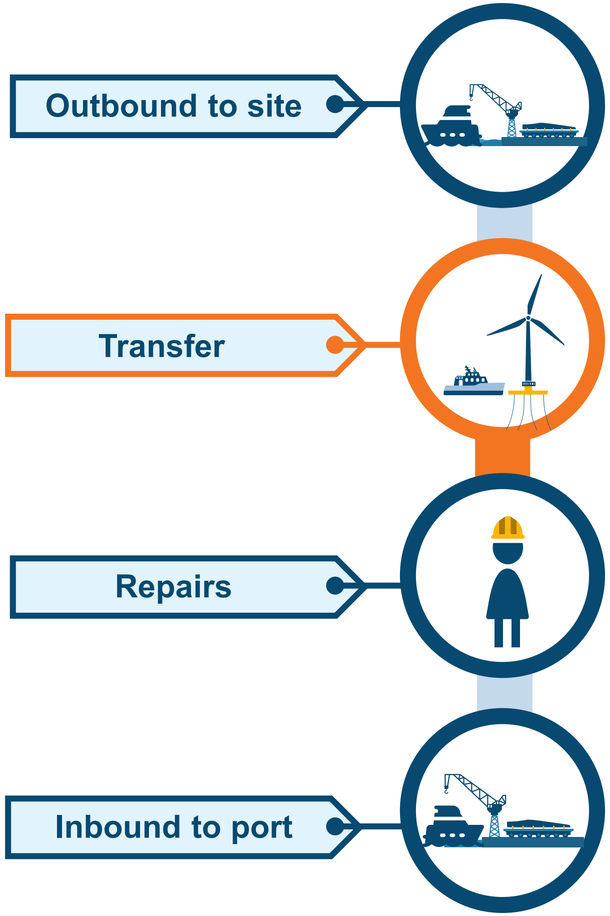
How to evaluate the accessibility and workability of floating wind platforms to optimize availability?

Crew Transfer Vessel (CTV)

Helicopter

Service Operation Vessel (SOV)

- Typically, max. **Hs of 1.5 m**. Independent of wave heading and wave period
- Not clear transfer limitations – **Lack of standards** and **operator dependent**
- Previous research investigated **frequency domain modelling** and **WH / Tp influence in motions**
- This work focuses on **time-domain modelling** to **quantify CTV accessibility**



Objectives

Research and tool development guiding questions

1. How can the accessibility of a floating wind platform can be accurately estimated?
2. Which physical phenomena should be modelled to assess accessibility of a floating wind turbine?
3. How do wave height, wave direction, and wave period impact accessibility of a floating wind turbine?

PEAK Wind

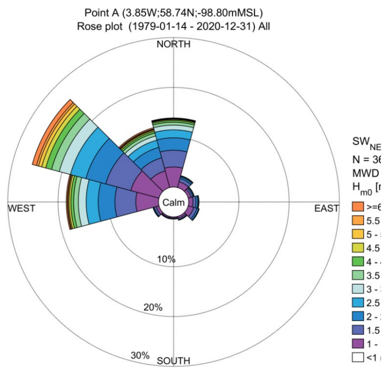
Agenda

Modelling of Accessibility and Vessel-Structure interactions

Overview of model environment, inputs & outputs

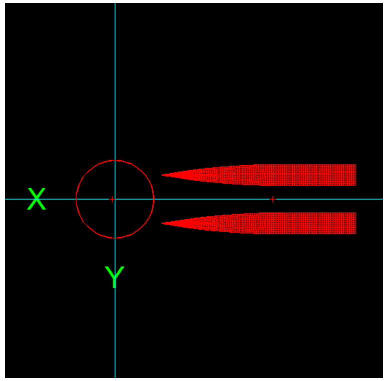
Holistic Model Components

- Met-ocean data analysis – Simulation geometry and weather input set-up
- OrcaWave – Radiation / Diffraction multi-body analysis
- OrcaFlex – Multi-body hydro-aero-servo-elastic simulations

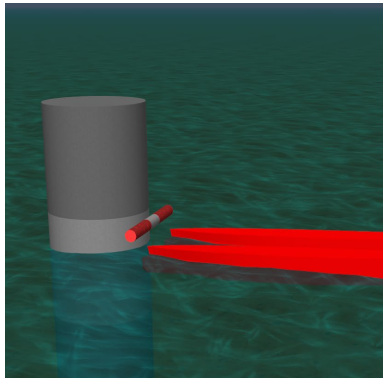


Environment

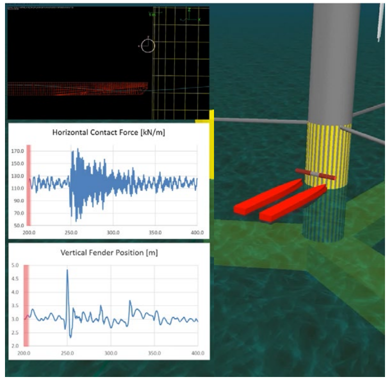
Vessel and Foundation



Radiation / Diffraction



Dynamic simulation



Evaluation

Source: CTV Picture courtesy of Northern Offshore Services (NOS)

Multibody FOWT – CTV system

Main physical phenomena affecting the coupled dynamics

Wind turbine aero-elastic model

- Aerodynamic drag affecting blades, nacelle, and tower
- Parked rotor, i.e. no WTG control

