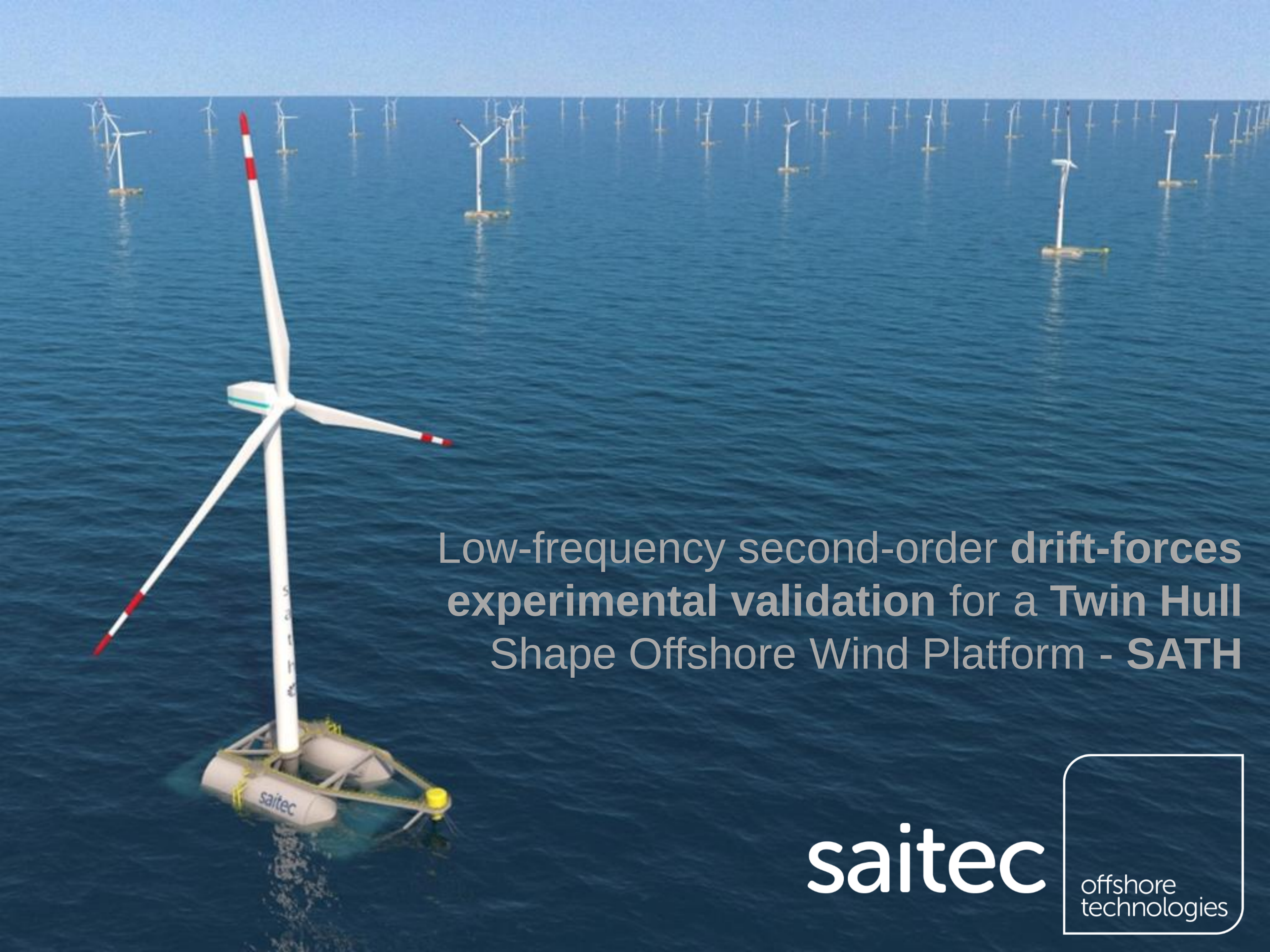

Low-frequency second-order **drift-forces experimental validation** for a **Twin Hull** Shape Offshore Wind Platform - **SATH**

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offshore technologies

Layout

- The Company
- Introduction to SATH concept
- Model testing motivation
- Experiments
- Numerical validation
- Main conclusions

The Company

COMPANY PURPOSE

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Spin-off from International Infrastructure engineering company

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Designing the future

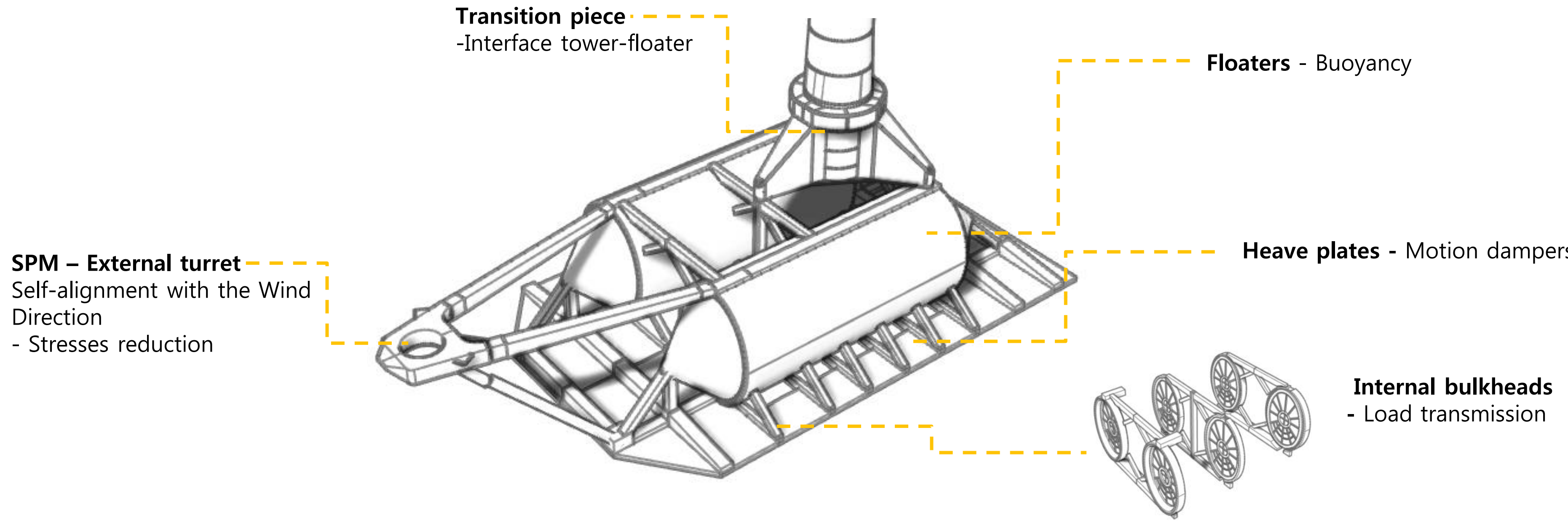
SATH™ INNOVATIVE FLOATING WIND SOLUTION

MAKING OFFSHORE WIND GLOBAL

Patented technology

Introduction to SATH concept

Swinging Around Twin Hull



CONCRETE
Reduced construction and maintenance costs

LOW DRAFT
2 MW – 6.5m
10 MW – 9.5m

SELF-STABLE
Easily transportation

Model testing motivation

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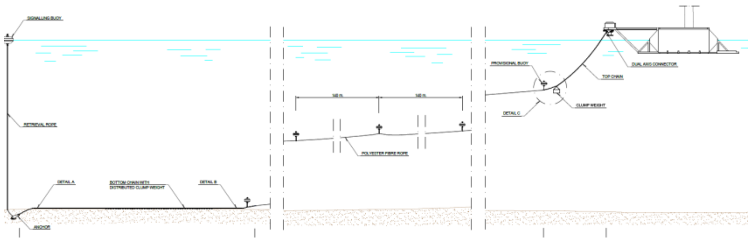
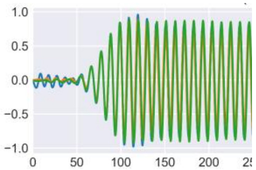
OBJECTIVE — Mooring System **optimization**



LIMITATIONS — Potential theory **assumptions**

METHODOLOGY — **EXPERIMENTS at IFREMER (July 2018)**
- Mean Drift Coefficients extraction
- Full-QTF Coefficients extraction

Collaboration Project SINTEF



NUMERICAL CALIBRATION
- WAMIT
- WADAM

FAST

Sima SESAM

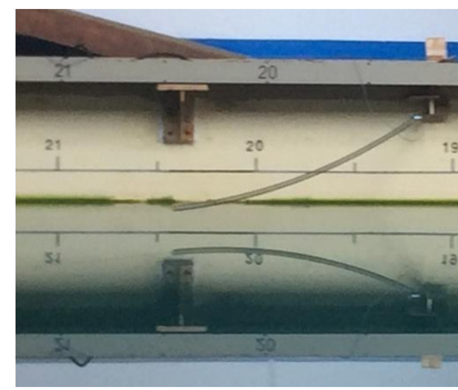
Experiments

Scale model

	Scale model 1/36	Full prototype-2MW
Length (m)	1.72	61.92
Width (m)	0.85	30.6
Total height (m)	2.05	73.8
Draft (m)	0.2	7.35
Total Mass (kg)	82.8	3863116.8

