TRL+ : DESIGN STRATEGY AND SIMULATIONS RESULTS OF AN UPSCALED SEMI-SUB PLATFORM

PO050

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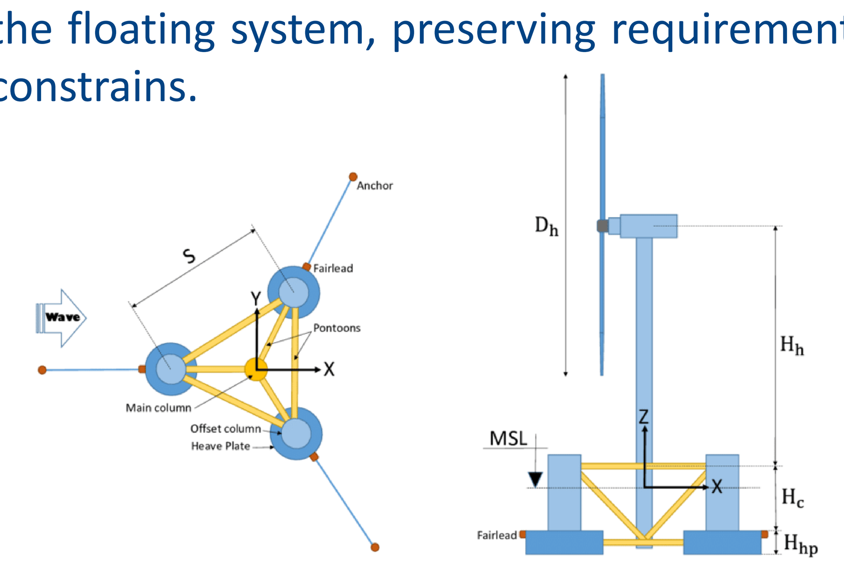
Abstract

The work presented is part of the activities planned within the TRL+ project, a national research project, financed by the Spanish Ministry of Economy, Industry and Competitiveness (MINECO), which aims to deliver innovative and highly competitive services to boost the offshore energy sector, supporting developers and players from the offshore industry. The project is intended to bring a contribution on the offshore energy sector by designing and investigate the behavior of a semi-sub floating platform. In particular it focuses on a rescaling process of the DeepCwind concept, aiming to tailor the platform to the DTU 10 MW Reference Wind Turbine, a turbine aligned with cutting edge offshore wind turbine generators.

Objectives

The TRL+ aims to create a public domain where researcher and professionals involved in the development of FOWTs can access the data and contribute on the improvement of the chosen semi-sub platform. This presentation illustrates the approach undertaken to carry out the design activities which defined the floating platform characteristics and the 10 MW DTU RWT control strategy.

The four columns semi-sub platform, designed within the DeepCWind consortium and later studied in the OC4 activities is upscaled to host the multi-megawatt DTU 10 MW RWT. The scaling procedure is carried out guaranteeing the seakeeping performances of the floating system, preserving requirements in terms of safety factors and wind turbine constrains.



* Draft and main parameters of the semi-sub DeepCWind floating platform (Source [1])

* Bimep test site arrangement

The platform design is combined by the mooring system, which must be redesigned. The procedure is conducted in parallel with the platform design, considering the morphological and atmospheric conditions recorded at the BIMEP test site.

The FOWT system definition is completed with a procedure aimed to tune the DTU 10 MW RWT controller, a crucial task to guarantee the achievement of platform stability and proper wind turbine operations.

Once the FOWT system is delineated, its validation is carried out by means of an extensive validation by means of numerical simulations and model testing activities. However the results of such phases will be presented in another context.