Fender contact-forces and vessel control model

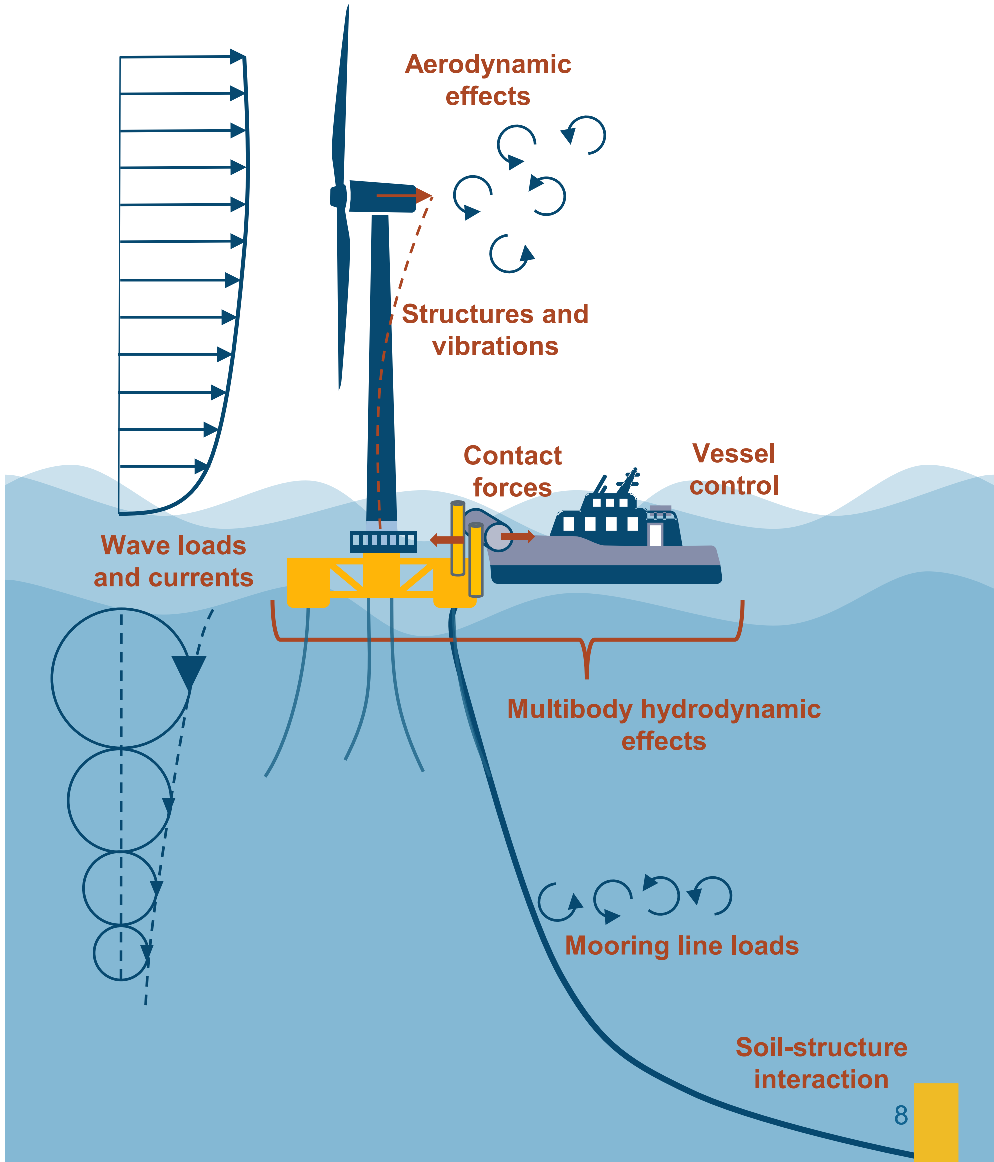
- P-controller pushing against the access point
- Deformable fender and contact forces acting on the floater

Multi-body hydrodynamic model

- Wave loads, added mass, and radiation damping affected by the multi-body configuration

Foundation, mooring lines, anchors

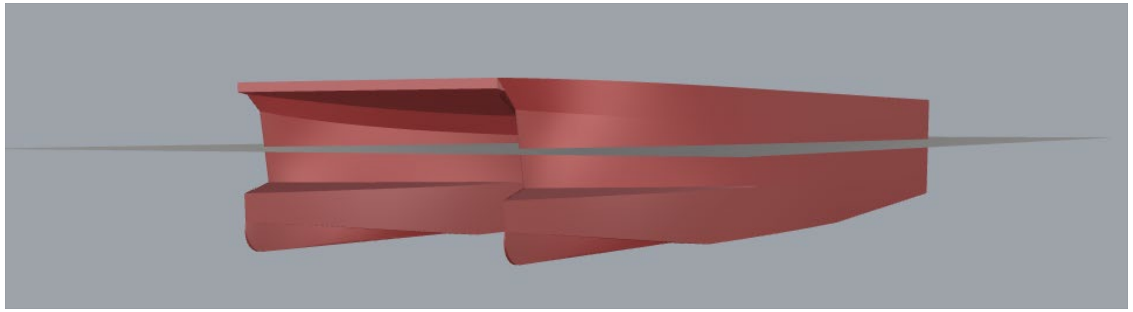
- Foundation geometry, mooring lines and anchors affect the dynamics
- Importance of water depth and site conditions on the concept selection

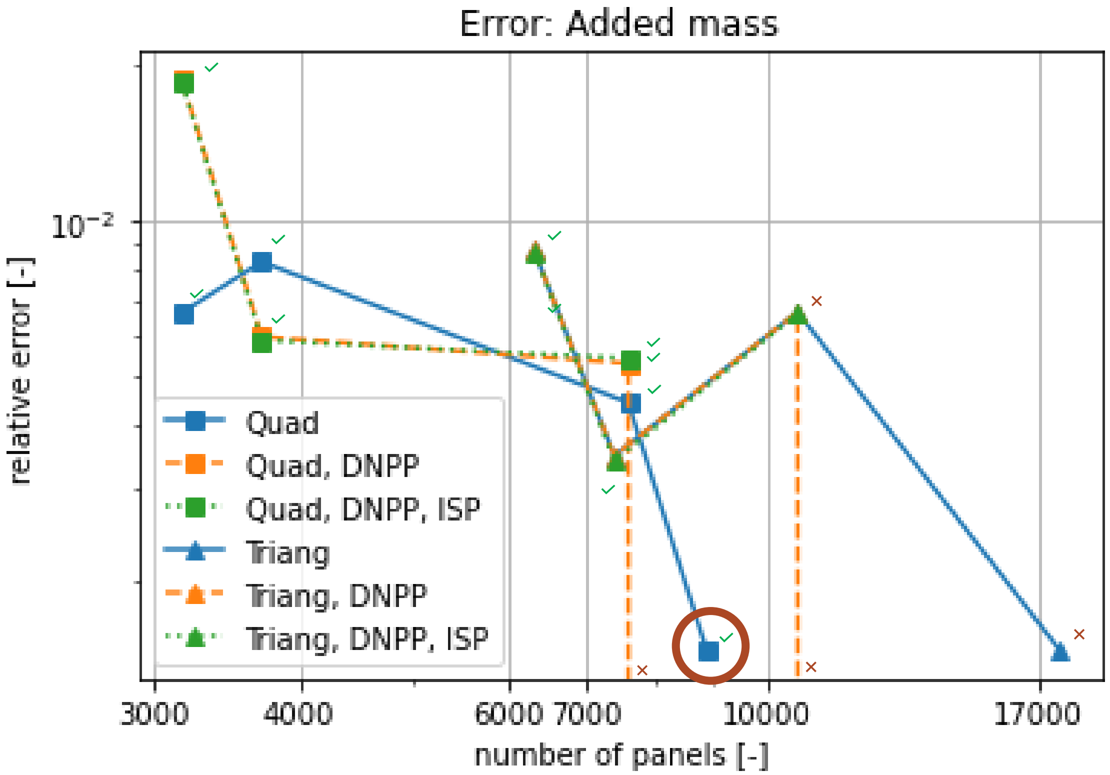


Multi-body hydrodynamics

OrcaWave set-up and multibody hydrodynamic analysis

1. Meshing bodies
2. OrcaWave multi-body radiation-diffraction calculation set-up
   - Potential flow approximation
   - Access point in central column
   - Neglected second-order and gap resonance effects for this study
3. Outputs used for time-domain simulations
   - Fully coupled (FC) added mass (12×12)
   - FC radiation damping
   - 1st Order Wave loads