Wind turbine
Computer-controlled

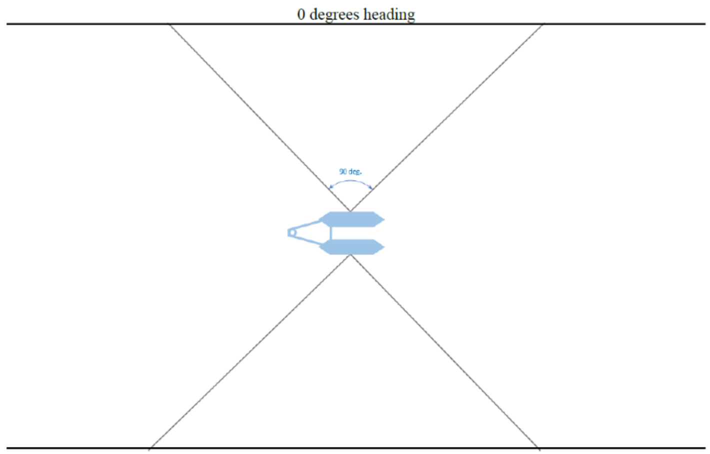
Qualysis
Track motion

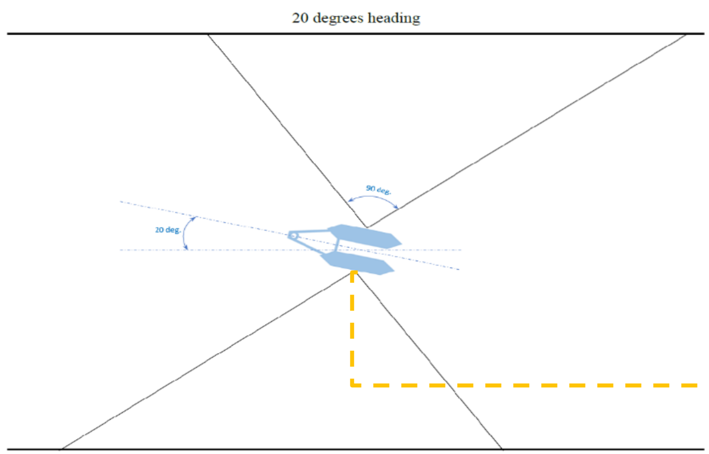


Load cells mooring system

Experiments

Experiments set-up





Soft Mooring

Simple an linear setup for identification of hydrodynamic coefficients.

VCG to decouple the pitch motion from the mooring system forces.

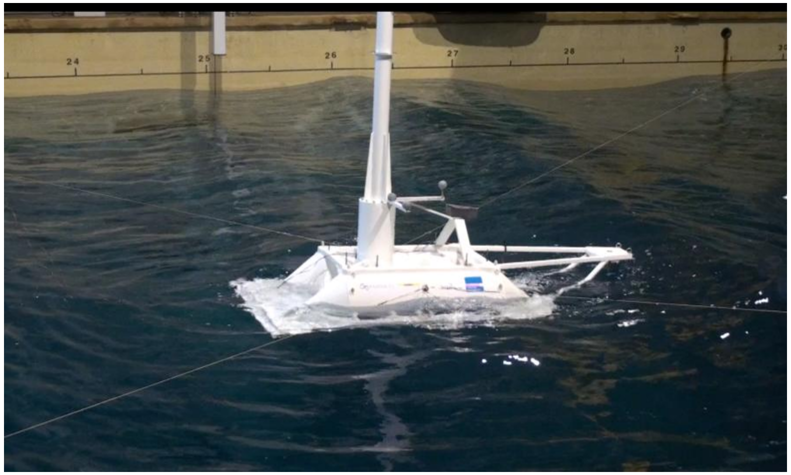
Experiments

Test campaign planning

Identification of mass properties

Calibration of waves

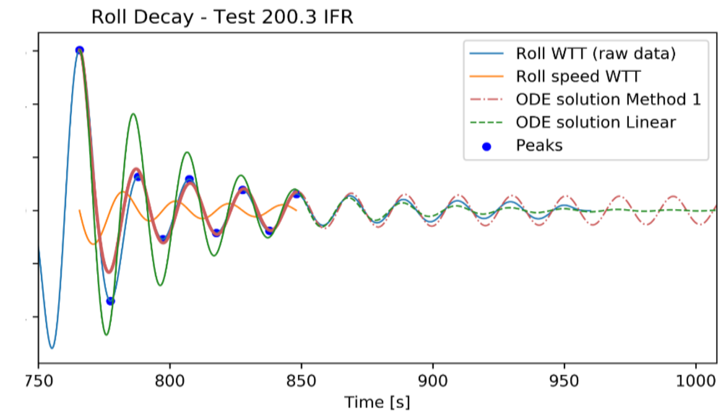
Characterization tests: decay; tilt; pull out

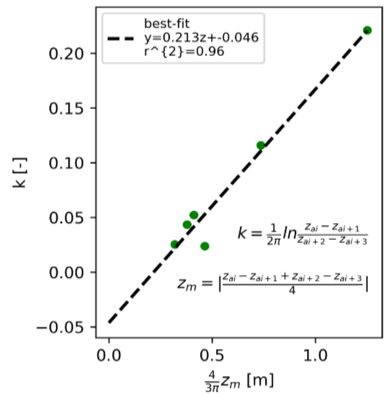


Tests in waves: periodic; irregular; pink noise

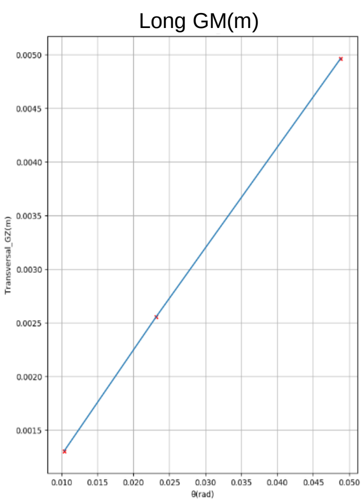
Experiments

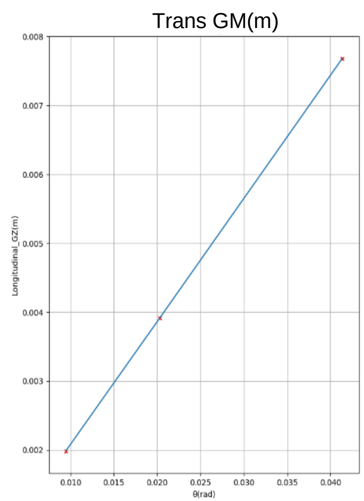
Characterization tests – Global verification of the structure behaviour

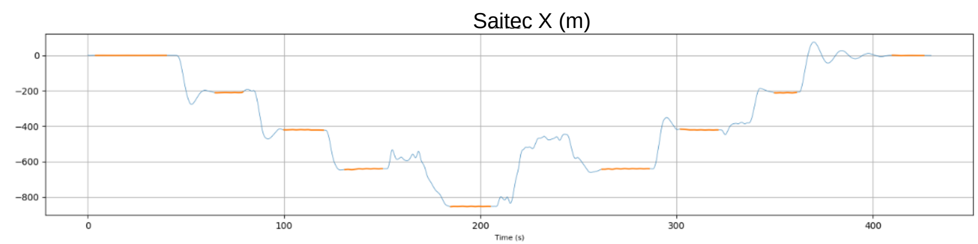


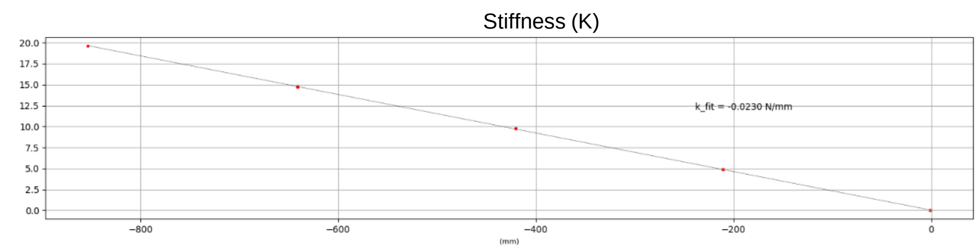


- Natural oscillation periods
- Linear & Quadratic damping
- Metacentric heights
- Mooring stiffness









Experiments

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Tests in waves– **Periodic waves**

