New England Aqua Ventus I

US DOE
Advanced Technology Demonstration Program for Offshore Wind

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Ocean Renewable Energy Conference XIII
September 18-19, 2018

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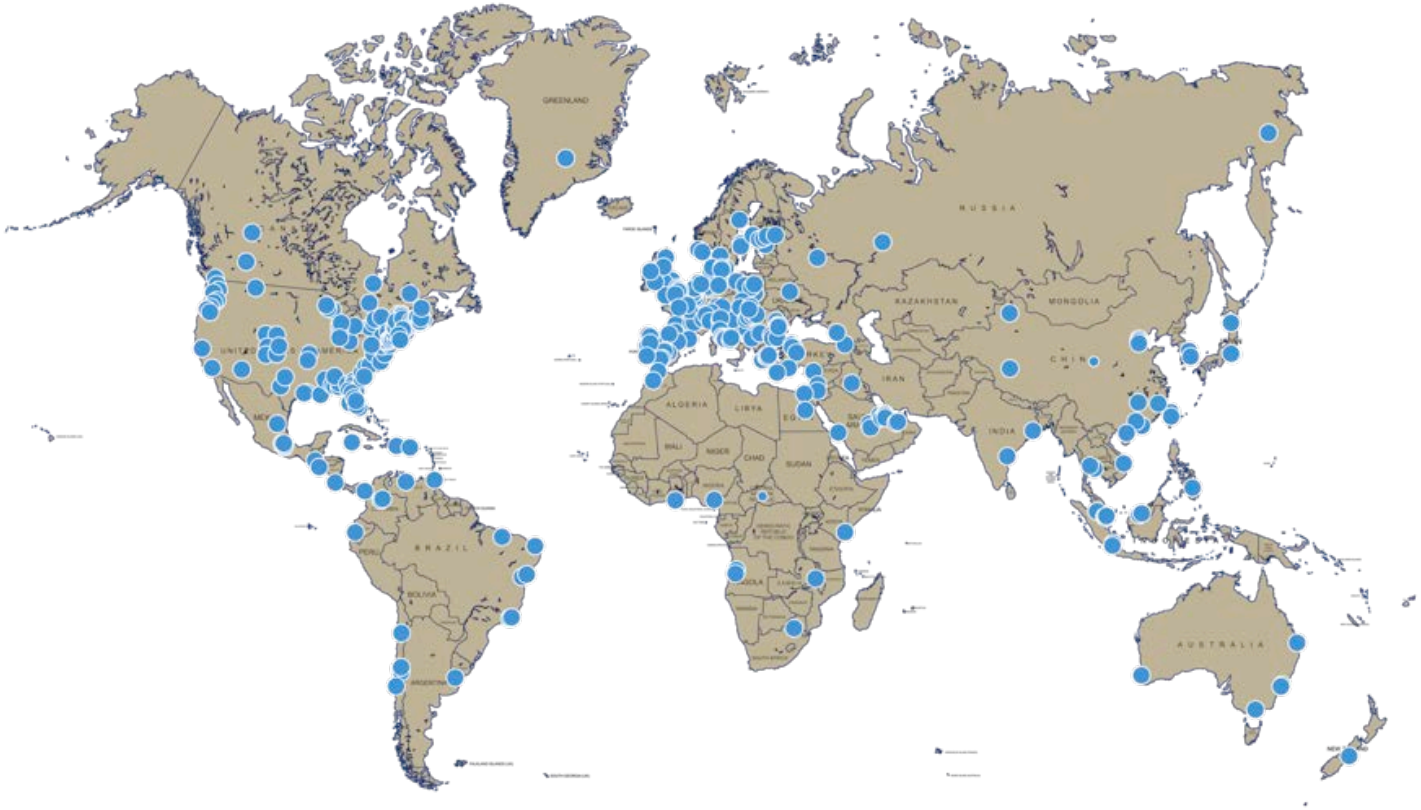
Outline

- Who We Are
- Project Overview
- Testing of Three Floating Wind Turbine Platforms
- Concrete Semi-submersible Technology (VolturnUS)
- Project Status
- Next Steps

- Founded though the NSF in 1996
- 180 faculty, staff and students/year
- 100,000 ft² lab
- 2,000+ students funded from 35+ majors at UMaine
- 78Spinoff companies

Our Partners and Clients:



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Over $130 Million R&D

Major Funding Agencies:

NIST
National Institute of Standards and Technology
U.S. Department of Commerce


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ADVANCED STRUCTURES & composites center

Wind Blade Research and Structural Testing

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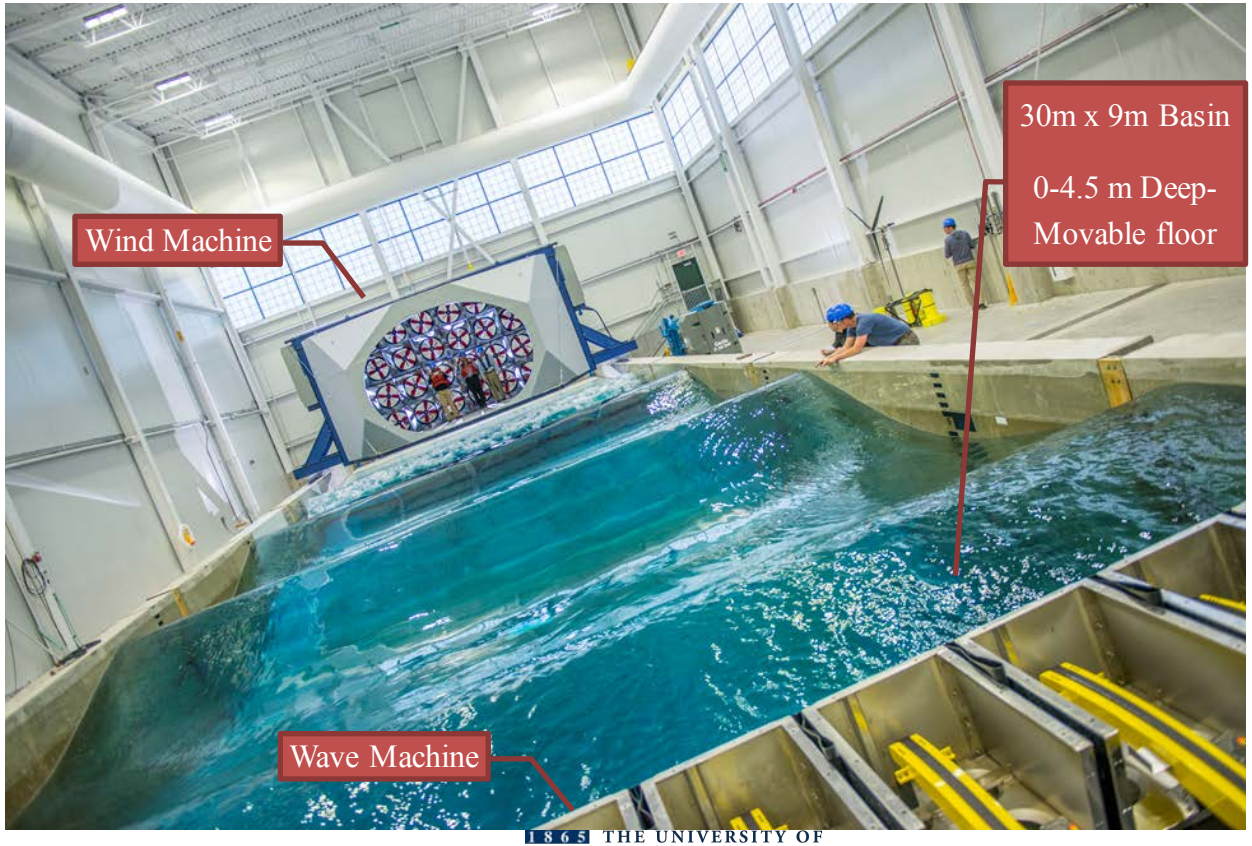
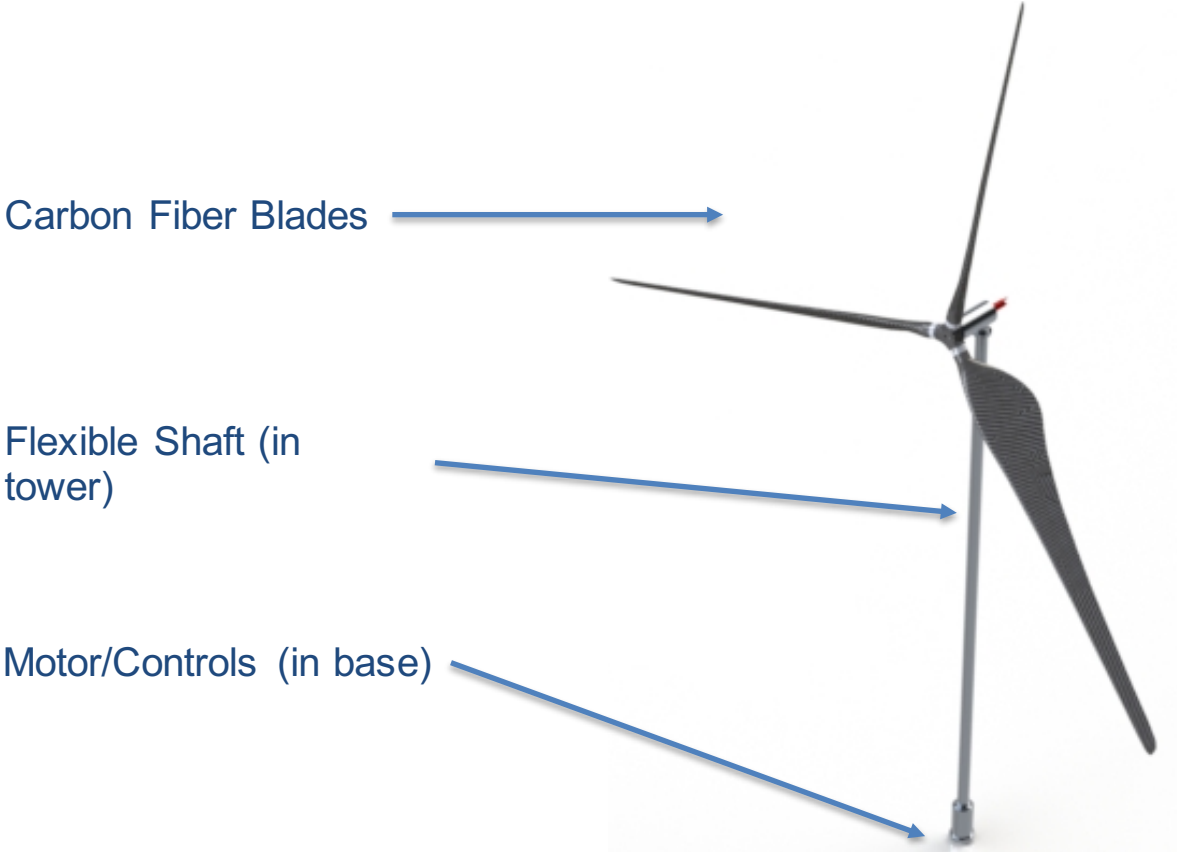
National Level Test Facility: Wind Wave (W^2) Ocean Engineering Laboratory

