

Methodology for floating offshore wind turbine Major Component Replacement (MCR) - Webinar



FLoating Offshore Wind Operations and Maintenance (FLOWTOM) project

Laure Cossalter, Tanguy Coquio, France Energies Marines

Benoit Augier, Ifremer

Mélissa Mak, EDF

Pierre Alain Frémont, SBM Offshore

PARTNERSHIP:



With the financial support of:



3. Case study : operability definition of MCR steps

Part I – Methodology development and case study specifications



Tanguy Coquio, FRANCE ENERGIES
MARINES



Case study specifications

- **2 floaters :**
 - FEM/EDF/Basin tests : Semi submersible UMaine VoltunUS-S Reference Platform 15 MW (NREL, 2020)
 - SBM Offshore : TLP FLOAT4WIND
- **1 vessel and lift crane :**
 - Tanker WK
 - Equipped with Caballo Marango's crane (1000t lift)



WK roll period : 10,5s

Pendulum mode : 7s (self hoisting crane)
9s (blade)
15s (package)



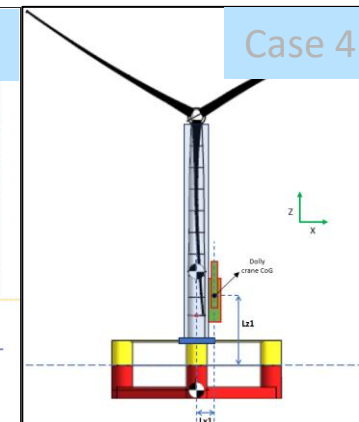
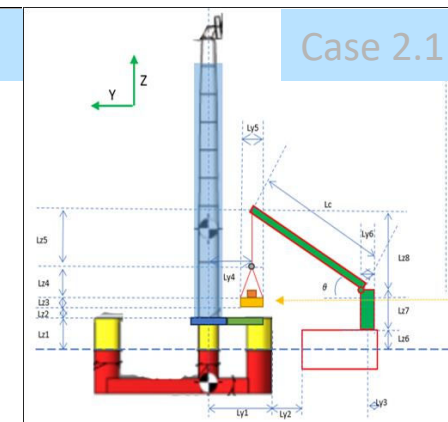
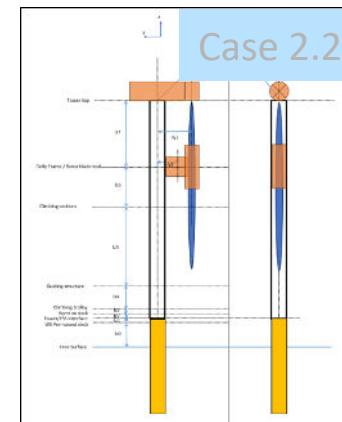
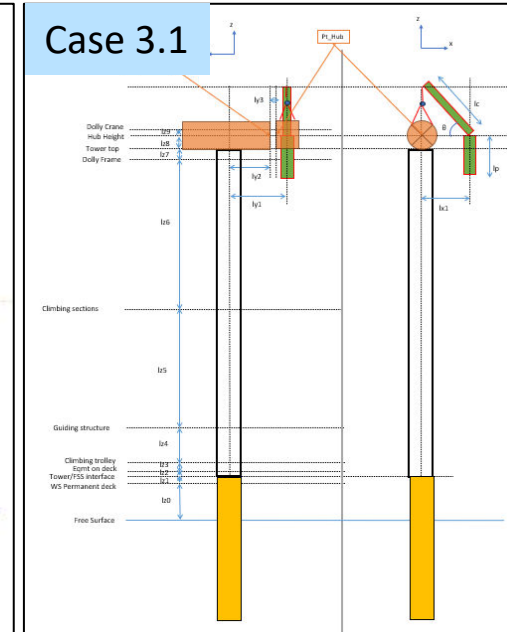
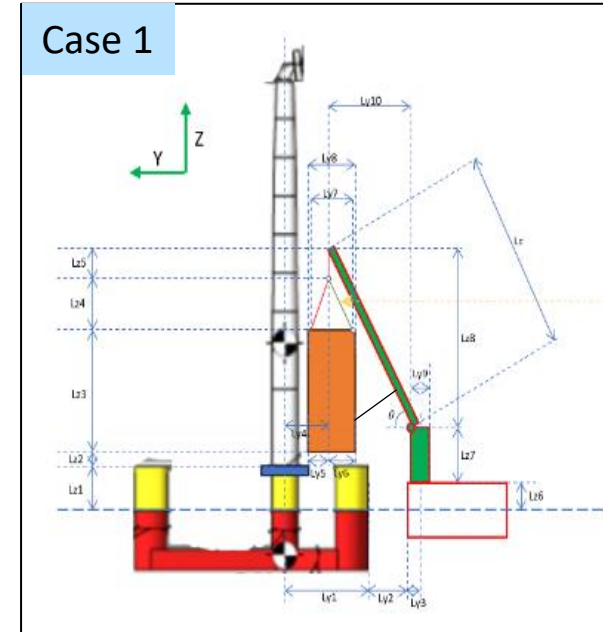
Case study specifications

