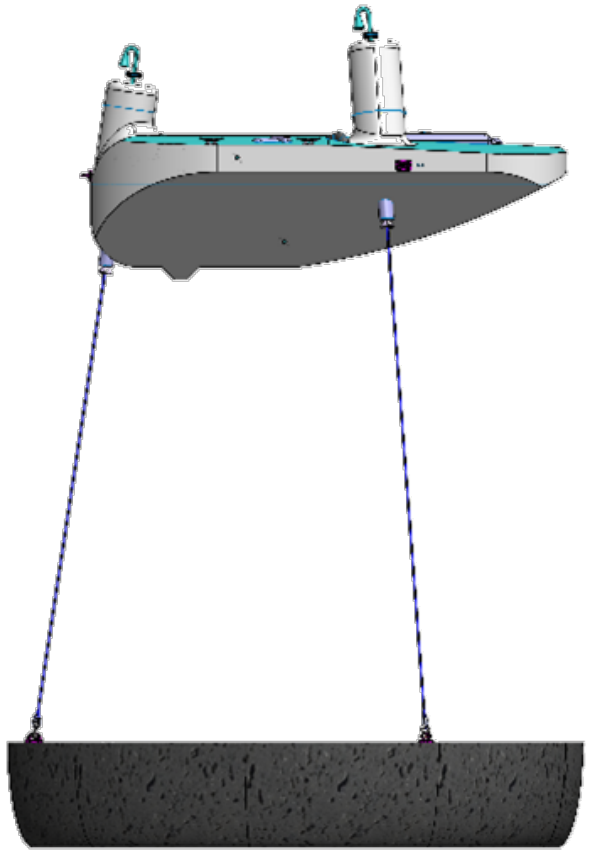
DE-EE0008625 – Performance Optimization and System Demonstration of a Multi-Mode Point Absorber



OSCILLA power™

MAINE Glosten JANICKI INDUSTRIES Kleinschmidt

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Presentation Date: July 19, 2022

Project Overview

Project Summary

- The purpose of this project is to improve performance, reduce costs, and develop a full-scale concept design of a 1MW Triton Wave Energy Converter (WEC) and validate the system with a 1:6 scale prototype. This work is needed to continue the development path to full-scale commercialization of the Triton. The combination of multimode energy capture, low-cost "tow and drop" installation, and high survivability are unique innovations for utility-scale WECs.

Intended Outcomes

- Through this project we intend to reduce the CAPEX & OPEX required and improve the energy production of the WEC. The goal is to achieve an Average Climate Capture Width per Characteristic Capital Expenditure (ACE) > 8m/$M and a Levelized Cost of Energy (LCOE) < 21c/kWh.

Project Information

Principal Investigator(s)

- Tim Mundon, PhD

Project Partners/Subs

- Glosten—float hull design
- Janicki Industries—hull BOM, FEA, & construction
- University of Maine—reaction ring design & construction
- Kleinschmidt--permitting

Project Status

Ongoing

Project Duration

- June 2019 - December 2023

Total Costed (FY19–FY21)

- $875K

Project Objectives: Relevance

The Marine Energy Program's mission is to conduct research, development, demonstration, and commercial activities that advances the development of reliable, cost-competitive marine energy technologies and reduces barriers to technology deployment. WECs will one day be part of the solution to achieve the goal of 100% electricity generation from zero carbon sources by 2035, generating economic opportunity and growth through the deployment of new energy technologies, and supplying clean, reliable power to underserved coastal communities.

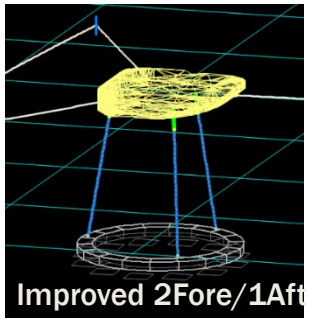
This project contributes to this mission by:

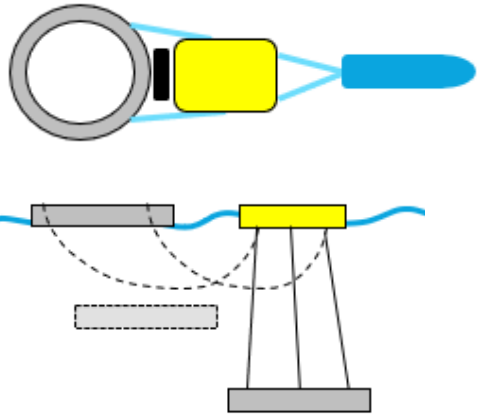
- Advancing an industry leading wave energy technology to further enhance its cost effectiveness.
  - Increasing the likelihood that wave energy technology will be adopted at a large scale
- Overcoming important and difficult engineering challenges through foundational R&D
  - Sharing data and work that can benefit the industry as a whole
- Advancing system design & validation:
  - Improved installation method will be tested.
  - We will strive to develop the design in line with IEC 62600-2 and DNV-OSS-312 standards with a view to ultimately becoming type certified.
- Reducing barriers to implementation by developing relationships between government, consultants, and local residents and gaining experience in mitigating environmental risk and permitting.
  - This project will help better define environmental impact and permitting needs for WECs which are not currently standardized.
- Improving use of data & tools to increase awareness of marine energy technology advances and lessons learned and develop a skilled marine energy workforce.
  - Goal is to increase the inclusion of marine energy in both coastal and energy resource planning processes.
  - Also will disseminate marine energy advances through publication of scientific papers.

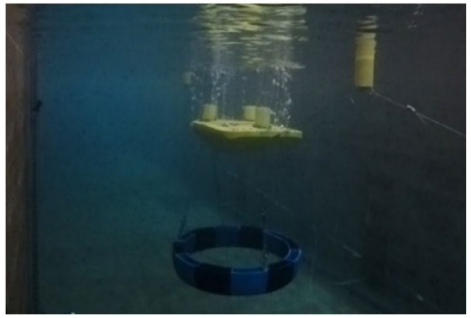
Project Objectives: Approach

Approach:

- Multimode energy capture: Triton's three-tendon architecture provides a unique ability to capture energy from the ocean in all six degrees of freedom (surge, sway, heave, roll, pitch, and yaw) enabling power to be produced across a wide range of ocean conditions.
- Low-cost "tow and drop" installation: Because the Triton uses flexible tendons to connect the float to the submerged reaction ring, this allows the system to be installed quickly by readily available marine vessels. These self-deployment functions remove the need for specialized vessels or heavy lift equipment.
- High survivability: Triton employs a method to submerge just below the surface when experiencing extreme waves. This approach was validated for a smaller-scale unit in previous work (DE-EE0007346) which showed the loads are mitigated significantly.



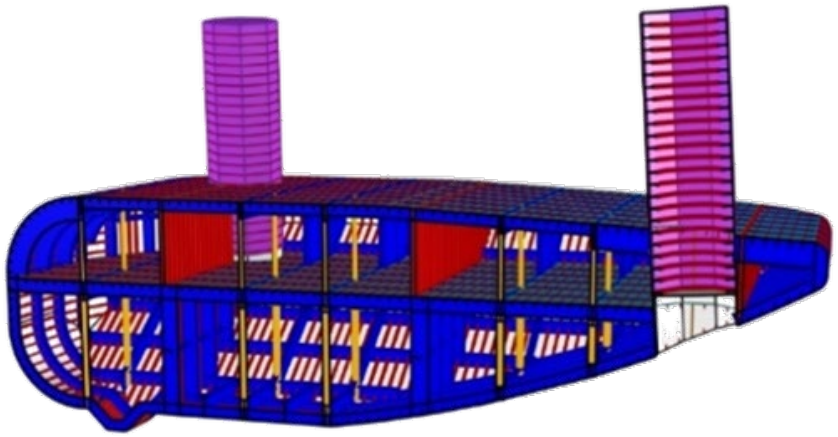




Project Objectives: Expected Outputs and Intended Outcomes

Outputs:

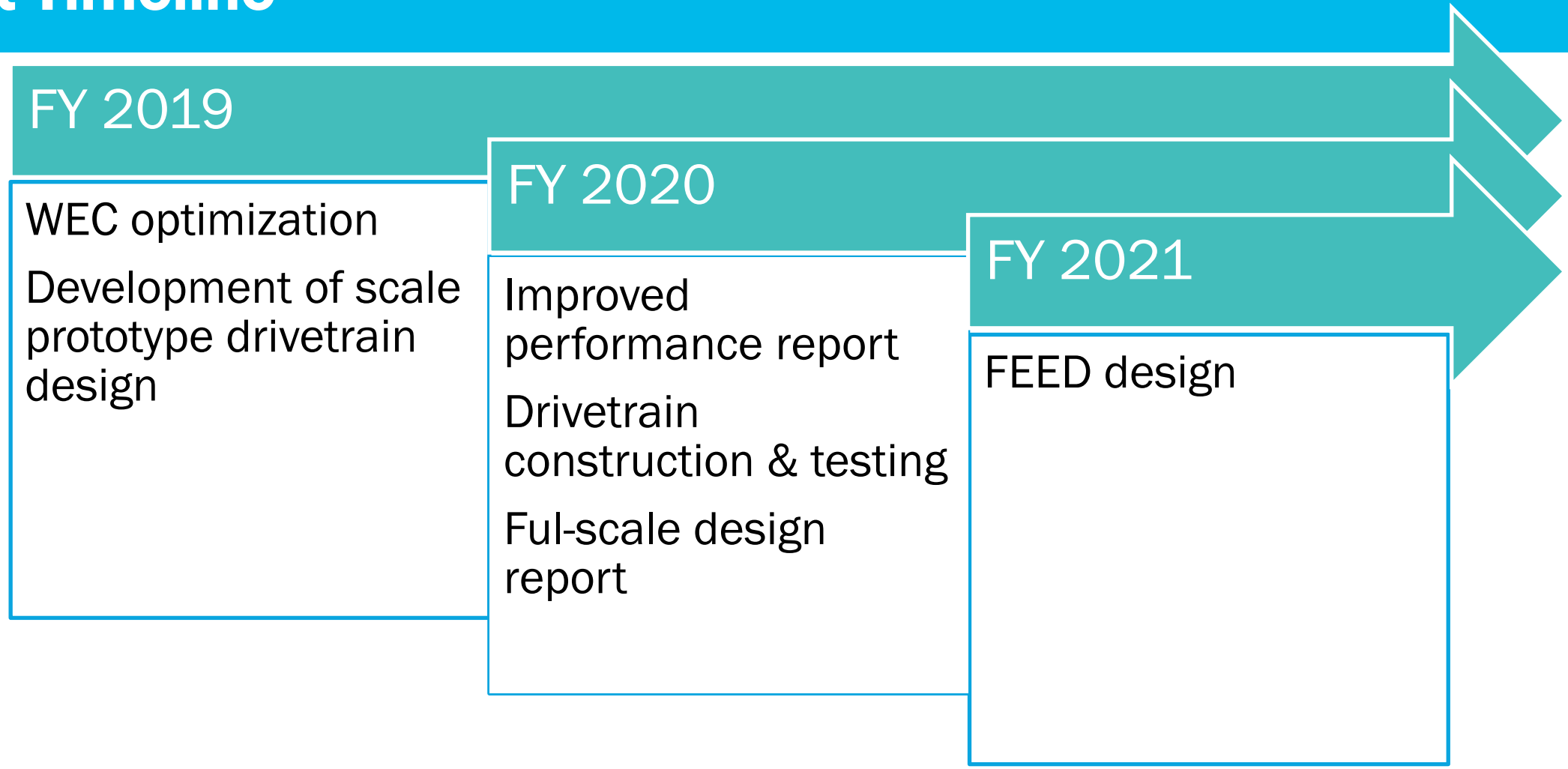
- A full-scale concept design
- A tested and validated 1:6 scale prototype.



Outcomes:

- The full-scale design and testing data will be fed into separate DoE project to develop full-scale unit.
- Data from 1:6 prototype will help validate numerical model.
- Testing of ballast system will help validate survival strategy at this scale.
- Composite structure will help validate material for full-scale use

Project Timeline



- BP2 provisional Go received June 2022.
- There were no Go/No Go decision points in the FY 2019 – FY 2021 reporting period after initial award.

