INITIAL ITERATIONS IN THE DESIGN OF AN INNOVATIVE FLOATING PLATFORM FOR WIND ENERGY PRODUCTION IN DEEP WATERS.

Jordi Serret, Innosea Ltd. UK

EERA JP Wind WORKSHOP on Ongoing research in offshore wind structures

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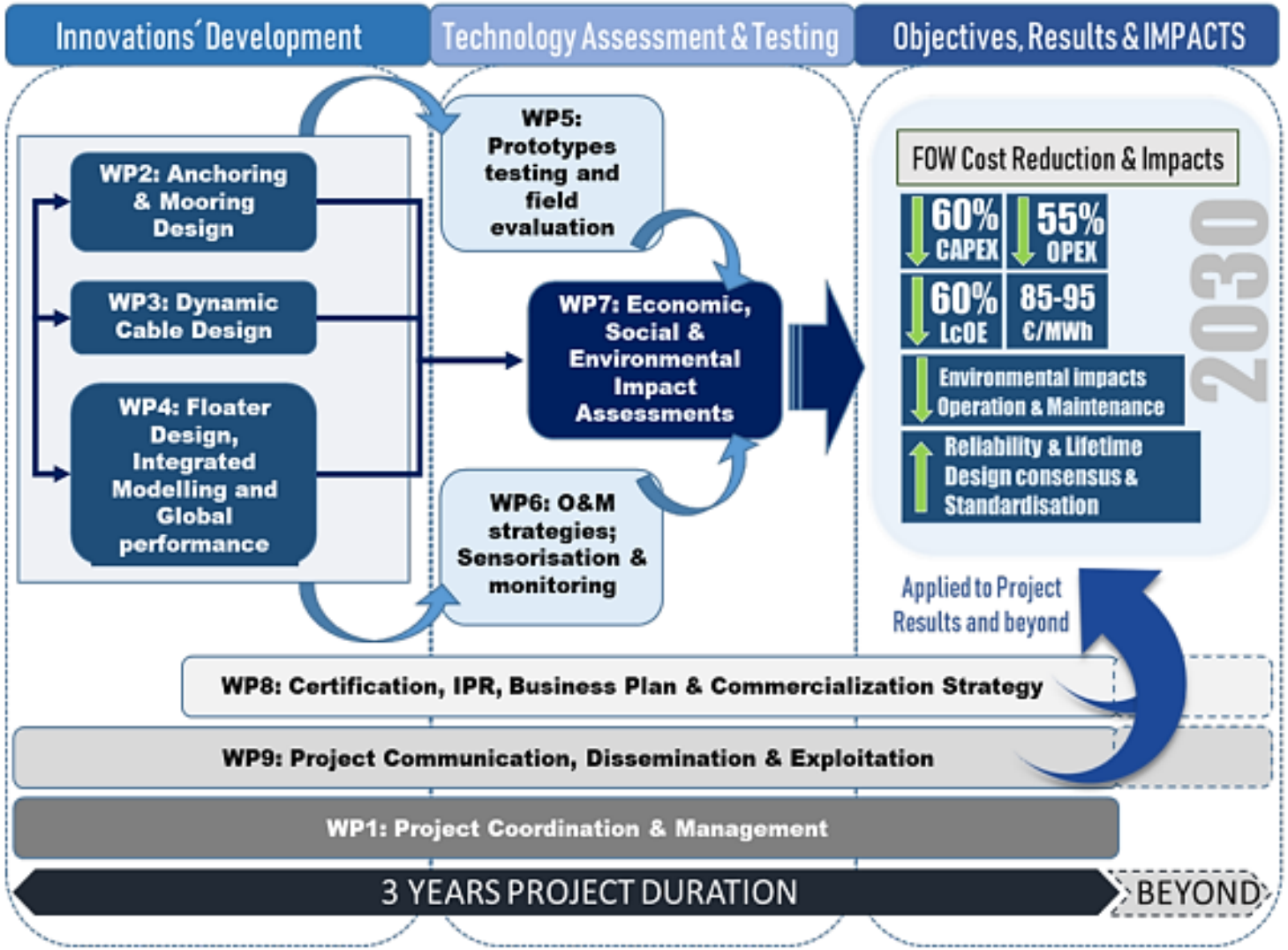
Outline of the presentation

- Introduction
- Sites
- Flotant concept
- Moorings
- Stability
- Wave-structure interaction
- Coupled simulations
- Testing