- **3 lift cases + 1 survival case**

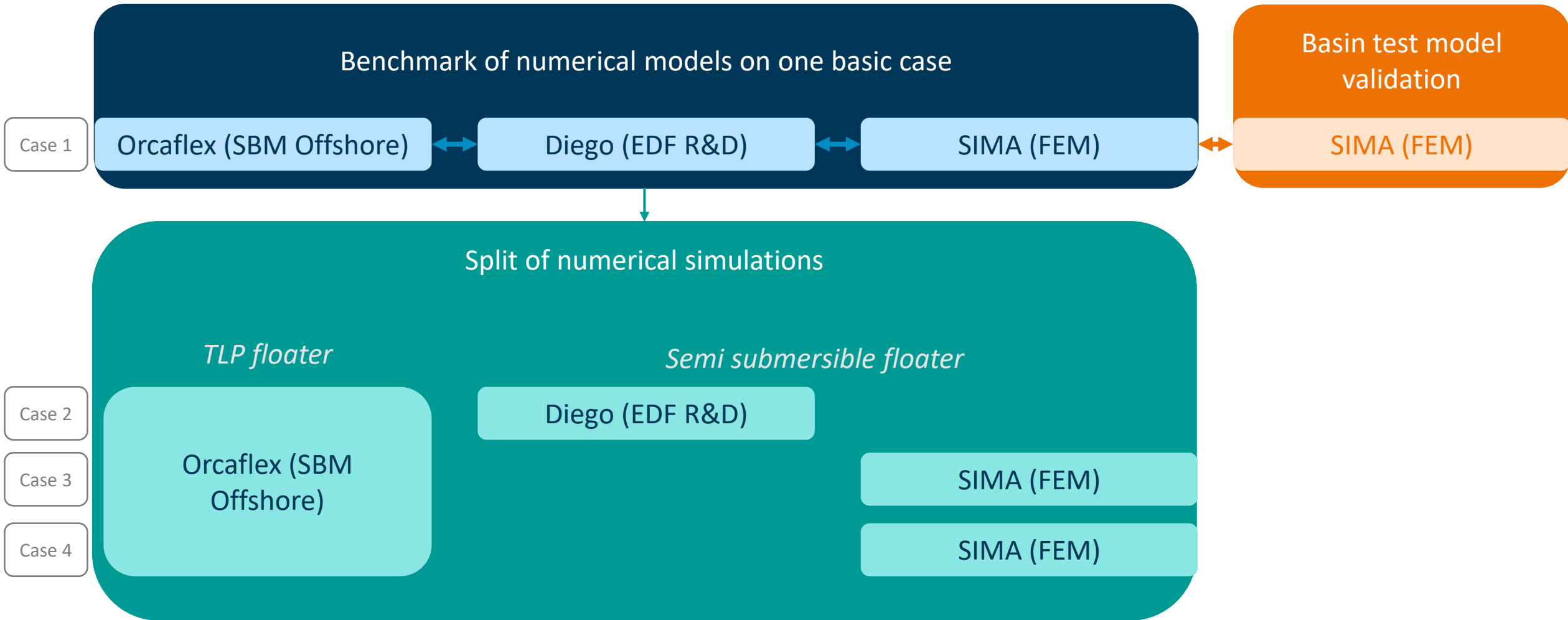
- Case 1 : Package system installation
- Case 2 : Blade replacement
 - Case 2.1 : blade transfer
 - Case 2.2 : blade connection FOWT standalone
- Case 3 : Hub replacement
- Case 4 : Survival case FOWT standalone