CTV controller

Logic and tuning method

Simple “helmsman” model

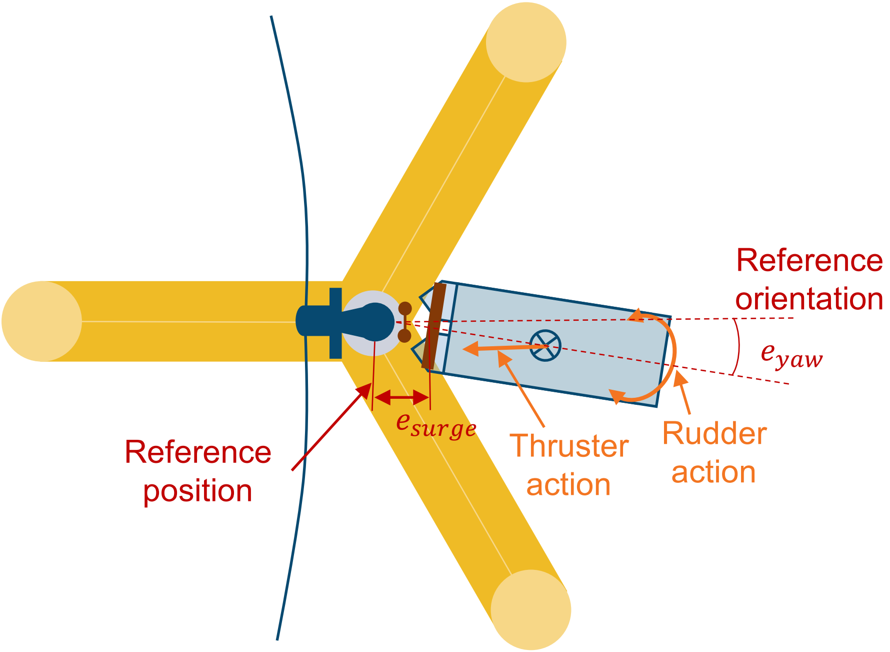
- The helmsman would push the fender against the ladder

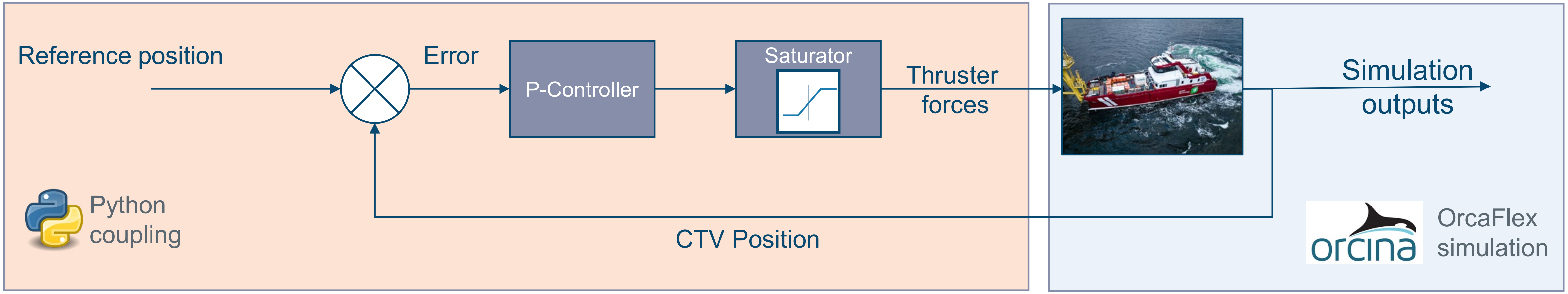
Thruster simplification

- The forces are assumed to be applied in the centre of gravity

Rudder control

- Yaw control to maintain vessel alignment with the platform



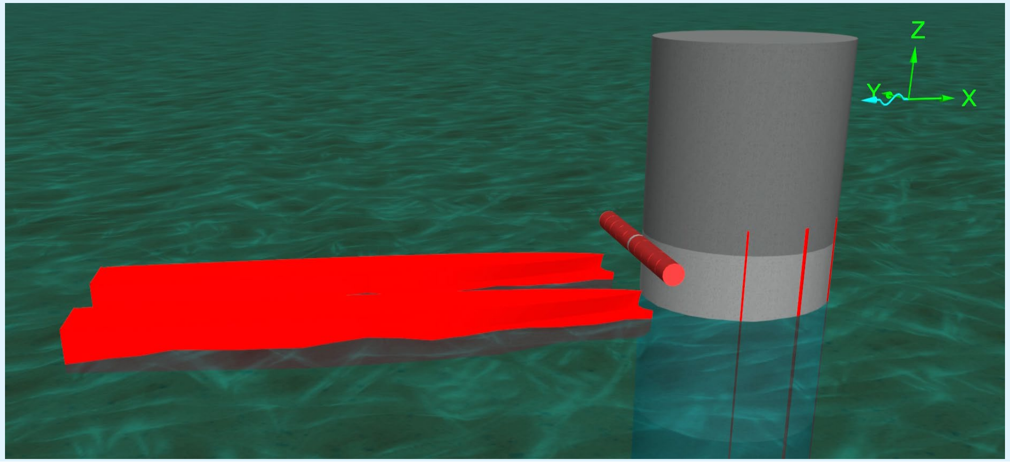


Fender model

Contact forces and fender slip identification

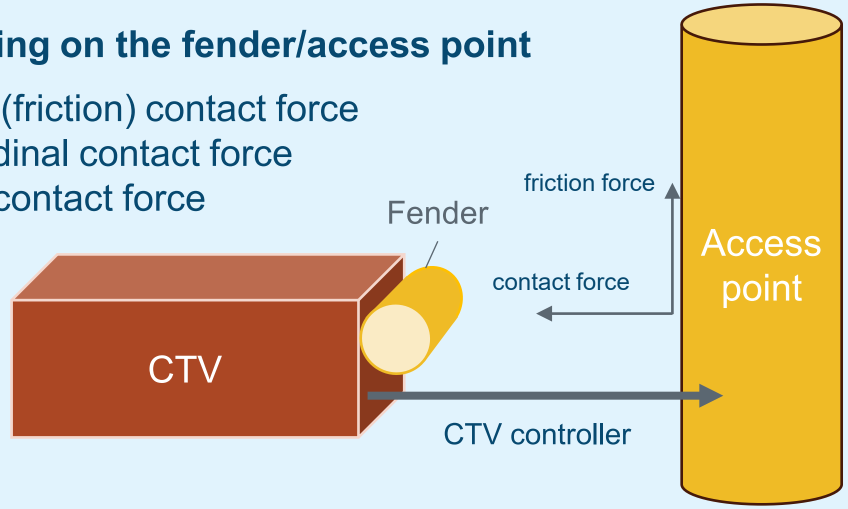
Modelling fender / access point interface

