Advanced TidGen® Power System

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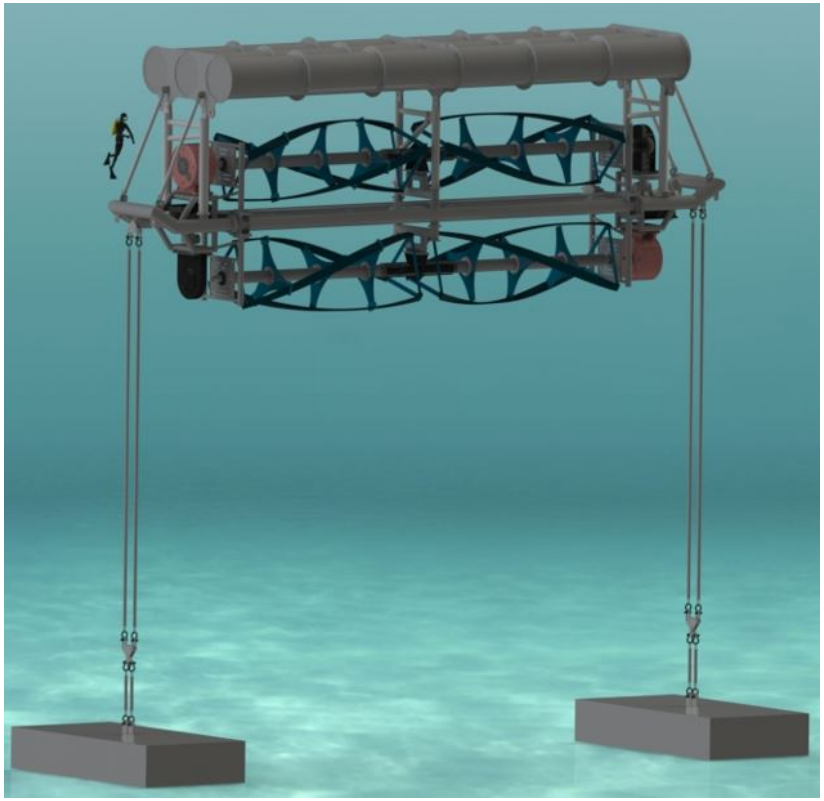


Marine and Hydrokinetics Program

October 8, 2019

Principal Investigator
Jarlath McEntee
Organization
ORPC

Project Overview

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Project Summary

Demonstrate a commercially viable tidal power system, integrating technologies through a program focused on cost of energy, risk reduction, and component life

- Design; construct, test, and verify subsystems
- Perform system integration
- Verify system performance
- Validate system reliability and availability by a continuous 12-month deployment

The integrated design will demonstrate significantly decreased LCOE.

Project Objective & Impact

- Produce a full-scale design
- Increase reliability of the structures
- Implement ORPC's Buoyant Tension Mooring System
- Implement ORPC's advanced control strategy
- Follow a certification protocol
- Verify system design by subsystem tests and a two-month integrated, system deployment
- Validate the commercial design by a 12-month test
- Implement focused environmental monitoring

Project Information

Project Principal Investigator(s)

Jarlath McEntee

WPTO Lead

Yana Shininger

Project Partners/Subs

- Composites Engineering Research Laboratory (CERL), Portland, Maine
- Montana State University - Composites Technologies Research Laboratory
- University of Maine School of Marine Sciences, Orono, Maine

Project Duration

- Project Start Date: 11/1/2016
- Project End Date: 6/20/2021

Alignment with the Program

Marine and Hydrokinetics (MHK) Program Strategic Approaches

Data Sharing and Analysis

- Foundational and Crosscutting R&D
- **Technology-Specific Design and Validation**
- Reducing Barriers to Testing

Alignment with the MHK Program

Technology-Specific Design and Validation

- Validate performance and reliability of systems by conducting in-water tests of industry-designed prototypes at multiple relevant scales

Performance and reliability of the system will be verified by subsystem tests and a two-month integrated, system deployment in Cobscook Bay, validating performance gains and verifying functionality in low velocity, and then by a 12-month test in Western Passage, Maine, verifying system performance and levelized cost of electricity (LCOE) reduction by >90 percent over baseline in high velocity.

Alignment with the MHK Program

Technology-Specific Design and Validation

- Improve methods for safe and cost-efficient installation, grid integration, operations, monitoring, maintenance, and decommissioning of MHK technologies

The Buoyant Tensioned Mooring System concept will be developed for a commercial-scale system to streamline system deployment during installation and maintenance operations while allowing for optimum vertical positioning within a water column for turbine performance.

Project Budget

There are no sizeable discrepancies in budget to note.