OBJECTIVE

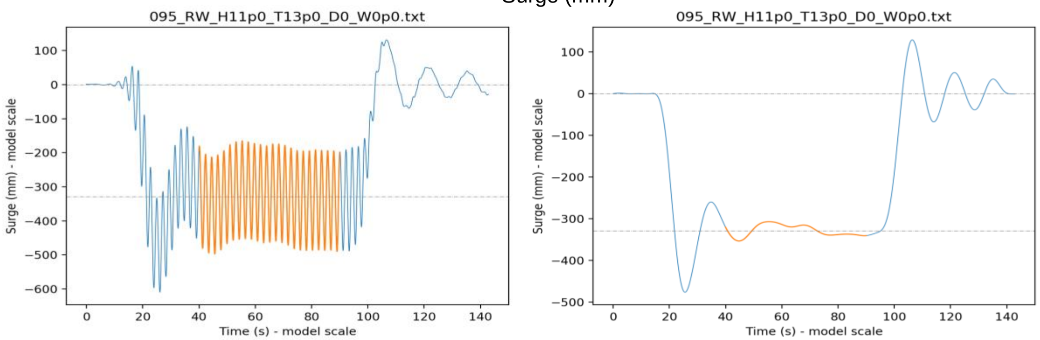
Extraction of the **Mean Drift force Coefficients** for different incidence angles and wave steepness

$$F = kx$$

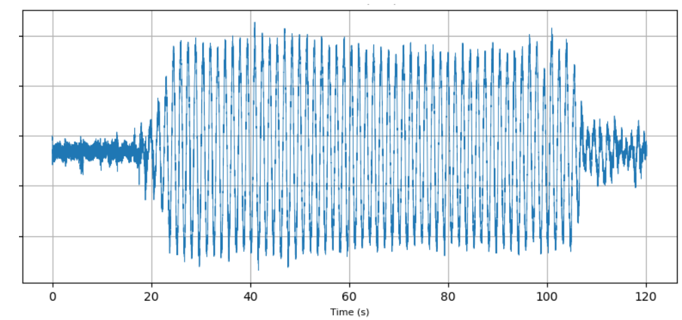
$$MDC = \frac{F}{A^2}$$

K = mooring stiffness measured (N/m)
X = mean displacement measured (m)
F = mean drift force (N)
A = wave amplitude (m)

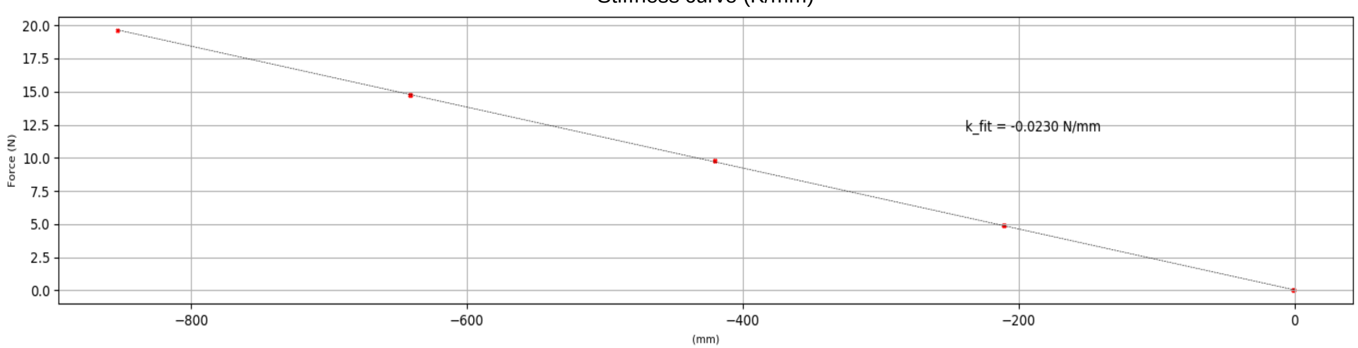
Surge (mm)



Wave elevation (m)



Stiffness curve (K/mm)



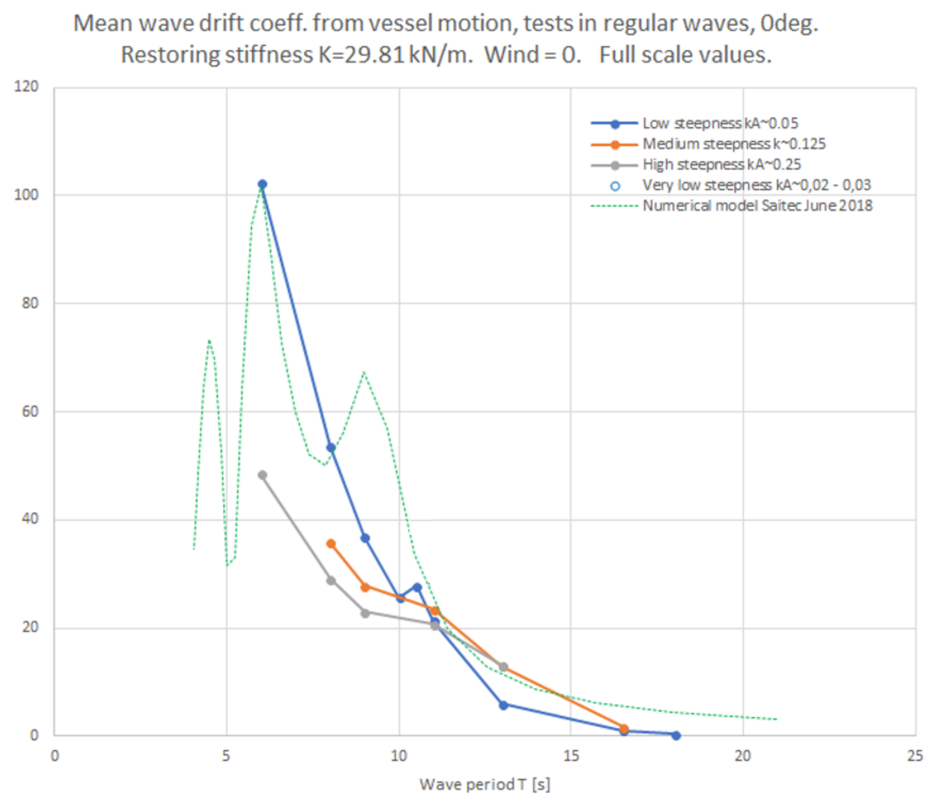
Experiments

Tests in waves– **Periodic waves**

Test Matrix:

Set 1: head waves; no wind; different steepness
Set 2: head waves; wind influence;
Set 3: 20º waves; no wind;

Real model		
Period	Height	Steepness
6.000	1.116	0.020
6.000	4.680	0.083
7.980	1.692	0.017
7.980	4.320	0.043
7.980	8.640	0.086
9.000	2.088	0.016
9.000	5.256	0.042
9.000	10.512	0.083
10.000	2.900	0.019
10.980	7.992	0.043
10.980	15.984	0.086
13.020	4.392	0.017
13.020	11.016	0.043
13.020	19.800	0.078
16.500	7.488	0.020
16.500	15.480	0.042



Potential theory over-estimates the coefficients
Favourable steepness dependency

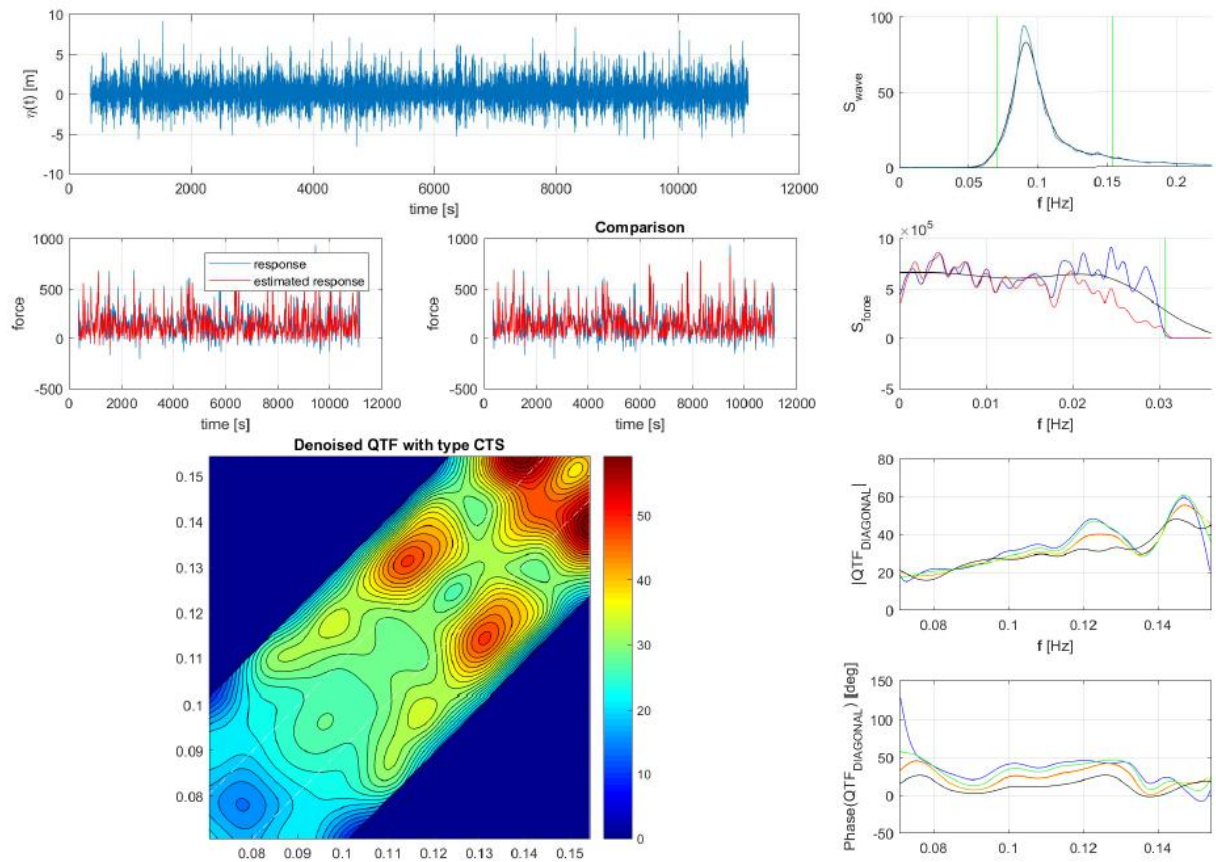
Experiments

SINTEF Ifremer saitec offshore technologies

Tests in waves– **Irregular waves**

OBJECTIVE

Extraction of the **full Quadratic Transfer Function coefficients** → Second order signal analysis technique based on cross bi-spectral analysis



