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D4.3 Optimization framework and methodology for optimized floater design

Floating offshore wind turbines are complex dynamic systems. The optimization in terms of cost and dynamic behavior is the focus of the present report, which is part of Subtask 4.1.3 of the LIFES50+ project. Subject to the optimization is the floating platform hull shape while adapting the wind turbine controller to the properties of the platform in every optimization loop. The framework includes several simulation codes and design scripts including a parameterized panel code and a simplified coupled floating offshore wind turbine model (SLOW); see Figure 1 for a general overview. Especially new is the inclusion of the wind turbine controller into the optimization loop where a linear model is included for model-based control design and a nonlinear model for the calculation of the time domain response.

The simplified model is an essential part of the framework, as the numerous iterations that are part of an optimization procedure require a sufficiently small runtime. The model consists of a nonlinear multibody system, which can be easily adjusted for new layouts of the floating wind turbine and platform. The efficient modeling results in a short simulation time, which enables the designer to run many system simulations and sensitivity studies early in the design and hence is also ideally suited for optimization applications. The load cases considered are the operational conditions of the Site B of the LIFES50+ Design Basis (D7.2).

Prior to the optimization a design space exploration was done based on a Design of Experiment methodology in order to verify the appropriate definition of the free variables, the free variable bounds, the cost function and the subsystem design assumptions. For the selection of the optimizer, a metamodel based on an Artificial Neural Network fit was applied in order to find the algorithm with the least necessary iteration and its settings.

The results of the optimization show that with the given set of free variables of a concrete semi-submersible platform it is possible to significantly reduce the response amplitude for the given site. However, this happens at the cost of increased expenditures for the material due to an increased structural mass. The benefit is not the increased mass, but the reduced draft which requires an increased column radius to fulfill the hydrostatic restoring requirement in pitch direction. With such a low-draft semi-submersible with thick heave plates a design for wave cancellation is possible with a significant reduction of the response of e.g. the tower-top and the rotor speed to waves. In a next step in LIFES50+ the optimization framework will be applied to optimize the two generic concepts to be selected. While the general findings are considered valid, a higher-fidelity study in the subsequent design phases, including other load cases and ultimate loads, will further enhance the method and prove the results.

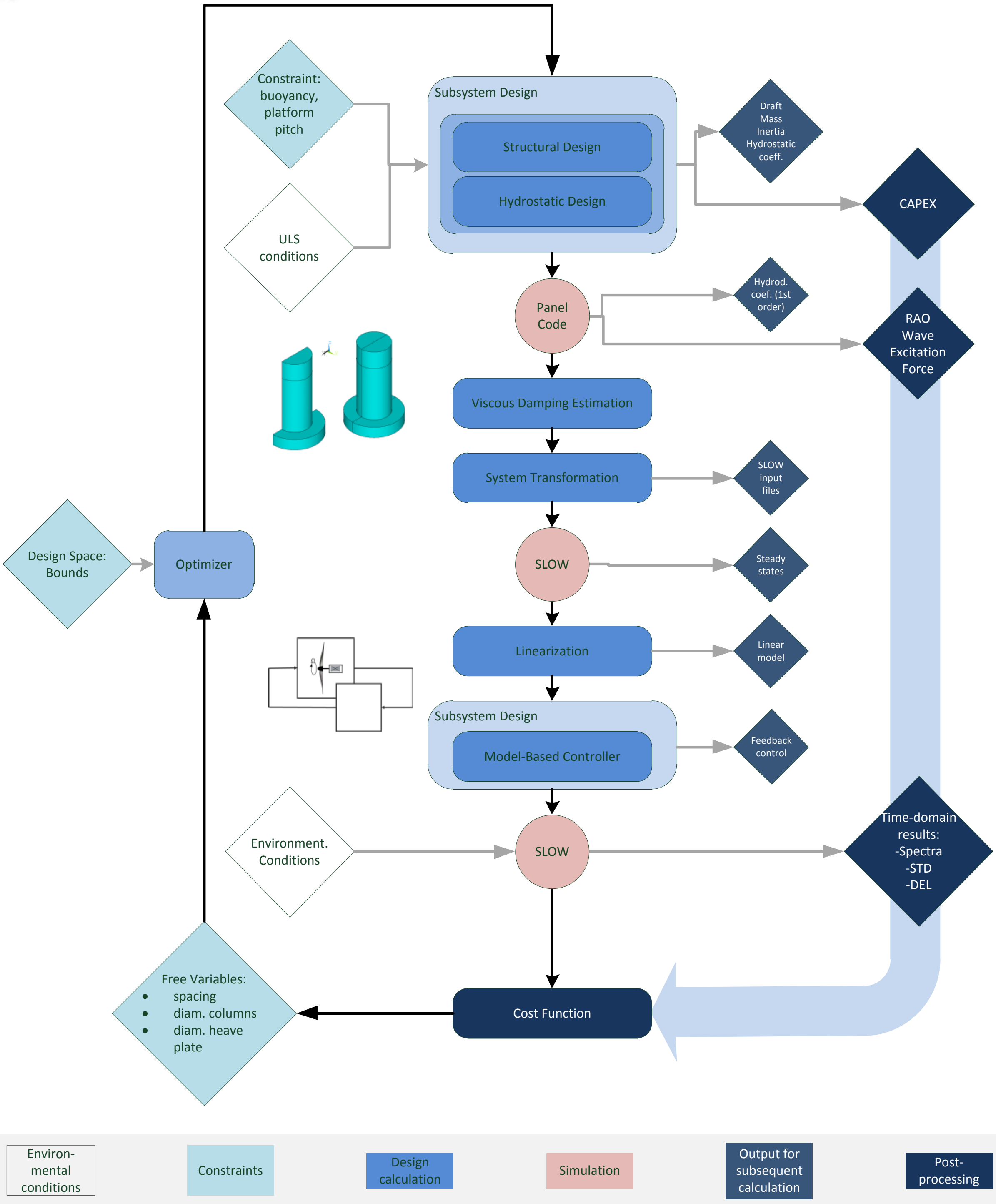

Figure 1: Workflow of optimization procedure