Total Project Budget – Award Information		
DOE	Cost-share	Total
$5,350,000	$6,251,742	$11,601,742

FY17	FY18	FY19 (Q1 & Q2 Only)	Total Actual Costs FY17–FY19 Q1 & Q2 (October 2016 – March 2019)
Costed	Costed	Costed	Total
$597,524	$1,018,867	$631,854	$2,248,245

The project is presently challenged by the high cost of constructing, moving, and installing very large gravity base anchors. Additional design work is required to investigate the use of high efficiency anchors such as rock pin or helical screw anchors.

The need to revisit the design of the anchoring system to achieve cost targets will lead to a project delay of approximately 2 years, due to the need to revisit the system design to incorporate and test lower cost anchoring techniques.

Management and Technical Approach

- **Project team is comprised of research partnerships and vendors**
  - **University of Maine School of Marine Sciences** has passive acoustic monitoring (PAM) equipment and basic software necessary to conduct marine mammal detection surveys. They contributed to the development of a draft Marine Life Monitoring Plan for Western Passage.
  - **Composites Engineering Research Laboratory** (CERL) provides access to more than a dozen precision analytic instruments that analyze the performance properties of polymer-based materials and composites.
  - **Montana State University** (MSU): Composites Technologies Research Laboratory includes: 5 Load Frames, Sub-structure Test Frame, with capability of 3-pt, 4-pt and cantilevered loading
- **High-level project schedule and key milestones**

  Budget Period 1 was completed June 30, 2018.
- **Milestones**

  M6.1: Design Basis review. Completed December 2017

  M7.1: BP1 Data upload. Completed, April-June 2018
- **The project is presently challenged by the high cost of constructing, moving, and installing very large gravity base anchors. The size and weight of the anchors has proved to be problematic.**

End-User Engagement and Dissemination Strategy

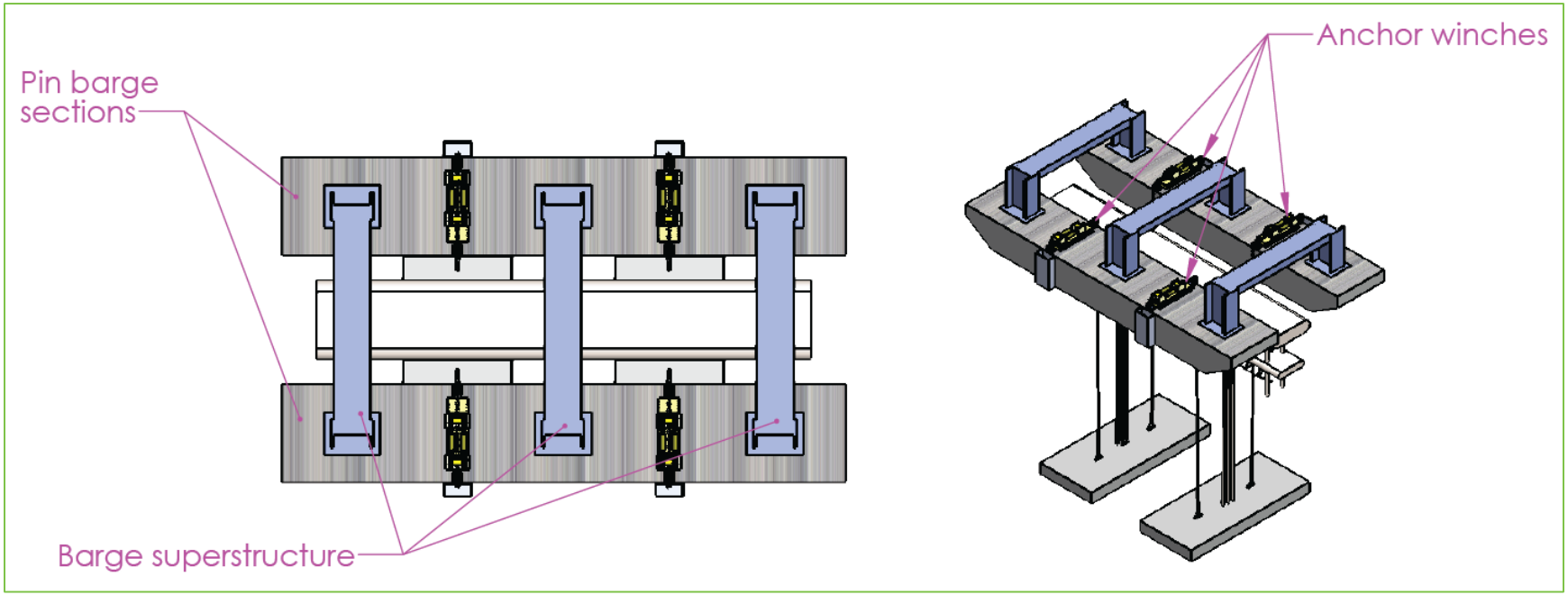
- Project's innovations offer considerable advancements for the MHK industry and are not reliant on COTS designs or technologies which need to be adapted to MHK requirements. This Project will be the first time these important hardware and software advancements are combined into a single system and will provide a proof of concept and validation of utility for the MHK industry.
- Working with federal and state regulators, ORPC has developed permitting and environmental monitoring approach for Western Passage.
- ORPC has continued to engage the Eastport community to seek their input on the technology and Western Passage site.
- Throughout the Project, ORPC will share information with DOE and DOE labs through annual reviews. ORPC will upload the data related to milestone development to the DOE-MHKDR.
- ORPC participates in industry conferences to disseminate information on the Project.