Methods

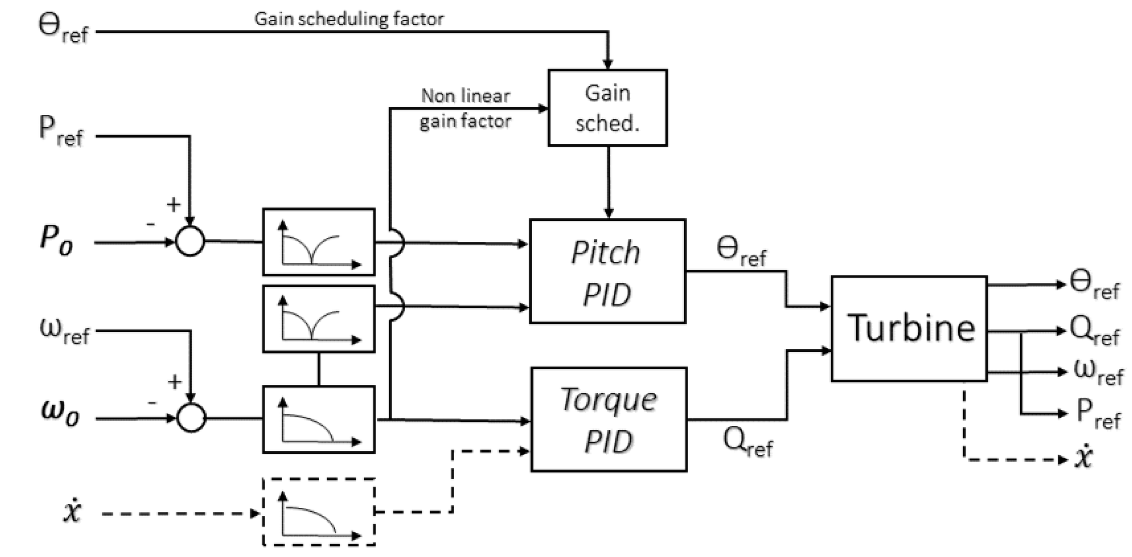
The objectives are pursued by means of numerical simulations executed with several tools at disposal of the Offshore Engineering and Ocean Energy Group at IH Cantabria.

Tanking the DeepCWind platform as a reference [2] the floater upscaling procedure was derived by means of the Froude law. Upscaling of the structural elements was taken into account in order to represent the displacement/inertia of the floater in a realistic way. Scantlings of the platform were scaled maintaining the safety factor used in the DeepCWind platform. The design of the floater and its station keeping system is compliant with the DNV standard [3].

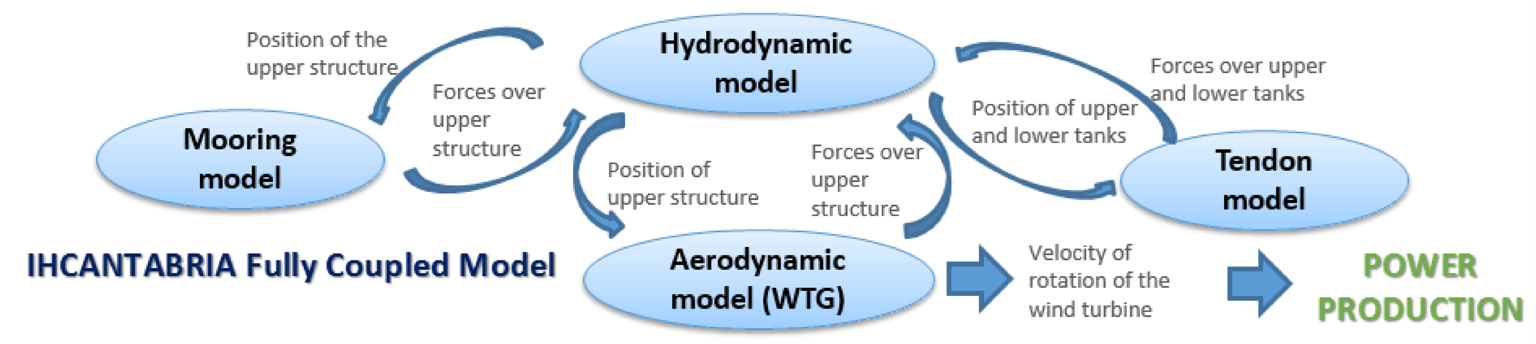
For the upscaling procedure three bigger platform scales were used in order to generate a trend line for the optimum solution. The selection of the optimum scale was based on the operativity of the platform, the costs of production/installation and the fulfillment of the technical requirements. Operativity of the platform was evaluated using the acceleration and maximum angles at the nacelle, while the production cost was estimated based on the structure weight.

Regarding the wind turbine controller definition, it was chosen to employ a controller based on the onshore DTU 10 MW RWT controller (baseline PID controller for both generator torque and collective blade pitch). The focus of the controller adaptation is posed on the full loads regions. Basically the targets aim to guarantee high levels of turbine performances and, a the same time, a stable platform behavior. The optimal trade off between the mentioned requirements is found by persecuting the optimal setup of the PID's gains and redefining the gain scheduling strategy. Moreover, in order to help the rotor speed stability above rated speed, the generator torque controller is set to constant torque rather than constant power [2].

Beside the adjustment of the blade pitch PID gain scheduling, the controller architecture is integrated with the introduction of the nacelle velocity as feedback for the torque PID. This solution is implemented to be compared with the basic control outline.