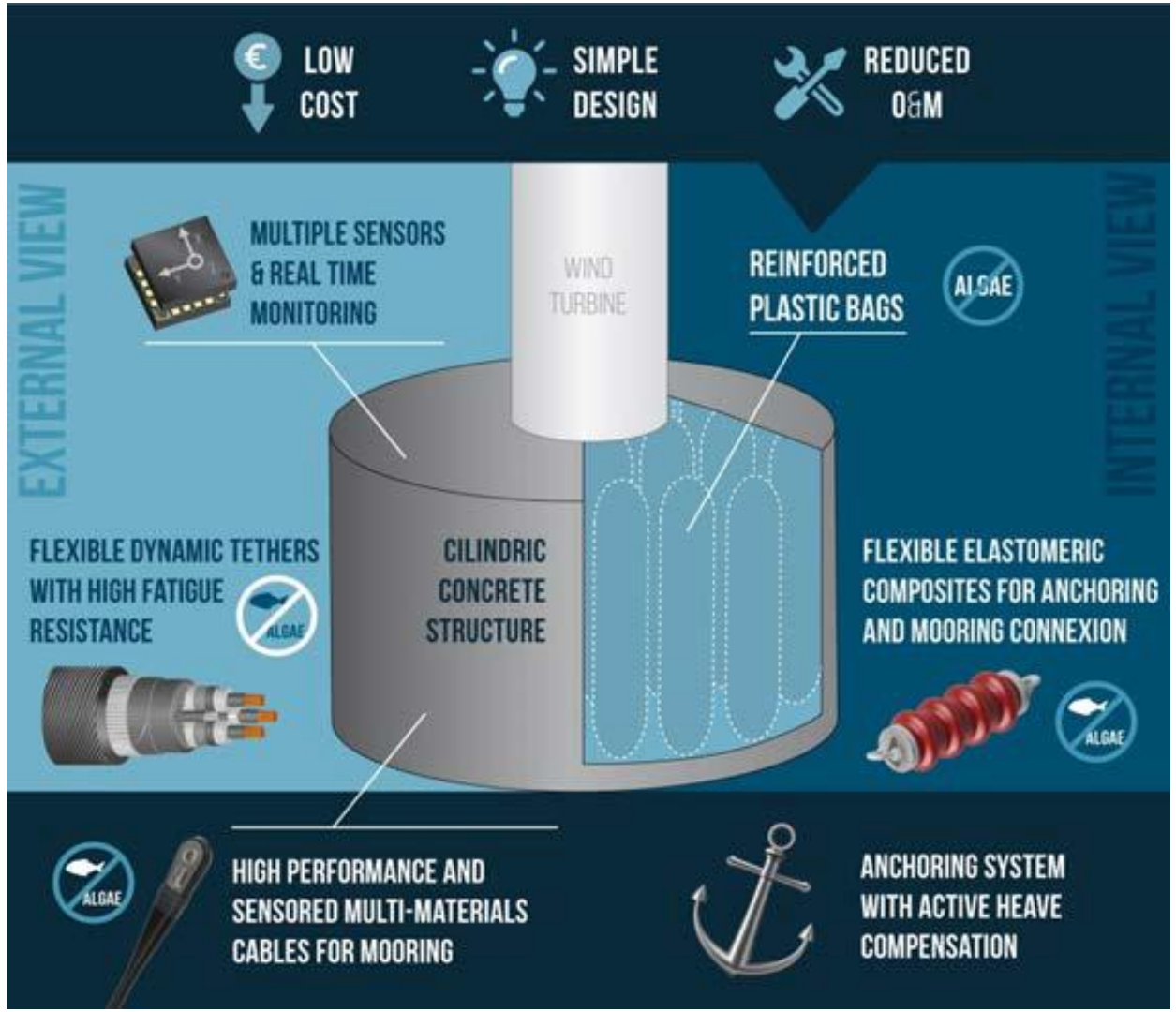
FLOTANT

Introduction

Introduction



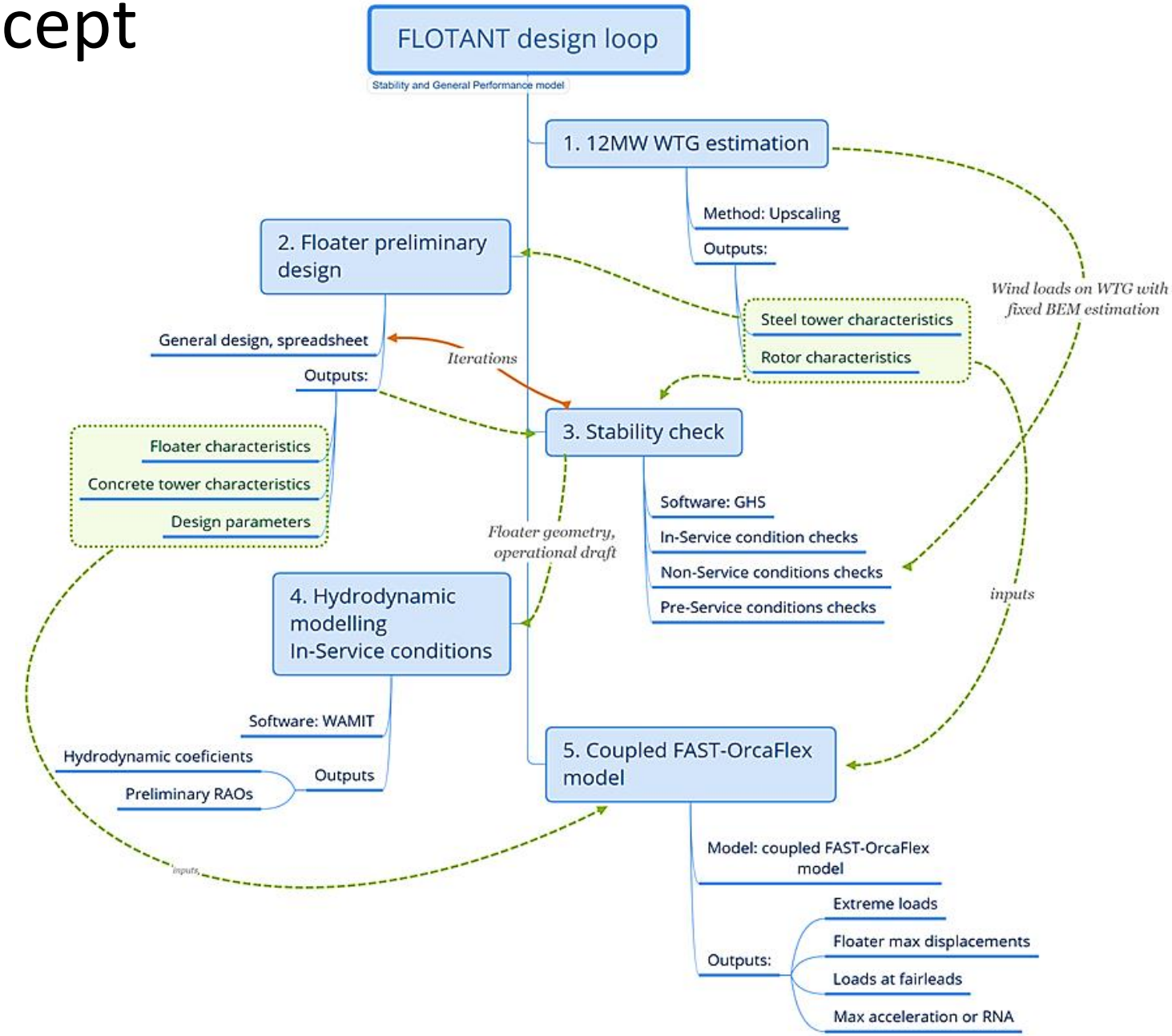
Introduction



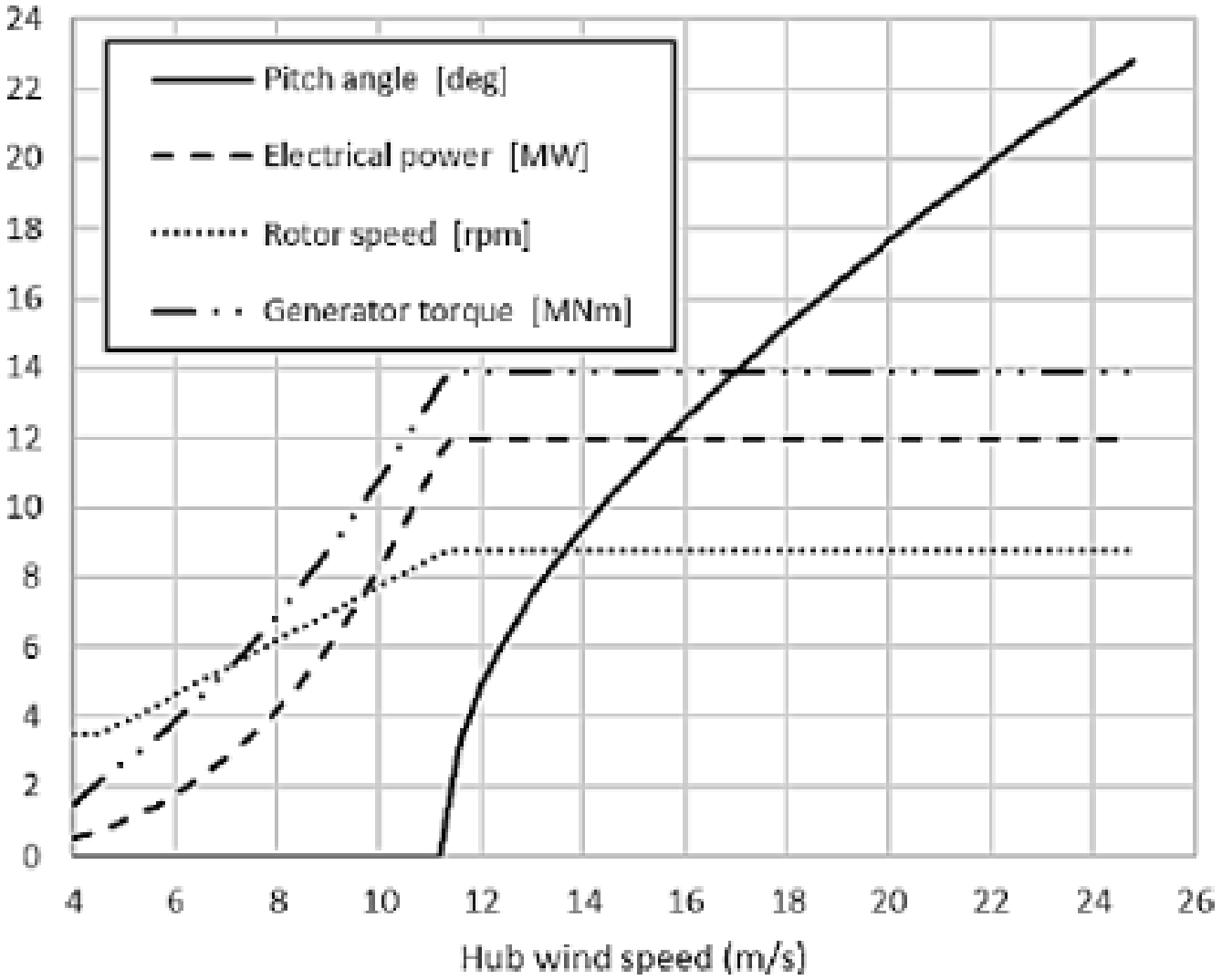
Sites

Item	Unit	WoB	GC
Water Depth	m	100.00	250.00
V_{50}	m/s	50.00	28.00
H_{s50}	m	15.60	5.11
T_{p50}	s	15.20	12.00
Seabed type	-	Basalt	Sand

Flotant concept

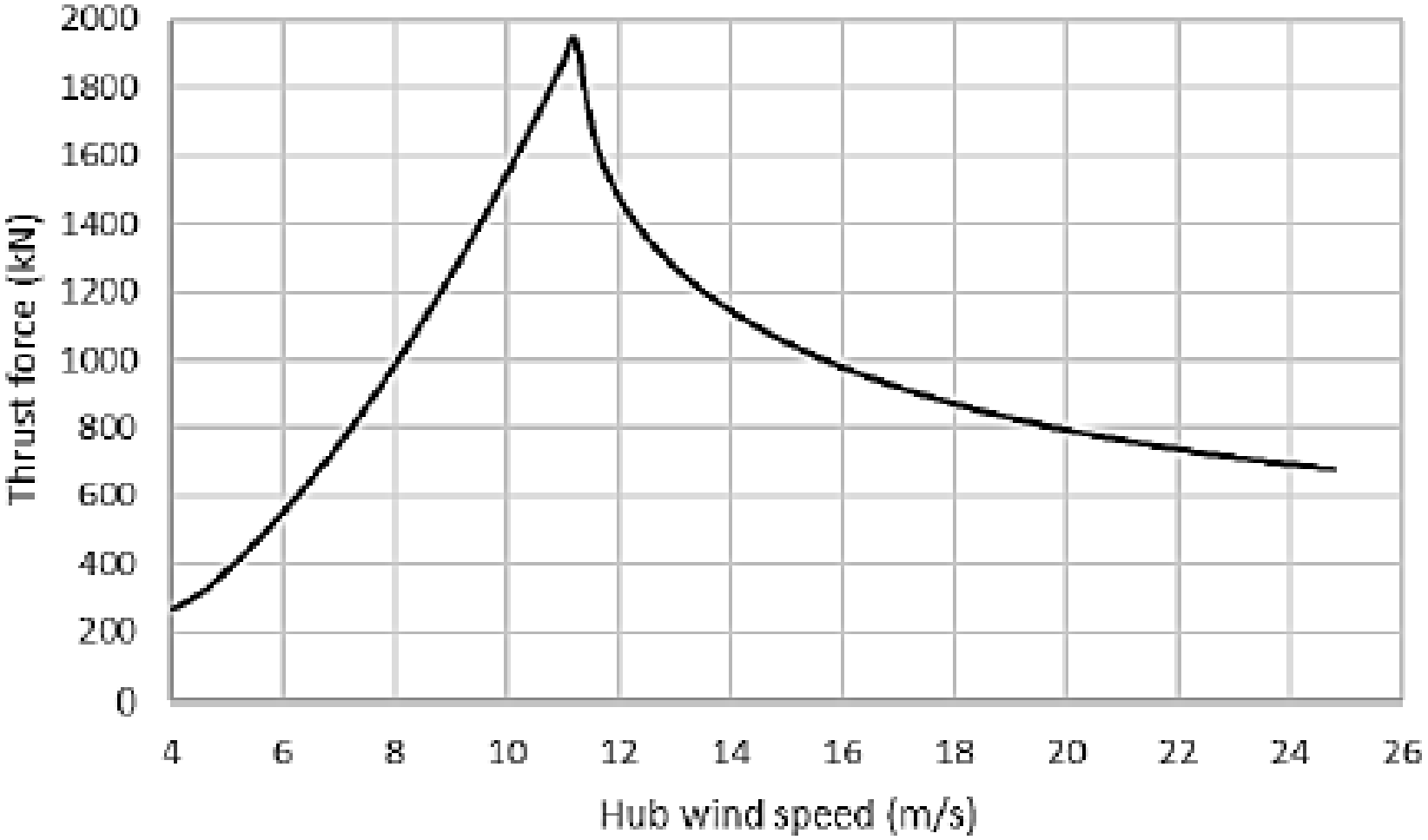


Flotant concept

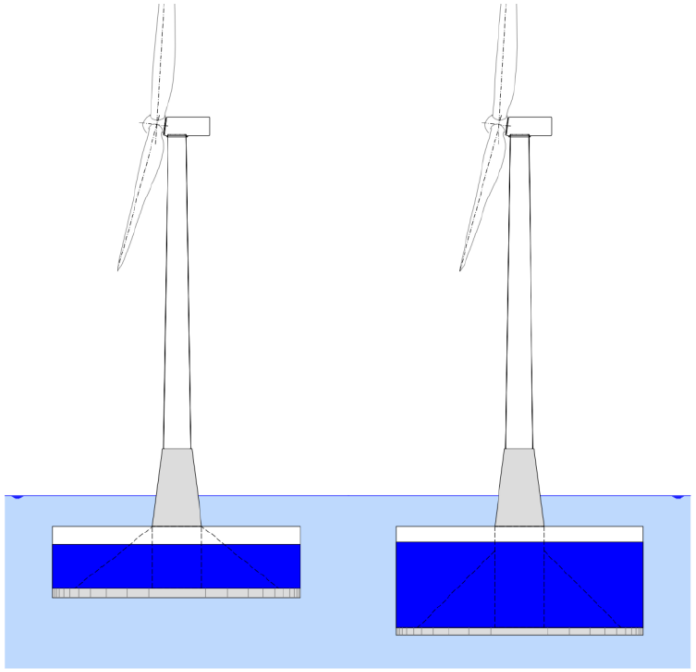


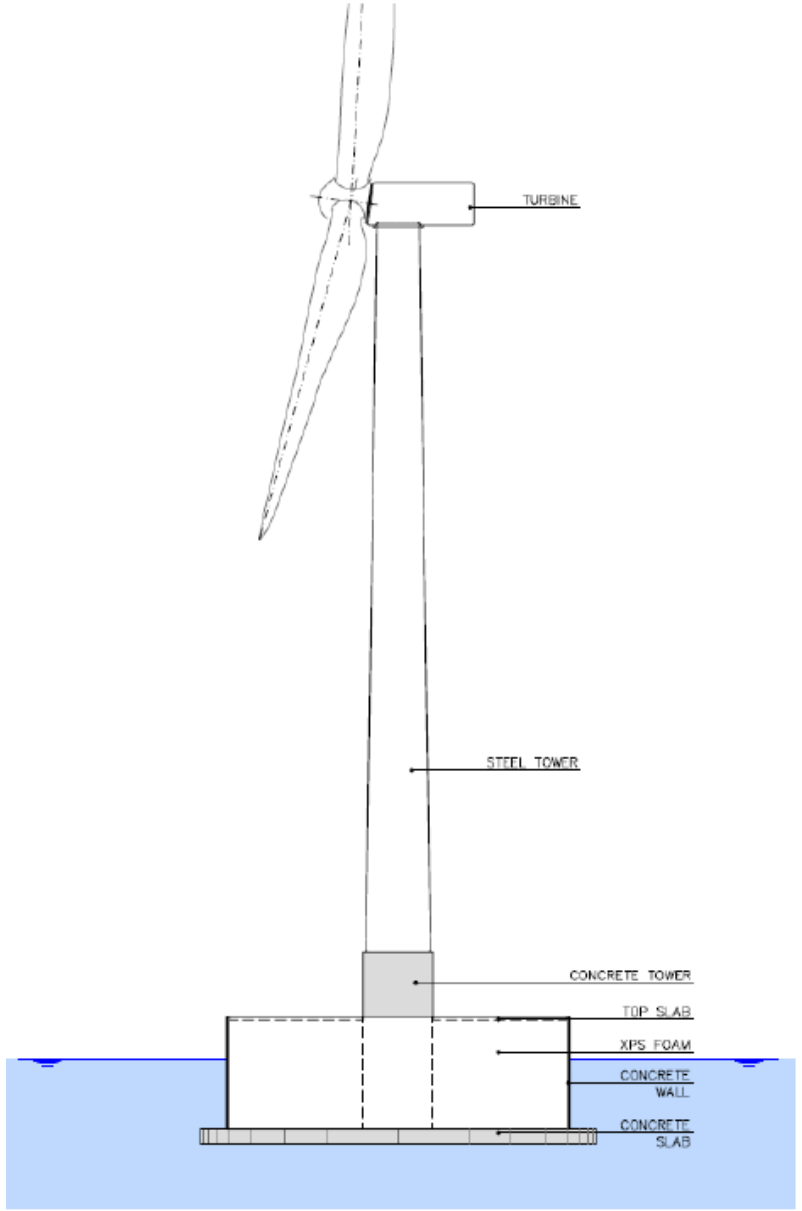
Item	INS12MW GWT
Output power	12.00 MW
Rotor diameter	195.40 m
Hub diameter	6.13 m
Hub height above sea level	119.70 m

