System Integration of an Instrumented Open-Source Tidal Energy Converter (OSTEC) Testbed

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Motivation

Overarching

- Design, build & deploy an instrumented axial flow tidal turbine

- Operation in a real tidal flow

- Turbine size allows scale-up of results (to utility scale)

- Provide public open- source data set

- Comprehensive model verification and validation (V&V)

  - Digital twinning

  - Numerical models

- Provide feedback on marine energy IEC standards

- 3-bladed axial flow device based on the MHKF1 hydrofoils, with a 2.5-m, 26 kW rotor

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Motivation
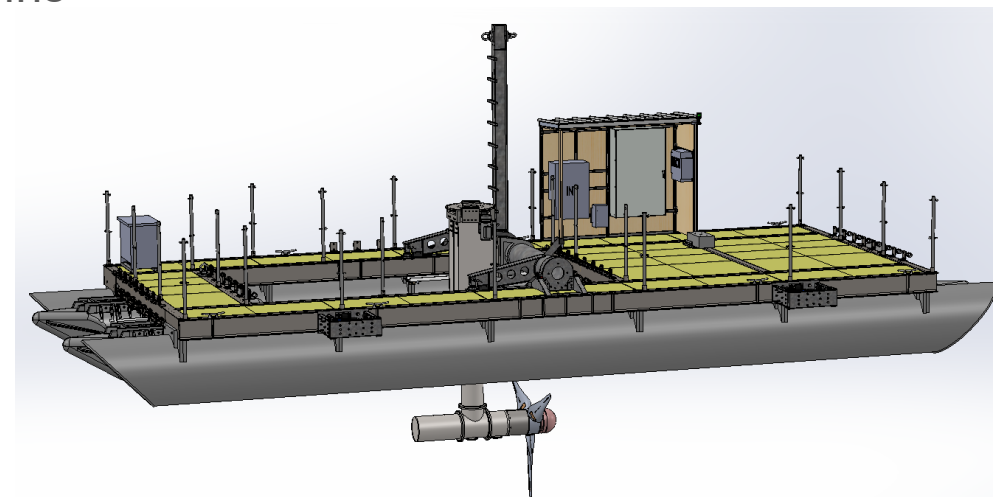
Research Goals

- Help marine energy industry make progress (technology ramp)