Quality Wind and Wave Scaling

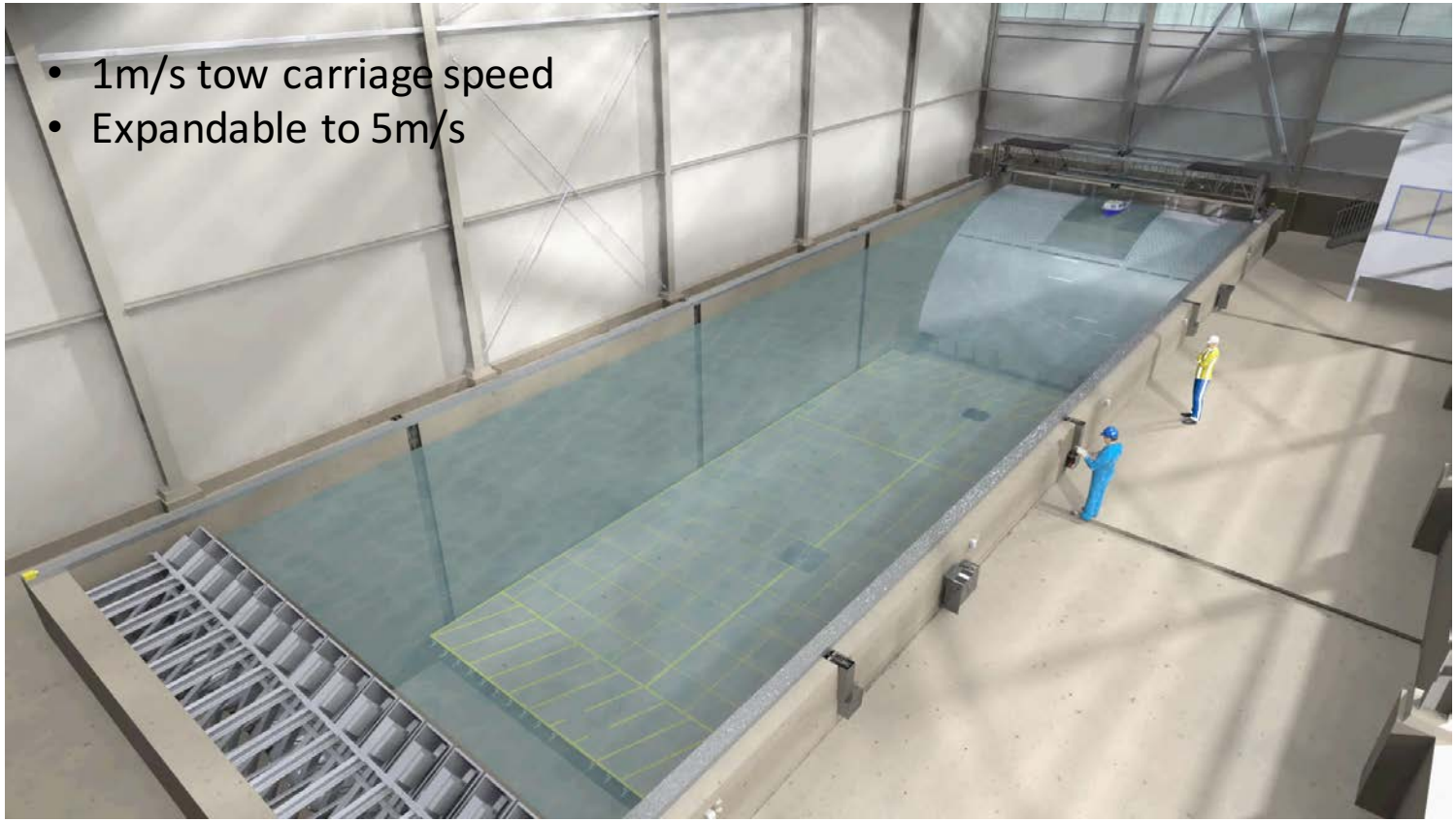


Next-gen Scale Turbine Modeling

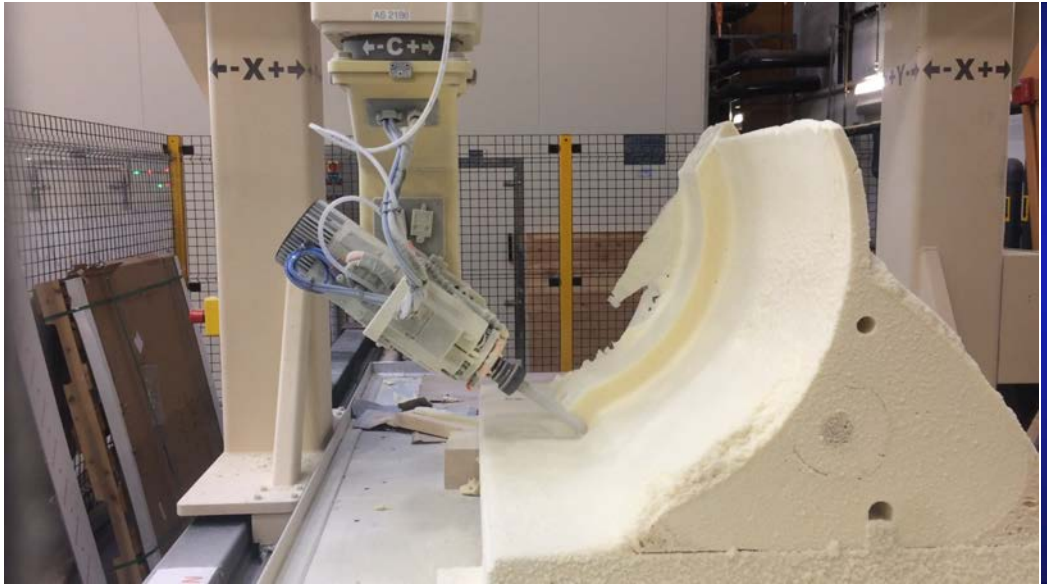


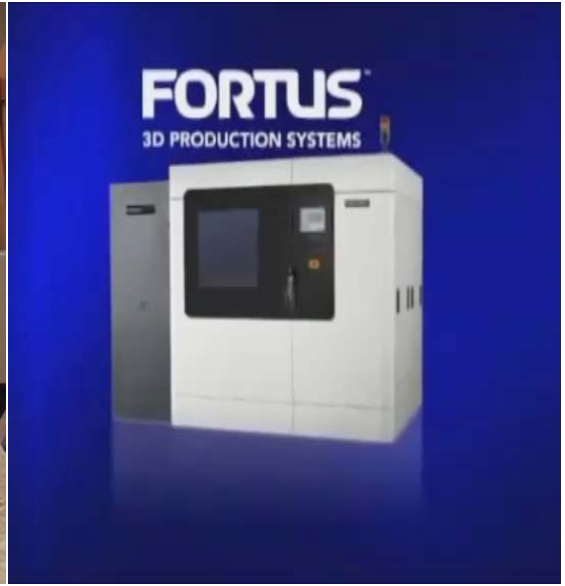
- Multi-scale offshore wind turbine capable of simulating a variety of commercial turbines of varying sizes (6-15MW+).
- Individual or collective blade pitch control.
- Carbon fiber blades
- Motor/controls mounted in hull.
- Light-weight tower top mass
- 3 m rotor diameter.

Towing System



Model Construction Equipment





5-axis CNC (4’x5’x8’)

3D Printing (3’x3’x2’)