Flotant concept



Flotant concept

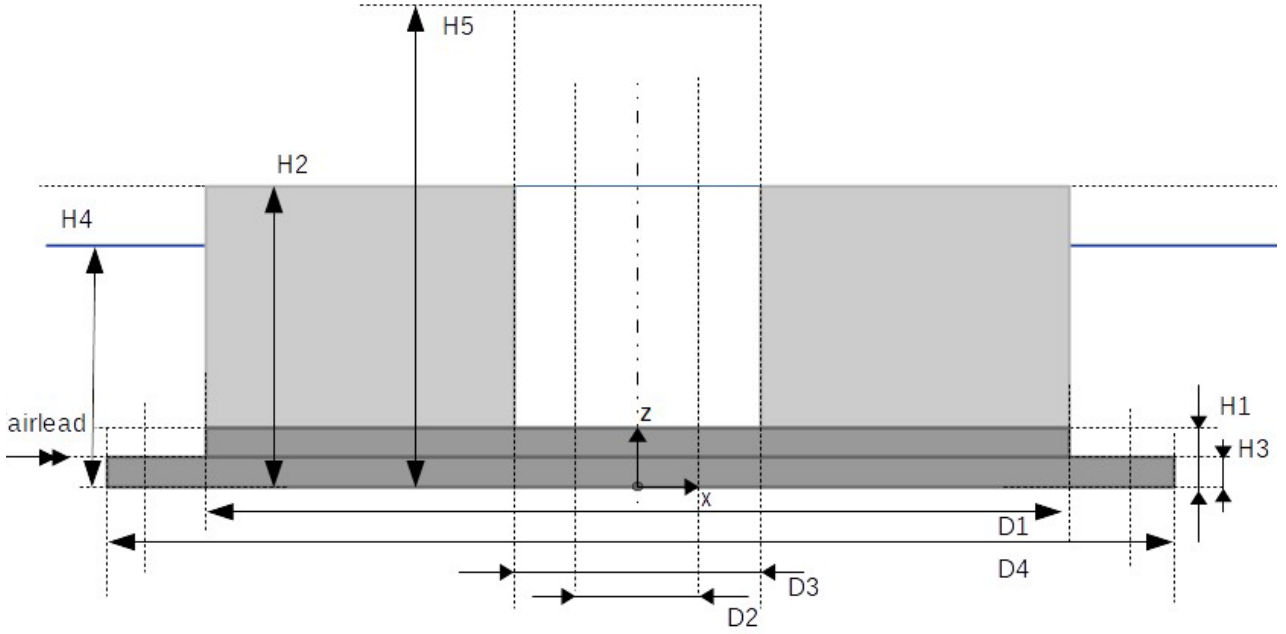




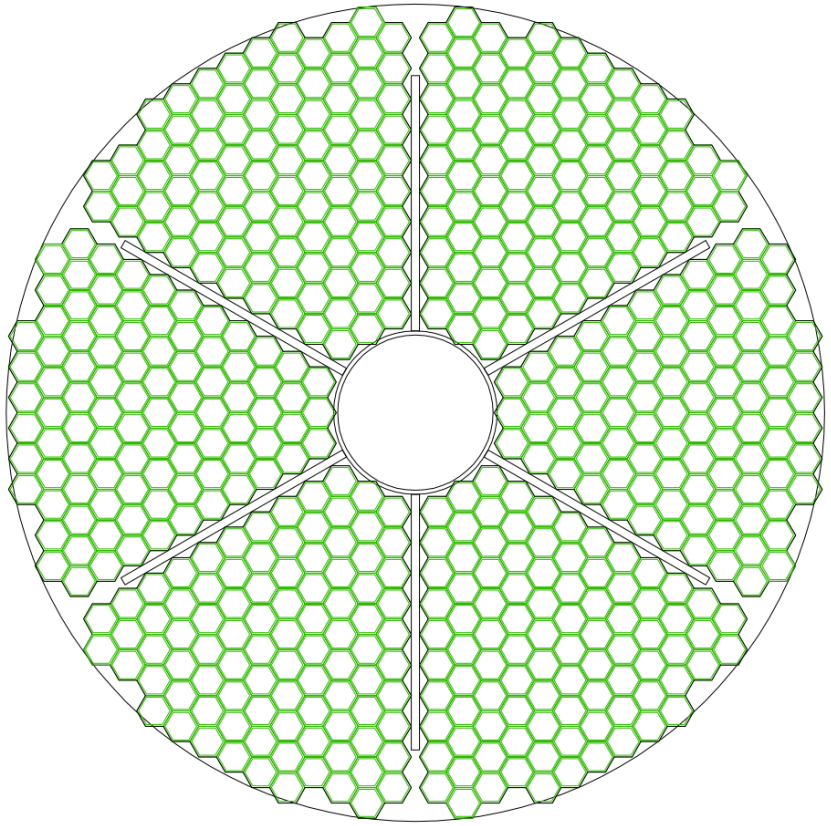
FLOTANT

Flotant concept

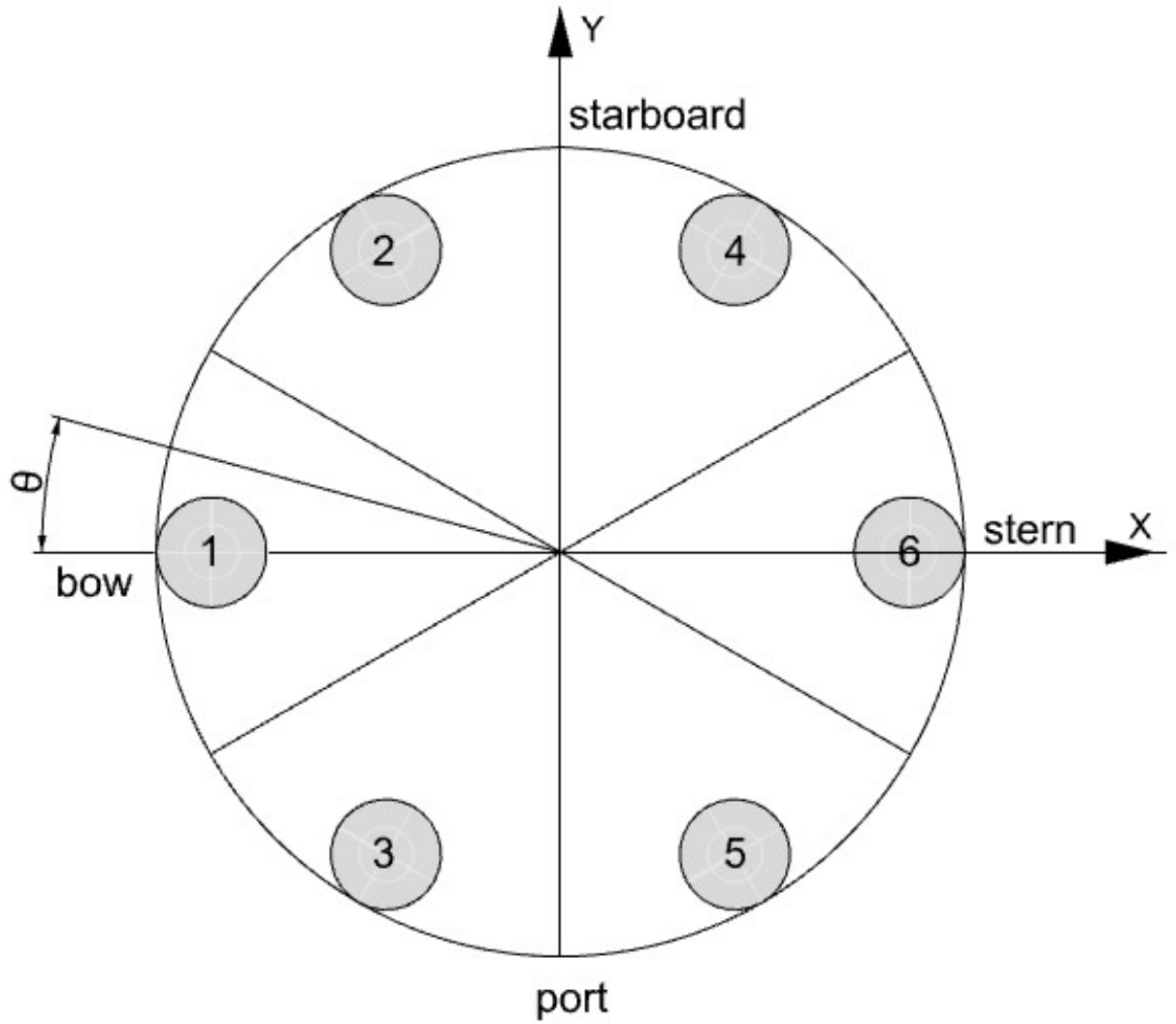
Item	Value
Height from keel to top concrete slab (H1)	3.25 m
Base height (H2)	18.00 m
Heave plate height (H3)	1.00 m
Draft (H4)	12.00 m
Concrete tower height (H5)	27.00 m
Base diameter (D1)	48.00 m
Steel tower diameter (D2) at the bottom	9.00 m
Concrete tower diameter (D3)	9.70 m
Heave plate diameter (D4)	52.00 m
Mass	20962.26 t
Concrete density	2.5 t/m^3
Foam density	0.04 t/m^3
Centre of Gravity (from keel)	5.19 m



