Design and Testing of an Open-source Tidal Energy Converter to Advance IEC Marine Energy Standards

M.C. Bichanich[1], M. Wosnik[1], V.S. Neary[2], K. Wakefield[2], D. Kim[2], R. Cavagnaro[3], A. Bharath[4], D. Forbush[2], B. Gunawan[2], S.E. Harris[2]

[1]Atlantic Marine Energy Center (AMEC), University of New Hampshire (UNH), [2]Sandia National Laboratories (SNL), [3]Pacific Northwest National Laboratory (PNNL), [4]National Renewable Energy Laboratory (NREL)

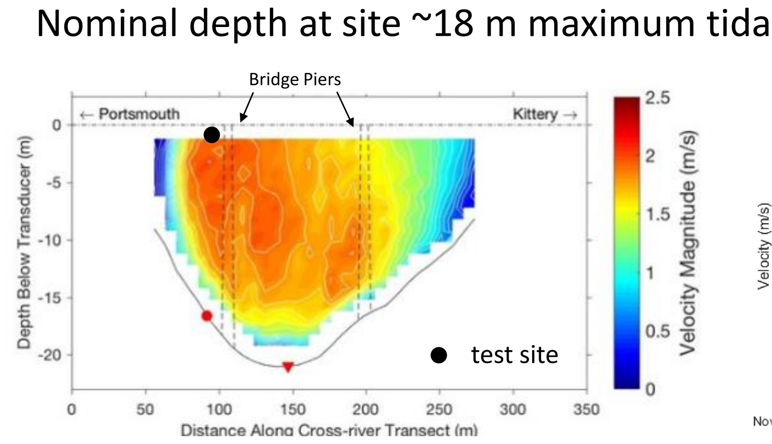
Motivation and Strategy

- Tidal energy is a predictable renewable energy resource around the world that remains largely underutilized due to harsh conditions and high hydrodynamic loads associated with the marine environment
- Publicly available data on flow-structure interactions of relevant-scale marine hydro-kinetic turbines (MHKTs) deployed in energetic tidal flows is limited
- The project team consisting of SNL, UNH, NREL, and PNNL, is tasked with the design, fabrication, deployment, testing of a 2.5-m fully instrumented reference model MHKT to collect, analyze and archive a complete load and performance characterization dataset

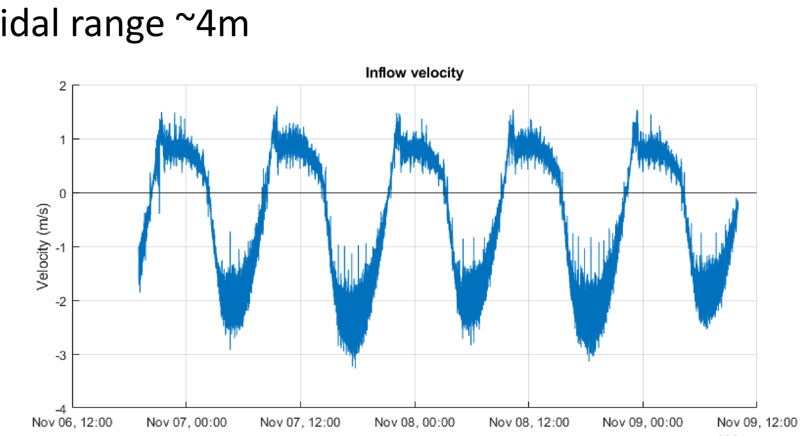
- **Data regarding the structural health, tidal resource, and performance of the turbine will be collected and published in the open-source Portal and Repository for Information on Marine Renewable Energy (PRIMRE)**
- **The data collected will help to inform the International Electrotechnical Commission's (IEC) standards for marine energy (TC 114)**

UNH-AMEC Tidal Energy Test Site / Energy Resource

- The Memorial Bridge is located between Portsmouth, New Hampshire and Kittery, Maine
- Memorial Bridge crosses the lower Piscataqua river in the Great Bay Estuary (GBE) system, one of the most energetic tidally driven flows on the East Coast of the USA
- Instantaneous currents can exceed 3 m/s during spring ebb tides at site (Acoustic Doppler Velocimeter), with 2-minute mean current speeds up to 2.8 m/s (Acoustic Doppler Current Profiler)
- Nominal depth at site ~18 m maximum tidal range ~4m