Experiments

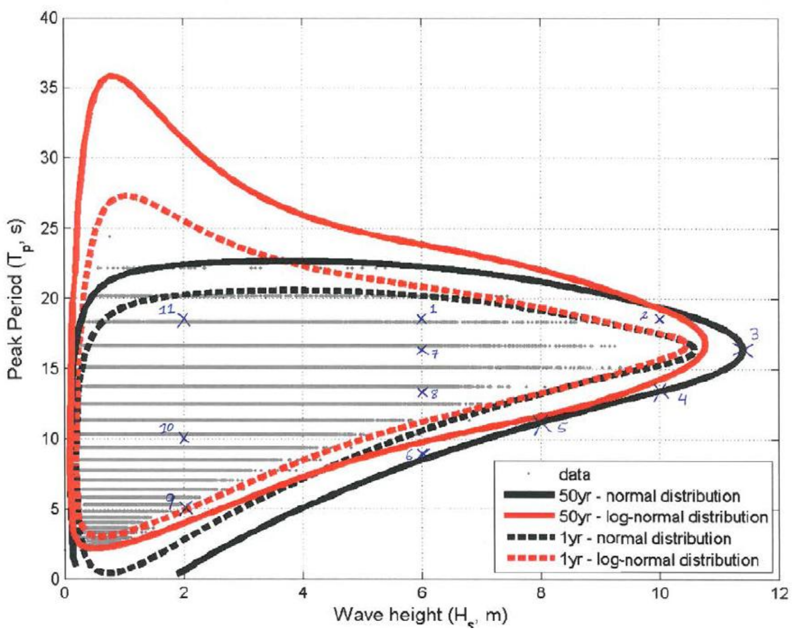
Tests in waves– **Irregular waves**

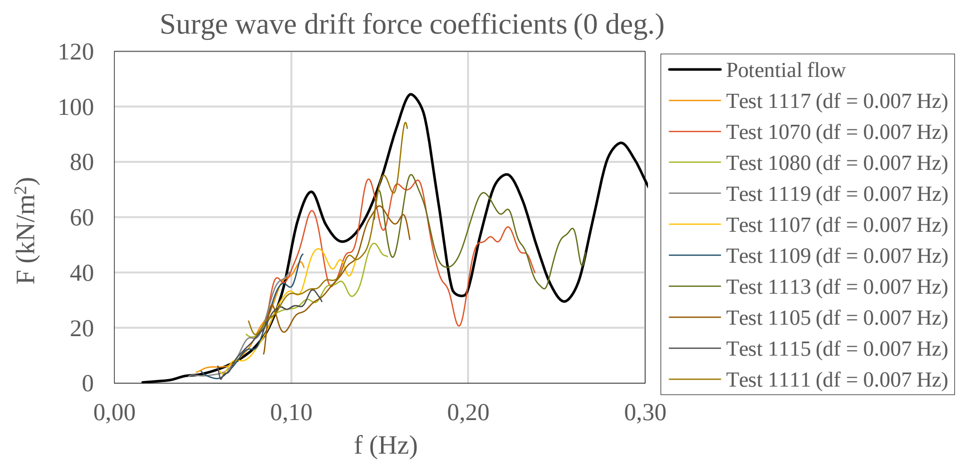
Test Matrix:

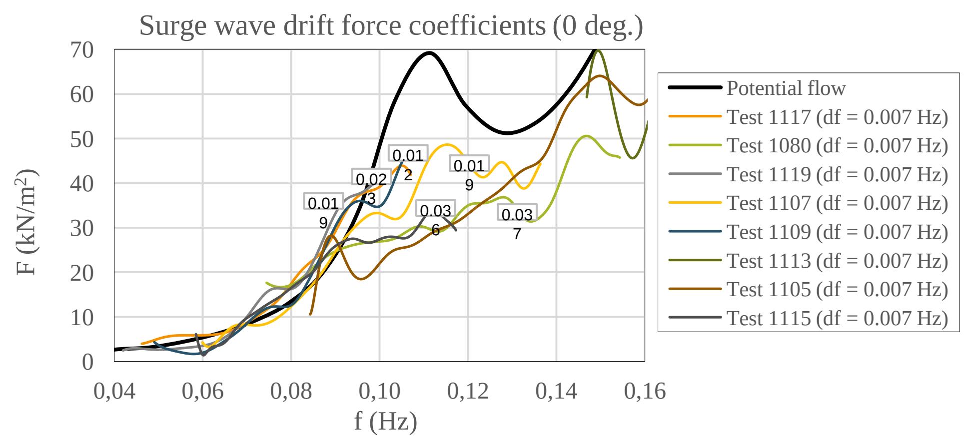
Set 1: pink noise (0º & 20º incidence)

Set 2: sea-states along the 50 years environmental contour (0º & 20º incidence)

Set 3: sea-states representative of operational conditions (0º & 20º incidence)







Favourable steepness dependency

Numerical validation

Frequency Domain Simulations
(Based on potential theory)

↓

Extraction of the **Mean Drift Force Coefficients** from tests

↓

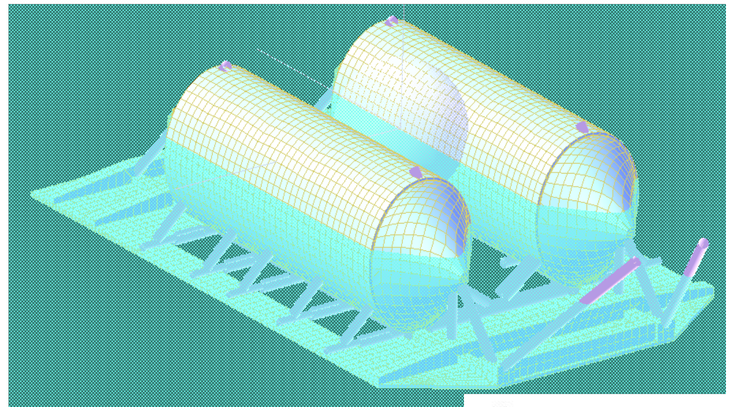
Correction of potential flow **Mean Drift Coefficients** f(steepness)

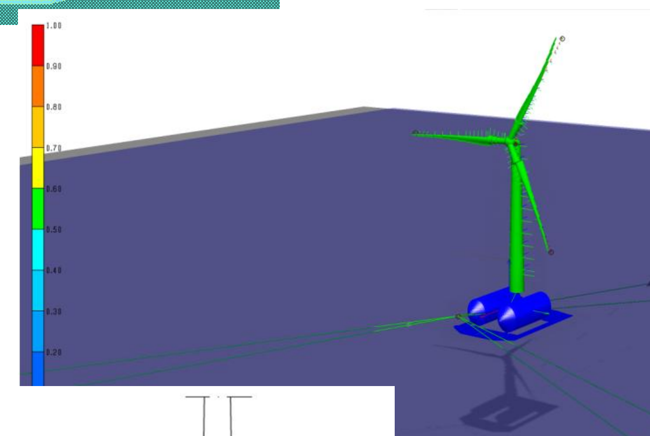
↓

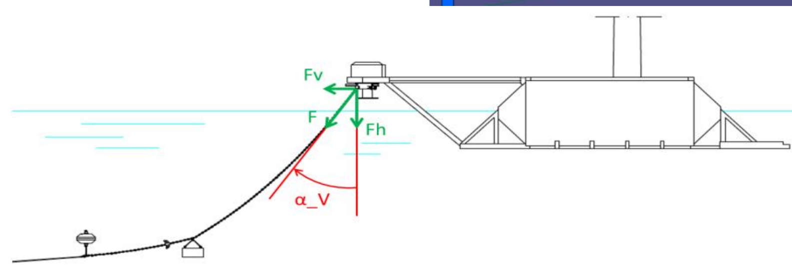
Time Domain Simulations using Newman's Approximation