Project Budget

Total Project Budget – Award Information		
DOE	Cost-share	Total
$3,461K	$865K	$4,327K

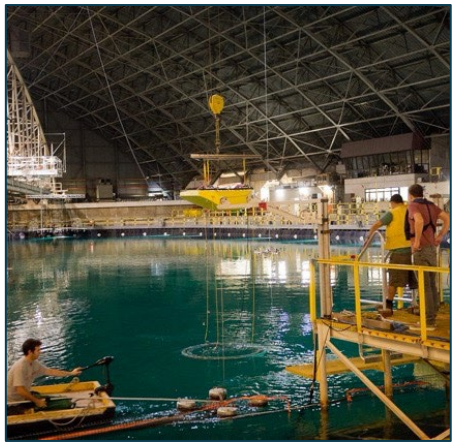
FY19	FY20	FY21	Total Actual Costs FY19–FY21
Costed	Costed	Costed	Total Costed
$163K	$513K	$199K	$875K

- OPI has completed BP1 within the approved budget

End-User Engagement and Dissemination

- Project beneficiaries:
  - End-users (utilities and project developers who are looking to utilize ocean waves for electricity generation at a large scale)
  - Isolated or underserved coastal or island communities who do not currently have access to affordable power
  - Others who have a vested interest in ocean energy being successful (marine & hydrokinetic (MHK) industry as a whole, DoE, and to some extent society as it is a step closer to carbon-free electricity)
- If successful, this project will provide validation of our proposed system improvements and design and hence our proposed cost of energy. It also marks a significant milestone toward the construction of our first utility-scale system
- Our engagement to date has indicated that a validated product, with confirmed costs, is required before this engagement can start in earnest
- We will make project results available through MHKDR (as required by DoE) and through conference and journal publications

Performance: Accomplishments and Progress



Parameter	Baseline System (WEP)	Improved System
Drivetrain/Power take off (PTO) Control	Basic Passive	Advanced/Independent Passive
Hull displacement	1950m^3	1950m^3
Surface Float Shape	'Baseline'	'Baseline'
Surface Float Material	Steel	Composite
Surface Float LOA	30m	30m
Surface Float Beam	23m	23m
Surface Float Draft	5.76m	5.76m
Surface Float Mass	750MT	450MT
Reaction Ring U/W Mass	1200MT	1500MT
Reaction Ring Diameter	30m	33m
Reaction Ring Height	6m	6.6m
Total Draft	83m	44m
Tendon Arrangement	1fore/2aft	2fore/1aft

WAVE ENERGY PRIZE
U.S. DEPARTMENT OF ENERGY

Performance Metric	Baseline System (WEP)	Improved System
ACCW (m)	5.41	9.71
CCE Hull	$641k	$308k
CCE Reaction Ring	$578k	$694k
CCE Total	$1.22M	$1.00M
ACE (m/$M)	4.44	9.71

Critical Success Factor	Target Value	Achieved Value
ACE (Avg Climate Capture Width per Characteristic Capital Expenditure)	> 8m/$M	9.71 m/$M
LCOE (Levelized Cost of Energy)	< 21c/kWh	20.7c/kWh
CAPEX (Capital Expenditure)	10% reduction	11% reduction
OPEX (Operational Expenditure)	10% reduction	12% reduction

- Target: Double ACE metric achieved in WEPrize
- Significant power capture enhancement driven by:
  - Incorporation of a lighter float/heavier ring
  - Using shorter tendons to better optimize surge power capture
  - Using a 10% larger reaction ring to increase added mass
  - Implementation of advanced passive PTO control techniques
- Cost reduction enabled by composites manufacturing

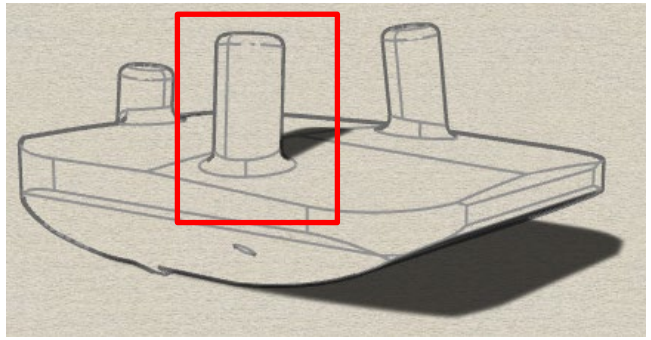
Average Climate Capture Width (ACCW) improved by 79%