UMaine/ DOE Project Overview

Started 10 years ago!

- Demonstrate two x 6MW floating concrete turbines by 2021-2022
- VolturnUS floating concrete tech:
  - Lends itself to serial production
  - LCOE for utility-scale <7c/kWh
- Northeast US - dense population, high electricity costs and expanding electricity demand
- 55 Million in Northeast in an area no bigger than Texas!
- $50.7M DOE Advanced Offshore Wind Technology Demonstration Program

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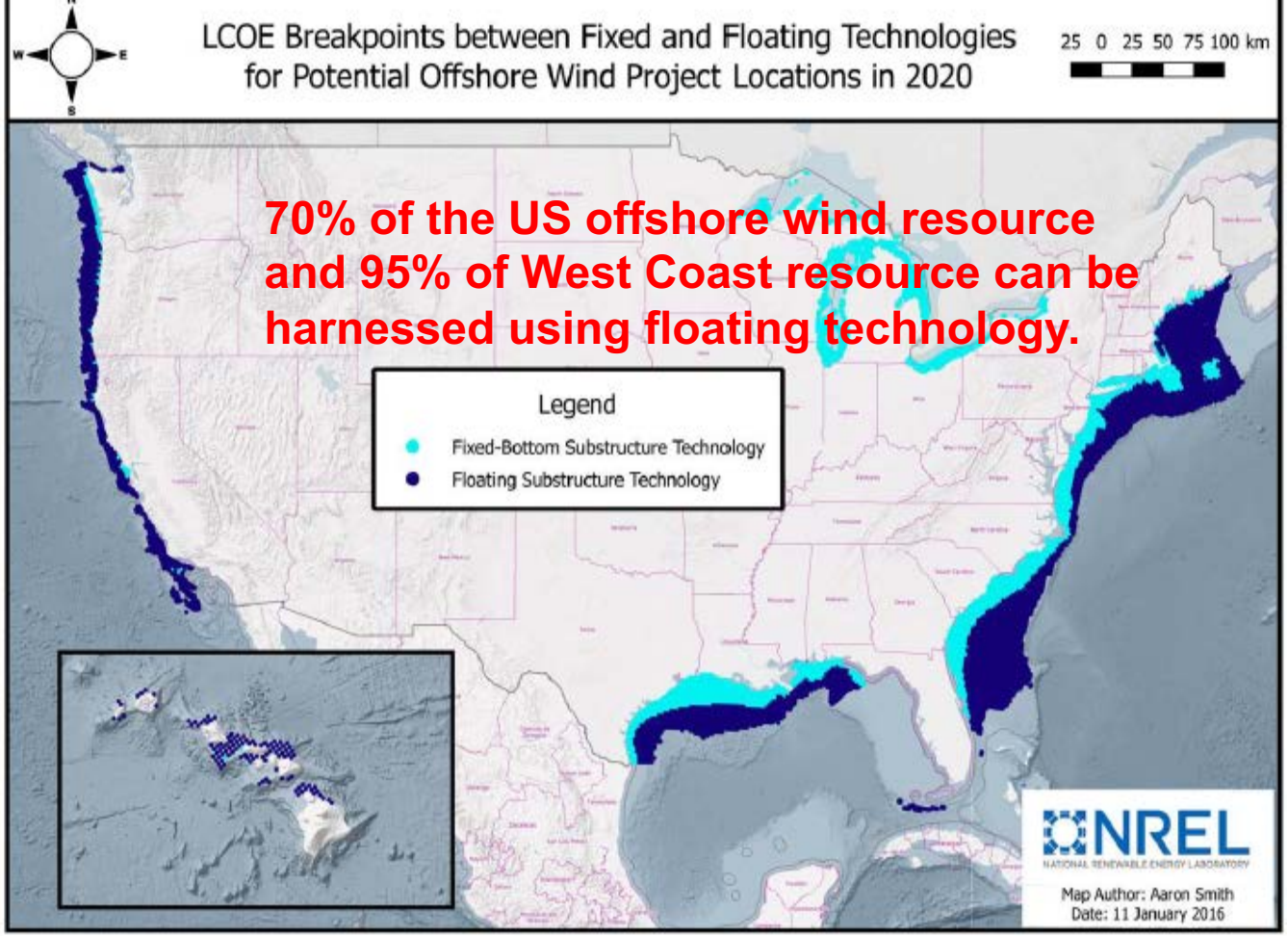
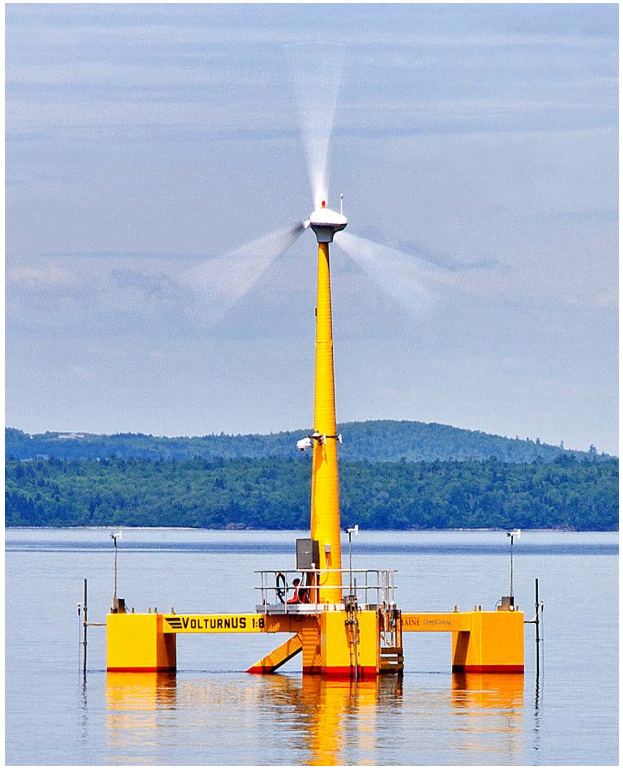

