Calibration and validation of Floating Offshore Sub-Station numerical model results through experimental tests

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Introduction

In recent years, there has been a proliferation of concepts for Floating Offshore Wind Turbines (FOWT), yet Floating Offshore Sub-Stations (FOSS) have seen limited development progress. These sub-stations play a crucial role in efficiently connecting the energy generated in windfarms to the onshore electrical grid.

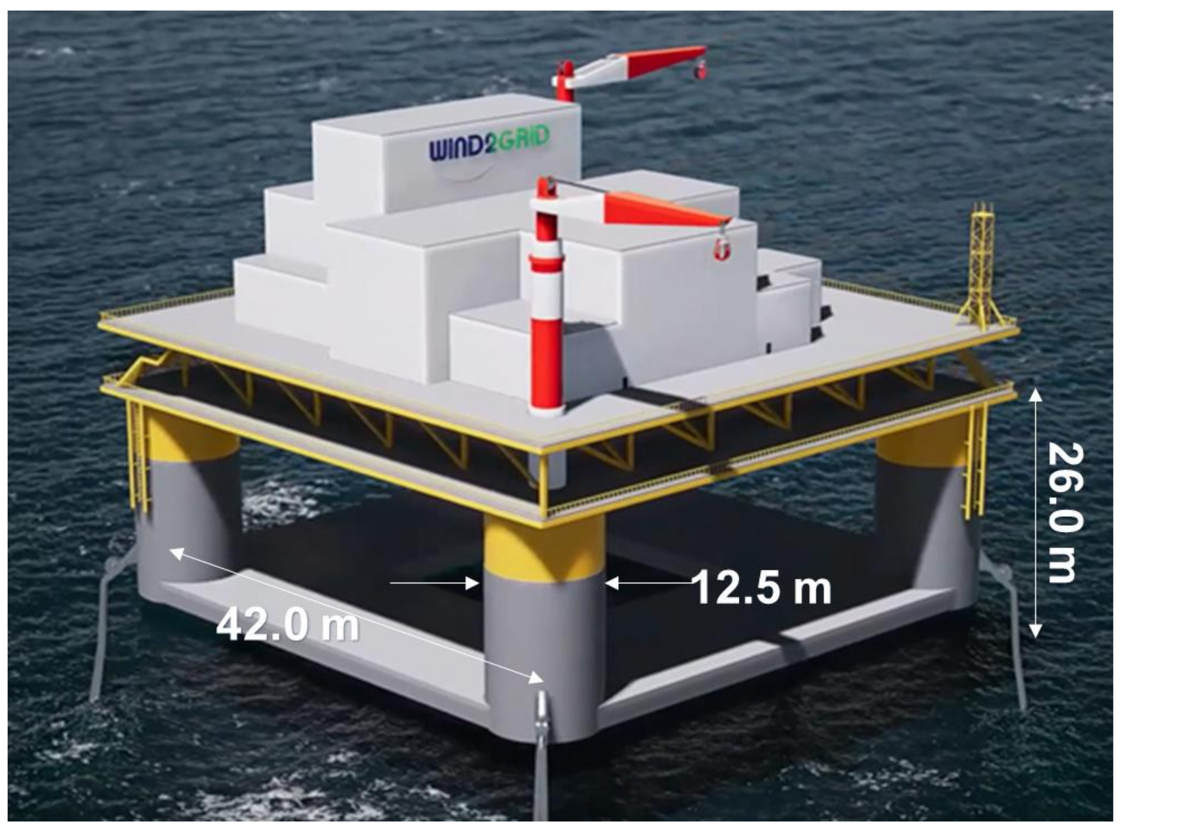
In this context, Nautilus Floating Solutions has worked in the applicability of its mature floater technology to FOSS for future commercial windfarms through the **WIND2GRID** project *(https://www.wind2gridproject.com/eu/)* with the support of a robust consortium of multiple Basque companies. **WIND2GRID** project involved tank test campaigns conducted at CEHIPAR, a wave basin in Madrid, Spain. These experimental tests are crucial for calibrating the numerical model and validating dynamic results obtained from simulations.

The proposed FOSS has been designed using the ScotWind´s NE6 area metocean conditions with a power capacity of 480MW. Weights and dimensions of the whole system are gathered in the table and figure on the right side.