Flotant concept

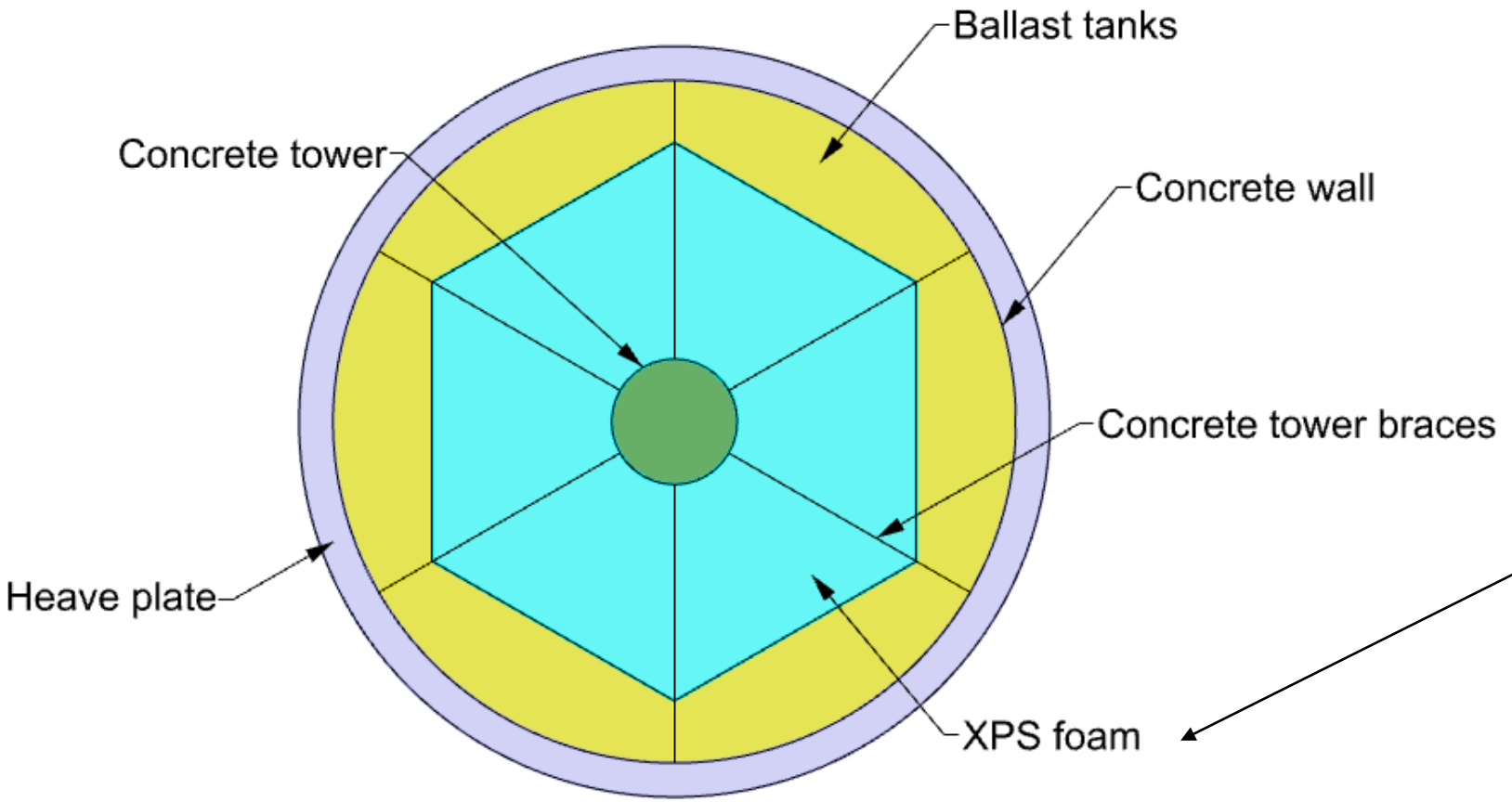


Flotant concept



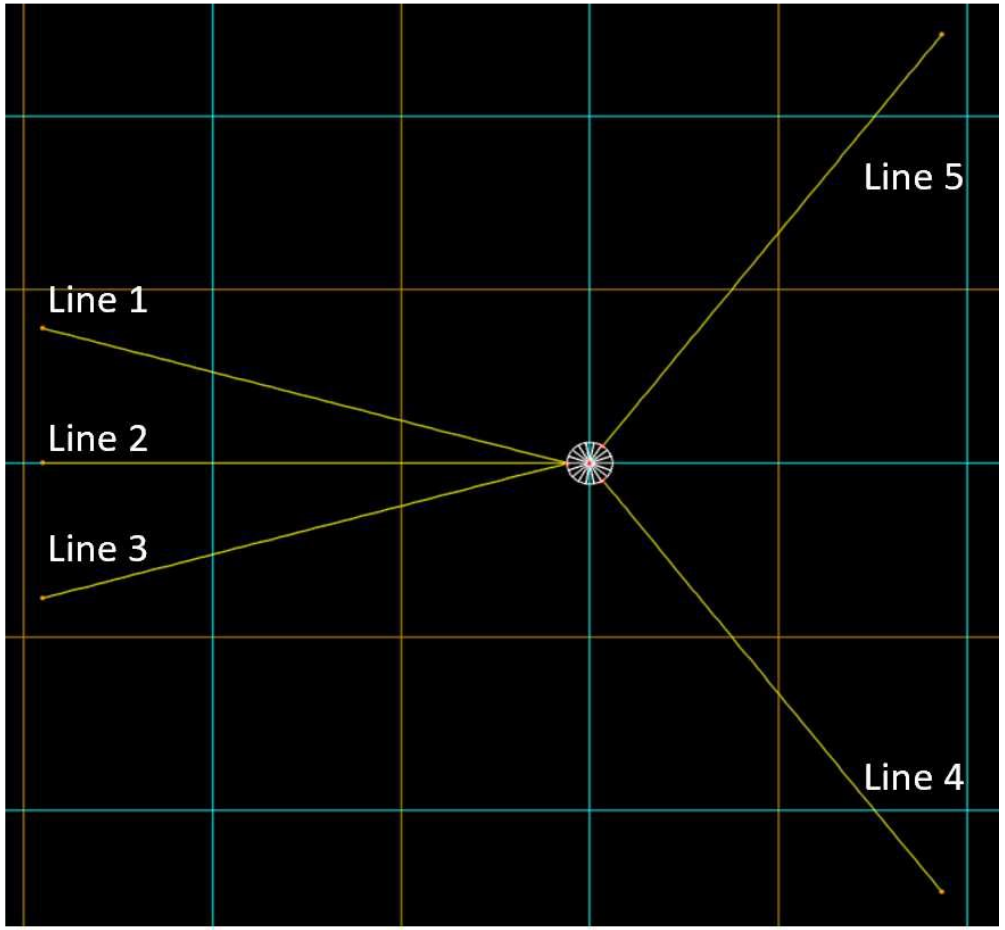
Wind

Flotant concept

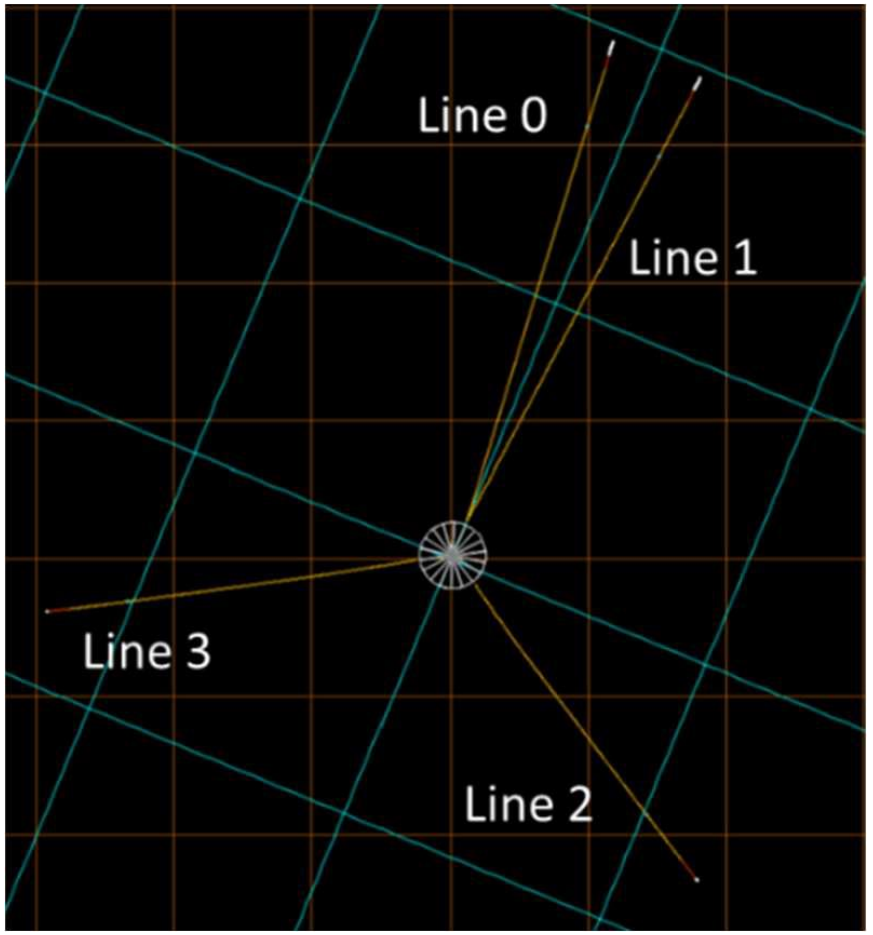


Moorings

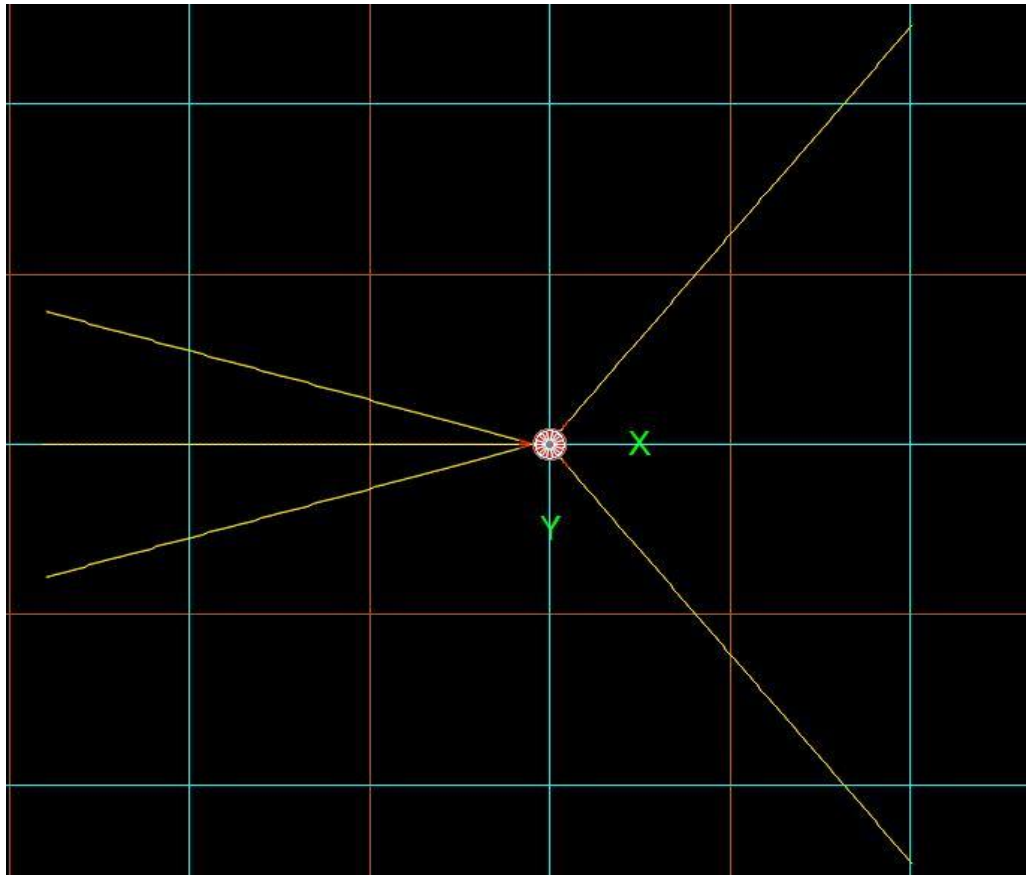
WoB

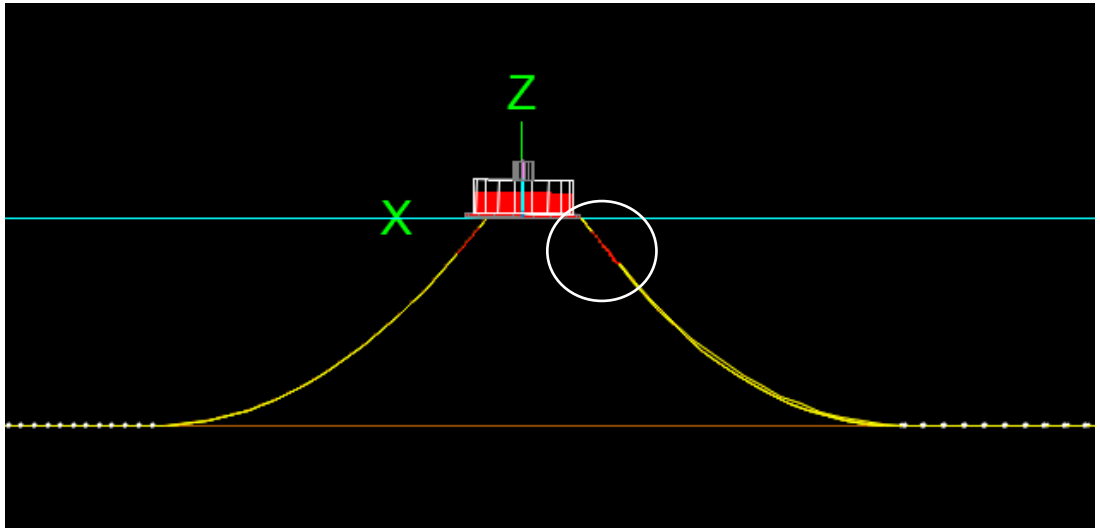


GC

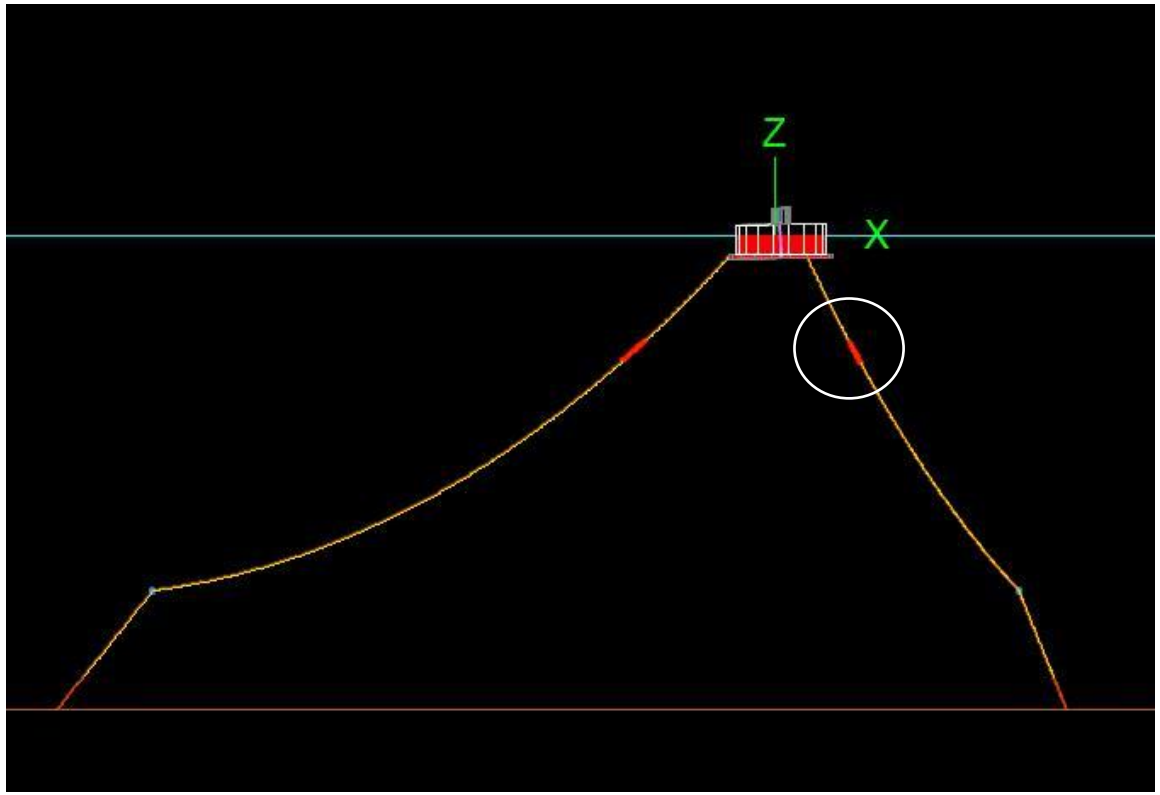


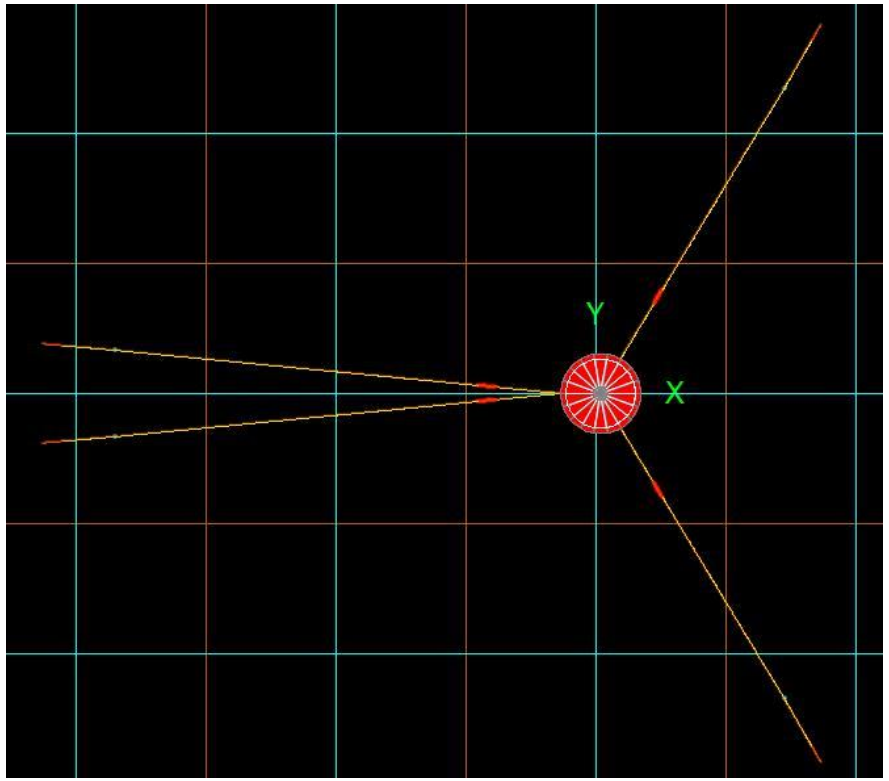
Moorings (WoB)





Moorings (GC)

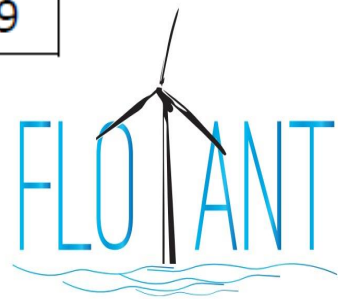