LCOE Breakpoints between Fixed and Floating Technologies
for Potential Offshore Wind Project Locations in 2020
25 0 25 50 75 100 km
70% of the US offshore wind resource and 95% of West Coast resource can be harnessed using floating technology.
Legend
Fixed-Bottom Substructure Technology
Floating Substructure Technology
NREL
NATIONAL RENEWABLE ENERGY LABORATORY
Map Author: Aaron Smith
Date: 11 January 2016

Key Accomplishments

- VolturnUS concrete hull technology- reduced hull construction costs in US
- Site Control
- PPA Term Sheet 23c/kWh x 20 years
- ABS positive review of hull 100% FEED
- Successful 1:8 scale pilot deployment



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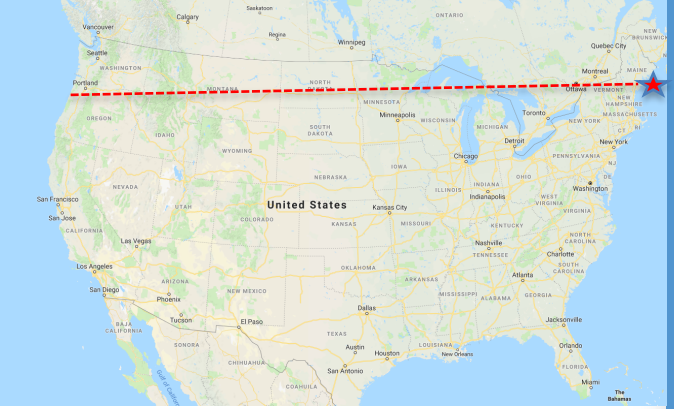

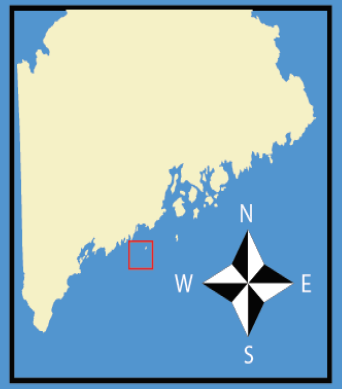

Latitude and Longitude of Site

Northern Boundary	43° 43’ 18.231”
Eastern Boundary	69° 20’ 16.759”
Southern Boundary	43° 42’ 15.436”
Western Boundary	69° 17’ 39.544”

University of Maine Deepwater Offshore Wind Test Site

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2010- Testing of Three Floating Wind Turbine Platforms

3 Hulls, 60 Metocean Conditions, largest floating offshore wind data set made public.

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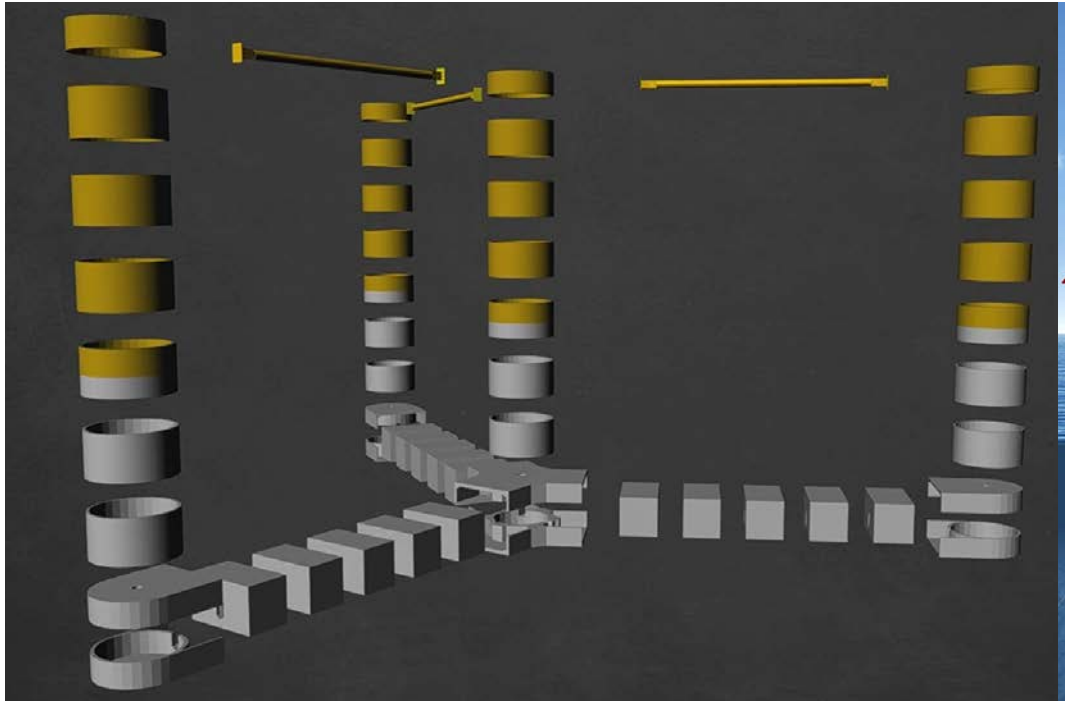
UMaine Concrete Patented Hull Technology

Tap Existing US Concrete Infrastructure.
Domestic Production Low-cost 1 Hull per Week Serial Production



PRECAST BRIDGE CONSTRUCTION
SARAH MILDRED LONG BRIDGE - KITTERY, ME
ON-SITE PRECAST TOWER SECTIONS

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Critical Technical Milestones Completed

- 1:8 Scale Prototype
- 1:50 Scale Model Tests of 100% FEED
- ¼ Scale Fabrication Effort
- ABS 100% FEED Approval