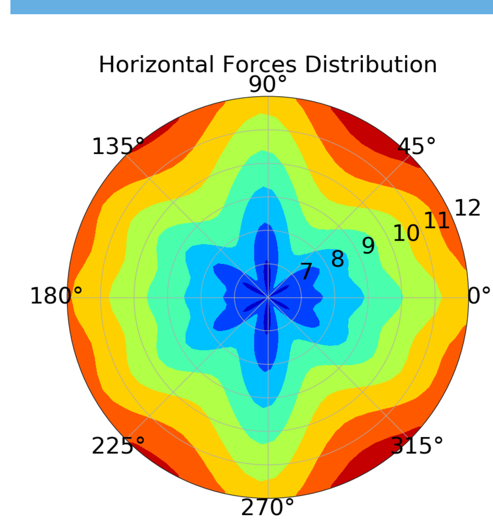
The controller optimal setup is obtained, in a first stage, by means of dynamics analysis performed on simplified models. Later, the influence of the controller on the overall system response is assessed by the in-house full coupled numerical model developed at IH Cantabria. Such tool allows to include the complexity of the whole system, considering the coupled effects of hydrodynamic, aerodynamic, mooring system dynamics, as well as the controller influence.

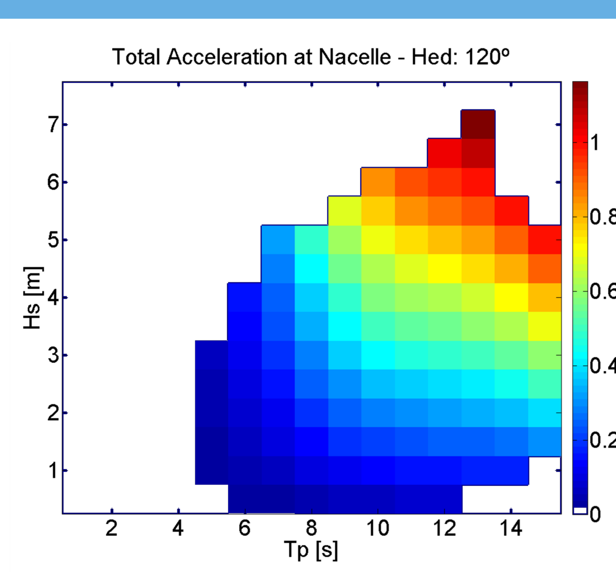


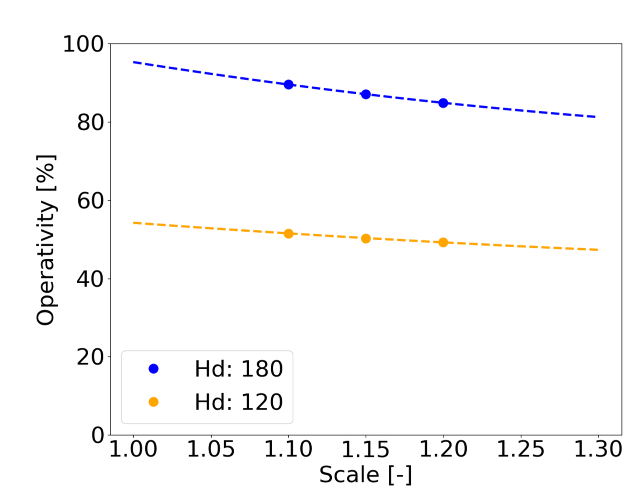
The model is based on a system of second order differential equations built around the Cummin's equation.

$$(M + A_{\infty})\ddot{x}_{(t)} + \int_0^t k(t-\tau)\dot{x}_{(\tau)}d\tau + Cx_{(t)} = \sum F_{(t)}$$

Results







In this section it is shown how the operativity of the platform evolves with the scale. Horizontal forces graph shows which might be the preference directions to reduce wave forces, while the scatter acceleration graph shows the evolution of the nacelle acceleration with the Wave Peak Period and Significative Height.

Conclusions

The purposes of the TRL+ project have been introduced. The DeepCWind platform has been rescaled in order to accommodate the DTU 10 MW RWT, a turbine comparable with commercial forefront machines. The platform and mooring system upscaling strategy aims to minimize the cost of production/installation of the wind turbine while attaining a good operativity and fulfilling the technical requirements. On the other hand, the approach adopted to adjust the DTU 10 MW RWT controller aims to avoid negative damping and maintain stable turbine operations. It focuses not only on the adjustment of the gains, but also by setting the gain scheduling strategy and optionally, feeding the generator torque PID with the nacelle velocity.

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