

Introduction

The design of OWTs in the US differ from the European experience due to extreme weather conditions, different soil conditions, regulations related to noise mitigation and supply chain availability. For floating OWTs, technical barriers include insufficient experimental data and poor understanding of the interactions between different subsystems.

To address these differences and barriers, upgrading **national testing facilities** and developing **coupled simulations** are required to understand the behavior of OWT structures for U.S.-specific loading and geotechnical conditions and to reduce the levelized cost of energy (LCOE).

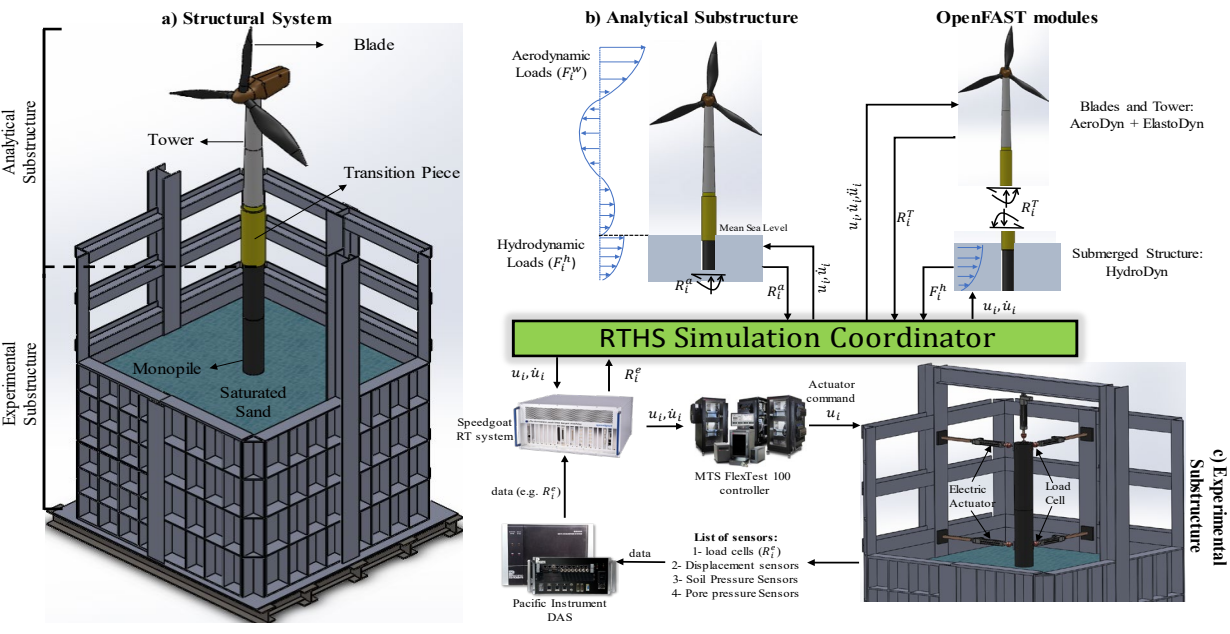
The goal of this DOE-funded project is to upgrade the **soil-foundation interaction (SFI) testing facility** at Lehigh by acquiring new capabilities and to develop a **coupled aero-hydro-mechanical hybrid simulation approach** to accurately model U.S. field conditions in the laboratory and simulate current and next-generation fixed-bottom and floating offshore wind turbines (OWTs). The upgraded testing facility and the hybrid simulation approach for OWTs will be used to perform pilot projects simulating U.S.-specific environments. These efforts is accompanied by a marketing campaign to broaden its user base.

Hybrid Simulation Concept

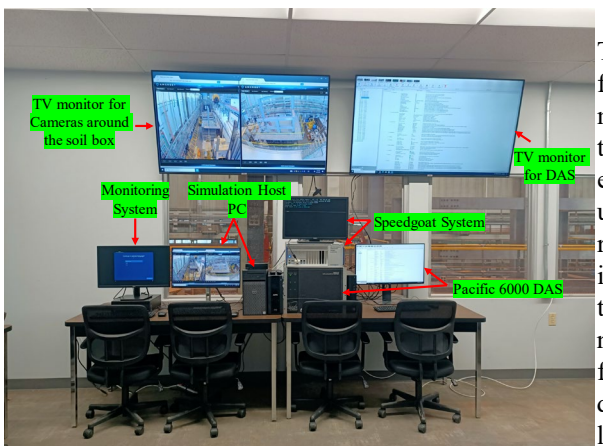
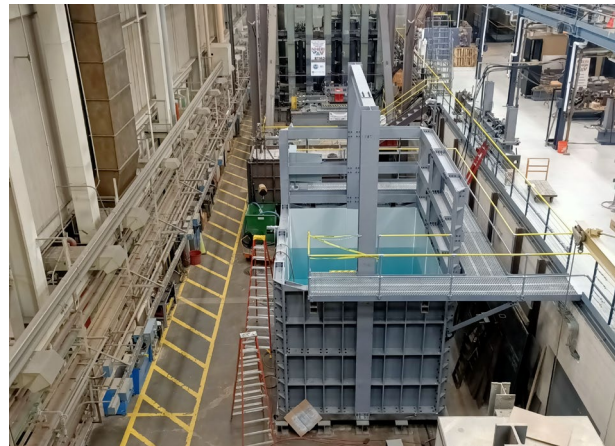
In a hybrid simulation, the OWT system is divided into subsystems; some modeled numerically (i.e., **analytical substructure**), and others experimentally tested in the laboratory (i.e., **experimental substructure**).

These subsystems are kinematically linked in the spatial and time domains to ensure that the interaction between the subsystems is properly captured which enables accurate understanding of the response of the complete OWT structure.

Real-Time Hybrid Simulation (RTHS)



Experimental Testing Facility



Actuators & Control Systems

MTS Controller: Provides real-time closed-loop control, with transducer conditioning and function generation to drive various servo-actuators.

Real-Time System: This model-in-the-loop kernel executes a model compiled through MathWorks Simulink.

Data Acquisition System: The enclosure has 16 slots for input and output modules with a Universal Serial Bus computer interface for data output.

Electric Actuators: The facility has 5 high force with excellent lead accuracy. The actuators total stroke length is 10 in.

Capabilities and Future Plans

The RTHS Testing Facility allows for: (1) generating real data from large-scale tests; (2) simulating the coupled aero-hydro-mechanical interaction of the whole OWT structure as opposed to the sequential iterative process currently used by design engineers; (3) applying loads to model operational conditions under calm sea (high-cycle fatigue), operational conditions with rough sea state, and extreme events (low-cycle fatigue); (4) investigating different soil and foundation conditions, simulating their installation in the laboratory and evaluating the response of new concepts; (5) testing new designs to identify flaws before field deployment; and (6) evaluating the response of different designs, foundation systems and investigating the effects of snap loads and anchor uplift for floating OWTs.