VolturnUS 1:8 Launch
1,600 Attended on May 31, 2013

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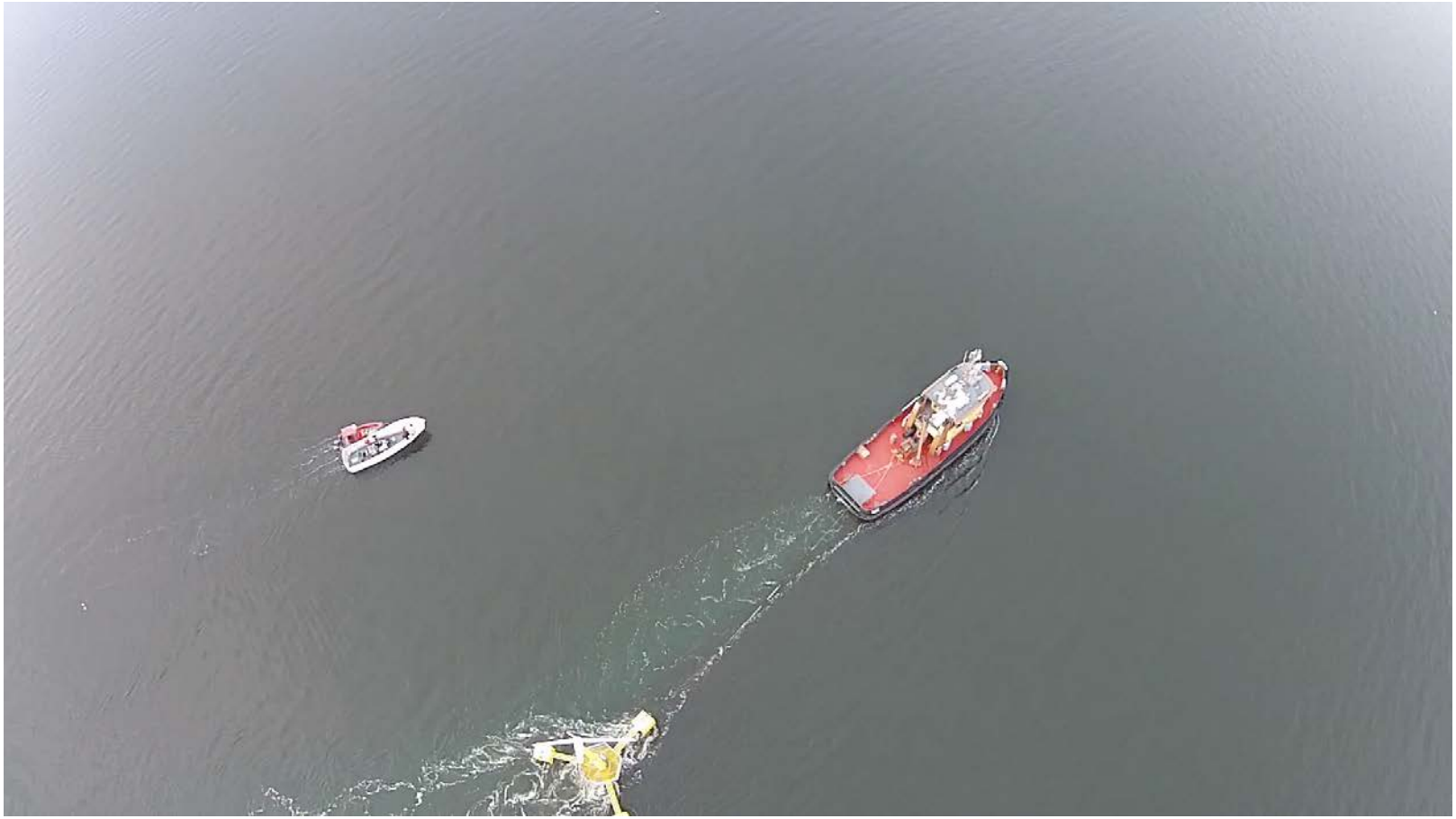

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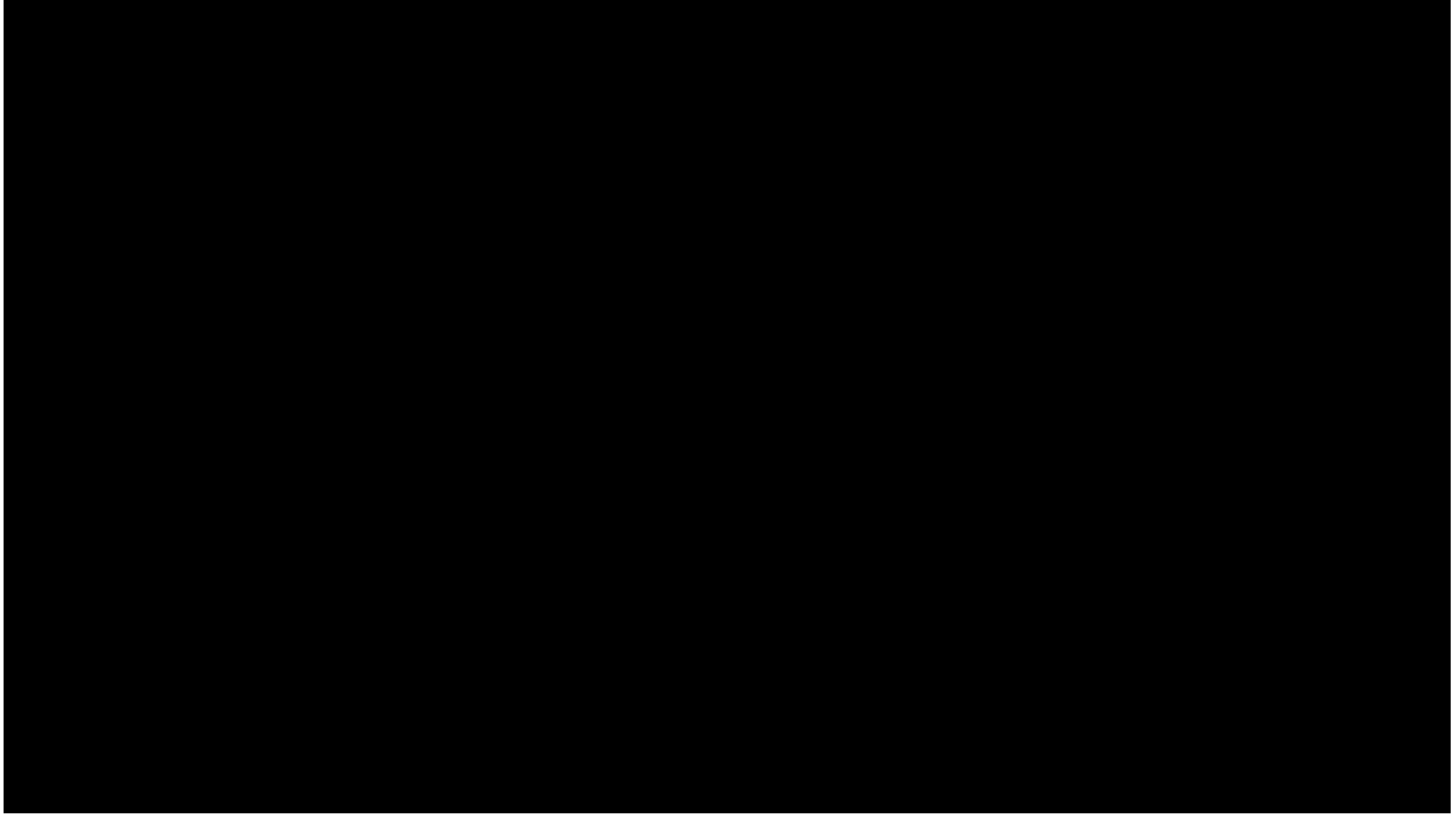
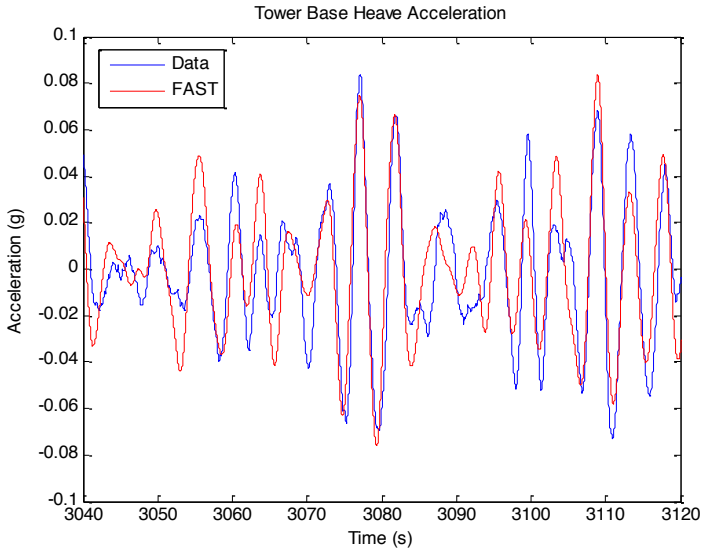