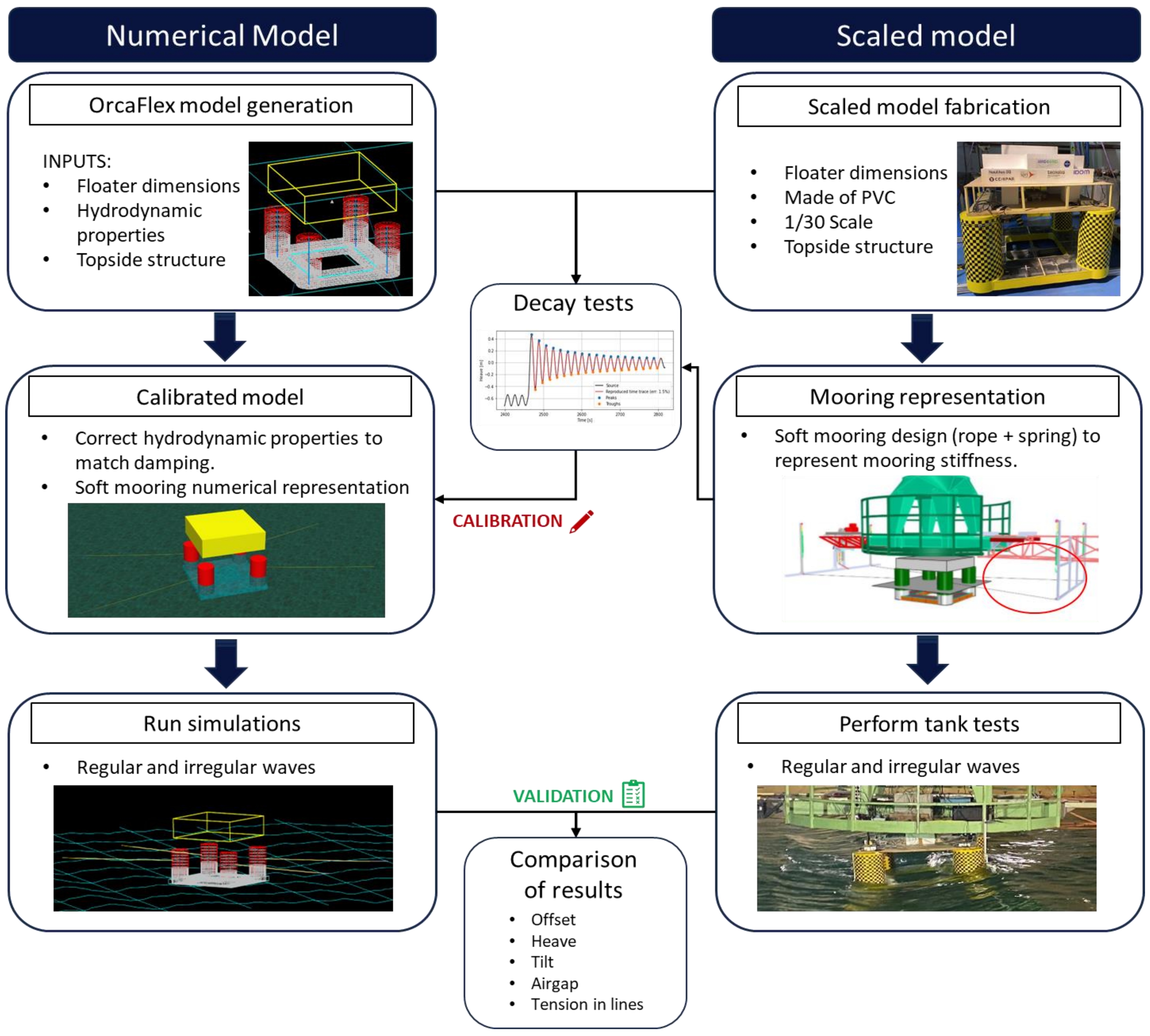
This system needs to guarantee adequate performance to fulfill the following requirements:

- Enough buoyancy to accommodate the top side weight.
- Limited tilt angles and accelerations.
- Sufficient air-gap clearance of the main deck.
- Clashing avoidance between mooring lines and dynamic cables.

FOSS COMPONENT	Mass [t]
Floater	5,574.5
Top side equipment	2,131.6
Total FOSS w/o ballast and w/o mooring	**7,933.2**
Vertical Weight of the suspended mooring lines	626.0
Total FOSS w/o ballast	**8,559.2**
Sea water passive ballast	3,287.7
Total FOSS displacement	**11,846.9**

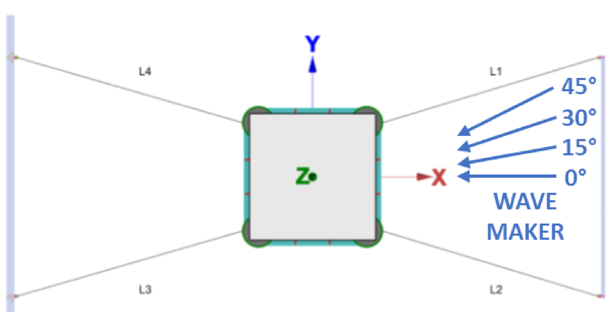


Calibration and validation process



Based on the metocean conditions of the project site, three sea states were defined for four different wave headings:

	Hs (m)	Tp (s)
Sea State 1	4	8.50
Sea State 2	6	10.50
Sea State 3	8	12.5

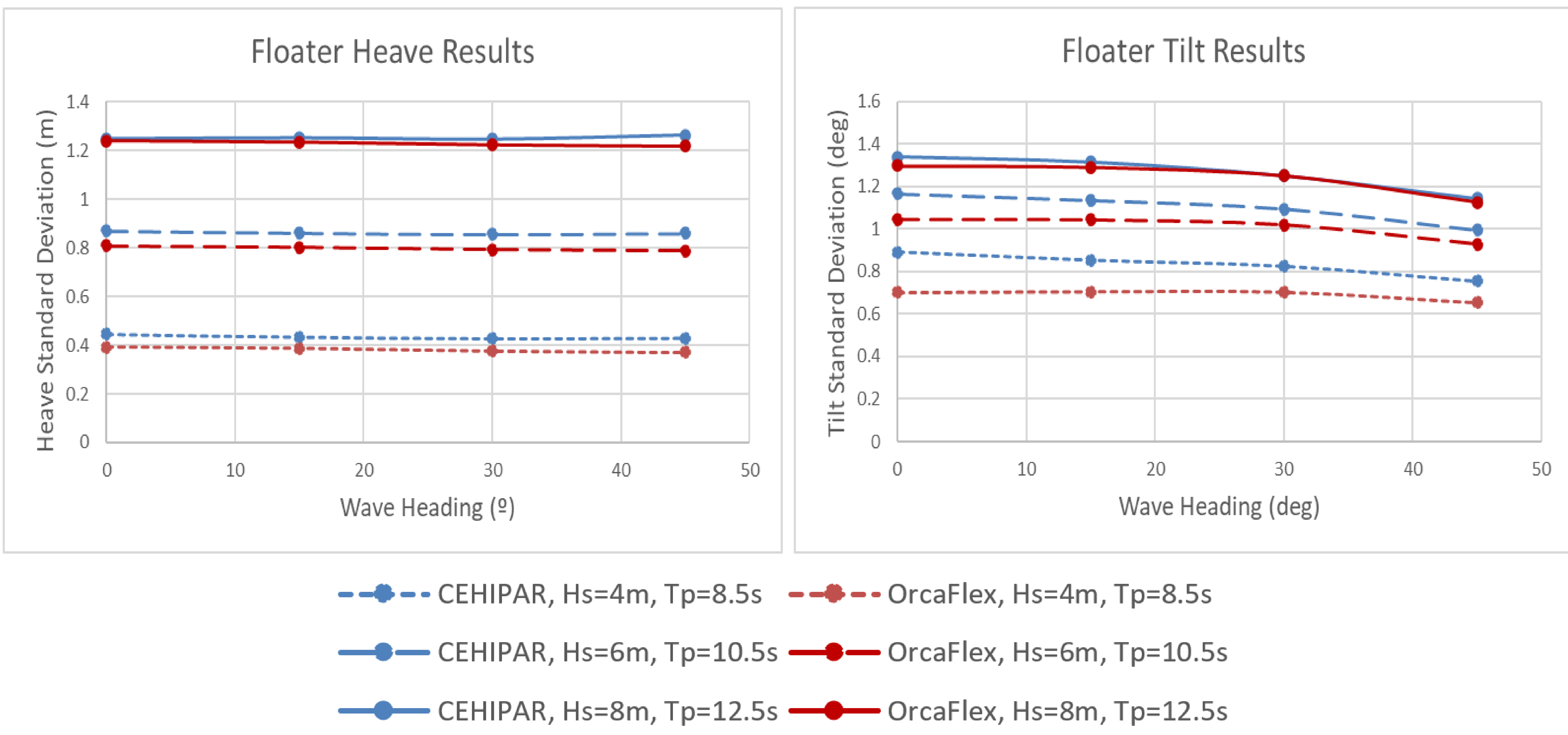


Results

The graphics below compare standard deviation values of floater heave and tilt for 12 load cases, showcasing results from numerical model tests versus experimental tests. Standard deviation serves as a robust statistical indicator, offering a representative measure for comparing results across the entire time interval of the tests performed in the time domain.

The plots indicate good agreement between test results and OrcaFlex® simulations, particularly for sea states with larger waves, with occasional deviations observed for smaller waves.

Notably, heave results remain consistent across different wave headings due to the uniform damping effect of the pontoon in heave.



Tilt results demonstrate good conformity for larger waves, but this conformity diminishes for smaller waves, likely due to peak period influences. Furthermore, mooring lines effect on pitch should not be highly significant. However, the soft mooring design used in tests seemed to have a relevant impact on the damping in surge, sway and yaw, impacting the offset and consequently appearing pitch irregularities as well.

Conclusions

Calibration and validation process of the numerical model was successfully performed, and results showed that the developed FOSS design complies with the defined requirements for the selected sites. However, it is important to highlight that the damping effect of the soft mooring system defined at the wave basin caused some relevant deviations in some results. The main reason for this is that the pulley used in the vertical soft mooring system caused some friction in the lines thus affecting the damping of the system. Therefore, for future phases, Nautilus believes that a horizontal soft mooring system with a simple spring attached to a fixed point is more representative of a real mooring system.

In conclusion, Floating Offshore Substations play an important role in the offshore industry and based on the WIND2GRID project results, Nautilus can provide a promising FOSS concept making use of the experience gained in FOWT.

Acknowledgements

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