↓

Optimization of the mooring system design

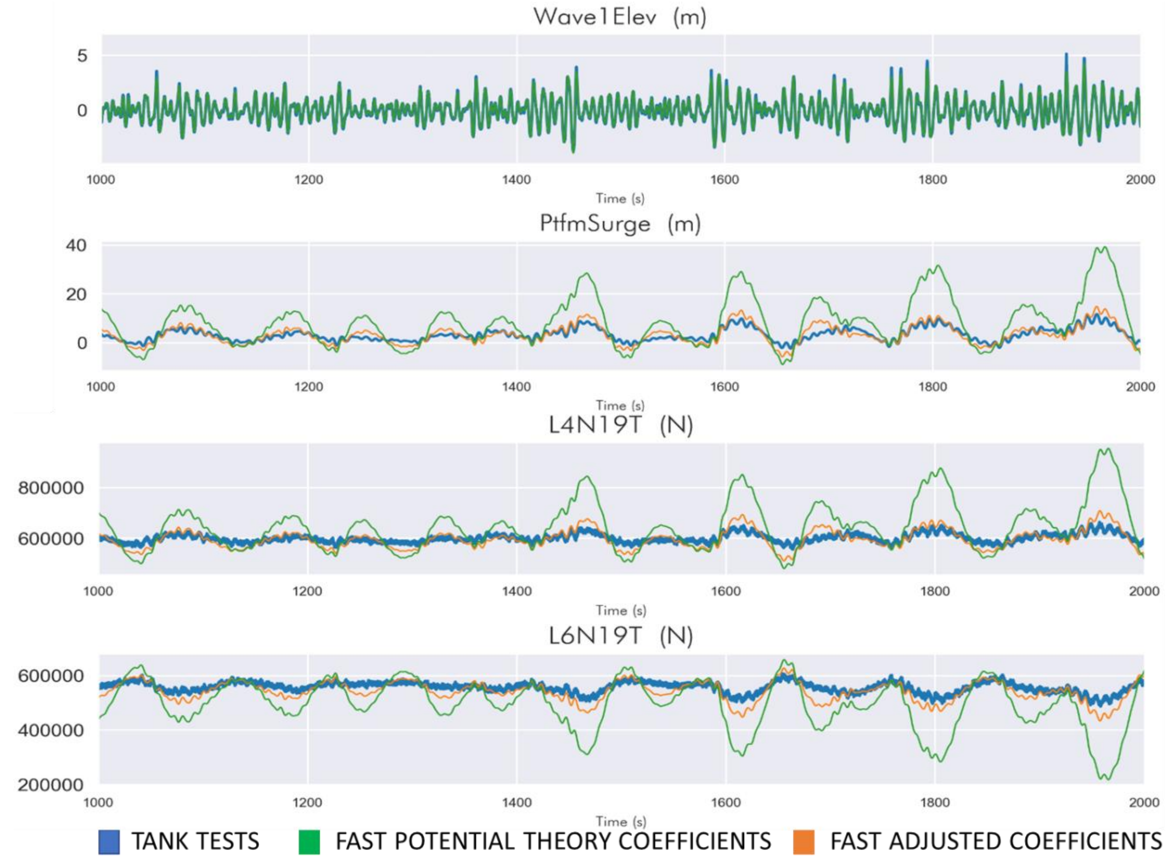


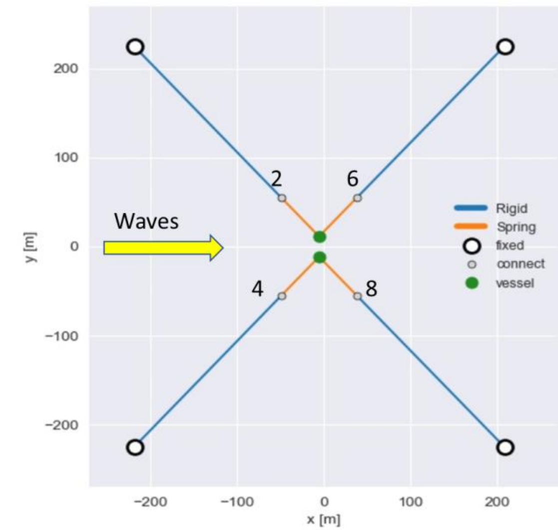


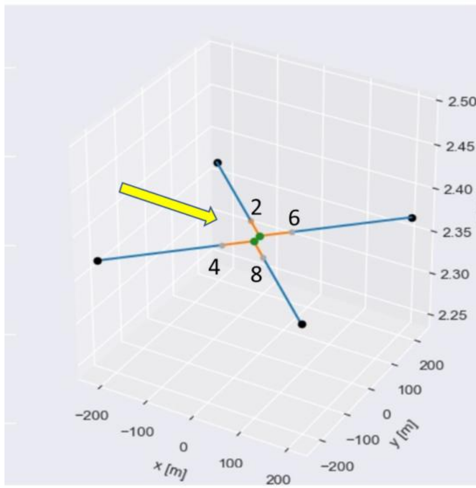


Numerical validation

Hs = 5m Tp = 8.8s

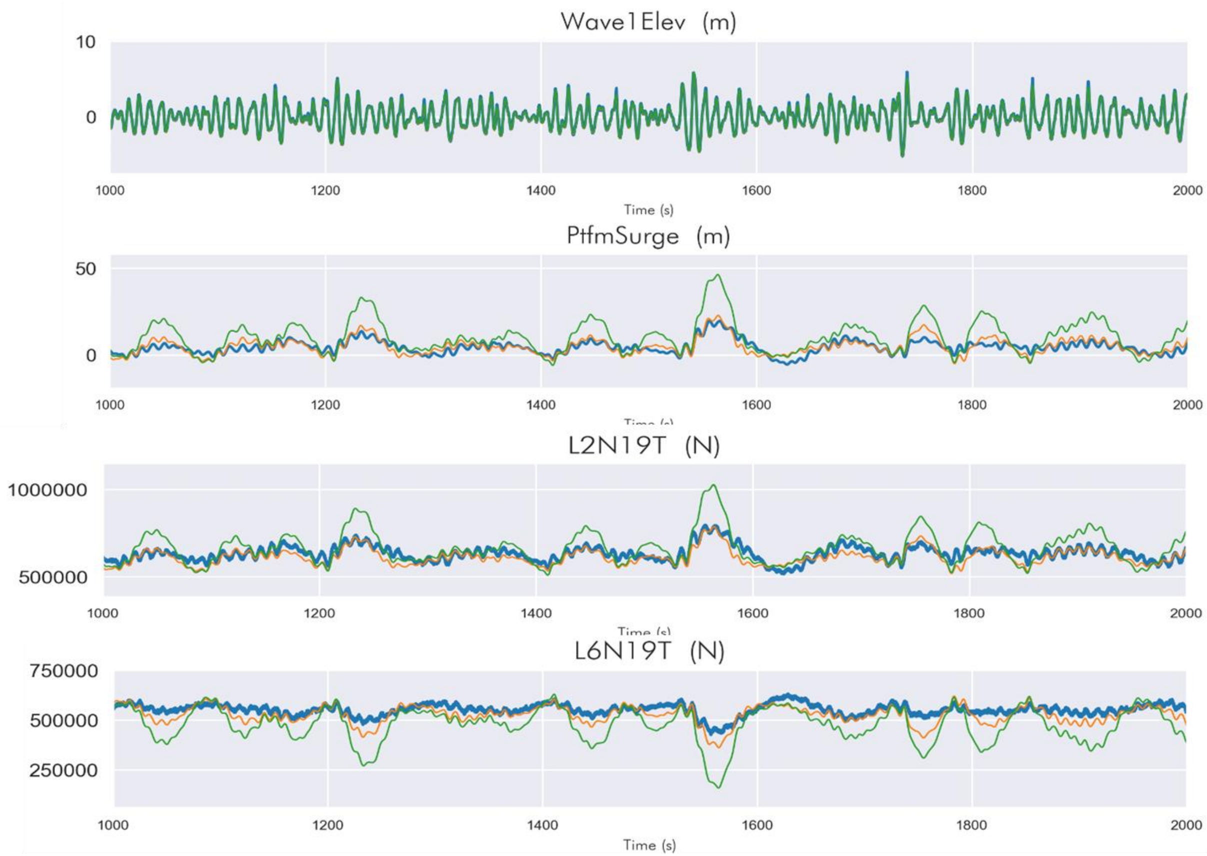




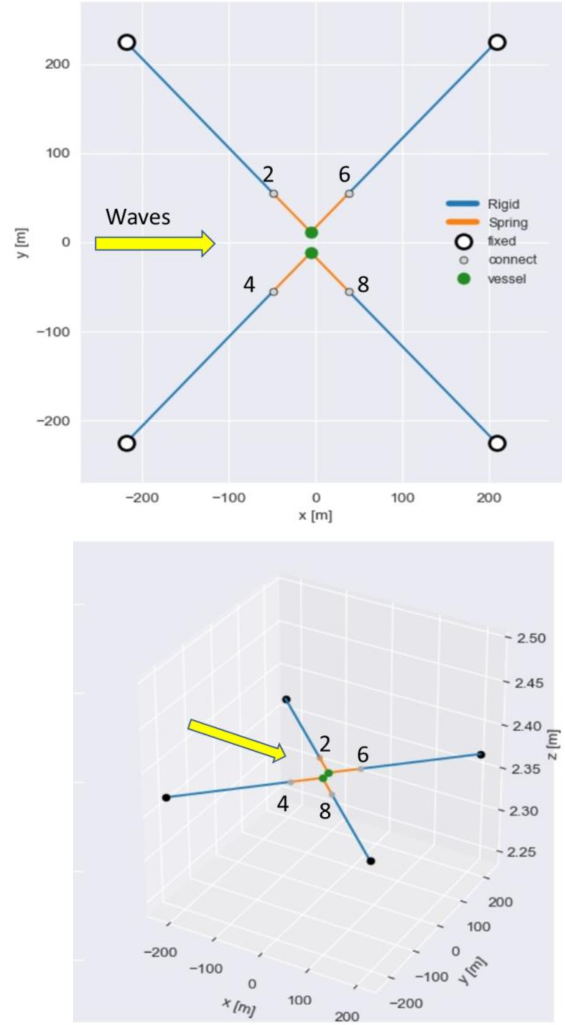


Numerical validation

Hs = 7m Tp = 11s



TANK TESTS FAST POTENTIAL THEORY COEFFICIENTS FAST ADJUSTED COEFFICIENTS