- Time synchronized data collection

  - Power performance

  - Mechanical & design loads

  - Tidal inflow conditions

- Effect of turbulence structures on tidal turbine performance & loads

- Dynamics of powertrain of axial flow tidal turbine
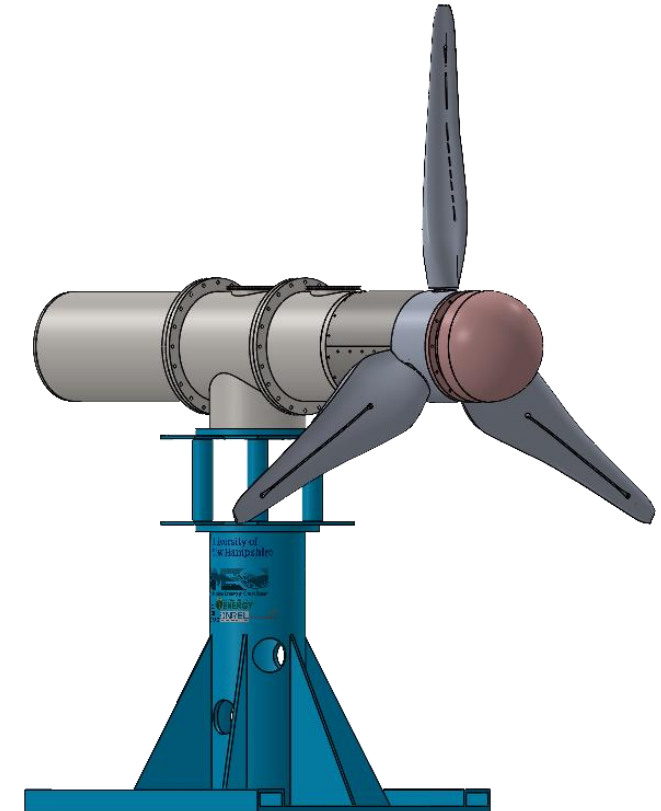