PhD thesis offer

<u>Title</u>: Generic analytical modeling of ship collisions against floating offshore wind turbines involving deformable vessels

Context & Objective

To achieve a global transition to renewable energies, offshore wind energy is a promising alternative, but its large-scale deployment poses several challenges. Recently, several collision cases between ships and offshore wind turbines have been reported (see for instance [1-2] and Fig.1) and, as offshore wind farming expands, the likelihood of collisions between ships and floating offshore wind turbines (FOWT) is expected to increase. The consequences of such collisions can be significant: perforation of the ship's tanks resulting in pollution or even in explosion in the case of a methane tanker or a hydrogen-propelled ship, damage to impacted wind turbines up to collapse of the tower, rupture of the anchoring lines leading to the drift of the platform and a collision with other wind turbines in the park.

Fig. 1a. A 37200-tons rudderless cargo ship drifted into the Hollandse Kust Zuid wind farm (Dutch North Sea)

Fig. 1b. The cargo ship Petra L. stroke an offshore wind turbine at Gode Wind 1 wind farm (Germany)

Although the finite element approach allows for a high-fidelity representation of the complex physical phenomena that take place in a ship-FOWT collision event, including large deformations, plasticity, fracture, and fluid-structure interaction, its implementation remains challenging in terms of computation time and expertise needed for model preparation.

Simplified methods based on analytical formulations are thus very useful to assess the damage of both the ship and the wind turbine, especially at preliminary design stage associated to risk assessment, where structural optimization and damage stability analysis require the simulation of hundreds of collision scenarios, involving different striking ships and impact conditions [3-4].

The present research aims to develop a fast and reliable tool, based on the super element (SE) approach [3], capable of predicting the outcomes of a collision between a ship and various types of floating offshore wind turbines. It is based on thesis work previously undertaken at ICAM[1] and University of Liège by S. Echeverry [4], I. Ladeira [5], T. Pire [6] and L. Marquez [7]. Up to now, no development that accounts for the striking ship's deformation has been made, leading to

[1] Institut Catholique d'Arts et Métiers – School of Engineering – Nantes University - France

overconservative predictions of the FOWT's damage. Moreover, the effect of some hydrodynamic forces such as the ones generated by the ship bow wave before and during the impact is still unclear.

In the proposed PhD thesis, the deformation of both bodies will be investigated and integrated into a single solver, which will significantly improve the assessment of the crashworthiness of both the vessel and the wind turbine. The resulting industry-oriented tool will allow the estimation of the damage sustained by the ship and the wind turbine, taking into account different geometries and impact speeds. In addition, the existing "fluid" solver MCOL [8], that considers the hydrodynamic forces during the collision, will be extended to account for the action of the ship bow wave. Validations of the developed tools will be conducted using LS-Dyna non-linear finite element software.

PhD thesis framework

The plan to achieve the above objectives is organized as follows:

- **Step 1**: Analysis of literature related to existing analytical, numerical and experimental works that involve ship collisions against offshore wind turbines.
- **Step 2**: Set-up of LS-Dyna models based on the Coupled Eulerian Lagrangian approach to analyze the influence of both the deformability of the striking ship and the hydrodynamic forces induced by the bow wave.
- **Step 3**: Development of a new SE solver to quickly assess the ship's deformation in case of head-on and side-way impacts and coupling with existing FOWT SE solvers.
- **Step 4**: Extension of the existing "fluid" solver MCOL by integrating the action of hydro-dynamic forces induced by the bow wave.
- **Step 5**: Validation of the coupled MCOL-SE solver by comparison with LS-Dyna results.
- **Step 6**: Publication of the results in peer-reviewed international journals and redaction of a PhD dissertation.

References

[1] Jasmina Ovcina Mandra. Cargo ship strikes turbine at orsted's gode wind 1 offshore wind farm, suffers massive damage, https://www.offshore-energy.biz/cargo-ship-strikes-orsteds-gode-wind-1-offshore-wind-farm-suffers-massive-damage/, 2022

[2] Margientimmer. Rudderless Julietta D causes damage to foundation of wind farm Hollandse Kust Zuid - Windpark Hollandse Kust South. https://hollandsekust.vattenfall.nl/en/blog/2022/02/02/rudderless-julietta-d-causes-damage-to-foundation-of-wind-farm-hollandse-kust-zuid/, 2022

[3] Hervé Le Sourne, Nicolas Besnard, Cedric Cheylan, and Natacha Buannic. *A ship collision analysis program based on upper bound solutions and coupled with a large rotational ship movement analysis tool.* Journal of Applied Mathematics, 2012.

[4] Sara Echeverry. *Numerical and analytical study of a spar-like floating offshore wind turbine impacted by a ship.* PhD thesis, University of Liege, 2021.

[5] Icaro Ladeira. *Development of a fast and reliable solver based on simplified formulae to assess the response of standalone tubular Offshore Wind Turbine support subjected to ship impact.* PhD thesis, Ecole Centrale Nantes, ICAM, 2023

[6] Timothée Pire. *Development of a code based on the continuous element method to assess the crashworthiness of an offshore wind turbine jacket.* PhD thesis, University of Liege, 2018.

[7] Lucas Marquez. *Analytical and numerical modelling of ship collisions against floating offshore wind turbines with concrete floaters*. PhD thesis, University of Liege, 2024.

[8] Hervé Le Sourne, Edmond Remy Donner, François Besnier, Michel Ferry. *External dynamics of ship-submarine collision.* In Proceedings of 2nd International Conference on Collision and Grounding of Ships (ICCGS), Copenhagen, 2001

Location and Supervision

This work will be carried out at ICAM School of Engineering, Nantes campus, France.

Supervision will be provided by:

- Hervé LE SOURNE (herve.lesourne@icam.fr) – ICAM / GeM laboratory
- Ye Pyae SONE OO (ye-paye.sone-oo@icam.fr) – ICAM / GeM laboratory

The PhD diploma will be delivered by Nantes University – Ecole Centrale de Nantes.

Job application

Applications (CV, cover letter and master's transcript) must be sent to the supervising team.

Start / Salary

Start as soon as possible / Annual salary: € 33 700