Surface mesh for StingRAY v3.2
AQWA model
Wave Energy Converter Structural Optimization through Engineering and Experimental Analysis

The Challenge:

Materially decrease the levelized cost of energy for a wave energy converter (WEC) through improved power-to-weight ratio (PWR) performance.

Partners:

Ershigs
National Renewable Energy Laboratory (NREL)
## Program Strategic Priorities

### Technology Maturity
- Test and demonstrate prototypes
- Develop cost effective approaches for installation, grid integration, operations and maintenance
- **Conduct R&D for innovative MHK components**
- Develop tools to optimize device and array performance and reliability
- Develop and apply quantitative metrics to advance MHK technologies

### Deployment Barriers
- Identify potential improvements to regulatory processes and requirements
- Support research focused on retiring or mitigating environmental risks and reducing costs
- Build awareness of MHK technologies
- Ensure MHK interests are considered in coastal and marine planning processes
- Evaluate deployment infrastructure needs and possible approaches to bridge gaps

### Market Development
- Support project demonstrations to reduce risk and build investor confidence
- Assess and communicate potential MHK market opportunities, including off-grid and non-electric
- Inform incentives and policy measures
- Develop, maintain and communicate our national strategy
- Support development of standards
- Expand MHK technical and research community

### Crosscutting Approaches
- Enable access to testing facilities that help accelerate the pace of technology development
- Improve resource characterization to optimize technologies, reduce deployment risks and identify promising markets
- Exchange of data information and expertise
Cost improvement through innovative hull structure R&D

**Technology Maturity**

- Test and demonstrate prototypes
- Develop cost effective approaches for installation, grid integration, operations and maintenance
- **Conduct R&D for Innovative MHK components**
- Develop tools to optimize device and array performance and reliability
- Develop and apply quantitative metrics to advance MHK technologies

**Improvement Goal**

<table>
<thead>
<tr>
<th></th>
<th>AW PWR</th>
<th>DW PWR</th>
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<tr>
<td></td>
<td>64%</td>
<td>15%</td>
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**Project Impact:**

- Advances technical performance of StingRAY WEC
- Delivers hull design for Wave Energy Test Site (WETS) deployment
- Industry-pioneering advancement of composite hull structures
Technical Approach

- Hull design optimization to improve energy capture and lower capital cost
  - Baseline hull design (H1) was product of separate DOE project
  - Focus on top-end mass reduction and lowering center of gravity
    - Similar to wind turbine design
    - Advantage from substitution of lower-cost materials
- Finite Element Analysis (FEA) confirmed by physical testing
  - Design Load Cases (DLC) consider appropriate range of
    - Environmental conditions
    - Design and operational situations
    - Limit states
  - Load confirmations intended to allow smaller design margins and lower cost
Accomplishments and Progress

- Optimized H2 design concept offers significant PWR improvement
  - H2 WEC hydrodynamic model has been developed
  - DLCs established and load calculations modeled and reviewed
  - Hydrodynamic simulations run with post-process analysis
  - Hull design concept delivered for WETS deployment
- Improved core competencies in design analysis
  - Internal FEA capabilities and expertise have been developed

<table>
<thead>
<tr>
<th>Linear Power Generation</th>
<th>Rotary Power Generation</th>
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<tbody>
<tr>
<td>Gen 0 5 Years of Prototype Design at OSU</td>
<td>StingRAY H1 2012</td>
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<tr>
<td>L-1 2002</td>
<td>StingRAY 2016</td>
</tr>
<tr>
<td>L-10 2007</td>
<td>MantaRAY 2009</td>
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<td>SeaRAY 2010</td>
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Project Plan & Schedule

- Period of Performance: 10/01/14 – 09/30/17
  - Extension discussions underway
- Schedule delays
  - Vendor strategic change
  - Scope modifications and increase
  - Internal resource constraints
- Go/No-Go decision point for Budget Period 1 expected in Feb/Mar 2017
- Budget Period 2 plans
  - Comprehensive H2 design assessment and review
  - Select, design, and test structural components
Project Budget

**Budget History**

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<th>FY2014</th>
<th>FY2015</th>
<th>FY2016</th>
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<tr>
<td>DOE</td>
<td>Cost-share</td>
<td>DOE</td>
<td>Cost-share</td>
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<td>$232K</td>
<td>$58K</td>
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- Scope modifications and increases
  - CPower took over FEA and design load modeling; new requirement to build appropriate internal capacity and expertise
  - Insertion of modeling and design of advanced H2 concept conceived ex-Project
- 118% of BP1 budget expended, CPower absorbing cost of increased scope
- No external cost-share

**Total Project Budget**

<table>
<thead>
<tr>
<th></th>
<th>BP1</th>
<th>BP2 (pending go/no-go)</th>
<th>Total (pending BP2 go/no-go)</th>
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<tbody>
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<td>Cost-share</td>
<td>DOE</td>
<td>Cost-share</td>
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<td>$373K</td>
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<td>$203K</td>
<td>$116K</td>
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Partners, Subcontractors, and Collaborators:
Ershigs – Structural assessment and design
NREL – Physical testing facilities and support

Communications and Technology Transfer:
• CPower-NREL Open House at National Wind Technology Center—November 2016
• Small Business Voucher (SBV)—NREL and Sandia National Laboratories
Next Steps and Future Research

**FY17/Current research:**
- H2 structural design and assessment
- Physical testing
  - Selection of test articles
  - Test Plan execution
  - Analysis and possible incremental FEA effort
- Deliverables
  - System Structural Report
  - Test Article Design Report
  - Continuing Application
  - BP2 Reporting

**Proposed future research:**
- Incremental FEA effort – Sandia/NREL SBV
- Focus on structural FRP manufacturability