Numerical validation

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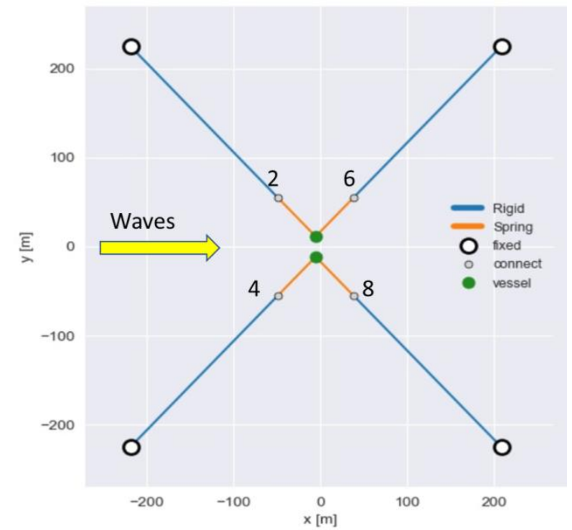
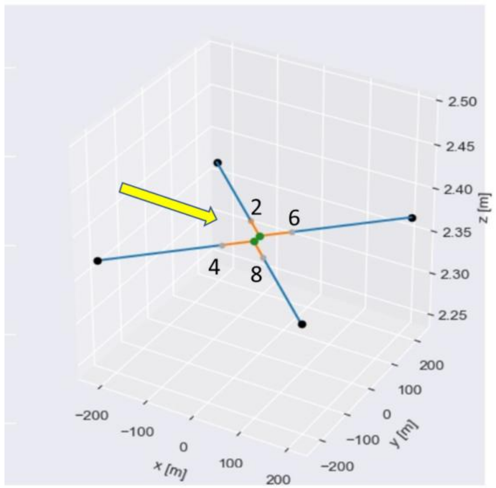
Hs = 9.4m Tp = 13s





Numerical validation

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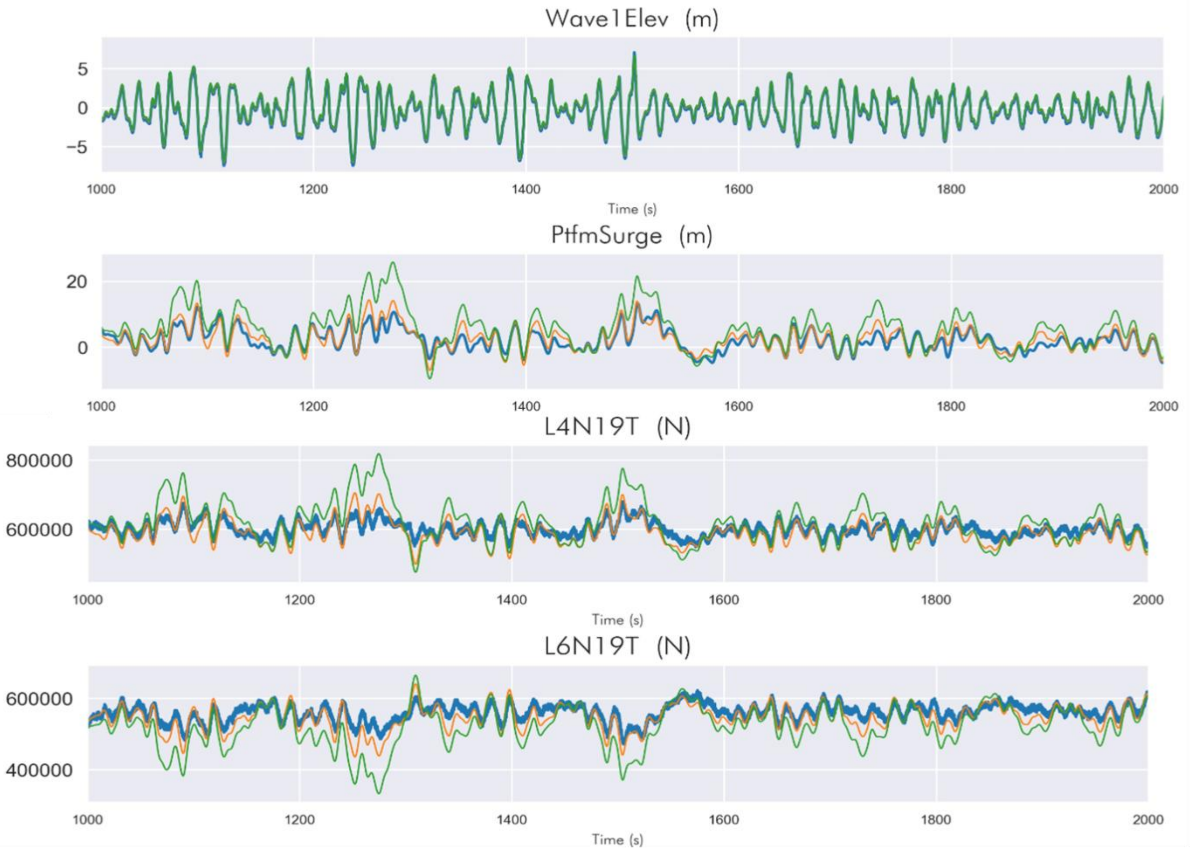
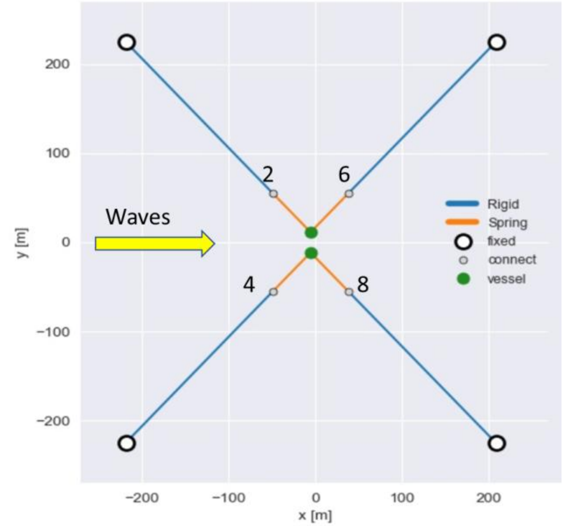
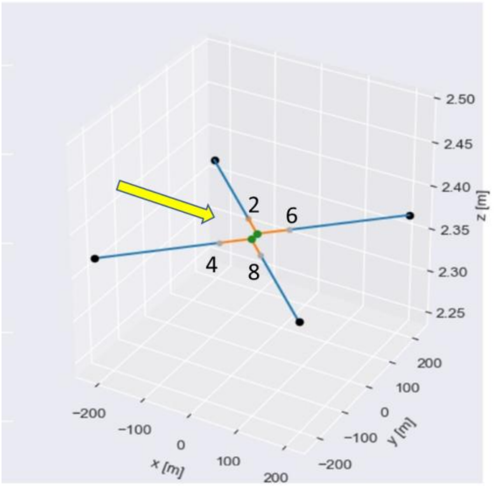
Hs = 9.7m Tp = 18s



