Initial Calibration of a FAST model of the MARINTEK Hybrid Semisubmersible Experiment

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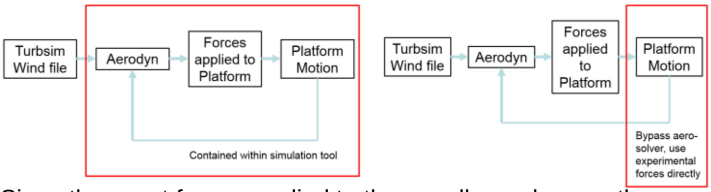
Abstract

Small-scale experiments of floating offshore wind turbines are invaluable for validation of design codes used in research and the industry. However, there are difficulties in scaling the aerodynamic and hydrodynamic forces of small-scale tests. The experiment from MARINTEK conducted in October 2015 uses a novel aerodynamic actuation system to eliminate the scaling effects by applying simulated aerodynamic forces using a system of wires and motors attached to the top of the tower of the experimental platform. This system allows for correctly scaled forces that can be measured directly during the experiment. Simulating this experiment presents some challenges, as modeling this aerodynamic system requires some additions to most design codes. In this poster, a FAST model of the MARINTEK semisubmersible platform is developed and compared to data from the experiments, with special consideration to the aerodynamic simulation.

Motivation

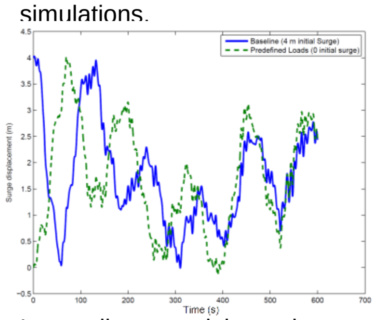
How to best model the aerodynamics of the hybrid system in a simulation?

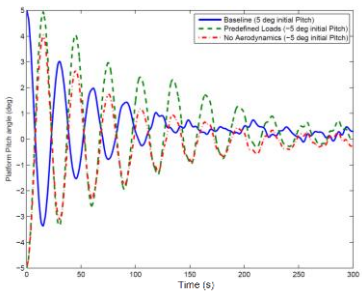


Since the exact forces applied to the nacelle are known, these could be applied directly to the simulation, bypassing the aerodynamic solver, but any inaccuracies in the hydrodynamic modeling would mean that the aerodynamic damping forces caused by motion of the rotor would be incorrect.

Initial Work

- A change to the source code of FASTv7 was written to enable an external file of aerodynamic force to be applied to the rotor, bypassing AeroDyn.
- A series of simulations were run using this modified version of FAST and the OC3 spar buoy model.
- An artificial experiment was created by running a set of baseline simulations
- The rotor forces of the baseline simulation were recorded and used in place of the aerodynamic forces in a second set of simulations.





- It was discovered that using predefined loads has little effect on the results if the platform model is similar to the platform that the aerodynamic loads are from.
- However, as the above figures show, if the phase of the platform motion is different, the out-of-phase aerodynamic damping forces have a large impact on the platform motion

Calibration of the Model

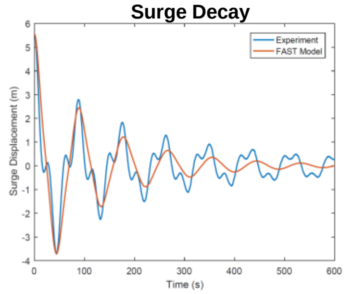
The MARINTEK experiment uses a braceless semisubmersible platform and a unique aerodynamic actuator consisting of tension-controlled wires attached to a rigid frame in place of a spinning rotor, as can be seen in the picture to the right.

The experiment included many combinations of wind and waves, including free-decay tests, free-decay with wind, regular waves, regular waves with wind, irregular waves, irregular waves with wind, and a variety of fault cases. This poster will focus on the decay tests with and without wind.

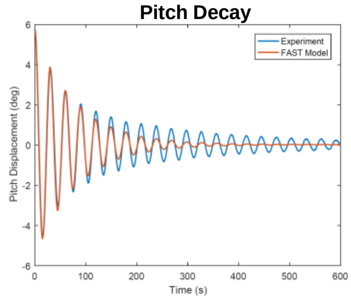
The intention of this work was to repeat the aerodynamic investigation performed on the OC3 spar buoy in previous work. However, the FAST model currently exhibits inaccuracies that will be discussed here instead.

Free Decay Tests:

Surge Decay



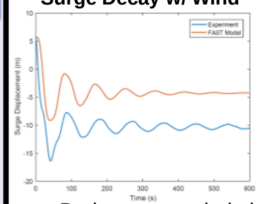
Pitch Decay



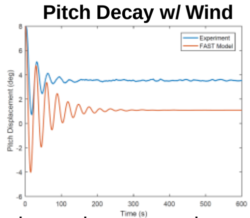
- Mass and inertia from report, drag coefficients tuned by hand
- Experimental surge decay exhibits coupling between the surge and pitch DOFs that the model did not show
- Both surge and pitch free decay's have large quadratic damping that isn't modeled correctly

Free Decay Tests with Constant Wind:

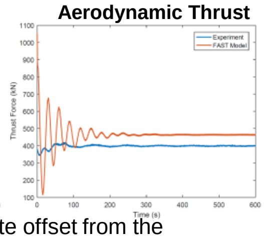
Surge Decay w/ Wind



Pitch Decay w/ Wind



Aerodynamic Thrust



- Both surge and pitch show a larger steady state offset from the constant (8m/s) wind in the experiment than the simulation.
- This was thought to be due to more aerodynamic thrust in the experiment, but there is actually slightly higher thrust in the simulation
- Therefore, there must be a discrepancy in the mass/inertia of the simulation model (if the mass was correct but the stiffness wasn't, the frequencies would be incorrect). Future investigation is needed to determine where this discrepancy is.
- In addition, there is more influence from the platform motion on the aerodynamic thrust in the simulation, further motivating this work, but the geometric model needs to be corrected before proceeding

References

1. Sauder, T., Chabaud, V., Thys, M., Bachynski, E., and Saether, L. *Real-time Hybrid Model Testing of a Braceless Semi-submersible Wind Turbine. Part I: The Hybrid Approach.* Proceedings of the 35th International Conference on Ocean, Offshore, and Arctic Engineering. June 2016.
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3. Berthelsen, P., Bachynski, E., Karimirad, M., and Thys, M. *Real-time Hybrid Model Testing of a Braceless Semi-submersible Wind Turbine. Part I: Calibration of the Numerical Model.* Proceedings of the 35th International Conference on Ocean, Offshore, and Arctic Engineering. June 2016.

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