Technical Accomplishments

- Anchoring and deployment system design has focused on development and detailed engineering of the deployment and mooring system for the TidGen®4 development system.

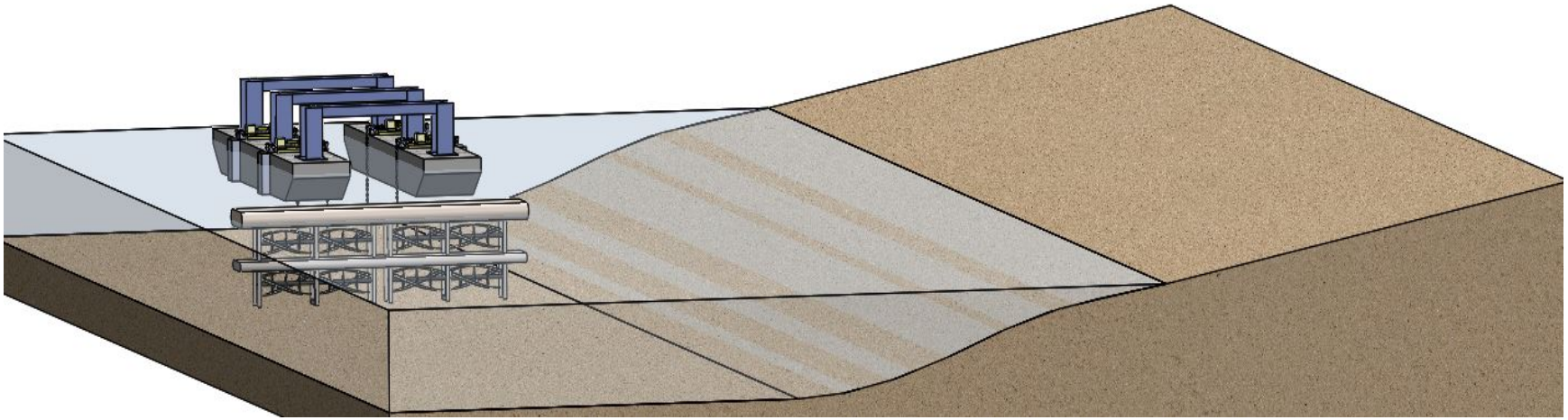
Subsystem Overview