- **2 dof conditions**

- X.X.1 : No constraint on the package
- X.X.2 : Simplified constraint on the package : constant tension tugger line
- X.X.3 : Full system design >> cancelled due to time restriction



Case study splits

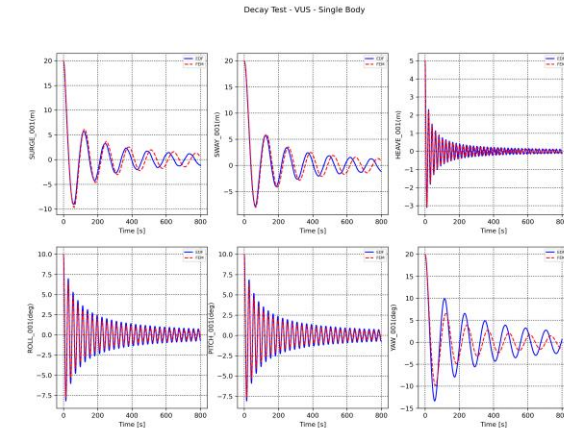


Numerical models overview

	EDF R&D	FEM	SBM Offshore
Software	DIEGO	SIMA	ORCAFLEX
Floater Type	Semi-Sub	Semi-Sub	TLP
Floater Name	VoltturnUS-S	VoltturnUS-S	Float4Wind
Hydrodynamic 1st order	Radiation/diffraction + additional drag elements	Radiation/diffraction + additional drag elements	Morison
Hydrodynamic 2nd order	MDF + Newman	MDF + Newman	Morison
Mooring	Chain Catenary - FEA	Chain Catenary - FEA	Hybrid Taut -FEA
Vessel Name	WK	WK	WK
Hydrodynamic 1st order	Radiation/diffraction + additional roll damping	Radiation/diffraction + additional roll damping	Radiation/diffraction + additional roll damping
Hydrodynamic 2nd order	MDF + Newman	MDF + Newman	MDF + Newman
Dynamic positioning	Linearized stiffness + linear damping	Linearized stiffness + linear damping	Linearized stiffness + linear damping
Radiation/Diffraction coupling between the FOWT and the vessel	Yes	Yes	No

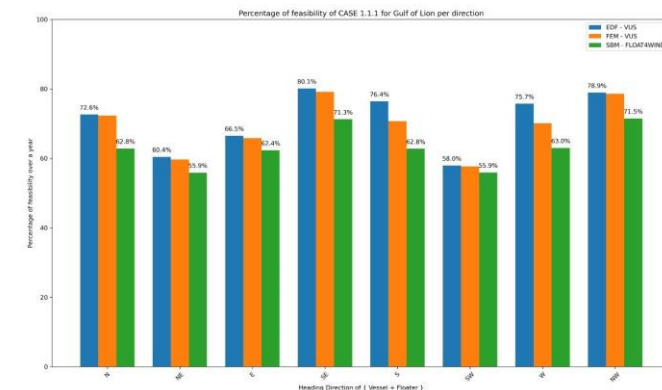
HDB comparison:

- **Step 1:** Single bodies regular RAOs comparison
- **Step 2:** Single bodies decay test
- **Step 3:** Multibody regular RAOs comparison
- **Step 4:** Multibody irregular RAOs comparison
- **Step 5:** Comparison of excitation forces and added mass in the time and frequency domains



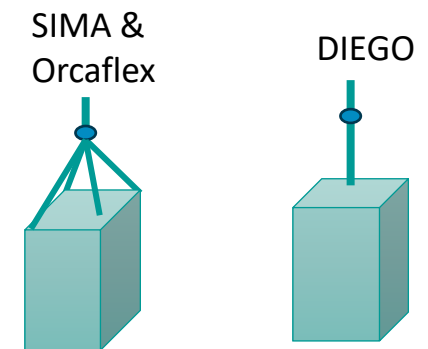
Cases comparison:

- **Step 6:** Case 1 representation
 - Comparison of bodies motions and package motions
- **Step 7:** Addition of 2 tugger lines
 - Comparison of bodies motions and package motions
 - Comparison of tugger tensions



Models benchmark outcomes

- HDB comparisons for each body provided satisfying results between SIMA, DIEGO and OrcaFlex
- The case 1 comparison presents some differences in the dynamic motion of the package:
 - Without tugger lines:
 - Different peak natural period of the pendulum In DIEGO compared to SIMA & ORCAFLEX
 - The crane line model in DIEGO was change to a simple line geometry solving this issue
 - Different Package offset:
 - Difficulty to obtain the same solved solution on pendulum motion
 - With tugger lines:
 - Adding tugger lines increases the differences for the package motions
 - Tugger lines are tension controlled:
 - With a speed limit of the winch in SIMA and DIEGO
 - Without speed limit control in OrcaFlex

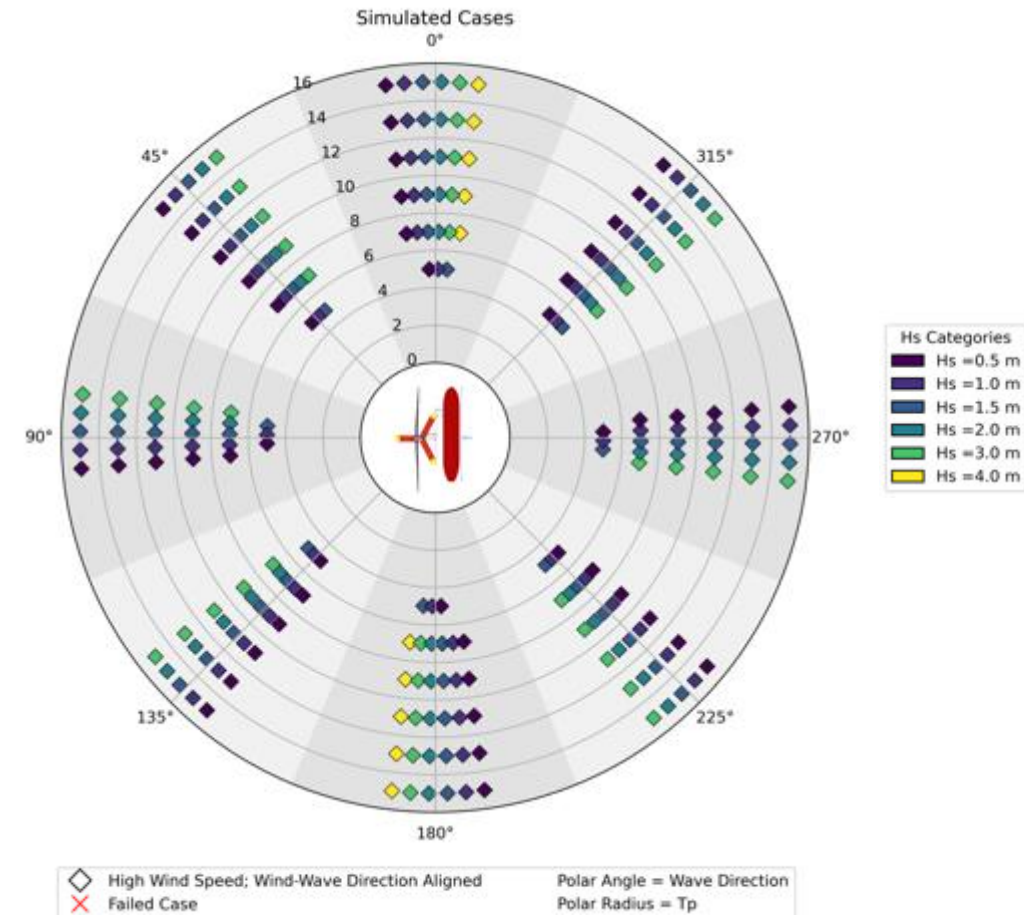


H _s	T _p						Wind @10 m elevation
	5	7	9	11	13	15	case 2
(m)	(s)	(s)	(s)	(s)	(s)	(s)	(m/s)
0.5	X	X	X	X	X	X	5.0
1.0	X	X	X	X	X	X	8.0
1.5	X	X	X	X	X	X	11.0
2.0		X	X	X	X	X	13.0
3.0		X	X	X	X	X	16.0
4.0		X	X	X	X	X	18.0