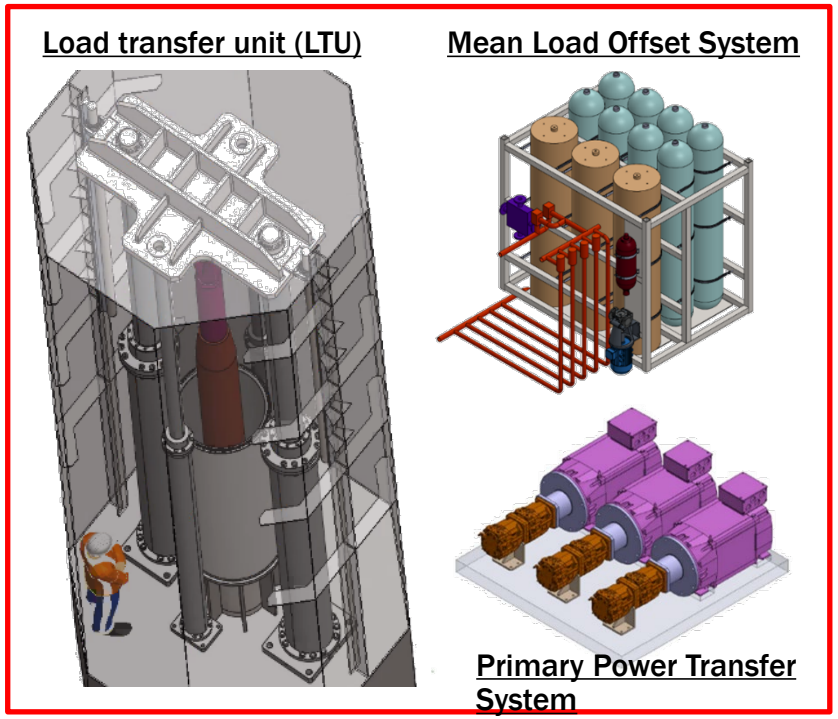
Average Climate Capture Width per Characteristic Capital Expenditure (ACE) improved by 2.2x

BP1 Recently completed.

All performance criteria met or exceeded

Performance: Accomplishments and Progress (cont.)

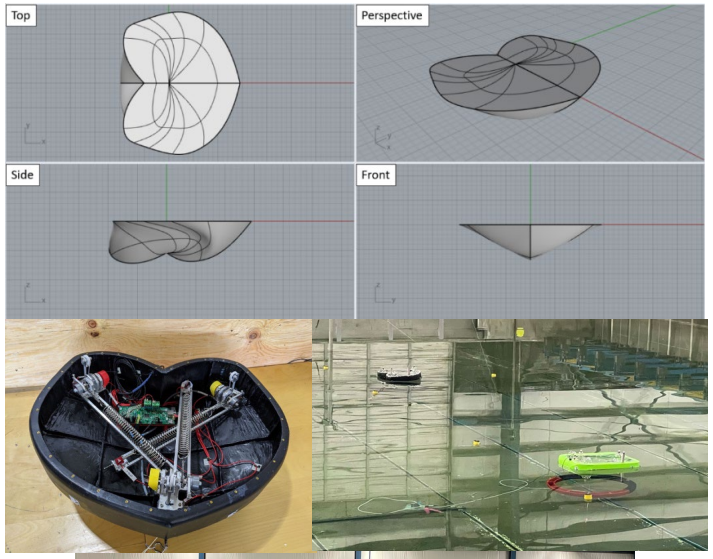




- Achieved a net 11% reduction in CAPEX:
  - Incorporation of advanced composite materials and volume manufacturing for the surface float. Assumes fleet deployment of 50 units.
  - Development of an improved ballast system relative to the original concept developed in DE-EE0007346
- Achieved a 12% reduction in OPEX:
  - Improved installation strategy
  - Switch to 2F/1R tendon arrangement
  - Development of the Hydraulic drivetrain in parallel project (DE-EE0008387)