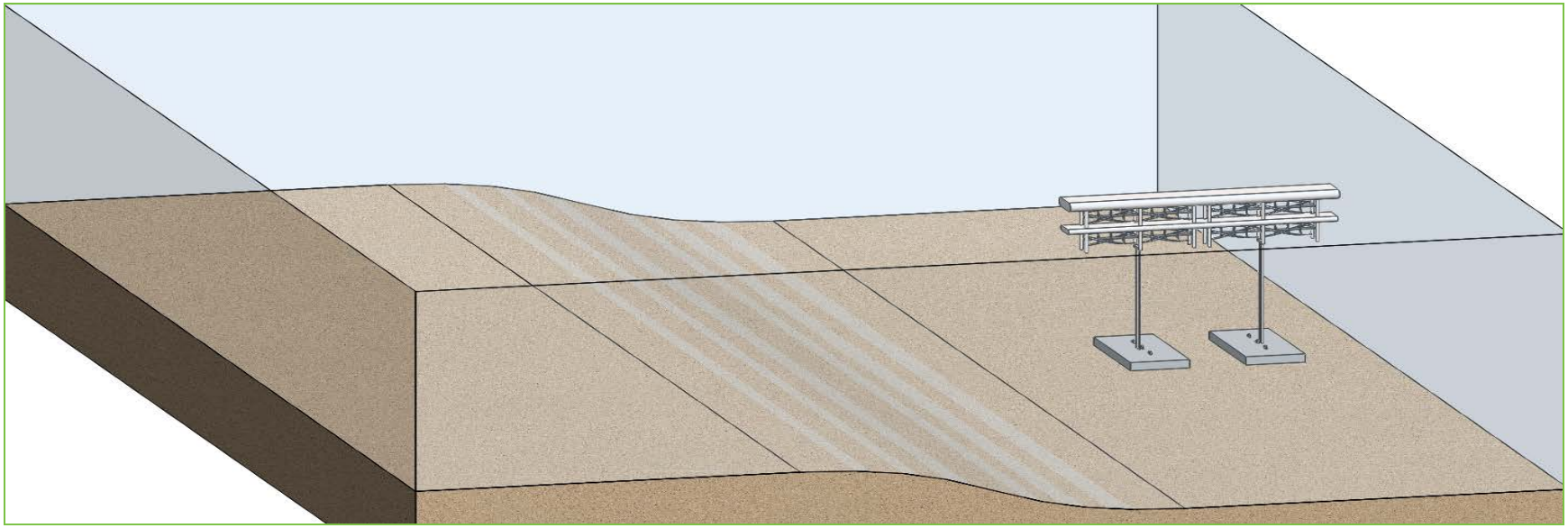
Subsystem Components



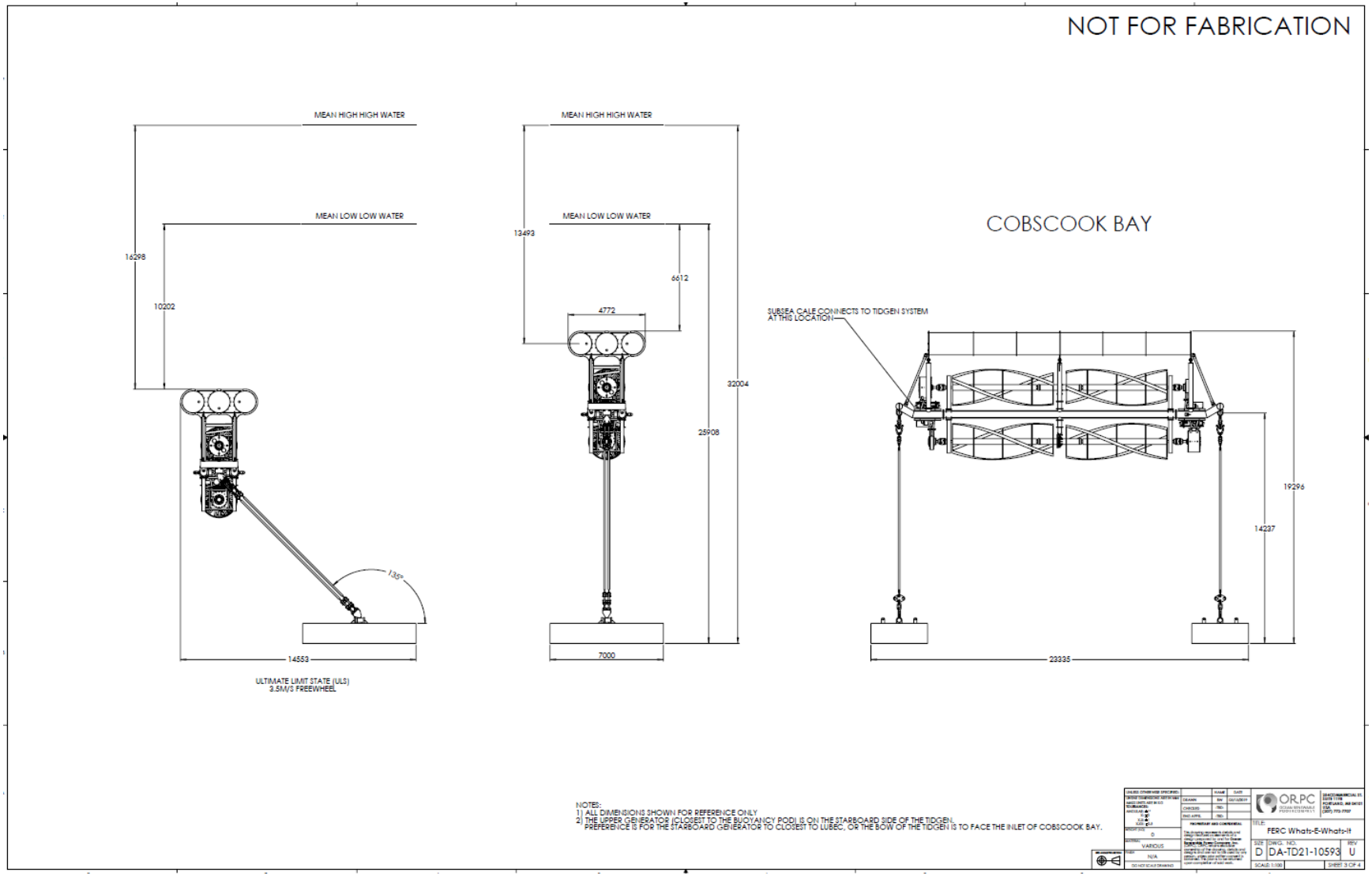
*** Additional equipment / subsystems

- Hydraulic / electric power unit
- Tow/Push positioning equipment/vessels
- Power / data cable equipment
- On-water safety equipment