- Tuning of Fender Parameters
  - Material: approximated to linear behavior
  - Surface: friction coefficient
  - Geometry: size and form
- Maximum vessel push force
- Simplified access – single contact point
  - Missing fender roll damping
- Behavior validated with benchmark study (Ferreira González et al., 2015)



Forces acting on the fender/access point

- Vertical (friction) contact force
- Longitudinal contact force
- Lateral contact force

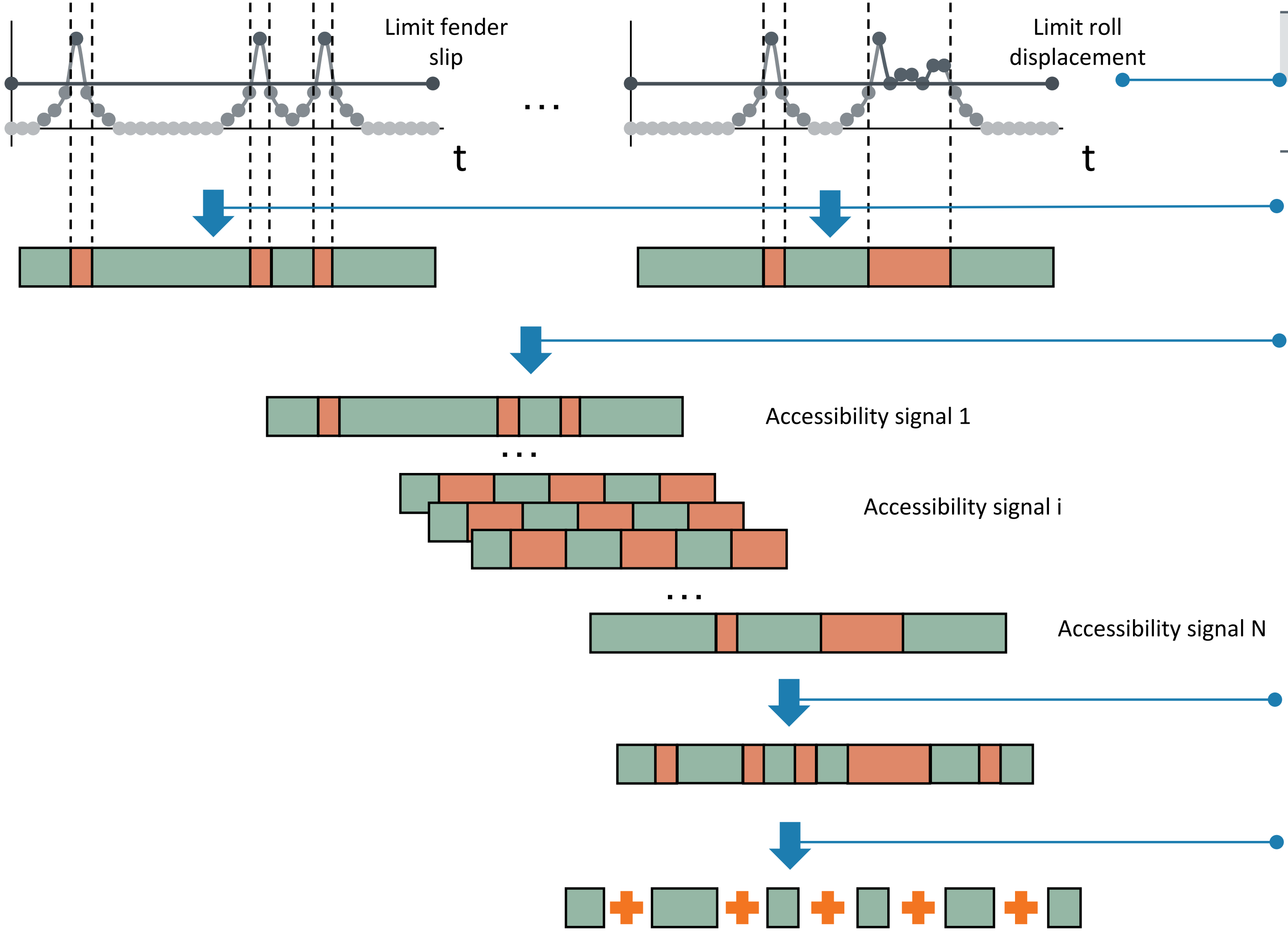


Source: CTV Picture courtesy of Northern Offshore Services (NOS)

Signal post-processing

Identification of accessibility windows for each sea-state considered

Limit	Value
Fender slip	0.5 m
Roll displacement	15 deg



1. Evaluate accessibility limits per signal
2. Combine accessibility signals
3. Evaluate accessibility windows through minimum duration limit (3 minutes)
4. Sum accessibility windows and assign accessibility score