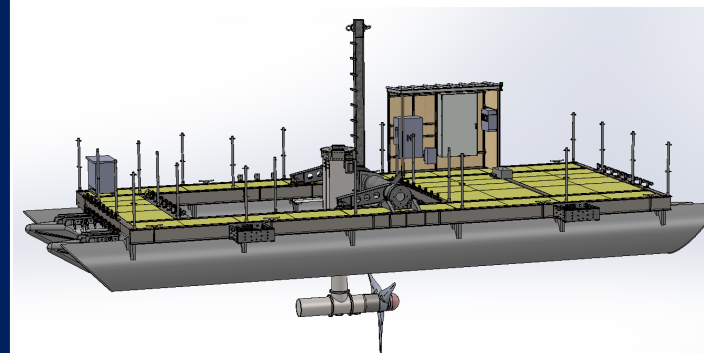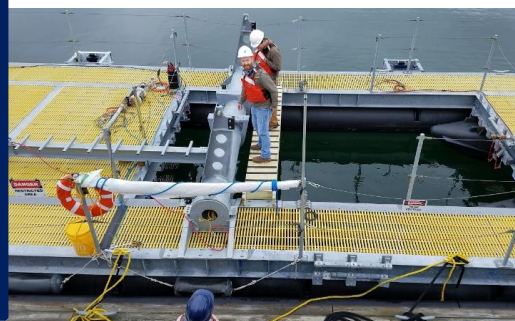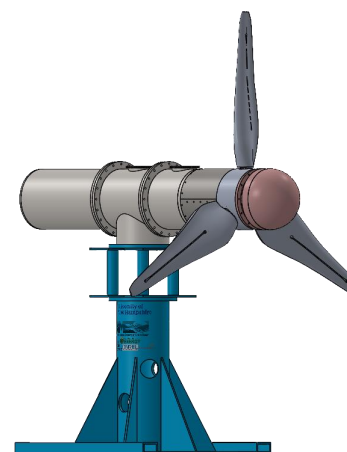
What is System Integration?

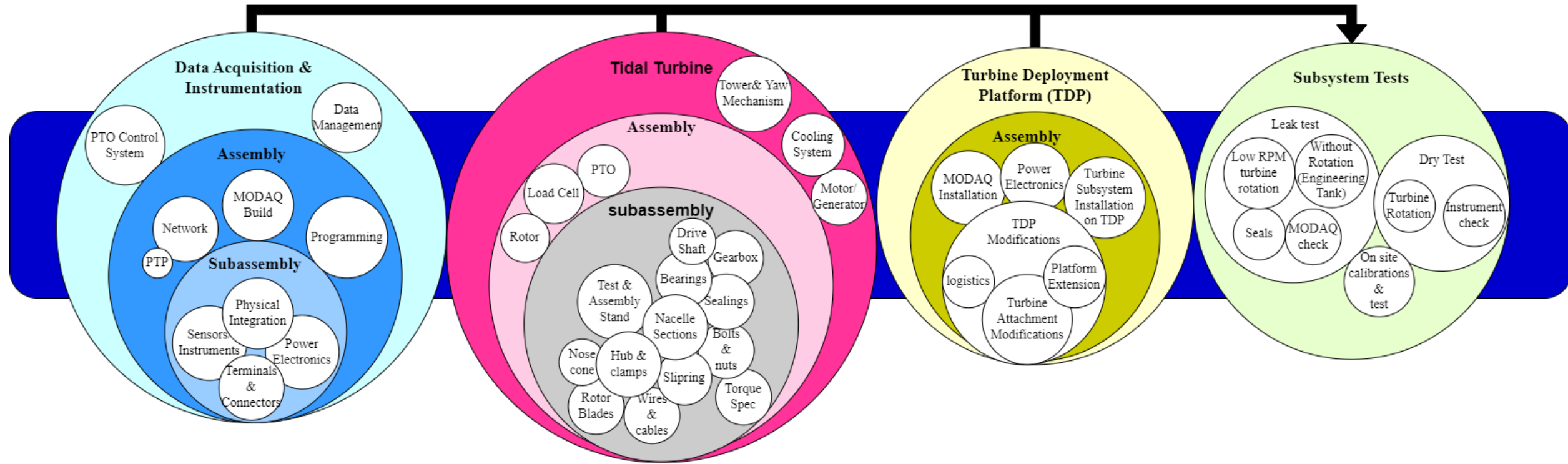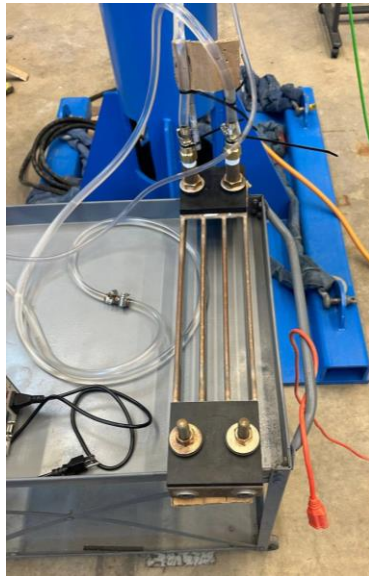**Parts** → **Assemblies & Subassemblies** → **Subsystems** → **Complete System**