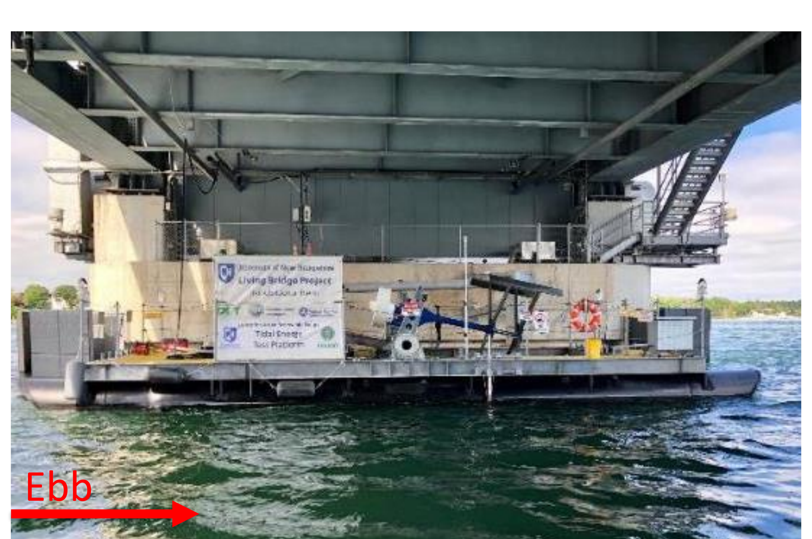
Spatial distribution of tidal current speeds at the Memorial Bridge (facing up-river) at spring ebb tide