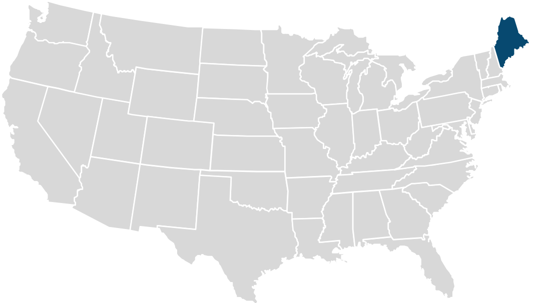
PEAK Wind

Agenda

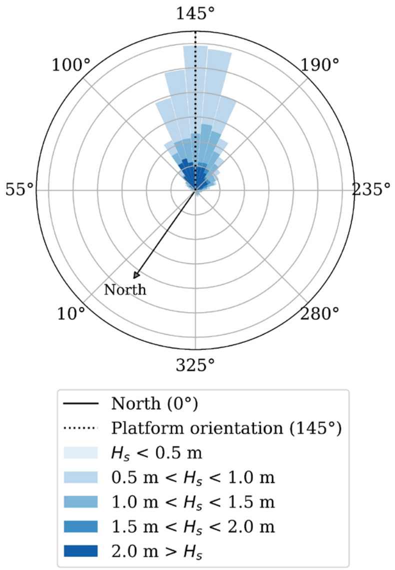
Simulation set-up

FOWT – CTV accessibility case study

Gulf of Maine
Buoy data

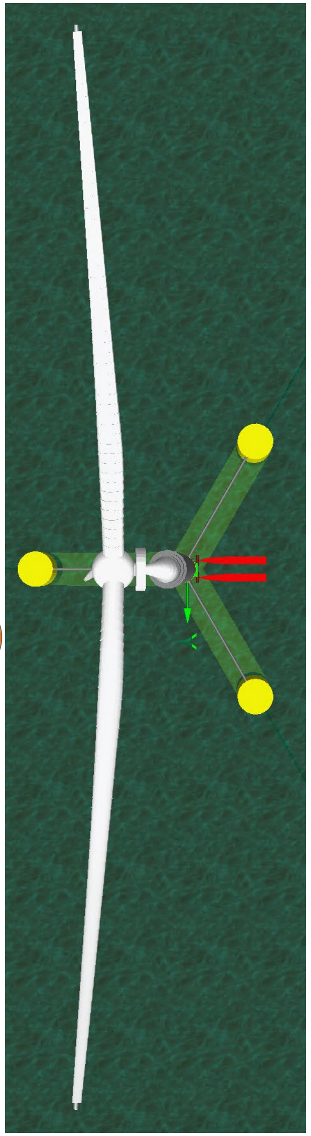


	Significant wave height [m]					
Wave period [s]	< 0.5	0.50	1.00	1.50	2.00	> 3.0
2	0.02	0.36	0.00	0.00	0.00	0.00
3	0.04	3.89	1.77	0.01	0.00	0.00
4	0.02	2.81	5.23	1.31	0.10	0.00
5	0.02	2.57	4.85	2.84	0.73	0.10
6	0.06	3.56	4.51	3.99	2.27	0.43
7	0.04	4.75	3.23	1.81	1.75	1.05
8	0.07	7.04	5.60	1.82	1.08	0.86
9	0.04	3.11	3.18	1.37	0.59	0.34
10	0.02	1.97	2.25	1.45	0.71	0.31
11	0.01	1.61	2.07	1.64	0.82	0.42
12	0.00	0.40	0.51	0.39	0.28	0.15