All directions

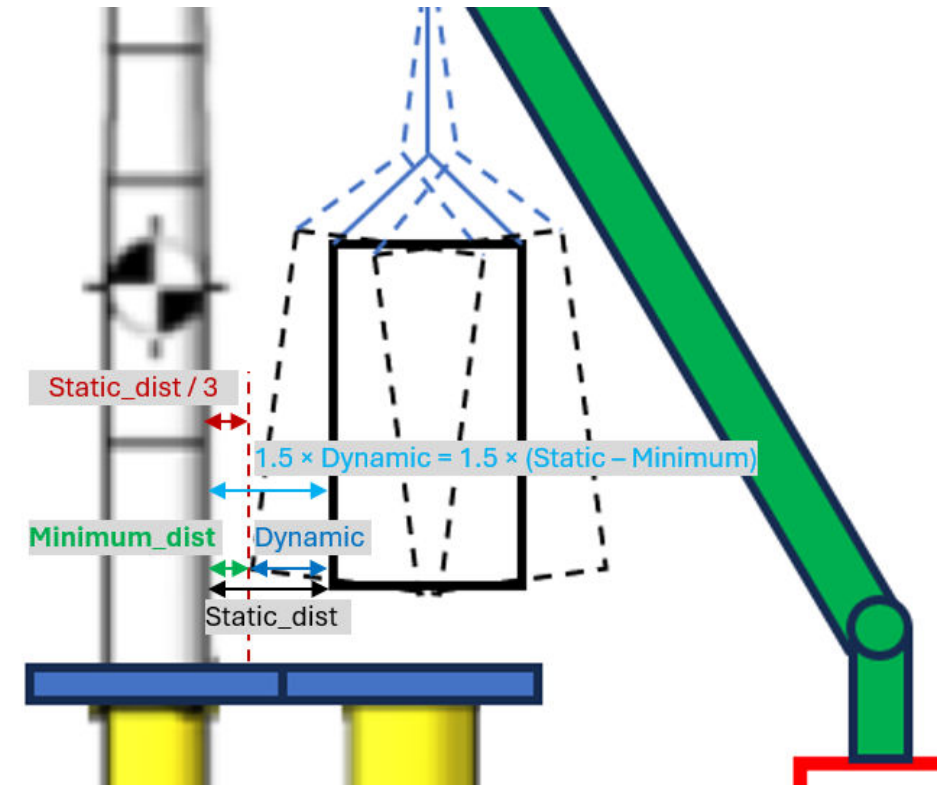
0° - 180°

Failed case by direction, H_s, T_p conditions



Model output & acceptance criteria

- 3 hours simulation on 1 wave/wind seed in time domain in 8 directions
- **Acceptance criteria:**
 - **Mean(min_dist) > 0.333 * Static_dist**
 - **Relative vertical velocity < 0,6m/s**
 - From lift center bottom surface to top MCR deck center surface
 - **Horizontal offset (lift vs center MCR) < 1,5m Case 1&2**
 - Only for dynamic motion :
 - X1: X position of the center (top surface) of virtual package
 - Y1: Y position of the center (top surface) of virtual package
 - X2: X position of package's center bottom surface
 - Y2: Y position of the package's center bottom surface
 - 1,5m offset is a good order of magnitude for horizontal motion (DNV ST N001)
 - **Horizontal offset (lift vs Nacelle) < 0,5 m Case 3**
 - **Tugger_tension < MBL/3**