OSTEC Systems Integration

Several levels of mechanical & electronical integration

Each has many parts!

System Integration

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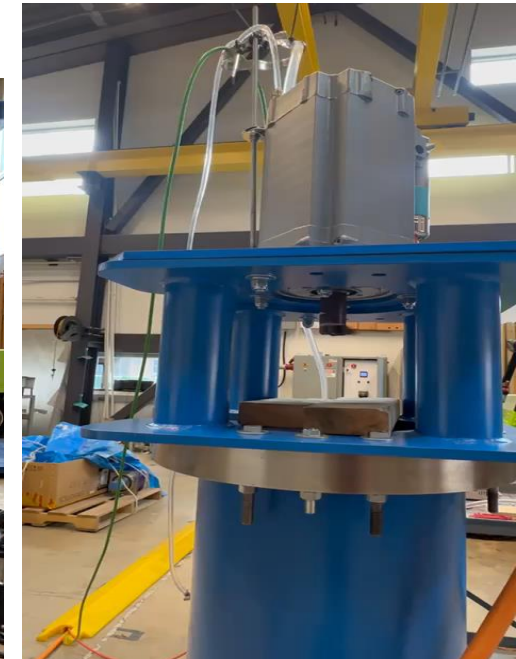
AMEC
Atlantic Marine Energy Center
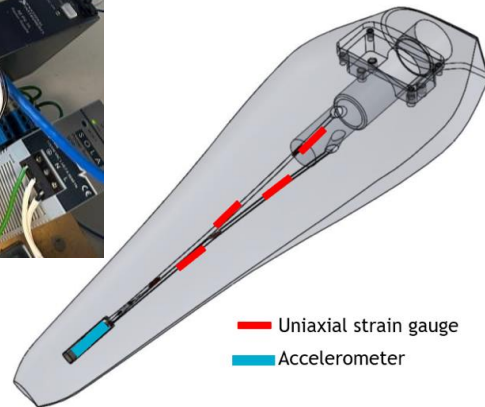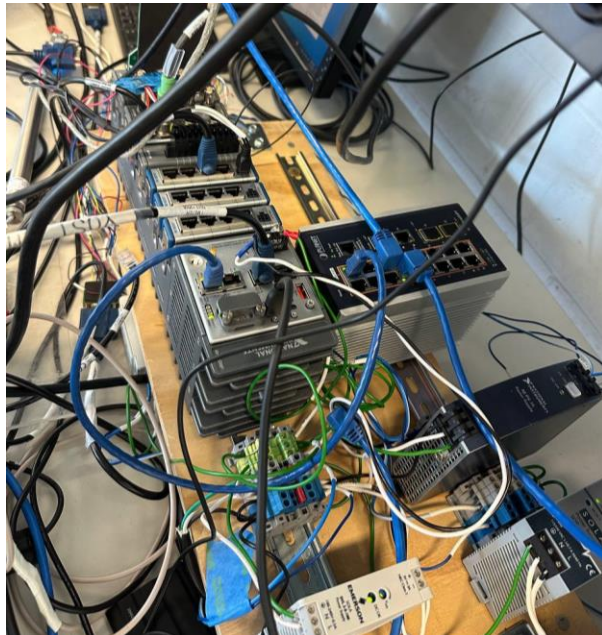
Turbine Subsystem: Mechanical Integration