VolturnUS-S
IEA 15MW RWT

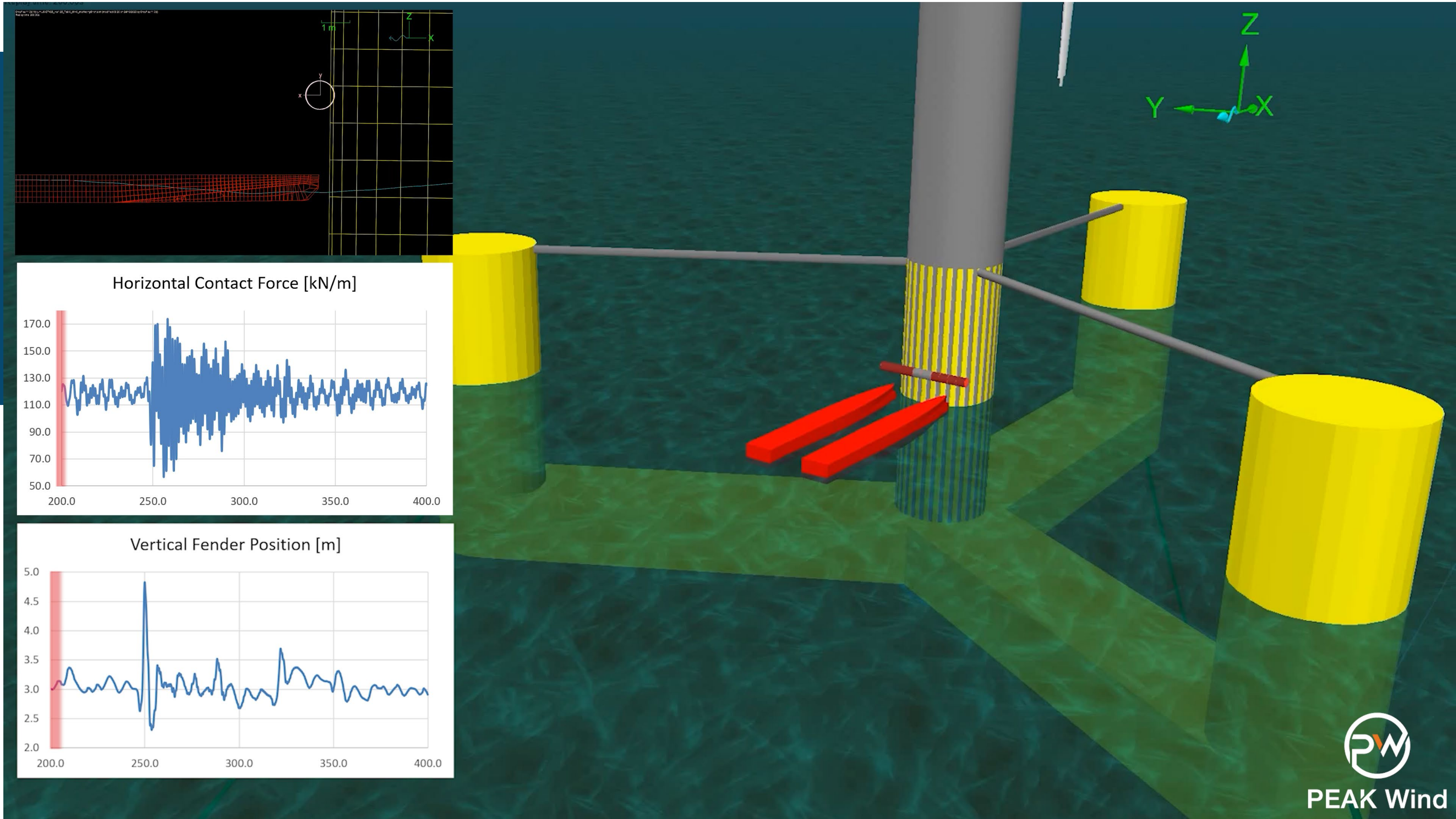
CTV
Catamaran 25 m



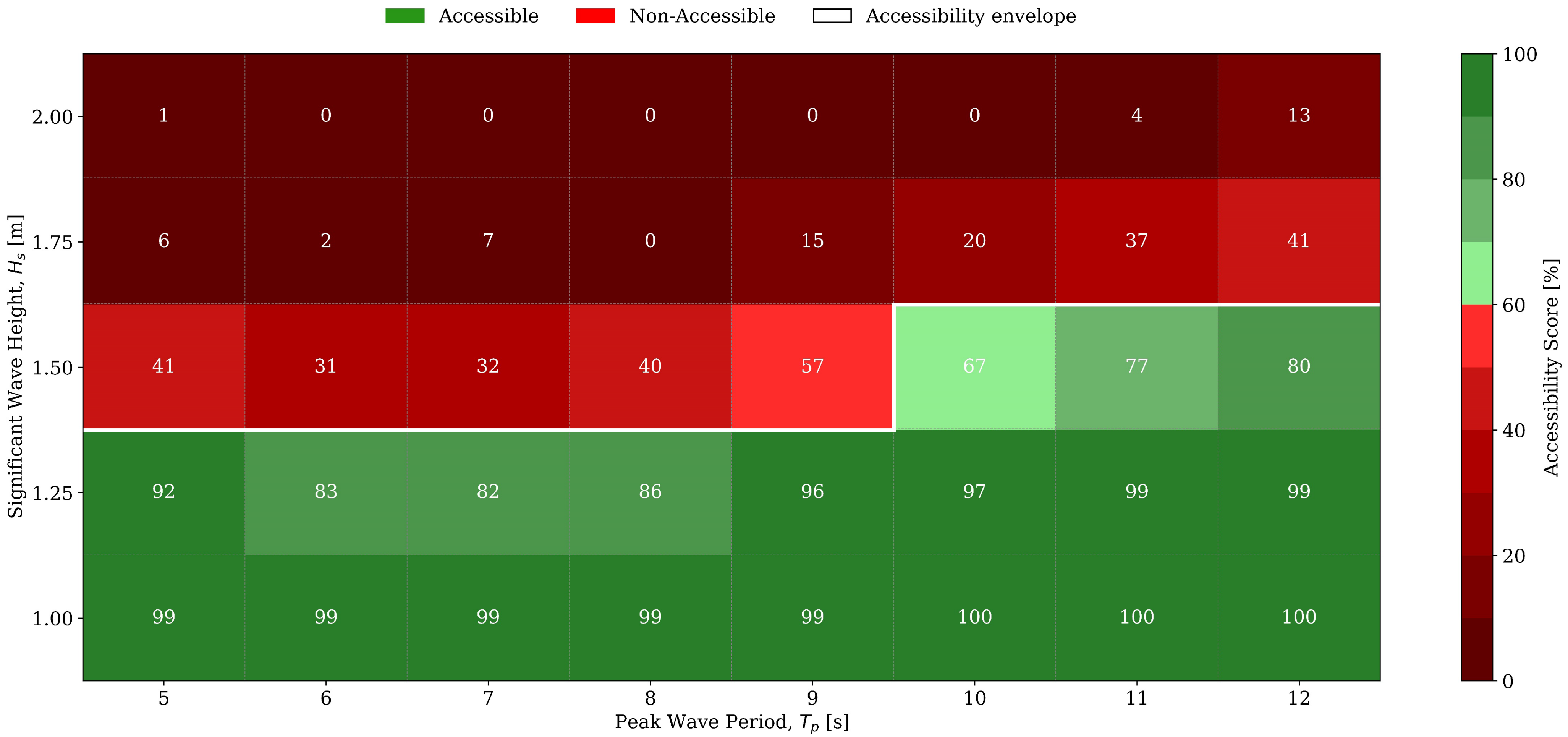
Dynamic simulation Results

3D simulation gives relative motions, fender, controller behaviours

Example
of Simulation

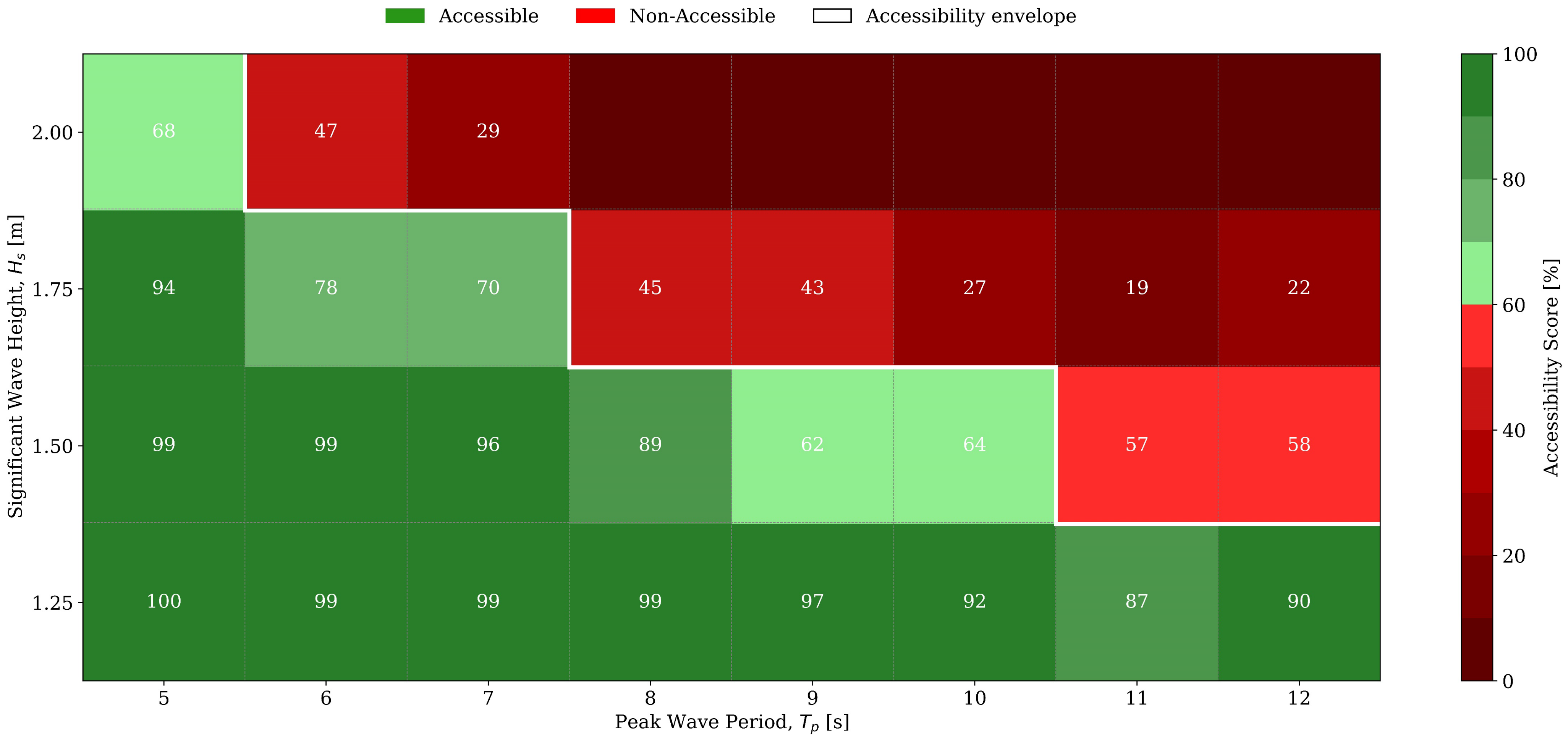


Accessibility scores at 0-degree wave heading



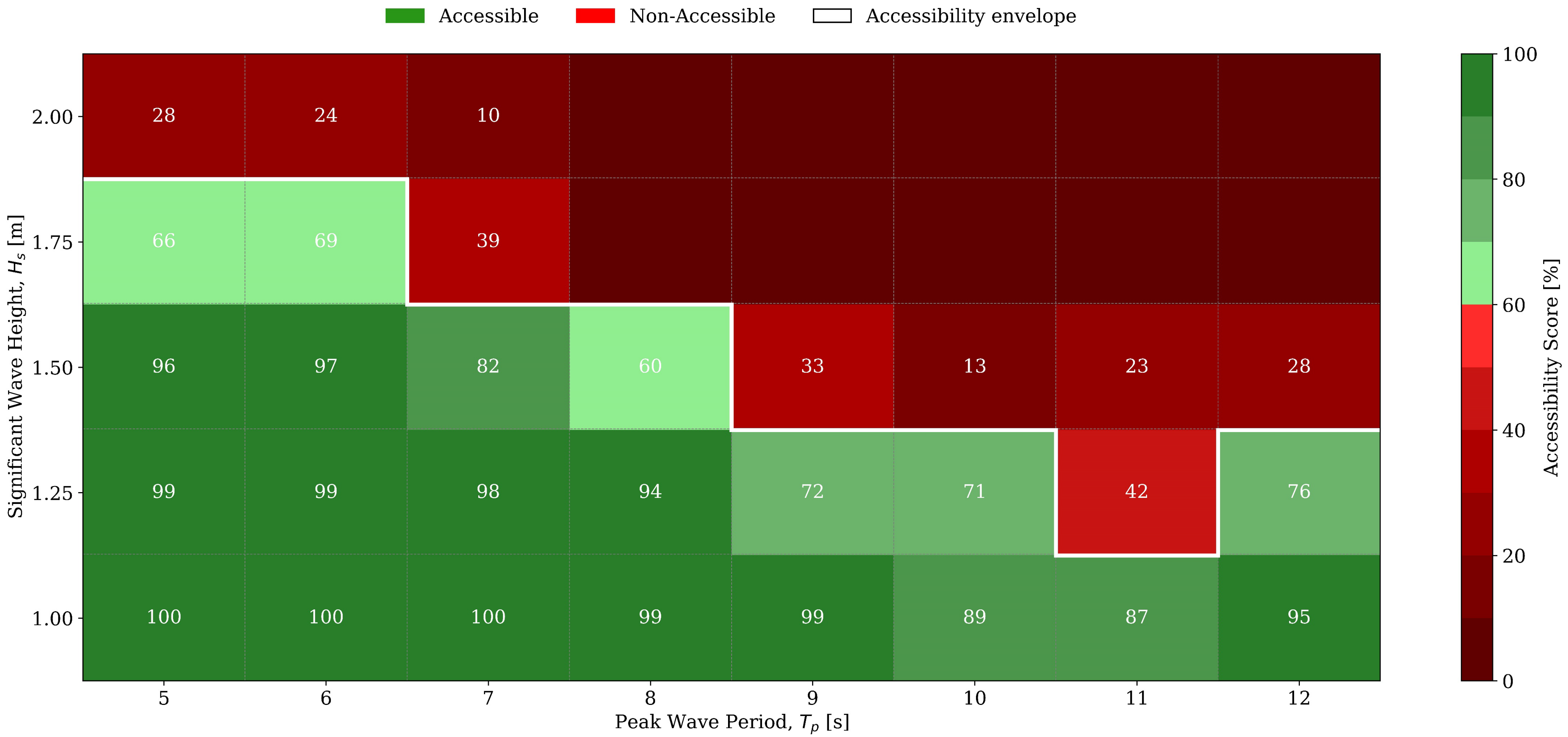