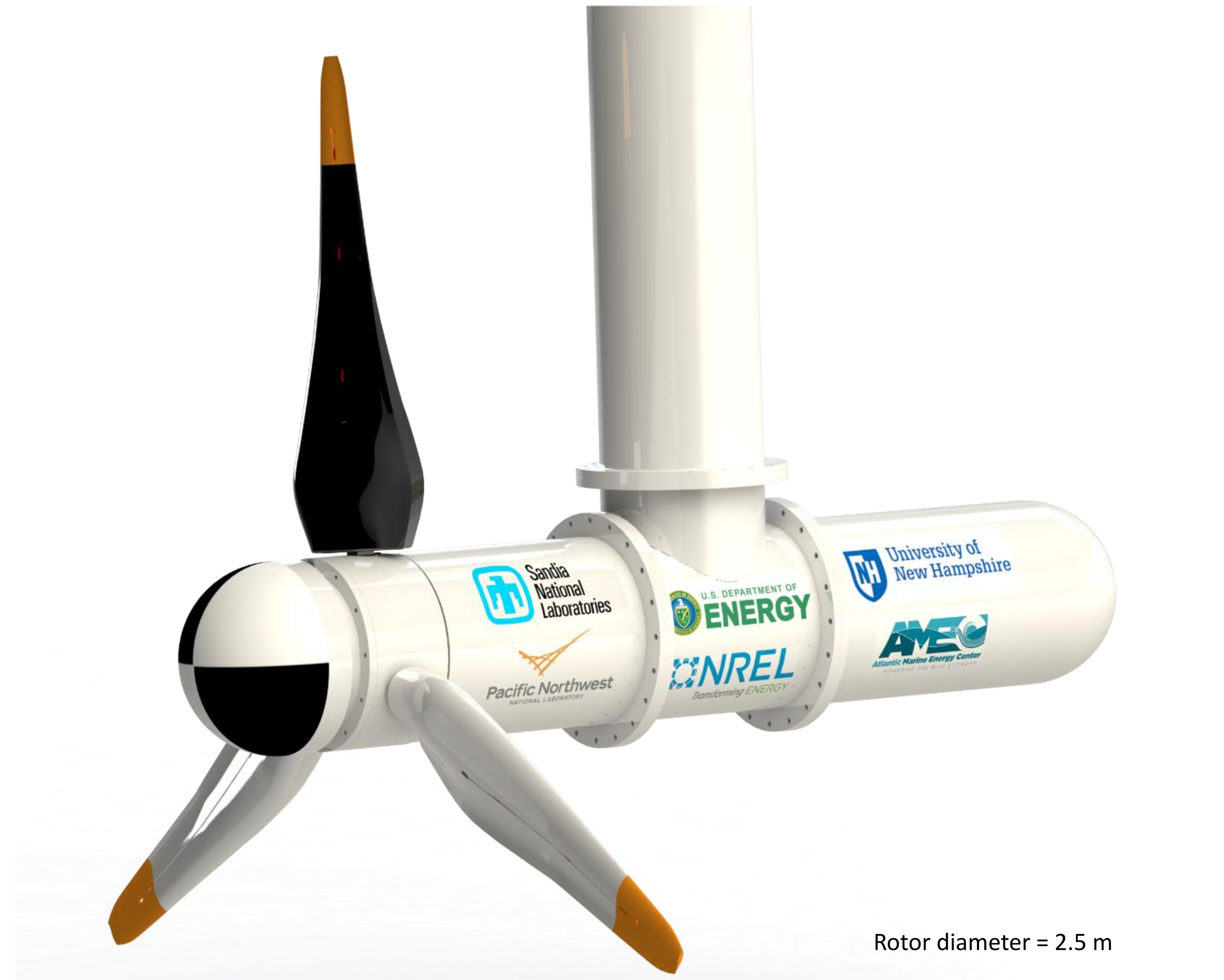


Inflow velocity at the Memorial Bridge sampled at 16 Hz with an ADV

Turbine Deployment Platform

- The UNH Center for Ocean Renewable Energy utilized USDOE funding for ocean renewable energy infrastructure to build a 15 m x 6 m floating Turbine Deployment Platform (TDP)
- HDPE pontoons provide buoyancy, and a galvanized steel frame provides structural strength
- The TDP is moored to a bridge pier via custom pile guides and 6.7 m tall vertical guide-posts
- Turbines are deployed through a moon pool (3.3 m x 5.7 m) via a turbine pitching mechanism