Lessons from VolturnUS 1:8 Pilot

Validation of Technology Performance

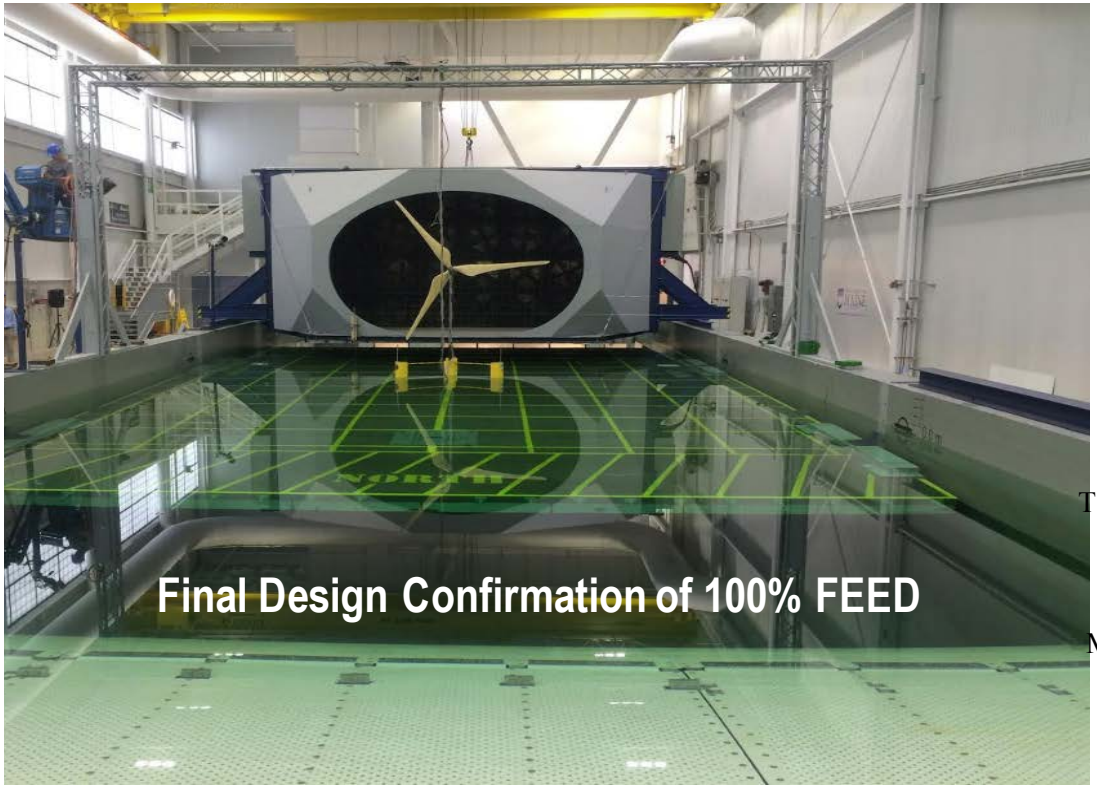
Pilot saw 40 scaled 50 to 500-year return period storms:

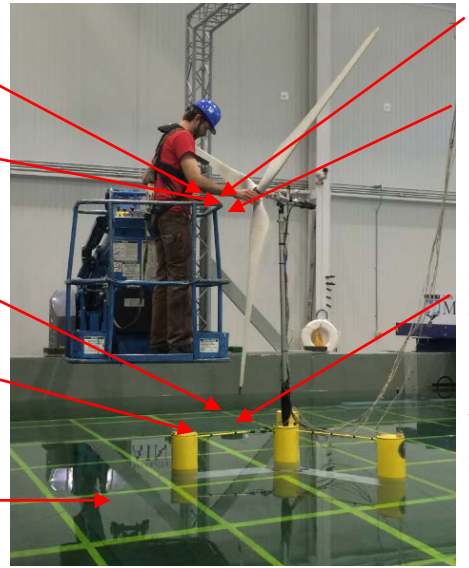
- ✓Max nacelle acceleration < 0.2g
- ✓Max heel angle < 7degrees



1:50 Scale Test of 6MW Hull

UMaine W2 Wave-Wind Basin





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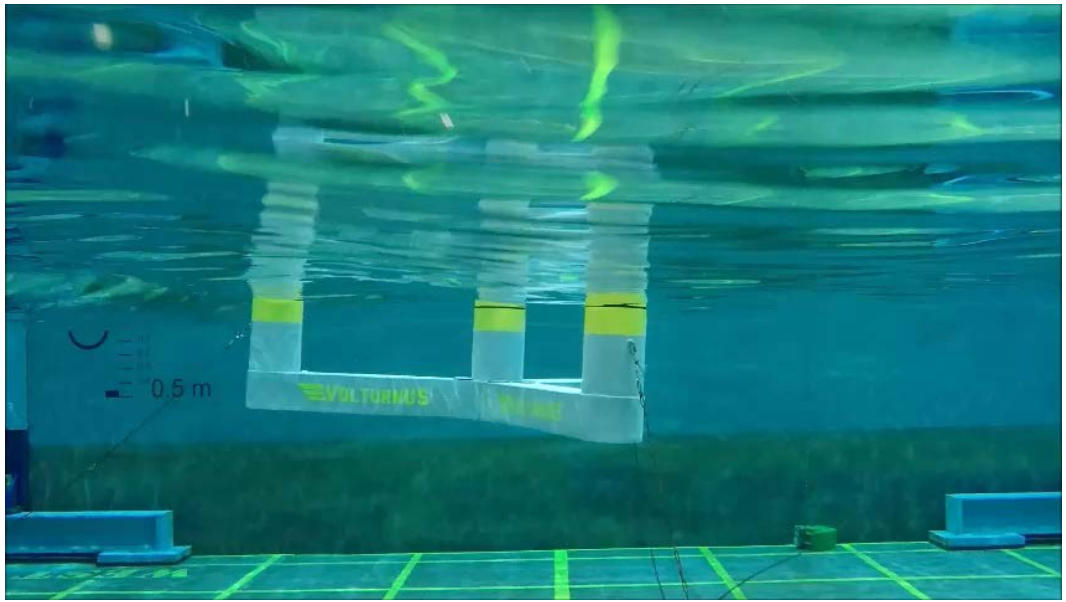
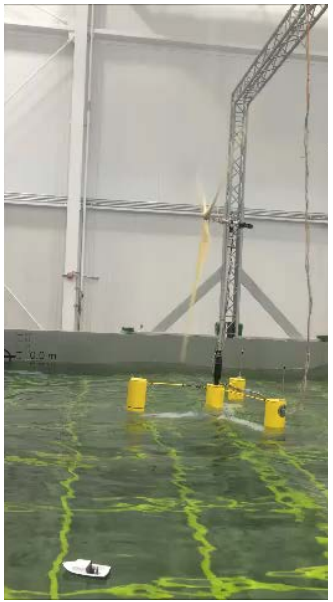
1:50 Scale Testing at UMaine

Confirmation of Design
50 year Extreme Waves with Turbine Operating





¼ Scale Mock Construction- 30 ton Concrete Structure Fatigue and Durability Testing

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ABS Hull 100% FEED Review

- **ABS has reviewed 28 design reports and data**

  and found 100% Hull FEED compliant

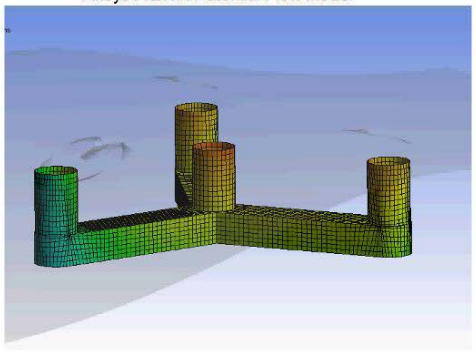
- **Primary Standard**

  ABS Guide for Building

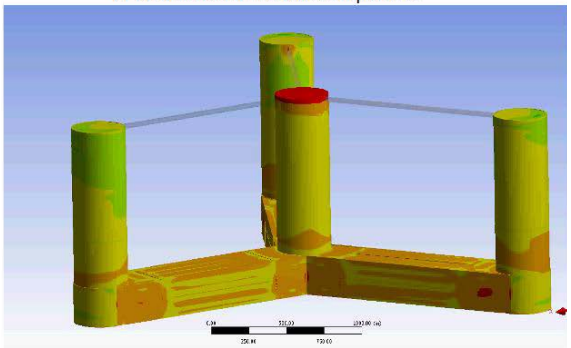
  and Classing Floating

  Offshore Wind Turbine Installations

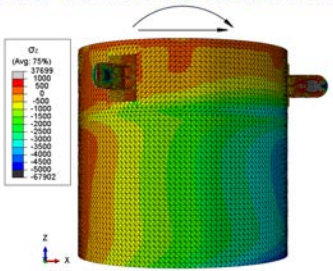
DLC 6.1: 50-year Return Wave Event
Ansys AQWA Potential Flow Model