TANK TESTS   FAST POTENTIAL THEORY COEFFICIENTS   FAST ADJUSTED COEFFICIENTS





Numerical validation

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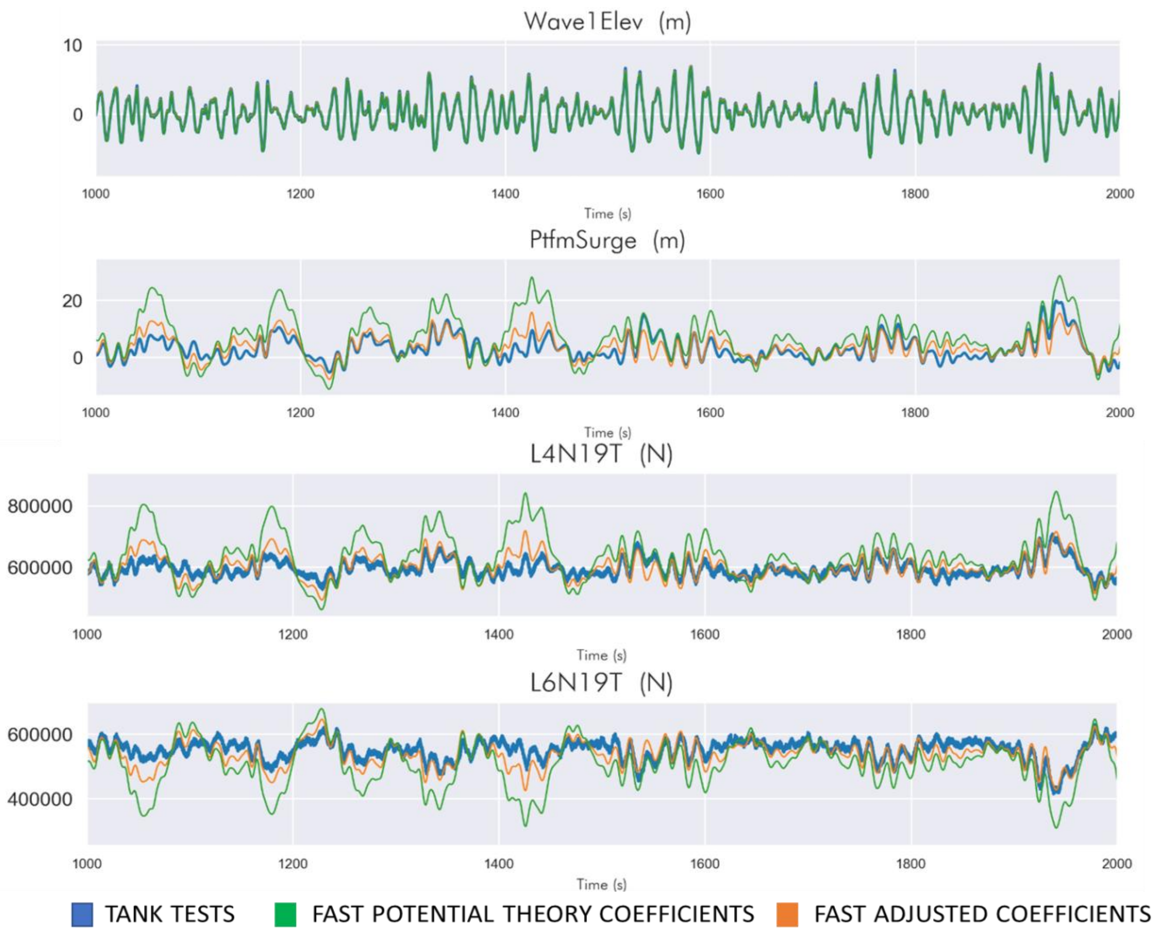
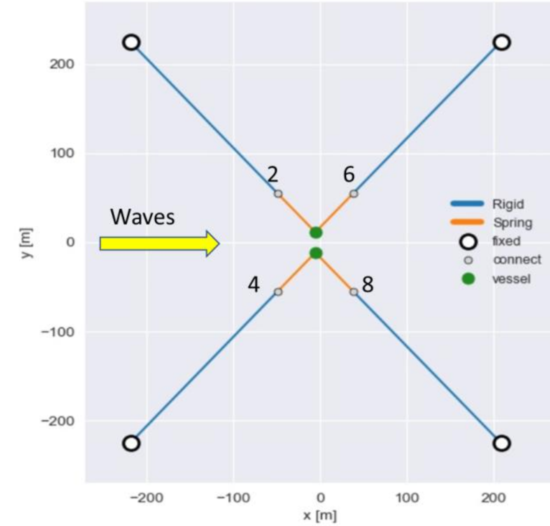
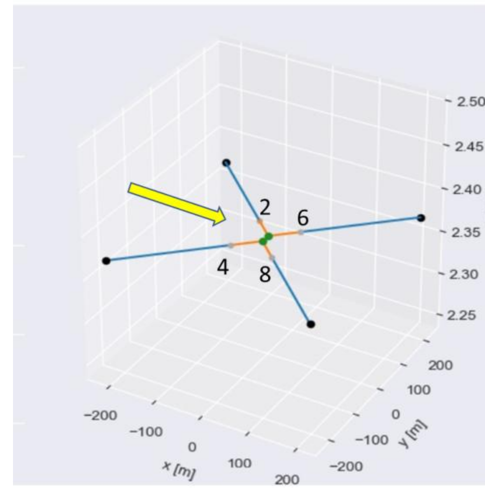
Hs = 9.7m Tp = 16s