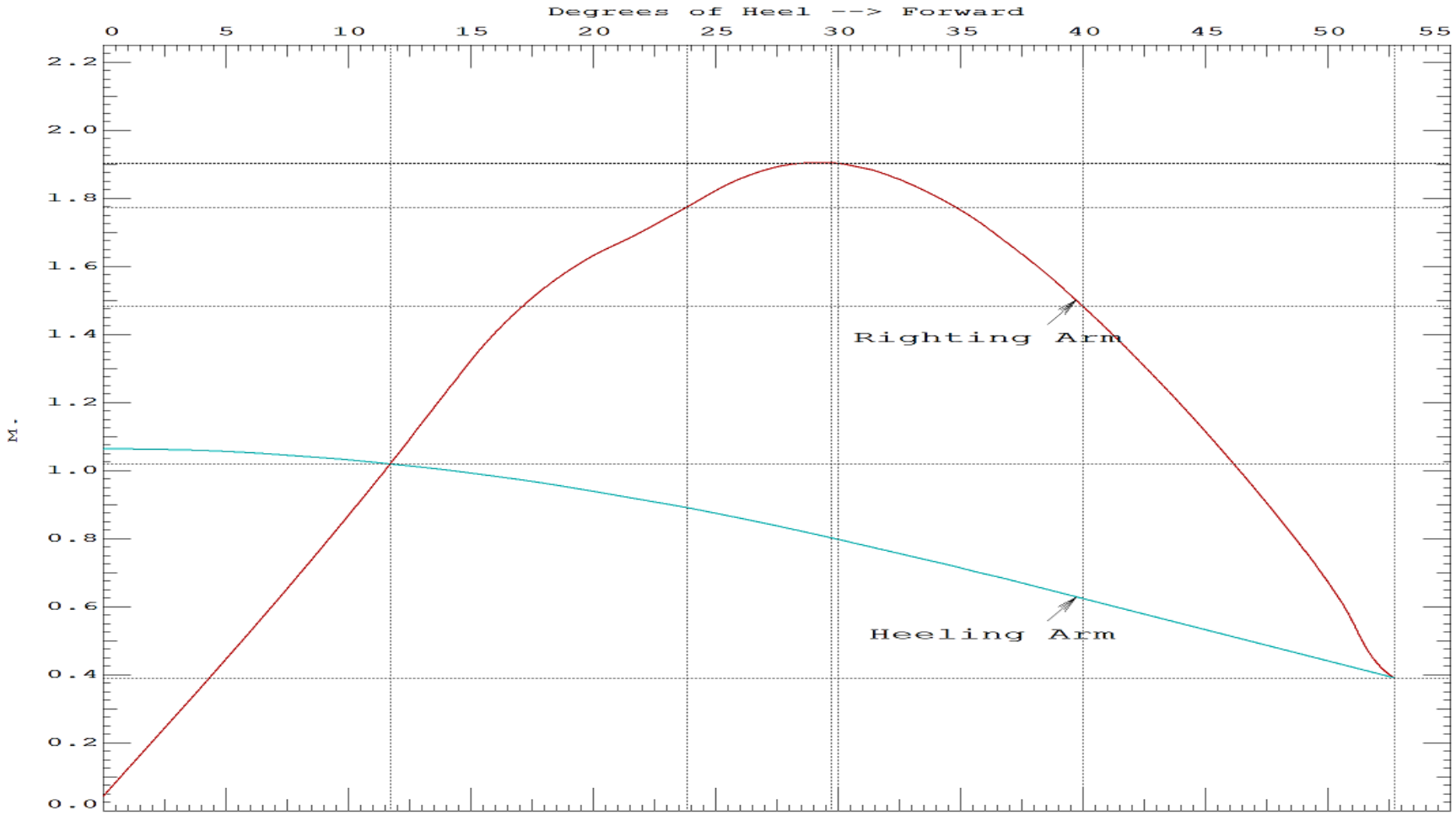
Moorings

Characteristic	Unit	GC	WoB
Line outer diameter	m	0.18	0.265
Mass density in air	kg/m	193.51	430
Axial stiffness	MN	892.00	1845
Seabed friction coefficient	-	0.50	0.50
Normal added mass coefficient	-	1.00	1.00
Normal drag coefficient	-	2.60	2.40
Axial drag coefficient	-	1.40	1.15
Fairlead positions	m	-10.99	-10.99
Unstretched length of frontlines	m	780.00	571.12/592.91/ 592.93
Unstretched length of backlines	m	738.24	630.00