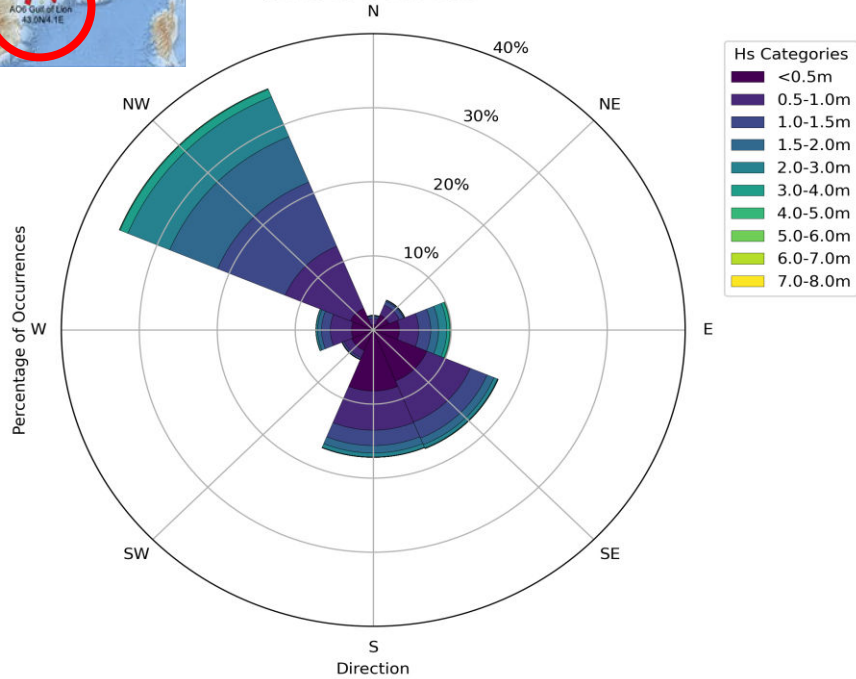
Failure rate by criteria [in %] for all simulations
Global failure [in %] for all simulations

Operability definition : sites selection



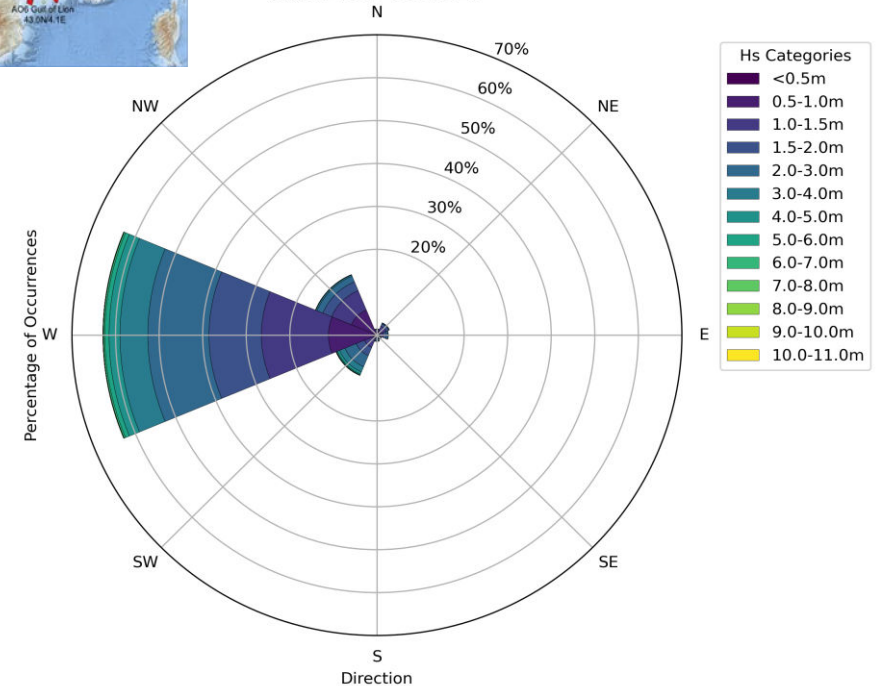
Gulf of Lion (AO6)

Hs from ERA5 by Direction
Jan-1979 to Dec-2020



South Brittany (AO5)