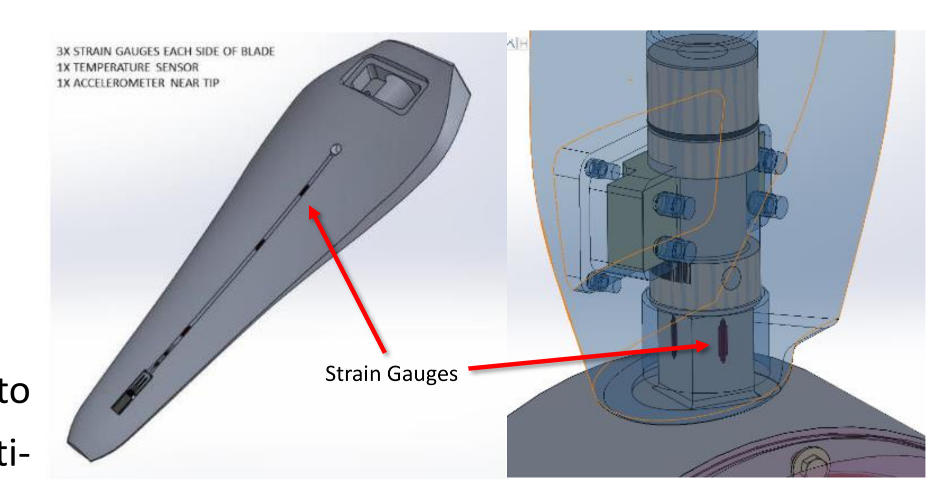
Rotor diameter = 2.5 m

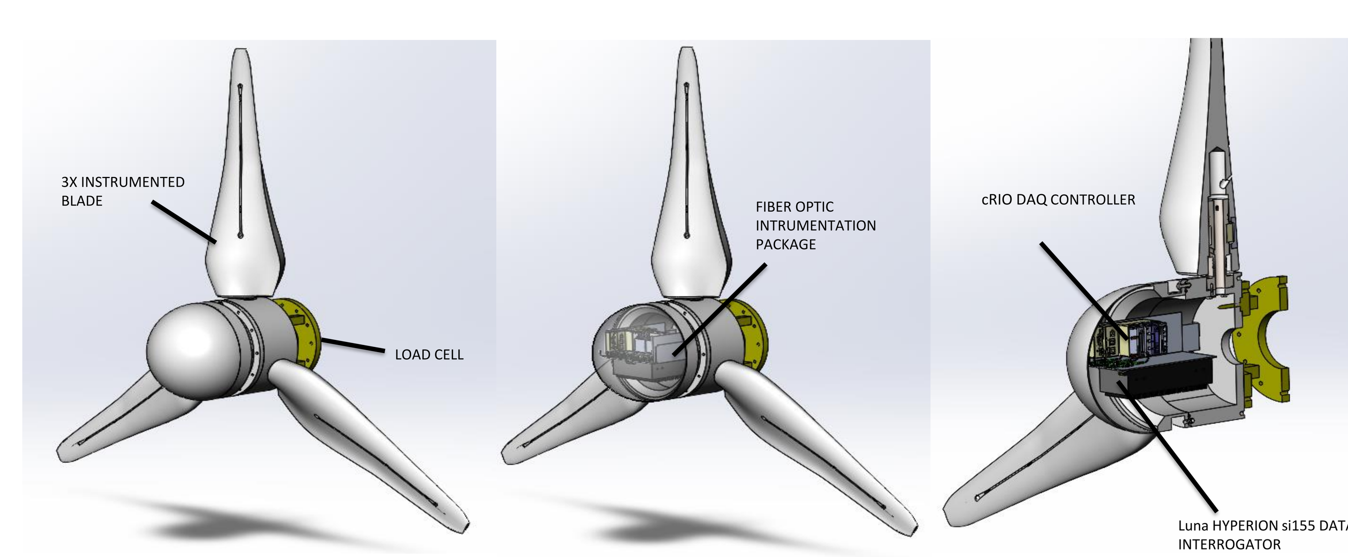
IEC Marine Energy Standards

- IEC 62600-2: Design requirements for marine energy systems
  - The performance of the MHKT under various loading conditions and failure modes will be tested
- IEC 62600-200: Power Performance Assessment of Electricity Producing Tidal Energy Converters
  - Metrics such as the power coefficient, capacity factor, and total power will be measured on this grid-connected MHKT
- IEC 62600-201: Tidal energy resource assessment and characterization
  - Key environmental factors such as the flow speed, salinity, and temperature will be measured
- IEC 62600-202: Early-stage development of tidal energy converters
  - THE MHKT will fall under Stage 3, field-scale testing with a Technology Readiness Level of 5-6

Instrumented Rotor Design, Blade Test Bed

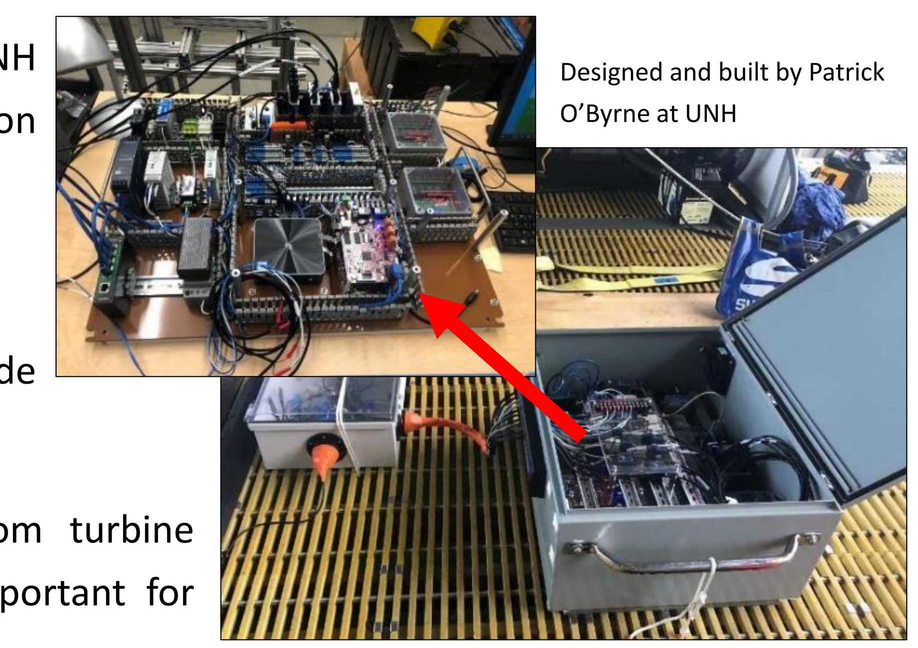
- The MHKT blades adopt Sandia's family of hydrofoil profiles designed for optimal performance in marine environment
- Each blade is outfitted with 3 fiber optic strain gauges on both sides and 4 gauges on the blade root, an accelerometer, and a temperature sensor
- The rotor of the turbine is attached to main driveshaft via a custom, multi-axis load cell
- The blade-to-hub attachment is designed to be modular; blades can be swapped out for experiments with other blades, materials, tips, etc.