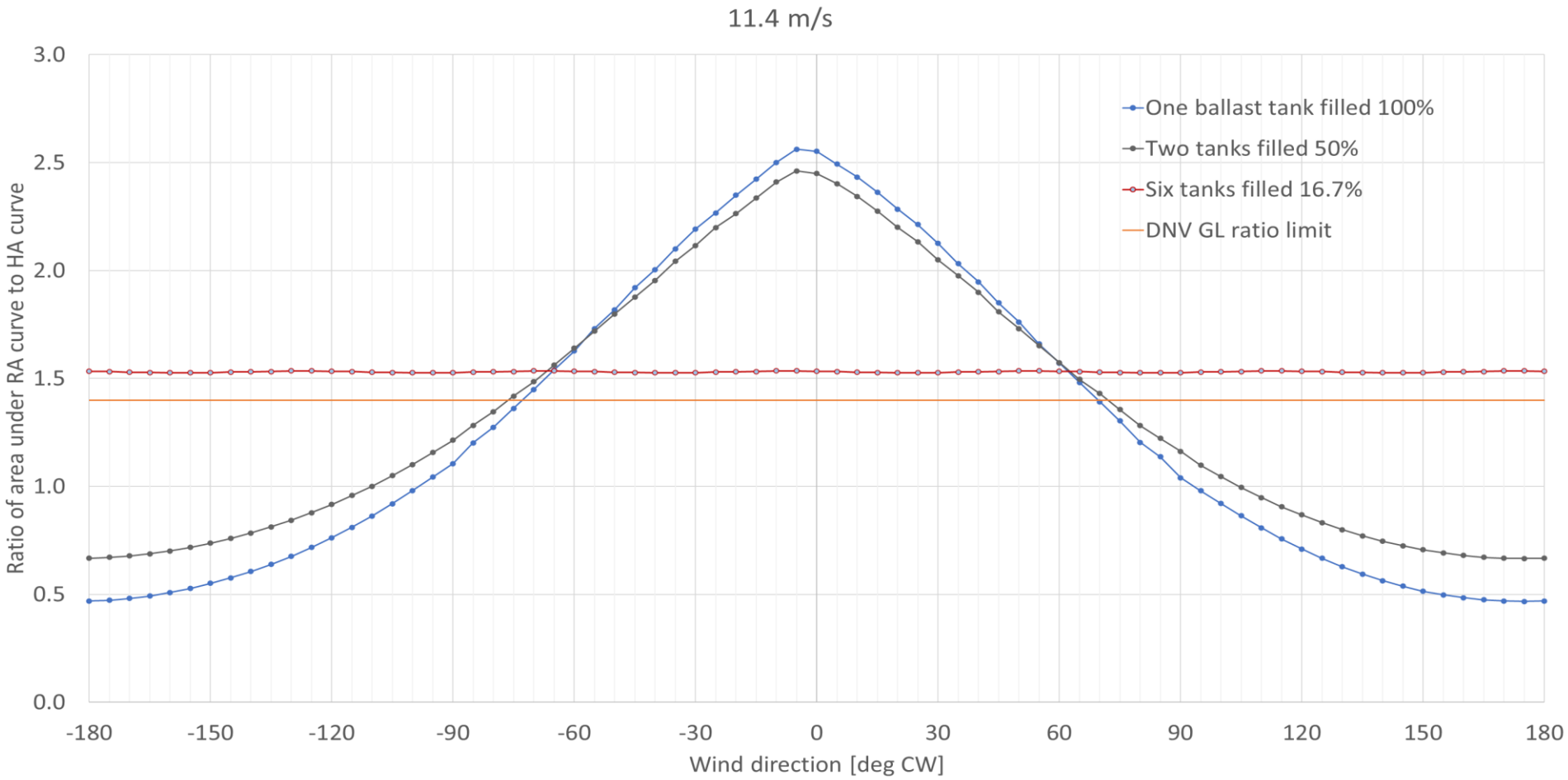
Site	Line	x (m)	y (m)	Z (m)
GC	1	-24	0	-10.99
	2	-24	0	-10.99
	3	13.8	-19.66	-10.99
	4	13.8	19.66	-10.99
WoB	1	-24	0	-10.99
	2	-24	0	-10.99
	3	-24	0	-10.99
	4	13.77	-19.66	-10.99
	5	13.77	19.66	-10.99



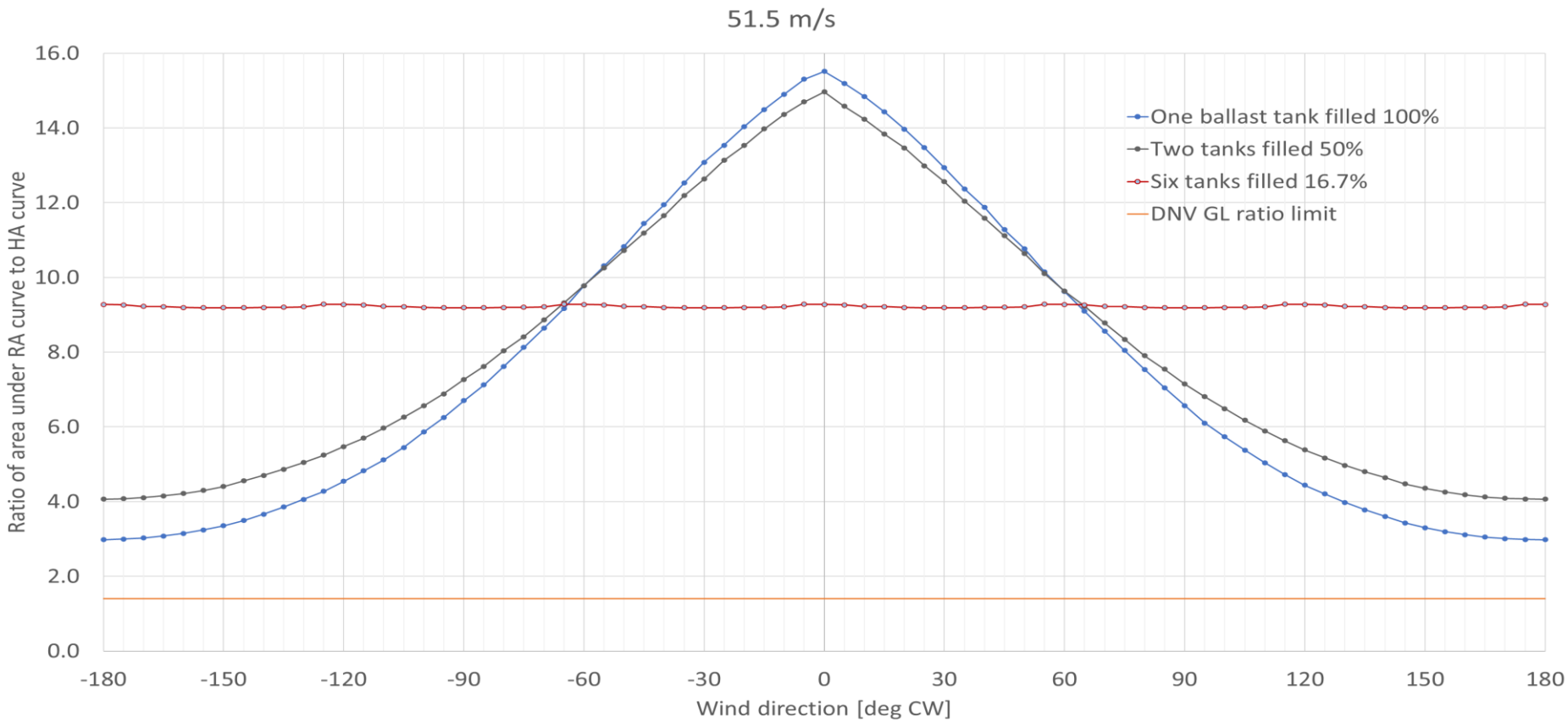
Stability


Degrees of Heel --> Forward
0
5
10
15
20
25
30
35
40
45
50
55
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
M.
Righting Arm
Heeling Arm

Stability


11.4 m/s
Ratio of area under RA curve to HA curve
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-180
-150
-120
-90
-60
-30
0
30
60
90
120
150
180
Wind direction [deg CW]
One ballast tank filled 100%
Two tanks filled 50%
Six tanks filled 16.7%
DNV GL ratio limit