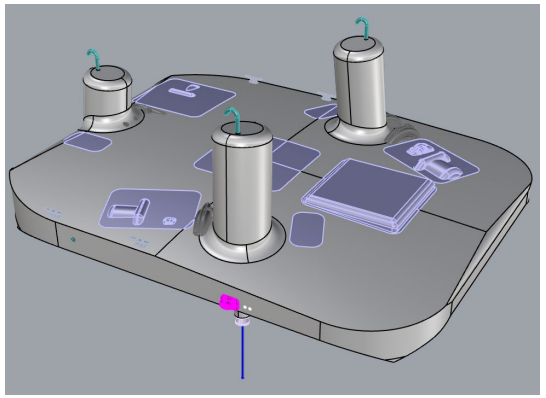
Performance: Accomplishments and Progress (cont.)

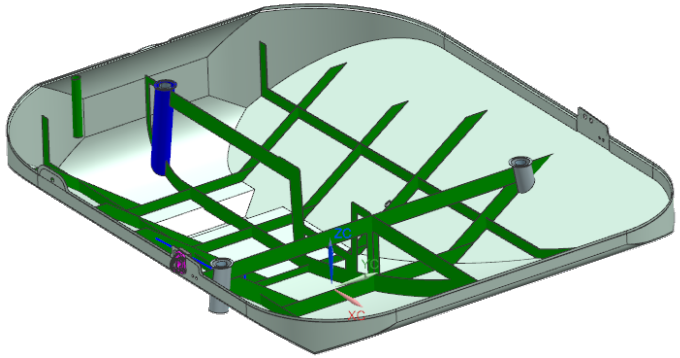
- We plan to apply for a patent for our installation approach.
- Worked with University of Edinburgh to employ a novel generative optimization algorithm to develop an improved hull shape
  - Tested with physical model at OSU with TEAMER support
  - The new hull did not offer an improvement, but developed a successful methodology that will be explored more in future work
  - We plan to publish on the approach to help inform the industry.

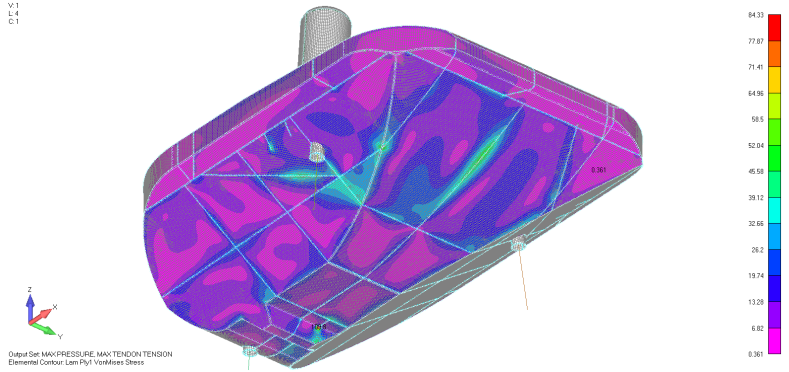


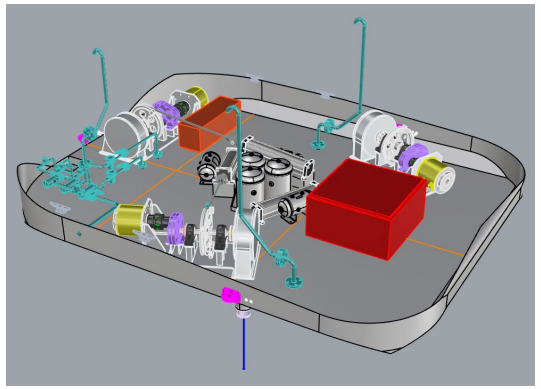
Performance: Accomplishments and Progress (cont.)