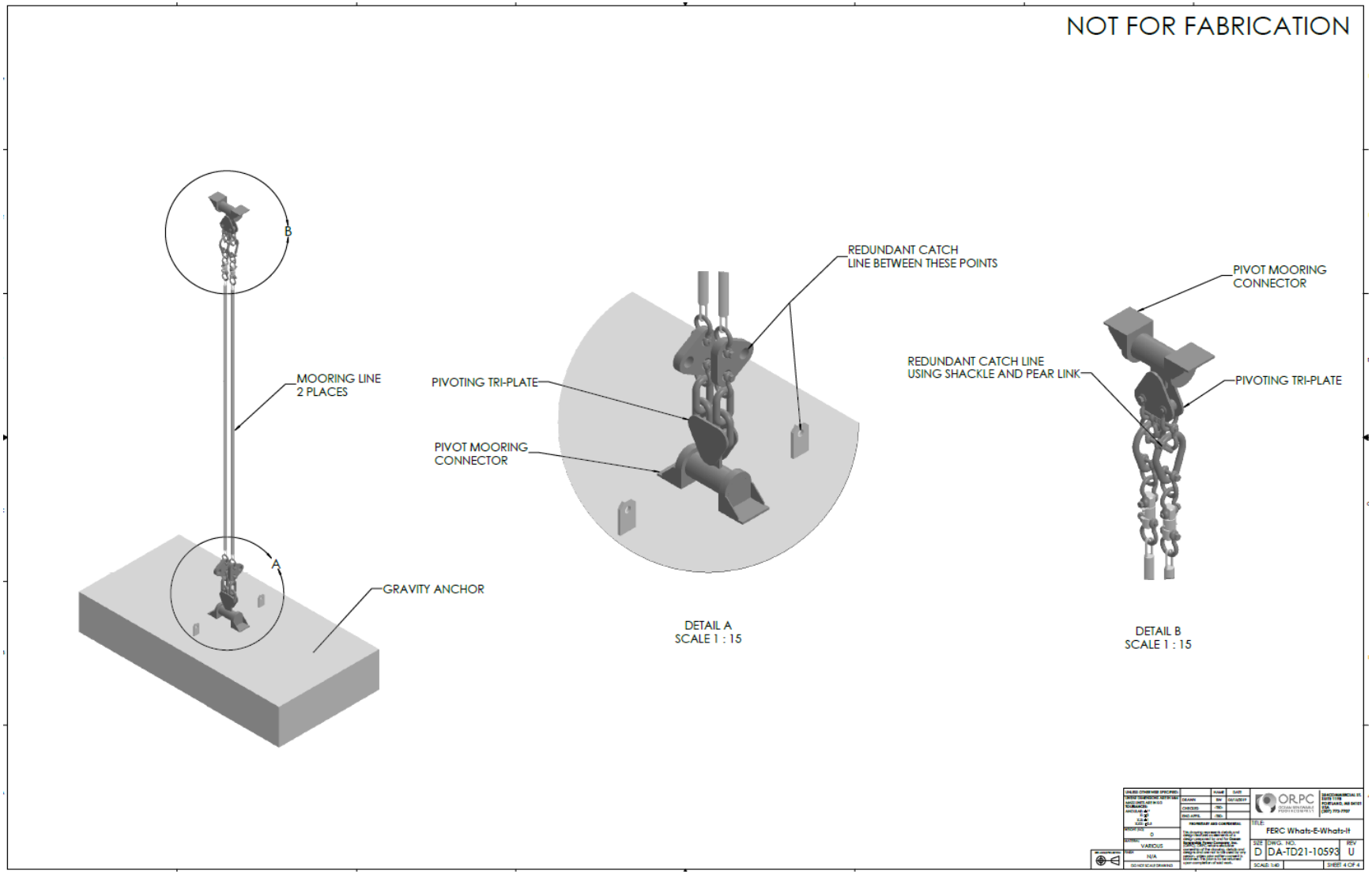




Technical Accomplishments



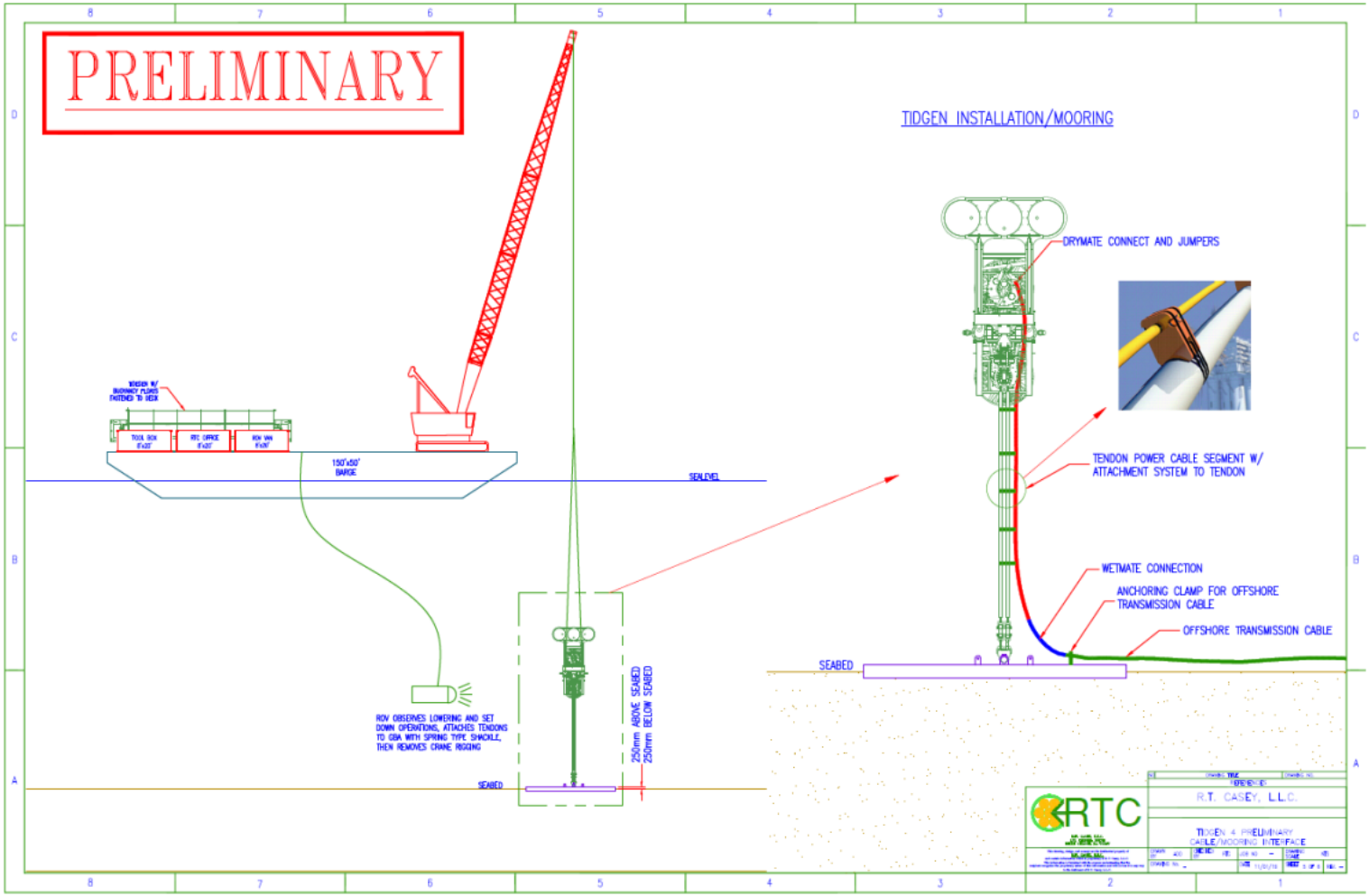
Technical Accomplishments



Technical Accomplishments

- ORPC worked with a contractor, holding a preliminary design review on the deployment system, which resulted in revisiting the mooring system design with an eye towards detachability.
- Cost estimates based on the developed deployment methodology indicate that costs may not meet cost targets.
- Consequently, further evaluation of the proposed methods and alternatives is being conducted.