- Run motor/generator & its control
- PTO drive line components
- Test coupling & bearing
- Communicate with load cell
- Test component functionality & data transmit
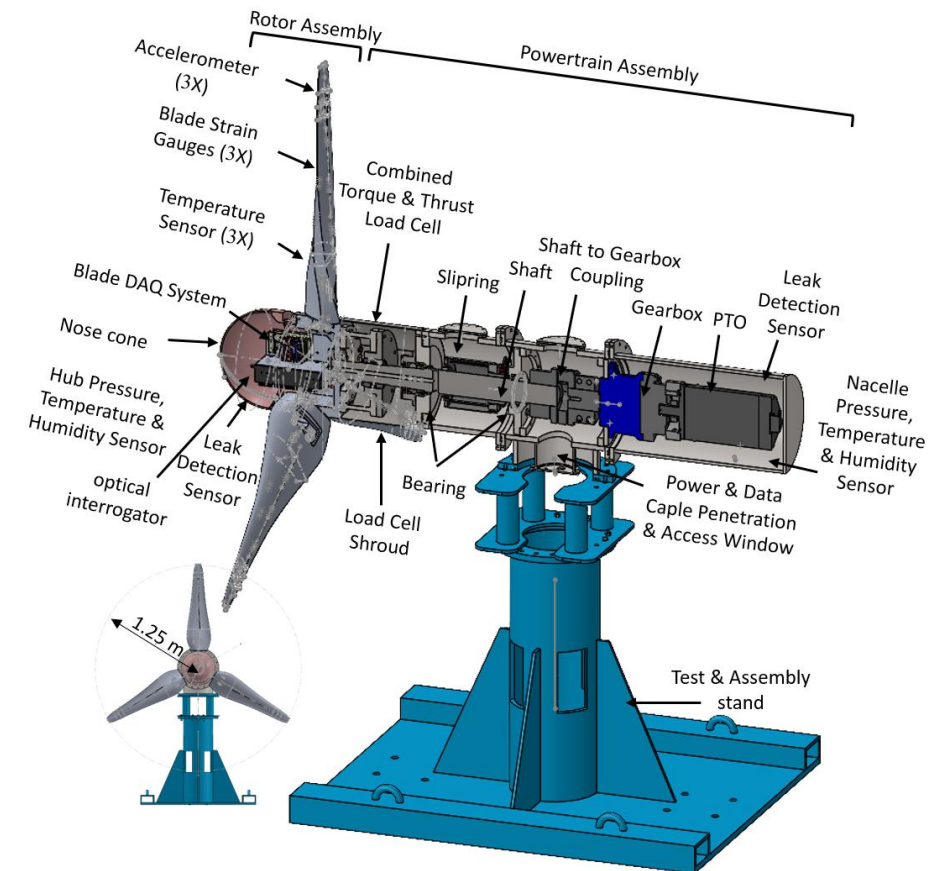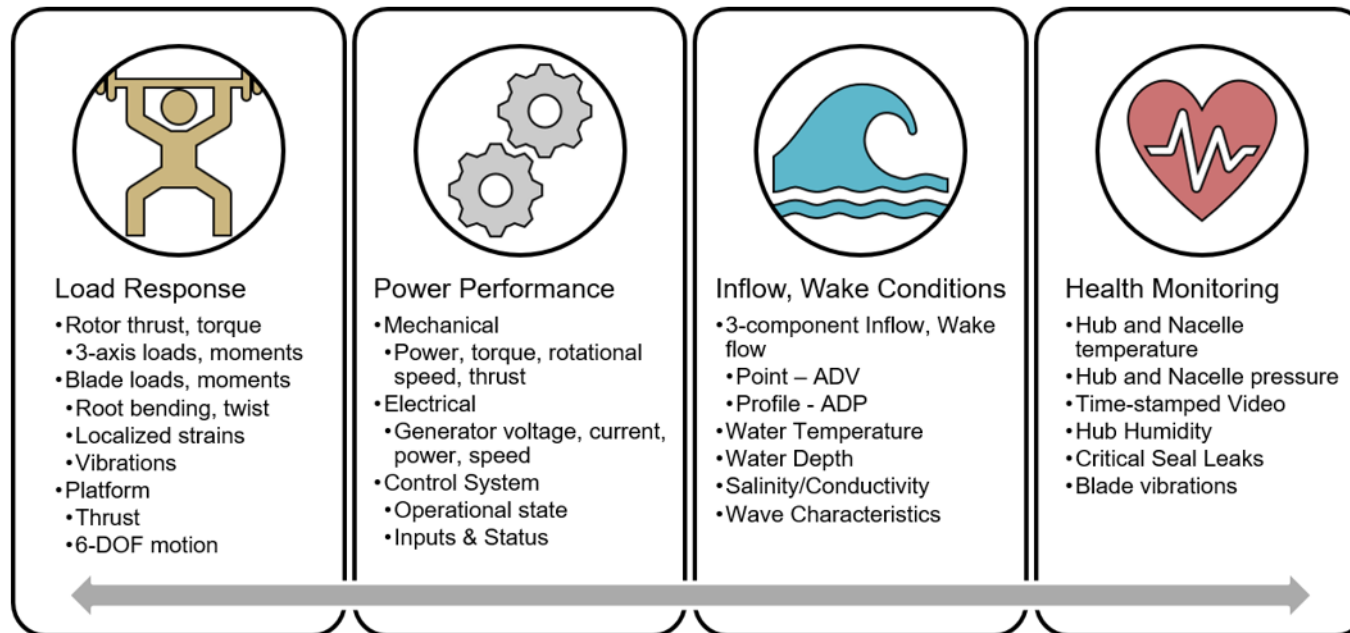
High Level Test