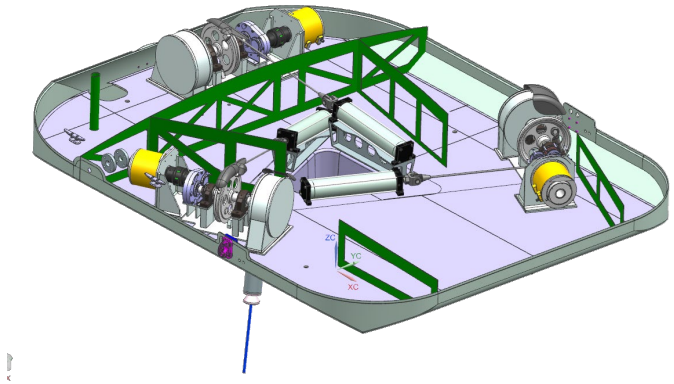
- Developed detailed design of 1:6 Triton prototype
- Tested 1:6 drivetrain in laboratory

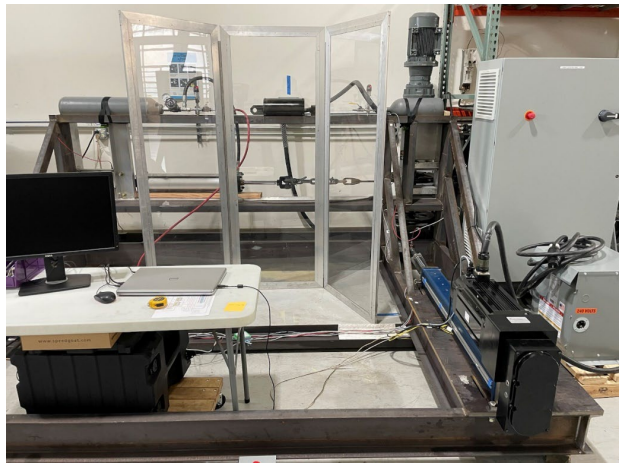




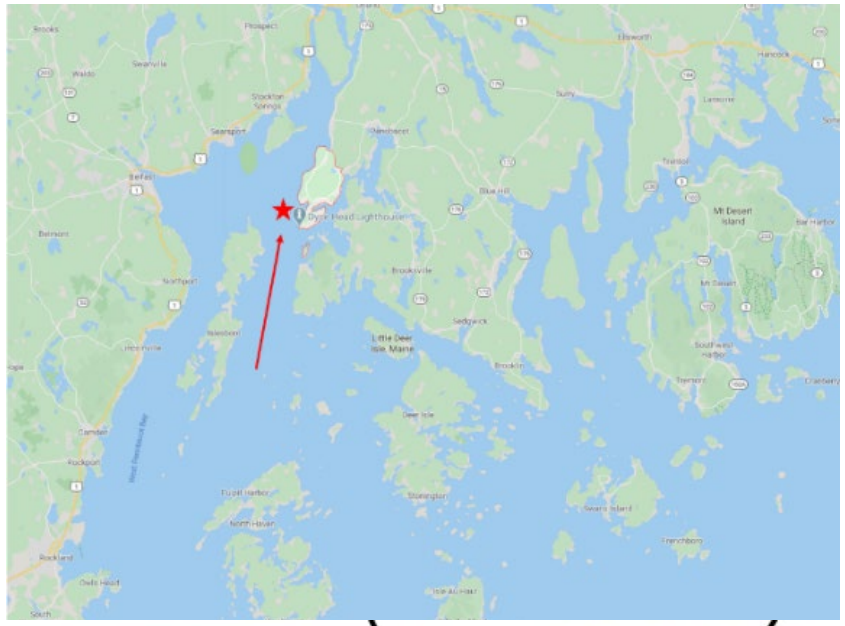








Future Work



- Anticipate procurement and manufacturing work to commence in Aug 2022 for 1:6 scale prototype
- Deployment expected in Winter 2022, allows preferred wave climate
- Remaining work:
  - Finalize detailed hull design for 1:6 scale prototype (OPI, Janicki, Glosten)
  - Obtain permits (OPI, Kleinschmidt, UMaine)
  - Fabricate & assemble (Janicki & OPI)
  - Transport & deploy at site (OPI, UMaine)
  - Operate for 3 months, collect data (OPI, UMaine)
  - Decommission (OPI, UMaine)
  - Post deployment analysis (OPI)

Q&A