Numerical validation

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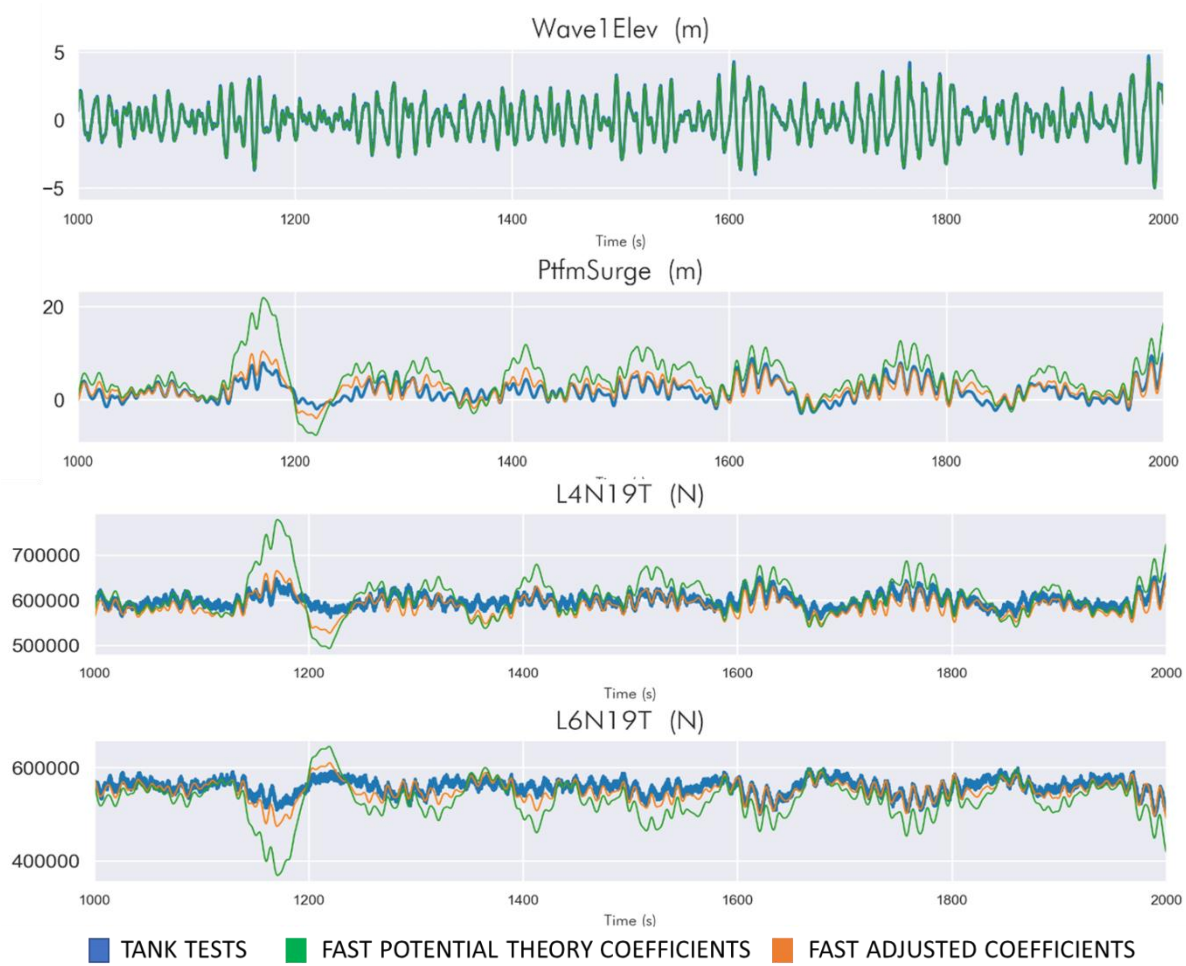
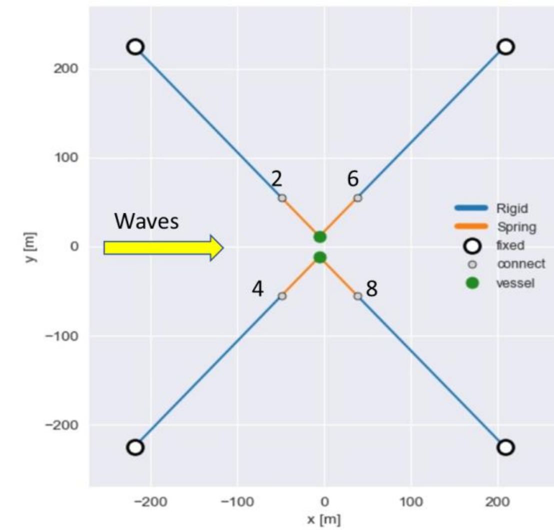
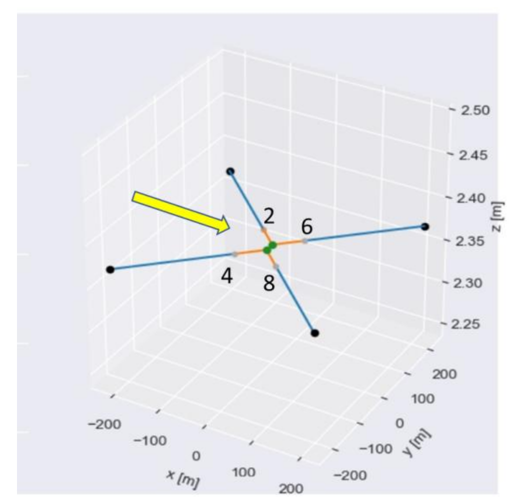
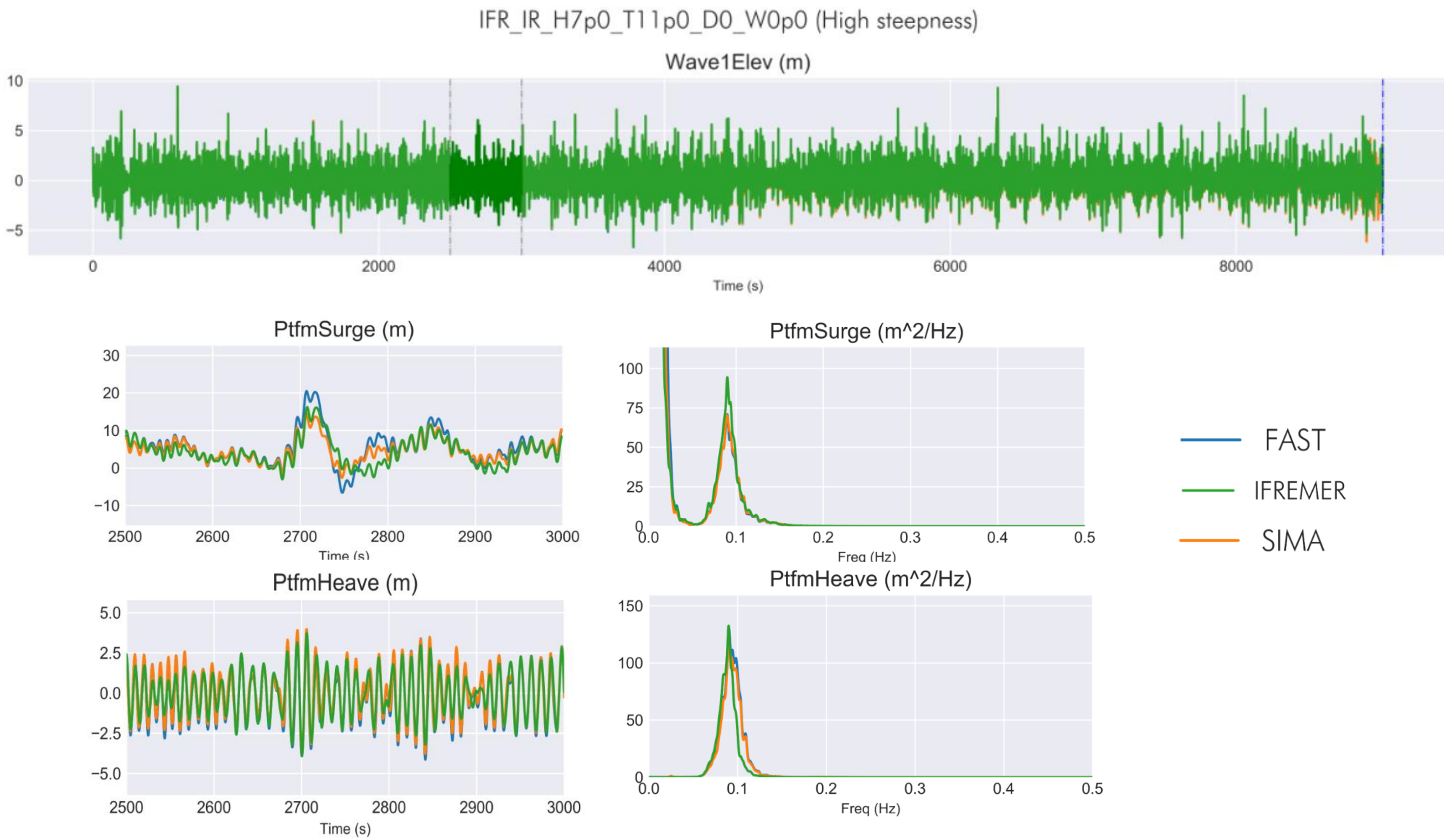
Hs = 5m Tp = 13s



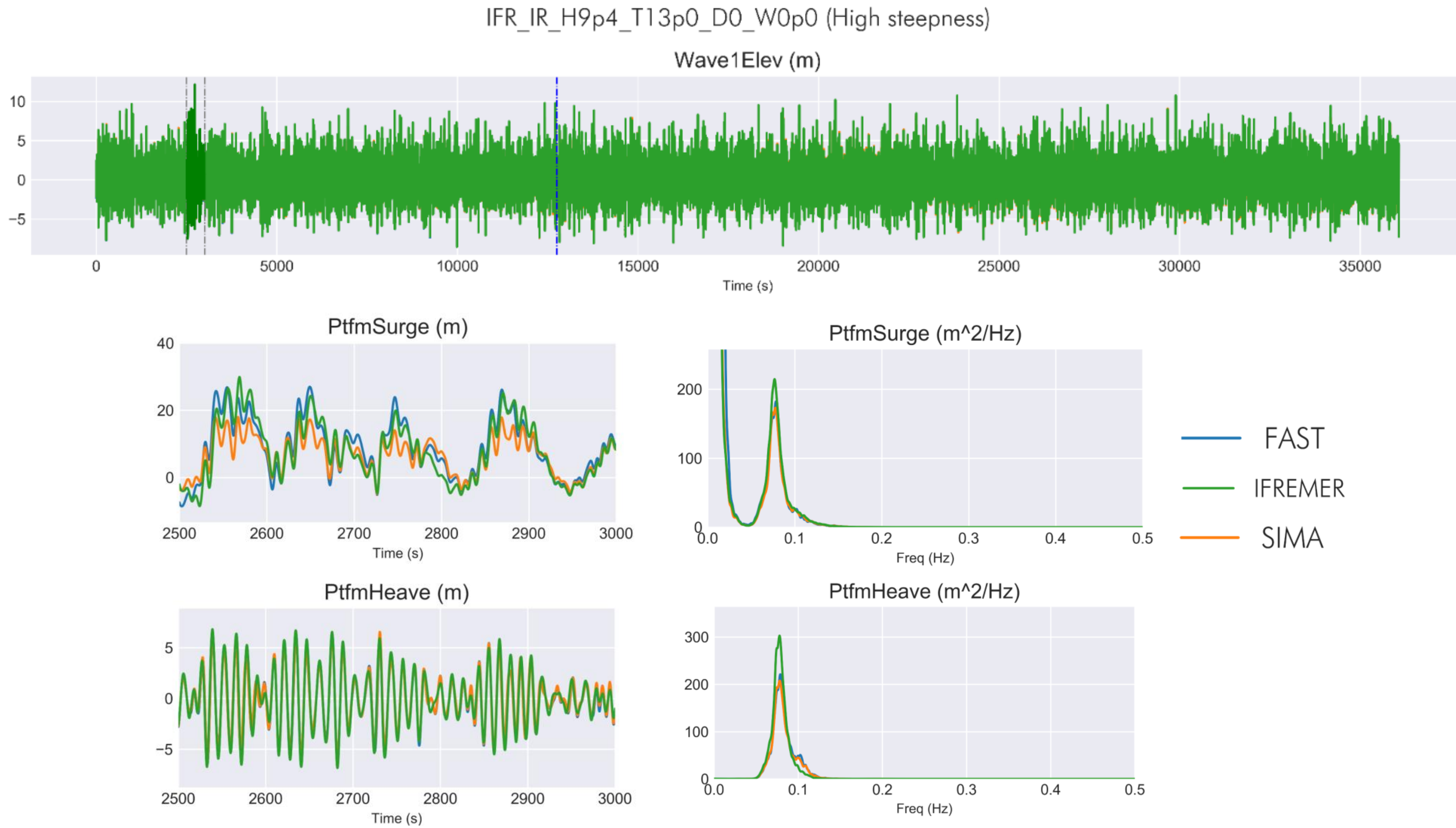




Numerical validation



Numerical validation



Main conclusions

- Soft mooring set-up – **Simplifications of results**
- Only wave tests – **No extra phenomena (wind or current)**
- Duration of the tests **– 3 hour sea-states**
- Wave tank basin characteristics – **No reflection**
- Potential theory – **Over-estimation of the results**
- SATH Technology – **Non-linear response for different wave steepness**
- Newman's Approximation – **Verified for SATH concept**
- Optimization of the mooring system – **Adjustment of numerical models**

Thank you for your attention

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