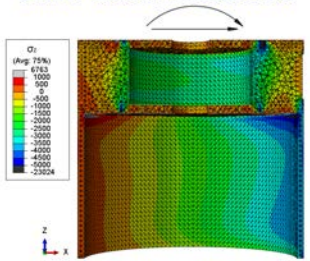
DLC 6.1: 50-year Return Wave Event
FEA Shell Model - von Mises Eq. Stress



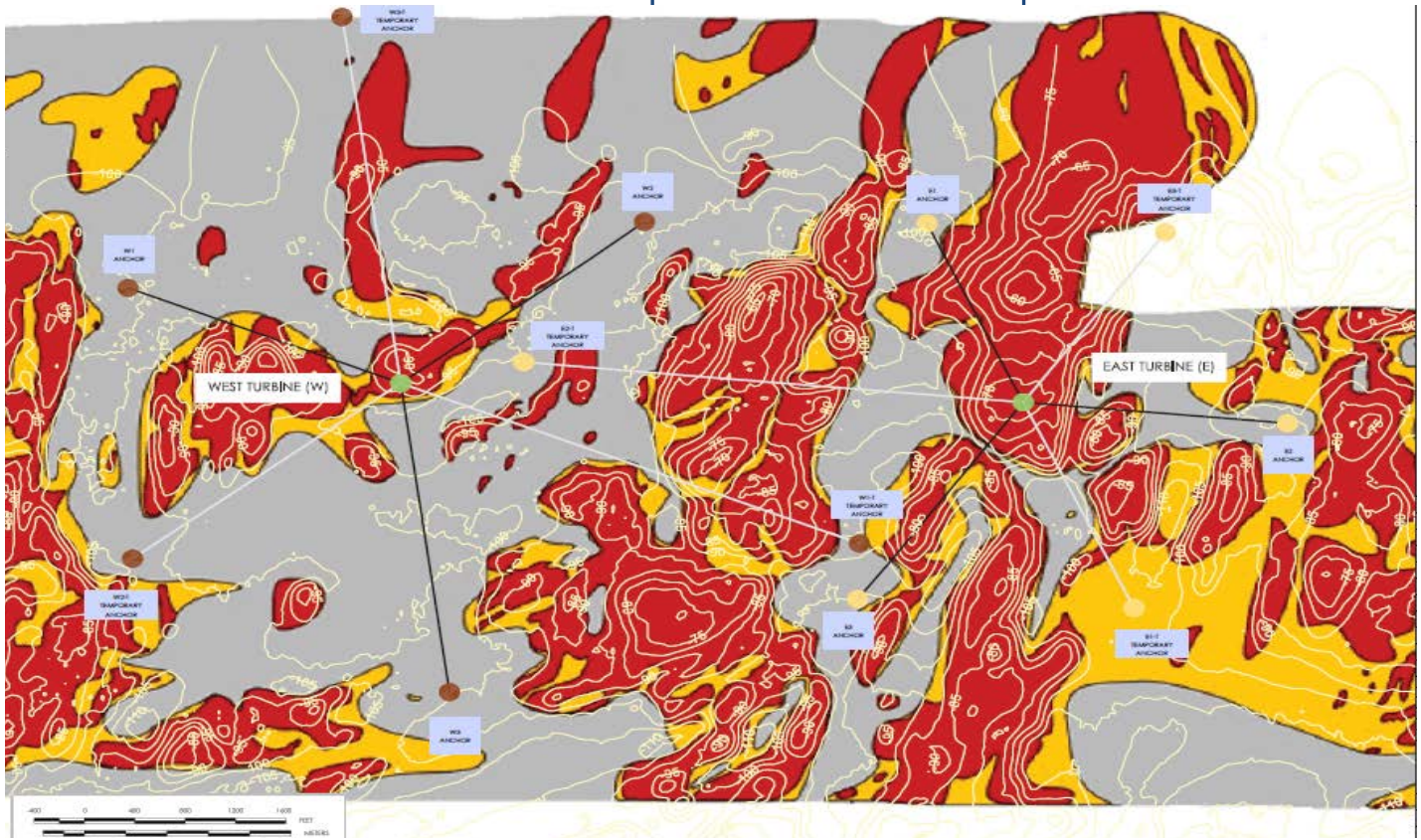
Center Column Connection Front



Center Column Section Cut



Mooring and Anchor Layout Determined
Based on Locations of Deep Sediment Deposits



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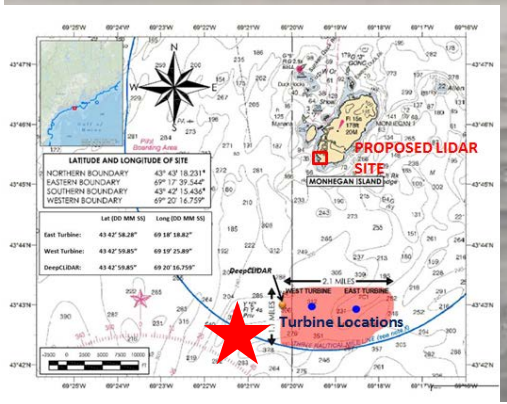
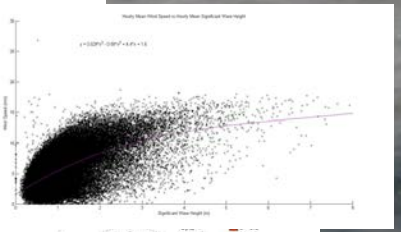
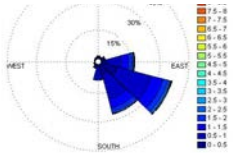
Over 16 Years of Metocean Data



Metocean Buoy



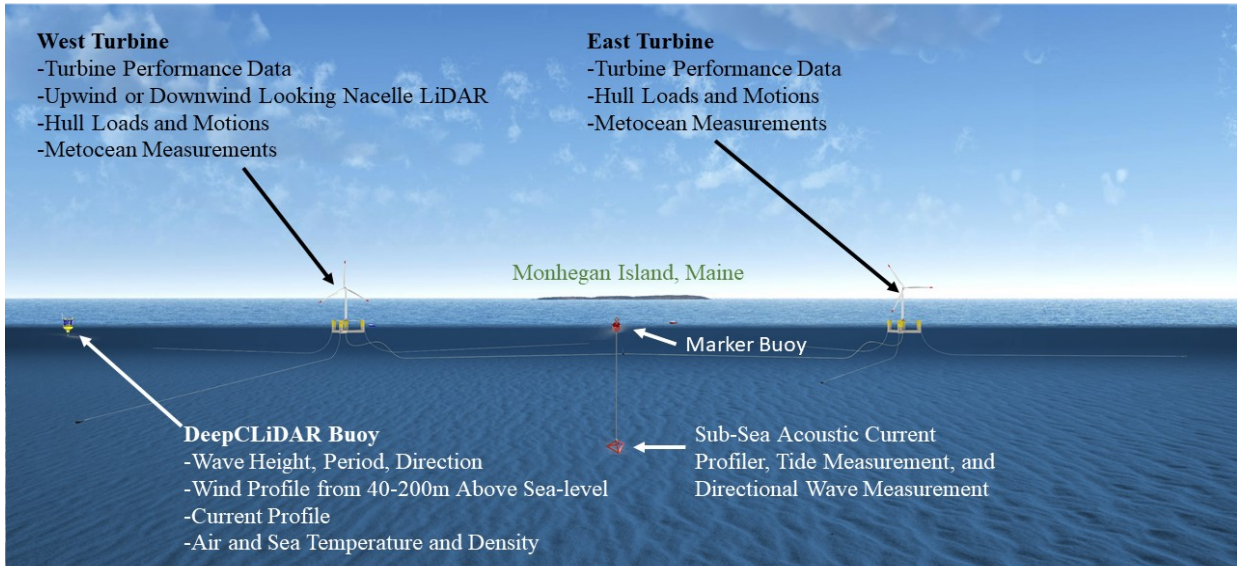


- Metocean Buoy
  - Waves
  - Wind speeds
  - Current from surface to sea floor
  - Temp, pressure, and visibility
  - Scatter plots for fatigue design
- Land-based LiDAR on Monhegan
  - Deployed March 18, 2014
  - Verify AWS atmospheric models
- DeepCLiDAR
  - Wind cube mounted on UMaine buoy
  - Deployed in 2014-2015 for further site characterization