Stability


51.5 m/s
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Ratio of area under RA curve to HA curve
-180
-150
-120
-90
-60
-30
0
30
60
90
120
150
180
Wind direction [deg CW]
One ballast tank filled 100%
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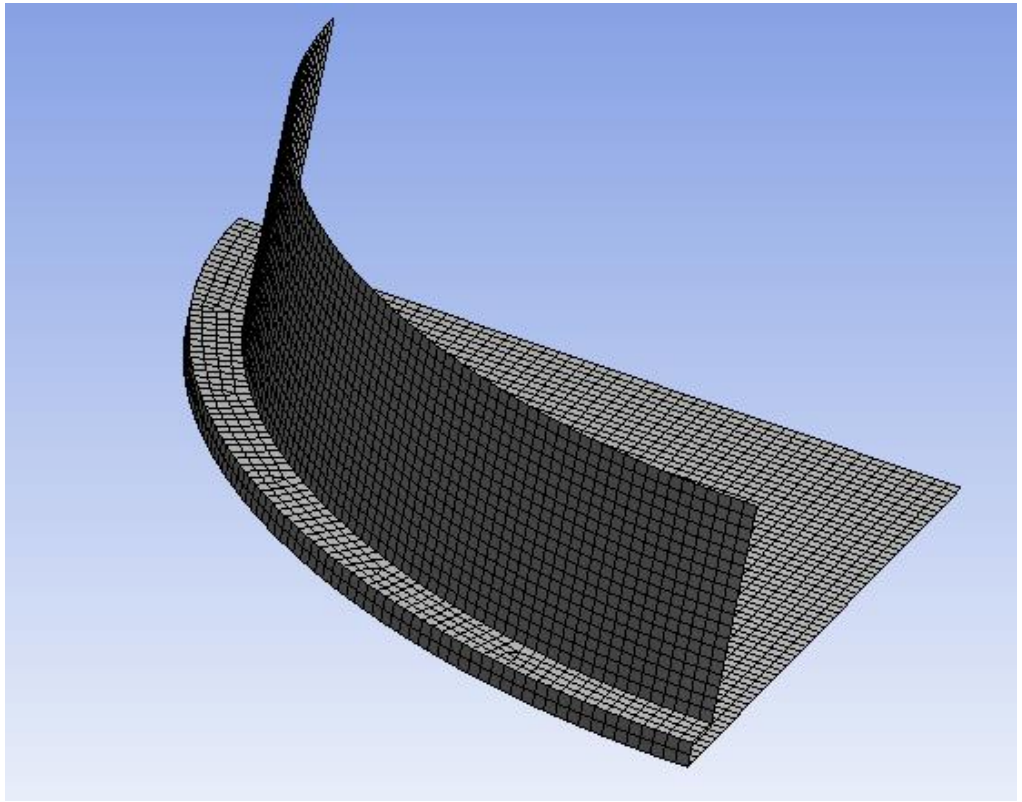
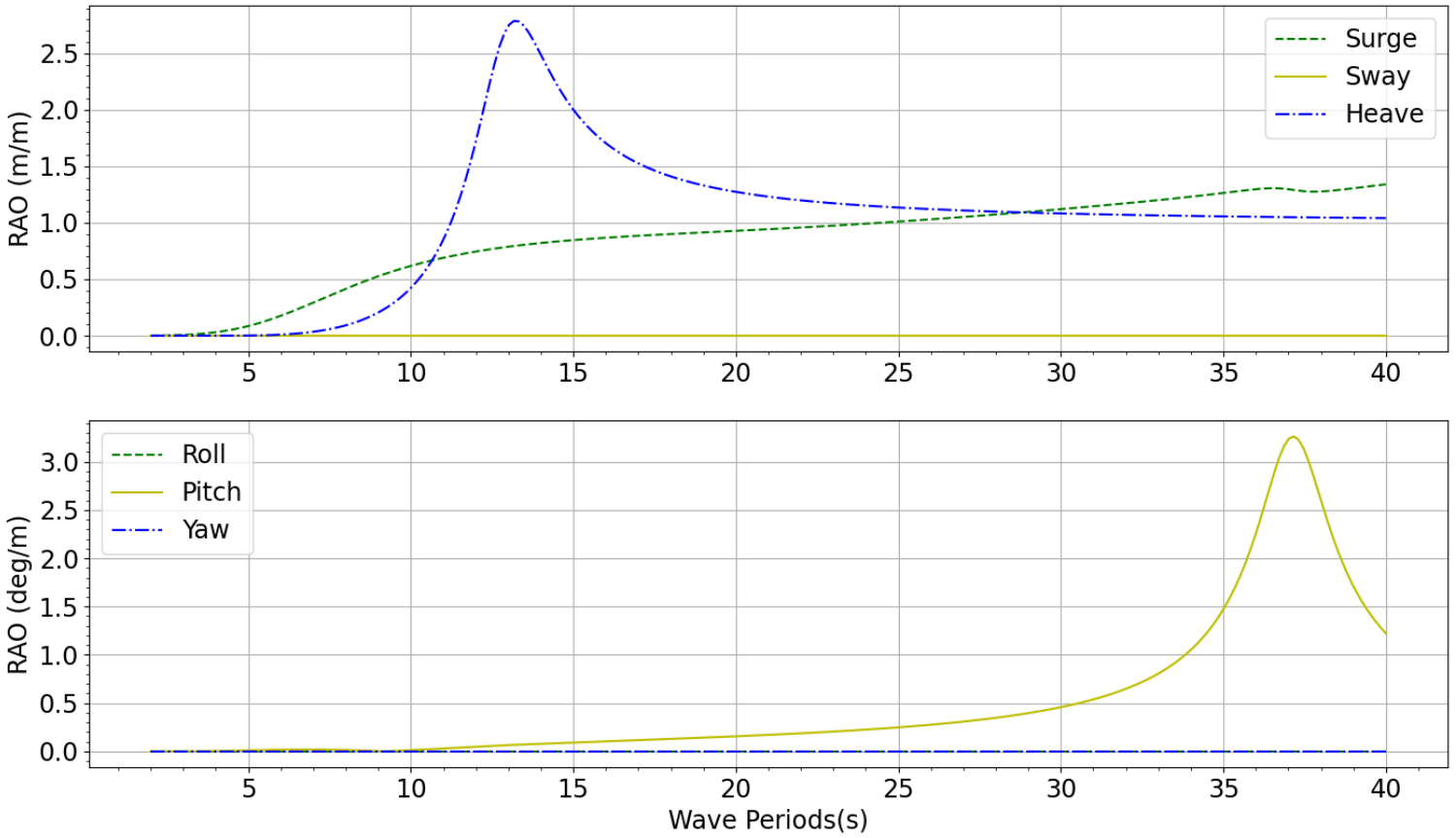
DNV GL ratio limit

Wave-structure interaction



Wave-structure interaction



Coupled simulations

	DLC	Wind	Wave	Directionality
Power Production	1.6	NTM	ESS	COD, UNI
Parked	6.1	EWM	ESS	MIS, MUL
Parked + Grid Loss	6.2			

No control

Item	Operation	Survival
Excursions (Max)	30.00 m	30.00 m
Platform yaw (Max)	< 15.00°	-
Platform yaw (SD)	< 3.00°	±7.00°
Platform pitch and/or roll (Max)	±5.00°	±5.00°
Platform pitch and/or roll (AVG)	±2.50°	-
Platform tilt (SD)	< 1.50°	-
Platform roll (SD)	< 1.00°	-
Operational acceleration (Max)	2.94 m/s^2	3.65 m/s^2 side to side 4.40 m/s^2 fore aft

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Coupled simulations

Design situation	DLC	Comments	Wind model	Sea state model	Current model	Water level
Normal power production	1.2	Turbulence + normal sea state (F)	NTM	NSS	NCM	NWLR or ≥ MSL
	1.6	Turbulence + severe sea state (N)	NTM	SSS	NCM	NWLR
Power production plus occurrence of fault	2.3	Extreme gust + grid loss (A)	EOG	NSS	NCM	MSL
	2.4	Turbulence + grid loss (F)	NTM	NSS	NCM	NWLR or ≥ MSL
	2.6	One mooring line damaged (A)	NTM	NSS	NCM	MSL
	2.8	Supply vessel impact, 2 ballast tanks flooded (A)	NTM	NSS	NCM	MSL
Start up	3.1	Normal wind conditions + normal sea state (F)	NWP	NSS	NCM	NWLR or ≥ MSL
	3.2	Extreme gust (N)	EOG	NSS	NCM	MSL
Normal shut down	4.1	Normal wind conditions + normal sea state (F)	NWP	NSS	NCM	NWLR or ≥ MSL
	4.2	Extreme gust (N)	EOG	NSS	NCM	MSL
Parked stand-by (standing still or idling)	6.1	Extreme wind and sea state(N)	EWM	ESS	ECM	EWLR
	6.3	Extreme wind and sea state + yaw misalignment (N)	EWM	ESS	ECM	NWLR
	6.4	Turbulence (F)	NTM	NSS	NCM	NWLR or ≥ MSL
Parked non-stand-by and fault conditions	7.1	Extreme wind and sea state + grid loss (A)	EWM	ESS	ECM	NWLR
	7.3	One mooring line damaged (A)	EWM	ESS	ECM	NWLR
	7.5	Supply vessel impact, 2 ballast tanks flooded (A)	EWM	ESS	ECM	NWLR
Transport, assembly, O&M	8.1	Towing to site of operation (N)	NTM	NSS	NCM	NWLR

Control: adaptation of NREL-5MW RWT controller

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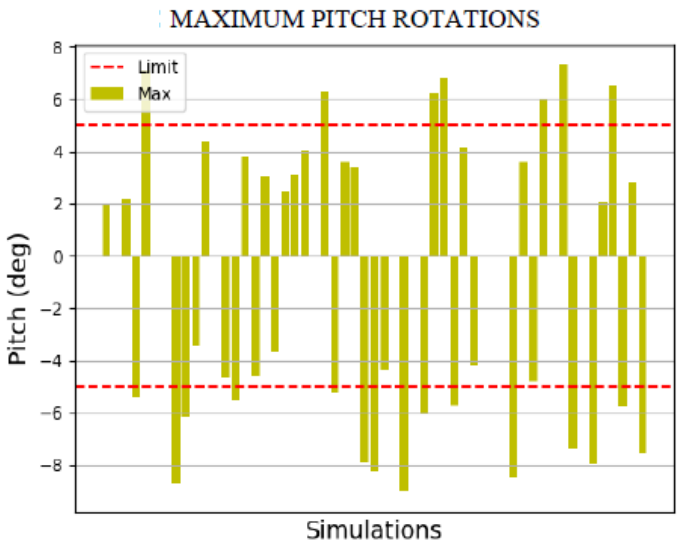
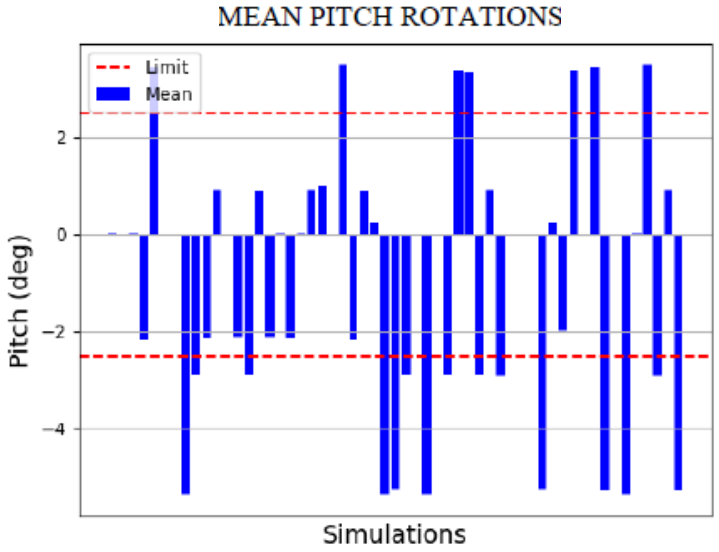
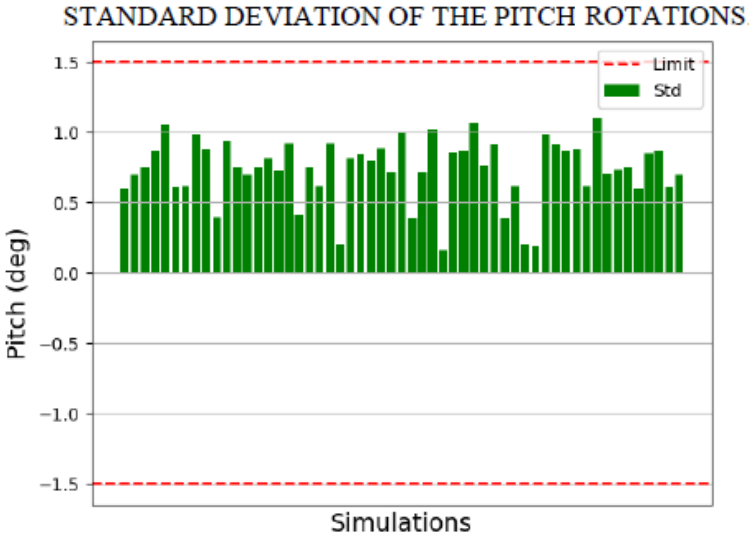
Coupled simulations