- Accessibility envelope defined as 60% of accessible time
- Clear dependency with wave period, higher accessibility for higher periods

Accessibility scores at 30-degree wave heading



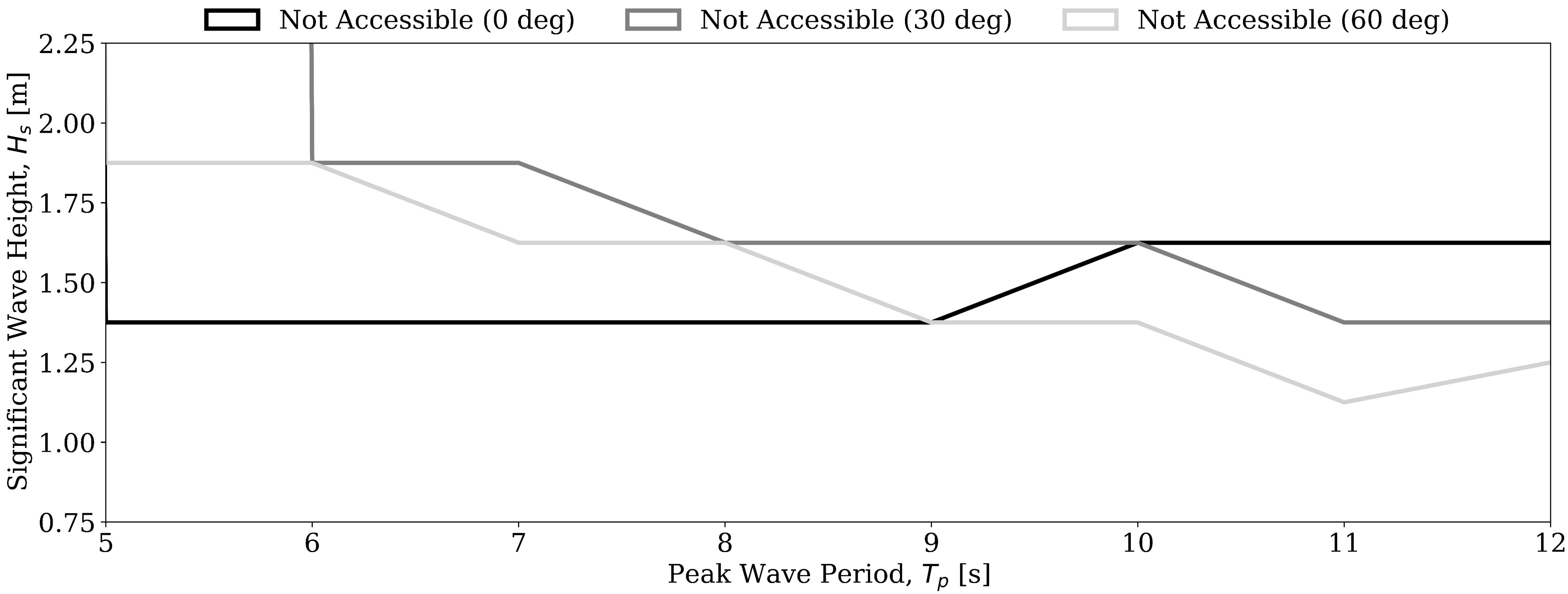
- Opposite behaviour than for 0-degree wave heading
- Observed a phase shift in the vessel and floating platform response → Increase in relative motions at high wave periods