5-year Instrumentation and Monitoring Plan

Key Objectives of Testing Plan:

- FOWT performance and design validation to support third-party certification efforts
- Validation of meteorological and ocean environments used in the design process
- FOWT numerical coupled model validation at a commercial scale
- System health monitoring to support operations and maintenance
- Support environmental monitoring as needed for permitting



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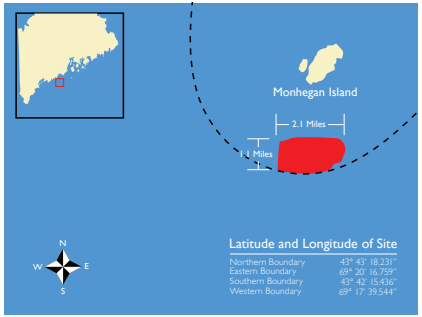
Pre-Deployment Environmental Studies

Extensive ecological, geotechnical, and cultural studies have been completed and are planned:

- Benthos: 2010-13, 2015
- Fish: 2010-15
- Marine Mammals: 2010-15
- Birds: 2010-15
- Bats: 2010-13, 2015
- Noise and Vibration: 2011, 2013
- Electromagnetic Fields: 2011, 2013
- Geophysical: 2010, 2013, 2015
- Terrestrial: 2014
- Aesthetics/Visual: 2013
- Cultural/Historic: 2010, 2014, 2015



Outreach Activities

- Hundreds of meetings
- Island voted on July 26, 2016 – affirmative 39-1 to hire professional to complete community benefit agreement

Timeline: New England Aqua Ventus I

- 2019 – PPA Contract Finalized and Design Complete
- 2020 – All Permits Received
- 2020 – Start Construction
- 2021 – Construction Completed

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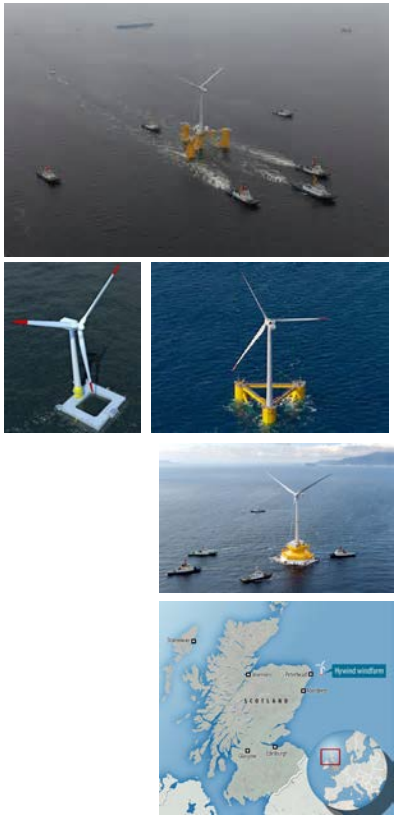
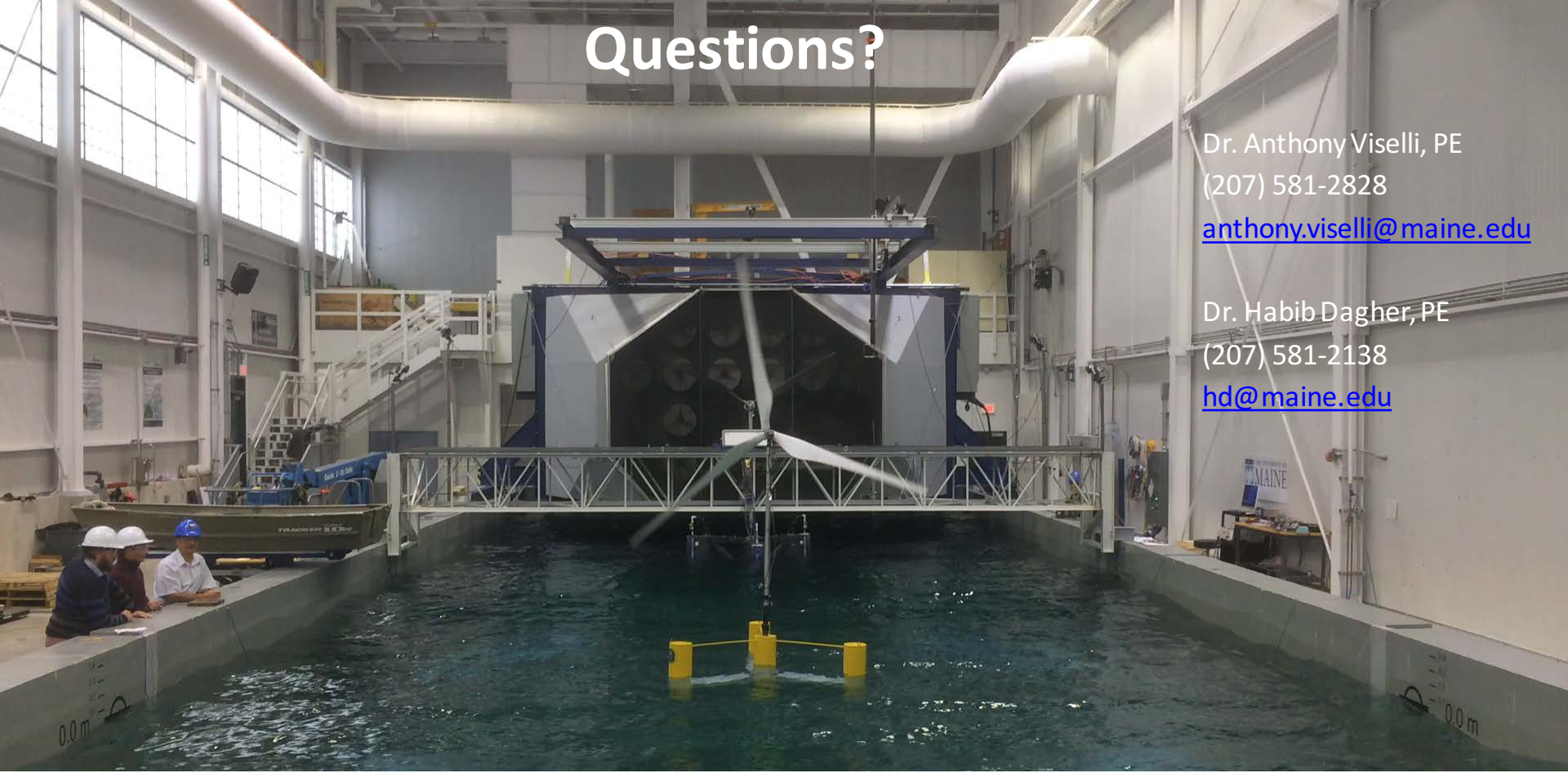
Fierce Global Floating Wind Competition

Examples:

- 2016 – France: three floating demonstration projects, each in the 24 MW range. Another project underway.
- 2016 – Portugal: approved 25 MW project
- 2018 – Scotland: 30 MW project
- 2017 – Japan: to deploy two additional demo hulls (in addition to 3 turbines off Fukushima) – 500GW potential.
- Germany - $1Billion annual funding for offshore wind R&D- big focus on floating



Questions?



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