Technical Accomplishments



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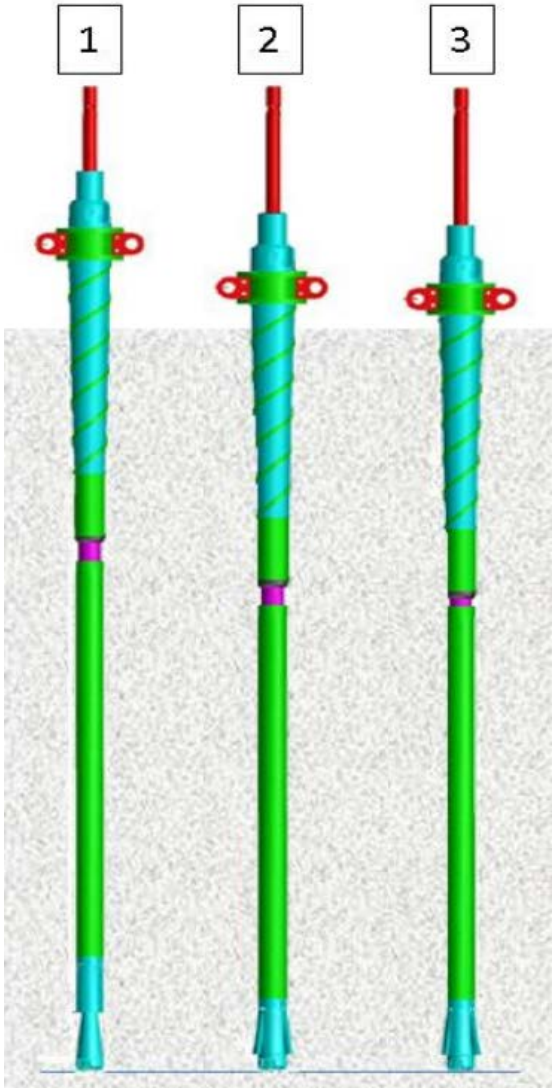
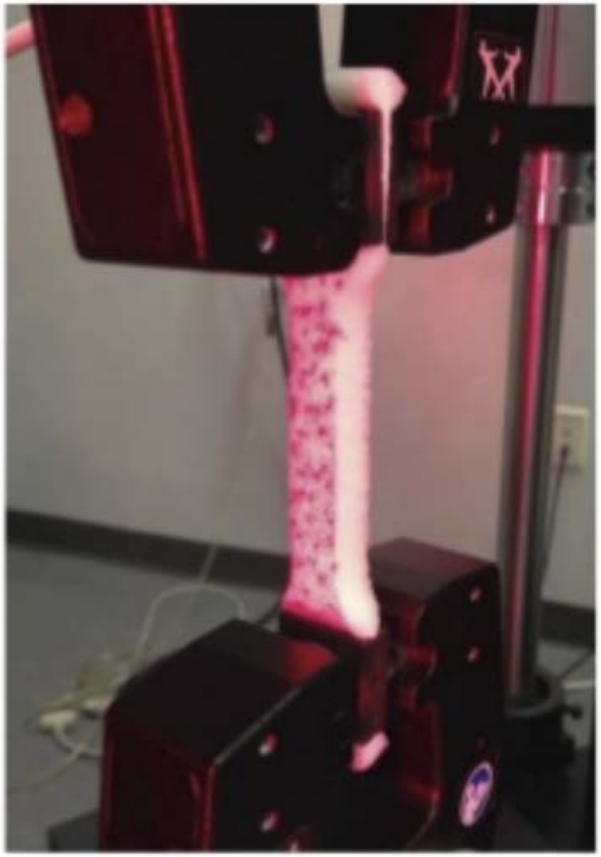
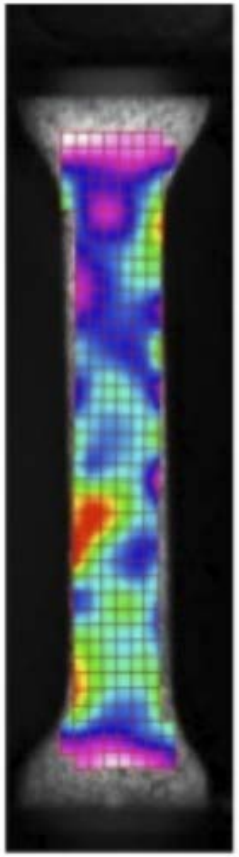


Technical Accomplishments

MSU has completed conditioning the coupons a round of testing following the design of experiments (DOE) laid out. The