Data acquisition build & test at UNH & NREL

Blade strain gages calibration & test at SNL

System build & test at UNH

Data Acquisition: Sensors & Instruments

- More than 100 data streams
- Terabytes of time synchronized data (hours to days)
- Several test conditions

Load Response
- Rotor thrust, torque
- 3-axis loads, moments
- Blade loads, moments
- Root bending, twist
- Localized strains
- Vibrations
- Platform
- Thrust
- 6-DOF motion

Power Performance
- Mechanical
  - Power, torque, rotational speed, thrust
- Electrical
  - Generator voltage, current, power, speed
- Control System
  - Operational state
  - Inputs & Status

Inflow, Wake Conditions
- 3-component Inflow, Wake flow
  - Point – ADV
  - Profile - ADP
- Water Temperature
- Water Depth
- Salinity/Conductivity
- Wave Characteristics

Health Monitoring
- Hub and Nacelle temperature
- Hub and Nacelle pressure
- Time-stamped Video
- Hub Humidity
- Critical Seal Leaks
- Blade vibrations

System Integration

Data Acquisition: Build

- Analyze, monitor, control
- Turbine setpoint control
- Test & operation of performance metrics
- Time synchronized with PTP network
- Recording important parameters

System Integration
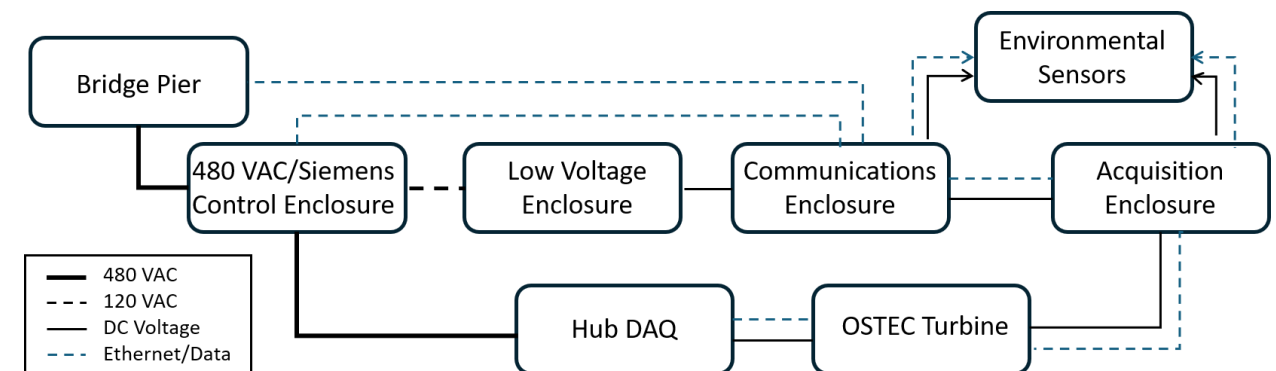
Subsystems Test

- Secured space in UNH High Bay Lab in Kingsbury engineering building
- PTO integration and configuration
- Instrumentation integration & testing of while recording to DAQ
- Mechanical integration
- Pressurization (vacuum) leak Test of nacelle & hub assembly
- Data flow monitoring
- System operation in air at normal and extreme operating speeds at various stages of assembly

System Integration

Before Deployment

- Transport the OSTEC Turbine subsystems
  - Logistics
  - Installation on the UNH-AMEC Turbine Deployment Platform
- In-Water Full System Shakedown
  - Checks of instrumentation,
  - In-situ calibration, or calibration verification
  - in-situ alignment check & adjustments (e.g. blades angle of attack)
  - Slow speed operation to safely check integrity of dynamic seal

Deployment & Test Site

- Move TDP with OSTEC Turbine to the Deployment Site
  - UNH-AMEC Tidal Energy Test Site
  - Memorial bridge, Portsmouth, NH
  - Tidal current speed overage over 2.5 m/s
  - Deploy & test
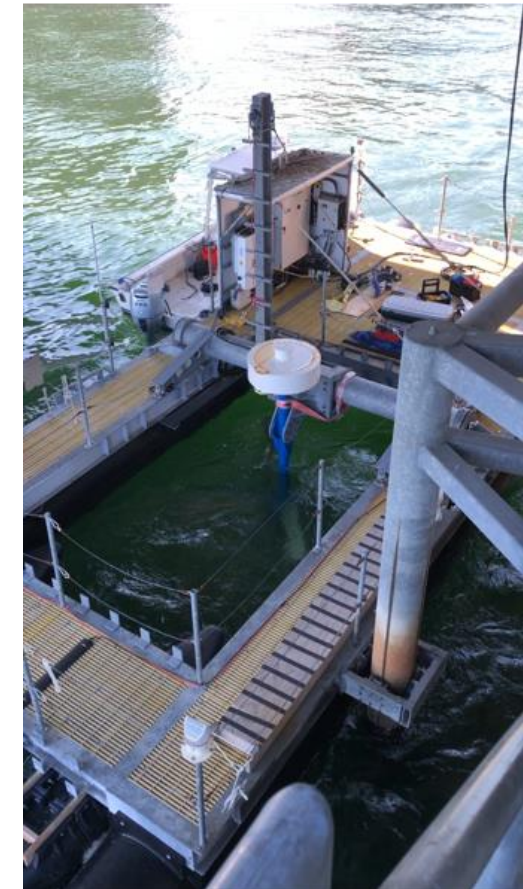
References & Acknowledgement

1. Neary, V.S.; Lawson, M.; Previsic, M.; Copping, A.; Hallett, K.C.; LaBonte, A.; Rieks, J.; Murray, D. Methodology for Design and Economic Analysis of Marine Energy Conversion (MEC) Technologies; Technical Report; Sandia National Lab. (SNL-NM): Albuquerque, NM, UEA, 2014.

2. V.S. Neary et al., "USDOE's Marine & Hydrokinetic Turbine System Test Bed for Model Verification & Validation," International Conference on Ocean Energy and Ocean Energy Europe 2022 (ICOE-OEE 2022), San Sebastian, Spain, 18-20 October 2022.

3. Bichanich, M.; Wosnik, M.; Neary, V.; Cavagnaro, R.; Bharath, A.; Forbush, D.; Kim, D.; Gunawan, B.; Wakefield, K.; Harris, S. (2022). Design and testing of an open-source tidal energy converter to advance Marine Energy IEC standards [Presentation]. Presented at UMERC+METS 2022 Conference, Portland, USA.

4. Neary, V.S., et al., USDOE Instrumented Marine Turbine Testbed: Experimental Test Plan. 2023, Sandia National Laboratories, Water Power Technologies: Albuquerque, NM. p. 150.

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AMEC
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Thank You

Questions