Accessibility scores at 60-degree wave heading



- Lower accessibility than for 30-degree WH, still better than at 0-degree WH
- At 11 s peak wave period significantly lower accessibility – enhanced roll motions

Combined Accessibility Envelopes



- Accessibility depends on wave period, and wave heading
- Different orientations can be optimal at different locations, depending on predominant wave conditions

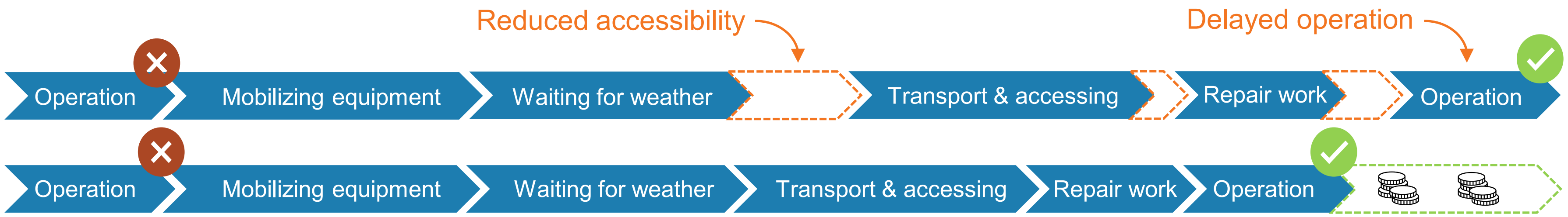
PEAK Wind

Agenda

Conclusions

Advancing towards accurate availability prediction for floating wind

- The **lack of standards** on limiting motions for **safe transfer** leads to project-specific considerations and **availability losses**



- The **time-domain fully-coupled model** can take into consideration **non-linear effects**
- The **accessibility quantification** through a **windowing algorithm** provides a novel **accessibility score** measure
- The **accessibility** by **CTV** shows great **dependency** to the **wave heading and wave period** – as expected
- This **methodology** can improve the **accuracy** of **O&M modelling for offshore wind projects**

Questions?
Reach out to **advanced.programs@peak-wind.com**

EERA DeepWind CONFERENCE 2024

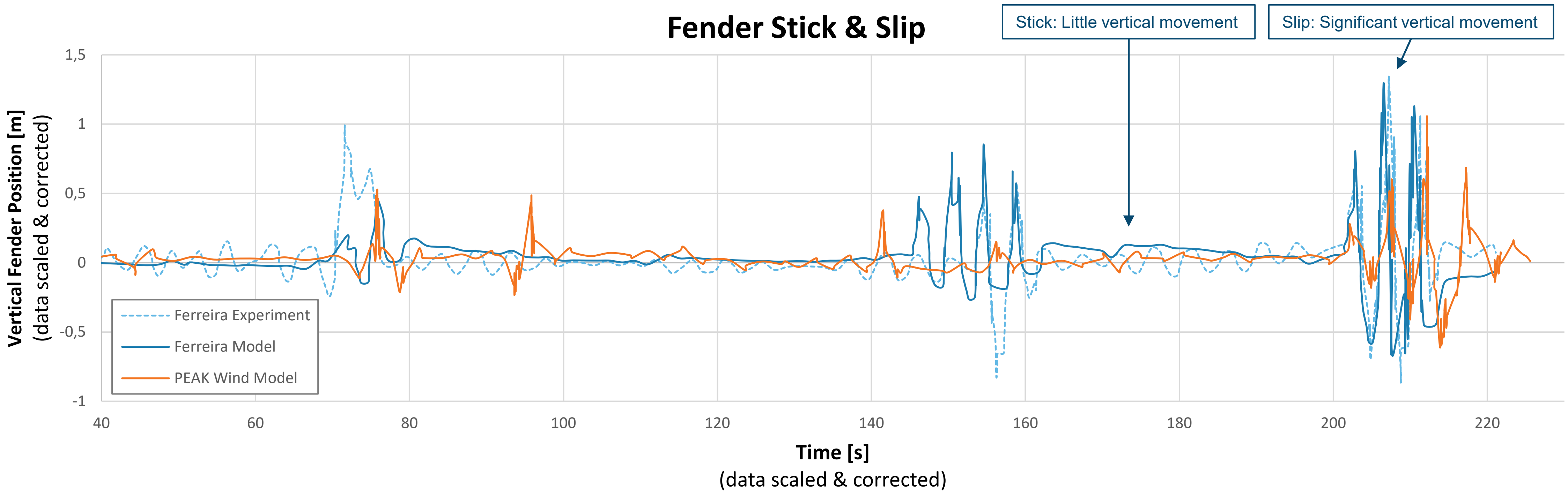
Thank you

Find out more at peak-wind.com

Appendix:
Complementary slides

Modelling of CTV Accessibility at PEAK Wind

Benchmark with Ferreira 2015: Numerical and Experimental CTV Landing Maneuver



Simulation Results:
Similar slip/stick behavior
- Magnitude of peaks
- Peaks per time

Limited Benchmark:
- 1 paper, 1 sea state
- Linear fender behavior

Validation of Multibody Sims