coupons have been soaked in a 50°C simulated saltwater immersion bath for 1000 hours. The saturated materials will provide a data set for design with the chosen material set.





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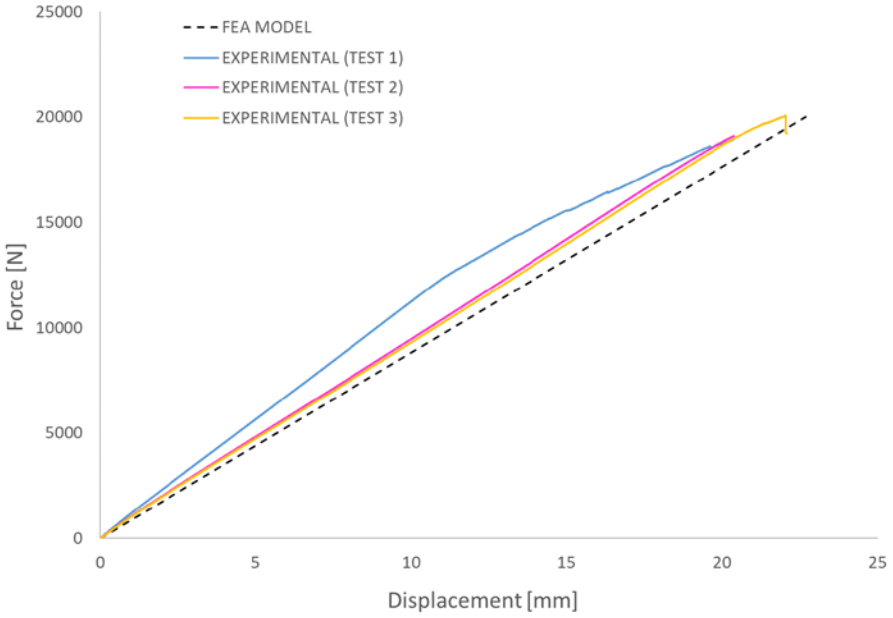
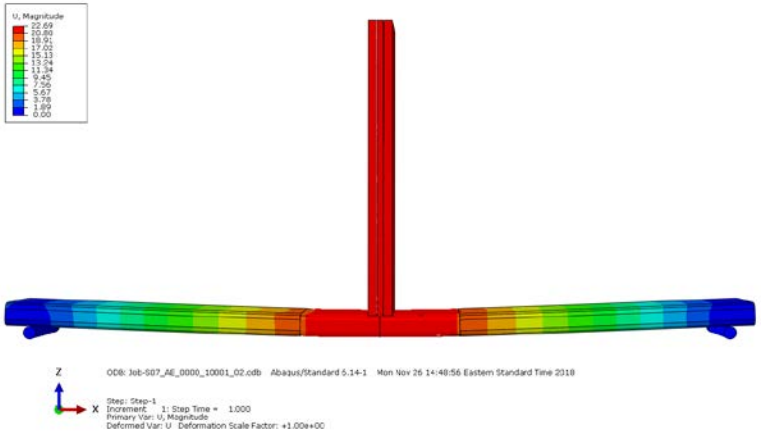
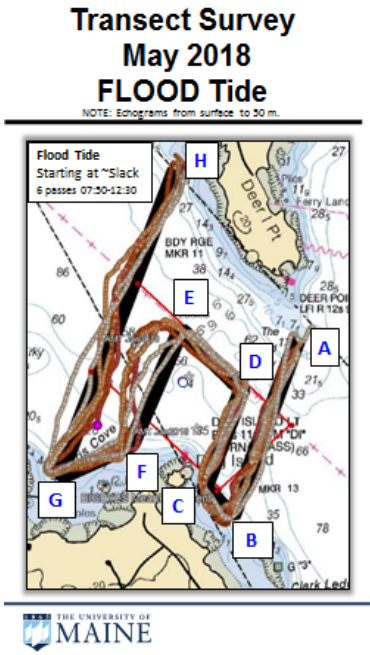