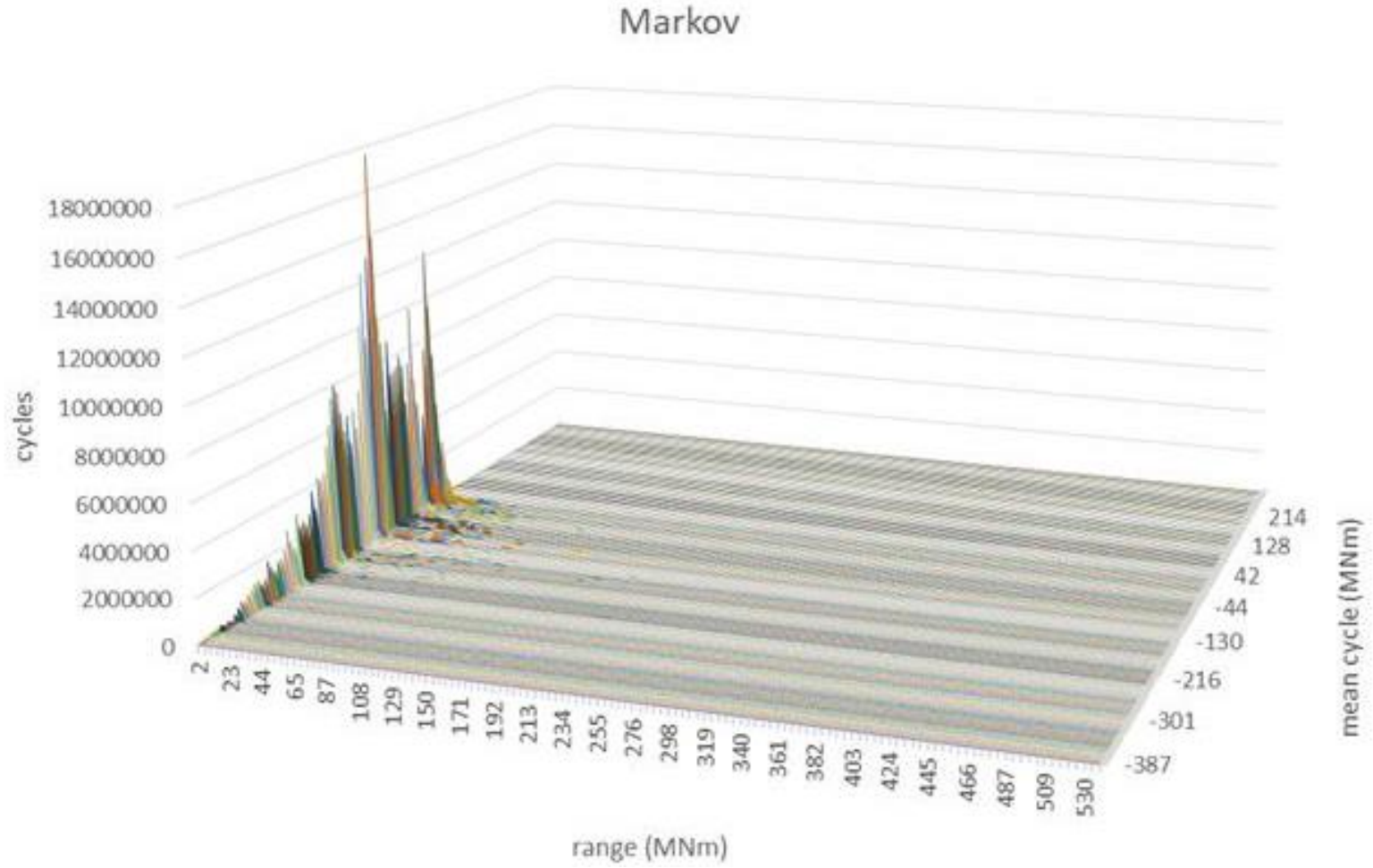




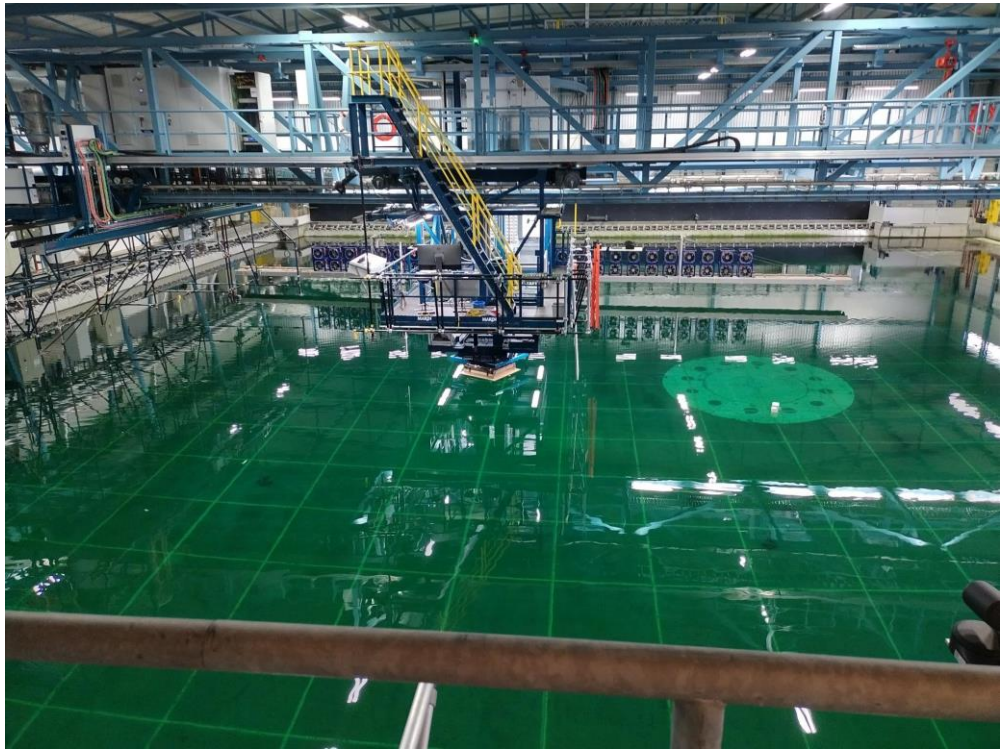
PERCENTAGE OF CASES SATISFYING DESIGN CRITERIA

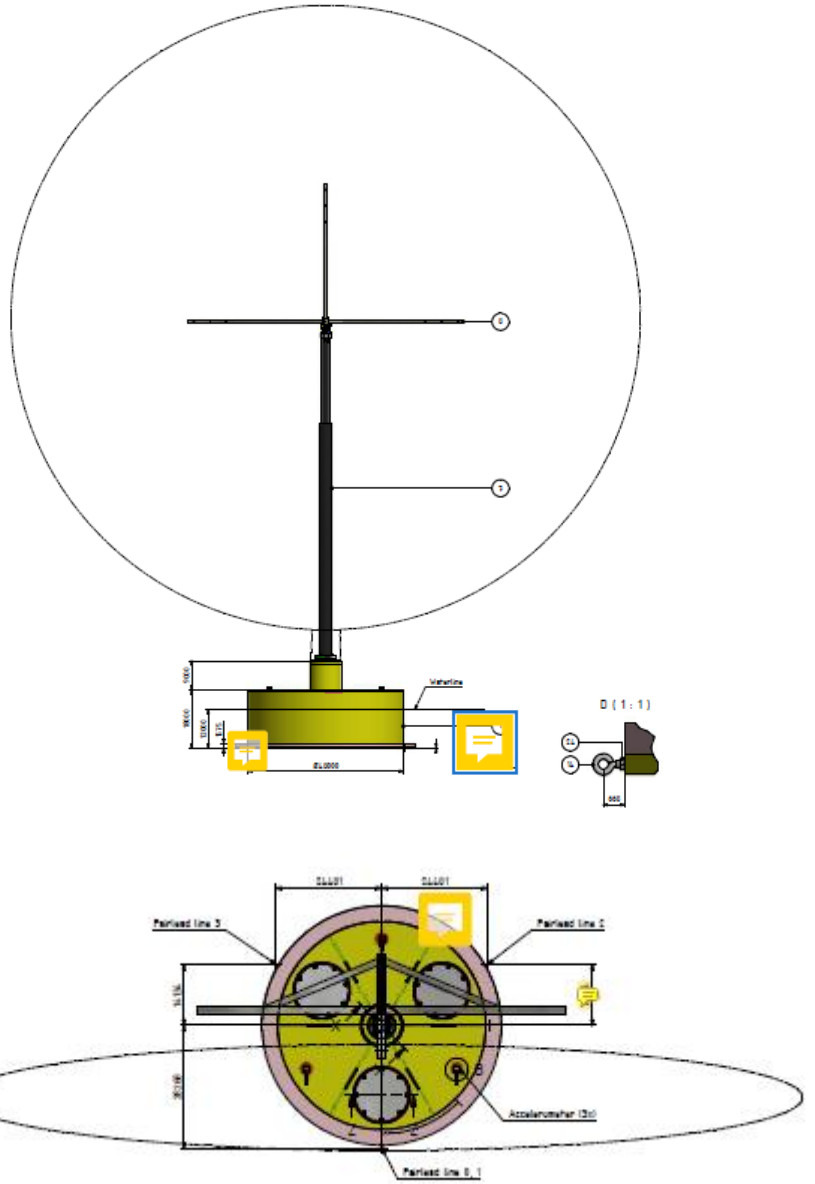
	Surge (Max)	Sway (Max)	Roll (Max)	Roll (AVG)	Roll (SD)	Pitch (Max)	Pitch (AVG)	Pith (SD)	Yaw (Max)	Yaw (SD)	Acc x (Max)	Acc y (Max)
(%)	67	100	73	78	100	58	60	100	100	78	91	91

Coupled simulations



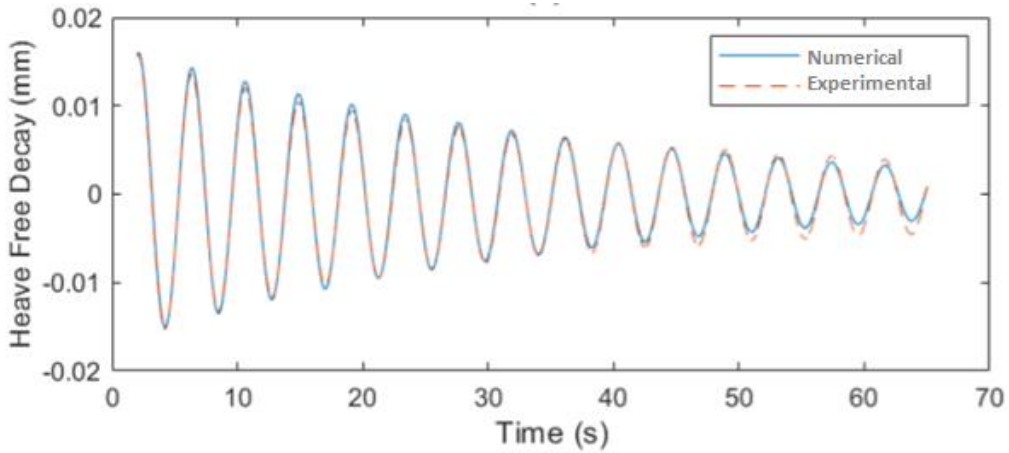
Testing




Waterline
D (1 : 1)
Fairlead line 3
Fairlead line 2
Accelerometer (3x)
Fairlead line 1

Testing


MARIN 10235


Heave Free Decay (mm)
0.02
0.01
0
-0.01
-0.02
0
10
20
30
40
50
60
70
Time (s)
Numerical
Experimental

Thank you, any questions?

https://flotantproject.eu/

INNOSEA
AqualisBraemar LOC Group

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