Hs from ERA5 by Direction
Jan-1979 to Dec-2020

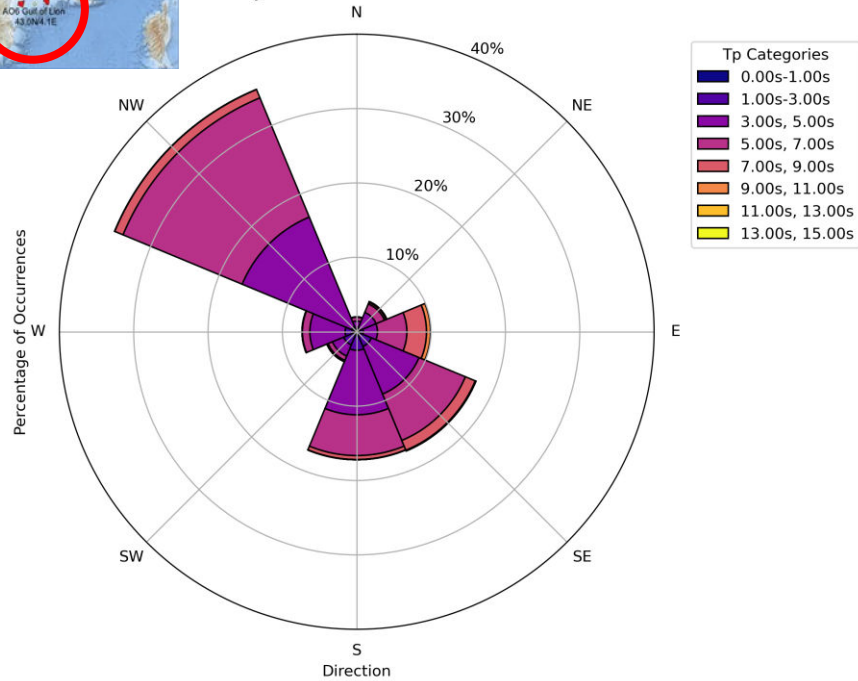


Operability definition : sites selection



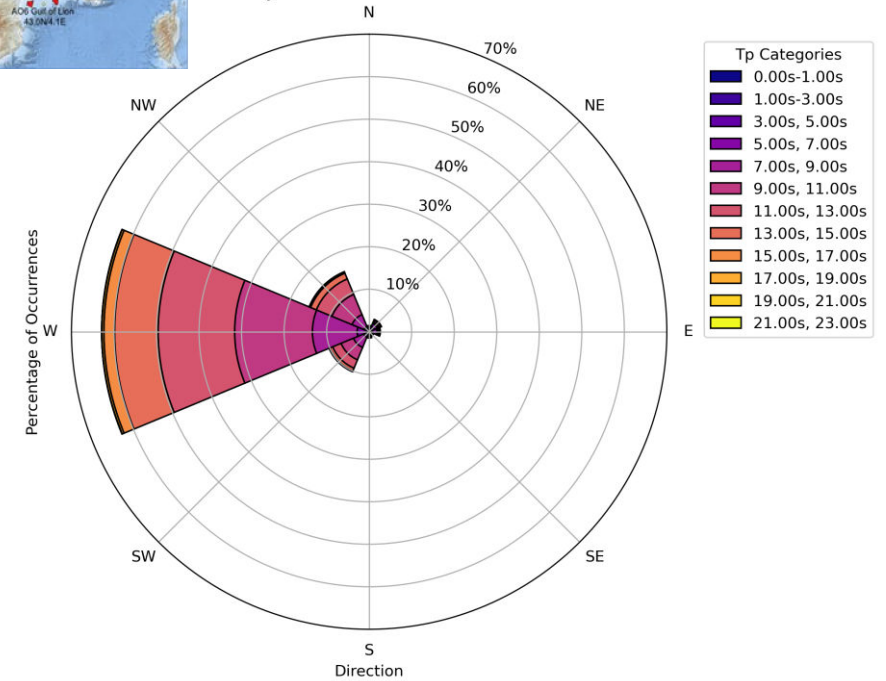
Gulf of Lion (A06)

Tp from ERA5 by Direction
Jan-1979 to Dec-2020



South Brittany (A05)

Tp from ERA5 by Direction
Jan-1979 to Dec-2020



DIEGO/SIMA/ORCAFLEX benchmark outcome

- **The benchmark allows to be confident in the operability result for the different cases (differences highlighted for package motions are acceptable)**
- **When comparing the TLP and the semi-submersible design, the operability results are similar. However, it is challenging to determine whether these differences are due to the floater concept or the numerical model**