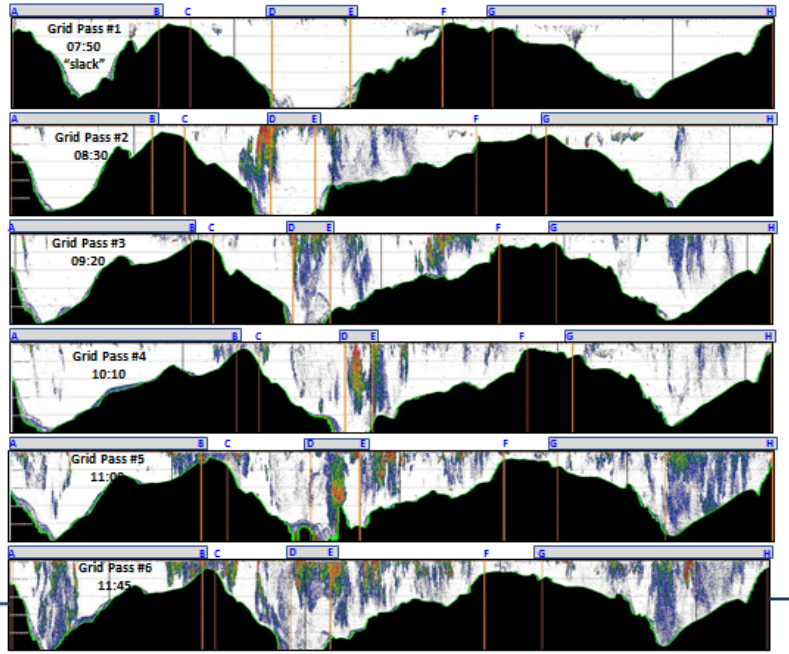


The turbine manufacturer performed a joint test. The test specimen was completed and will be tested with a test report outlining the methodology and results. These results will be used to validate Finite Element Analysis to ensure the overall turbine design will meet design requirements.

Technical Accomplishments

University of Maine School of Marine Sciences has continued preliminary data analysis from monitoring conducted in Western Passage in 2018 to inform appropriate plans during device operation, including statistical analysis, mammal vocalization assessment, and baleen whale detector data.





May 2018 transect survey, flooding tide: highlighting data collected on transects (B through G) between the bounding-channel transects including transects within the permit box (C through F). Note presence of backscatter from entrained air was present within the first hour of the flooding tide. Presence of entrained air persists and spreads through to the end of the survey 4.5 hours into the flooding tide

Future Work

- **Identify cost acceptable anchoring approach**
  - Gravity base anchors are not cost effective in terms of installation unless additional design work is completed to address the size and weight of these anchors by increasing modularity. This is an attractive approach, but still may not prove effective. Additional design work is required to investigate the use of high efficiency anchors such as rock pin or helical screw anchors.
- **Complete subsystem testing for turbines to demonstrate improved efficiency**
- **Field test system in low flow for two months**
- **Deploy system in high flows for one year**