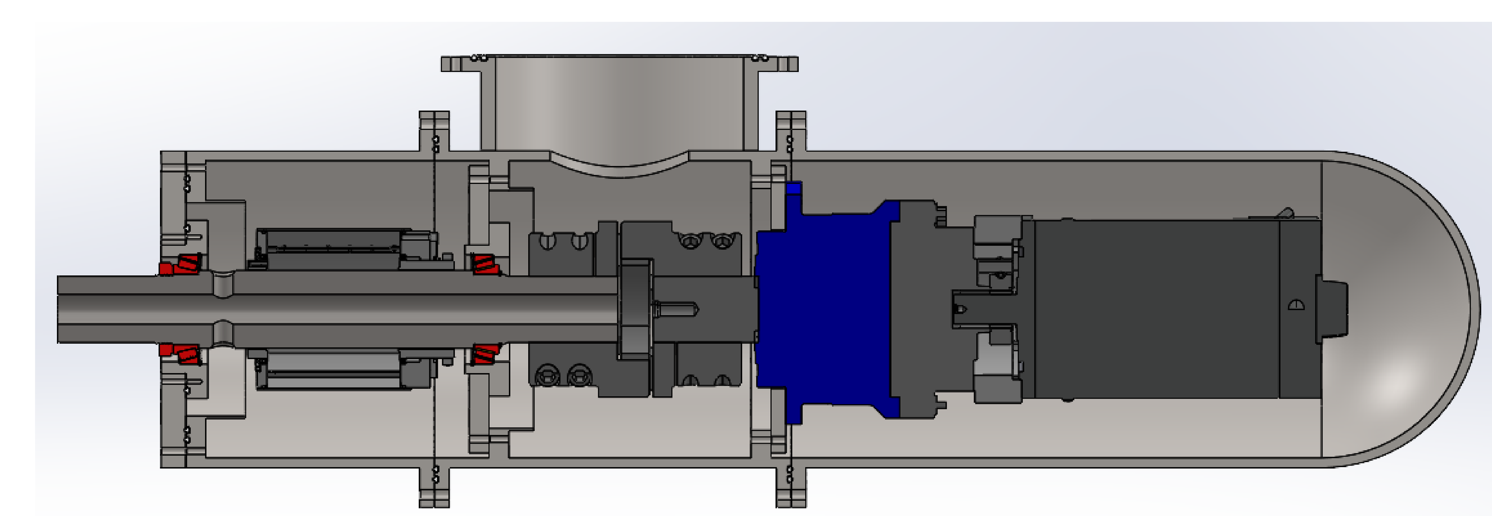
Data Acquisition

- In partnership with NREL, UNH developed a Mobile Data Acquisition System (UNH MODAQ, right)
- A separate DAQ system in the nose cone of the turbine records the blade strain
- Temporally synchronized data from turbine and environmental sensors — important for load and power characterization


Designed and built by Patrick O'Byrne at UNH

Modular Nacelle Design

- The modularity of the nacelle allows for replacement/testing of specific components
- The nacelle is made of off-the-shelf steel pipe sections with welded flanges on the interior and exterior for simplicity and modularity



Data Dissemination

- The data from all experiments and testing of various IEC measurement and load cases will be available through the open-source PRIMRE
- **This will be one of the first data sets of this kind to exist fully in the public domain**
- **This data will inform MHKT design and reduce time and cost for turbine developers and thereby reduce the cost of tidal energy**
- **The project will use current versions of the IEC marine energy standards and will inform future revisions**

International Electrotechnical Commission

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