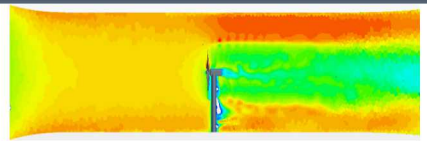
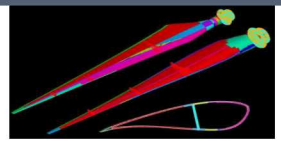
IMREC INTERNATIONAL MARINE RENEWABLE ENERGY CONFERENCE
NHA CONFERENCE
MARINE ENERGY TECHNOLOGY SYMPOSIUM
WATERPOWER WEEK 2019
SAND2019-6033C

Marine & Hydrokinetic Advanced Materials Program

PRESENTED BY

James R. Nicholas*, Bernadette A. Hernandez-Sanchez, Budi Gunawan, George Bonheyo, David Miller, Francisco Presuel-Moreno, Scott Hughes

FAU FLORIDA ATLANTIC UNIVERSITY
MONTANA STATE UNIVERSITY
NREL NATIONAL RENEWABLE ENERGY LABORATORY
Pacific Northwest NATIONAL LABORATORY

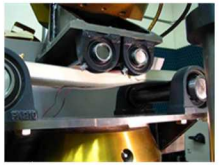
Water Power Technologies Office within the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE)

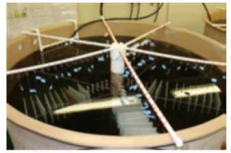
Program Overview

Marine and Hydrokinetics Advanced Materials Program: support the MHK industry through applied research and guidance on Materials & Coatings to enable viability, lower the cost of energy (COE), and accelerate commercialization

The Challenge: Proper structural/component materials and coatings are critical to reducing engineering barriers, COE, and commercialization time

- **Structure Design & Component: (LOADS! uncertainty in composite/design)**
- **Environmental Exposure Issues**
- **Cost (Manufacture, O&M, Reliability)**
- **Safety & Certification**





Current Program Objective: Helping MHK industry reduce uncertainty in using composites in their designs

- Direction taken from 2015 Workshop on Composite Needs for MHK and industry partners
- Past efforts involved determining materials needs for industry, examining coatings for biofouling, and examining marine effects on wind based composites

Materials can impact areas that affect commercialization

- Structure costs
- Design & manufacture
- Accelerate manufacturing or direct advanced manufacturing strategies
  - We are working to reduce risk through testing of novel materials and validate materials from other marine-based industries under MHK conditions.
  - Future testing on materials under deployed conditions are needed for validation.
- Reliability & Survival
- Operation & Maintenance
- Certification & Safety

Helping the MHK industry with materials challenges

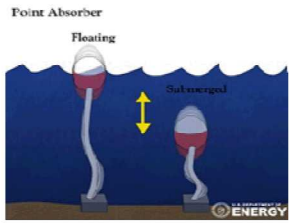
Courtesy of Resolute Marine Energy

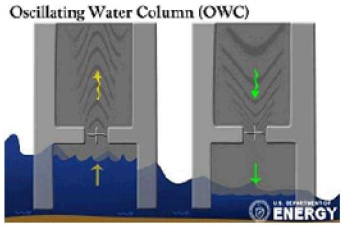
http://www.yachtsurvey.com/glassboats-1.jpg

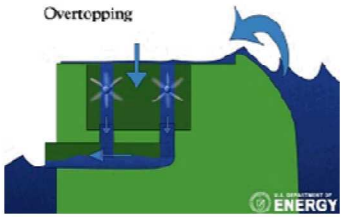
http://www.racerocks.ca/

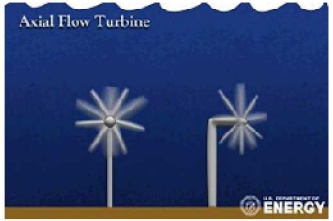
http://tidalenergytoday.com/2016/01/12/icit-emec-study-biofouling-of-marine-energy-technologies/

Why investigate fiber reinforced composites?



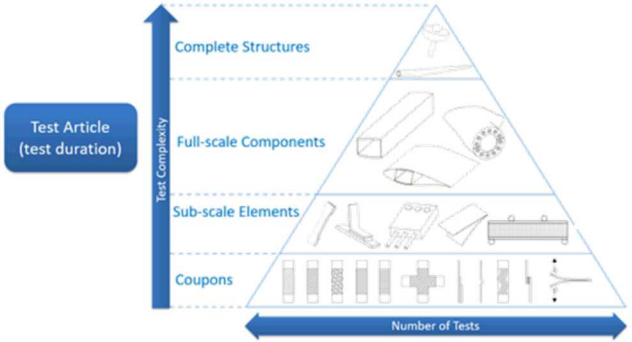






- **Areas of concern vary by design:** metals, hydraulic fluids, polymers, cement, magnetic, coatings, composites
- **Composites Include**: Reinforced rubbers, reinforced concrete, fiber reinforced plastics
- **Studies indicate impact to cost:** Reference Models (SNL, NREL); Wave Energy Scotland Structural Loads and Materials Landscape Study; and 2011 Carbon Trust report indicate the structure costs can be impacted by using light weight and non-corroding materials.

Goal is to address barriers & uncertainty in using composite materials for MHK.



Building block structural verification

Sea Water Effects on Composite Performance

Biofouling & Environmental Effects on Composites

Corrosion of Metal – Carbon Fiber Composite Interconnects

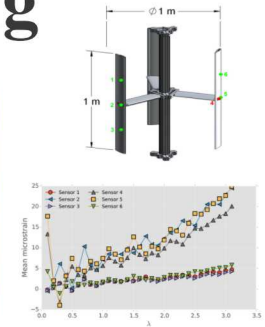
Environmental effects on mechanical property

- Saturation
- Strength
- Fatigue

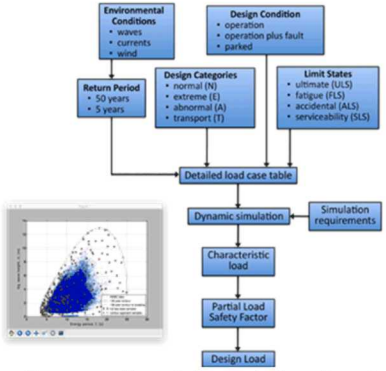
Design considerations for marine environment exposure

- Increase in factor of safety
- Maintenance schedules
- System Lifetime

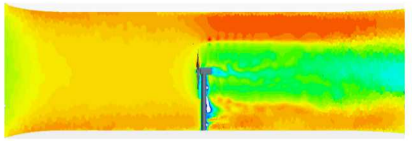
Provide Realistic Load for Material Performance Testing

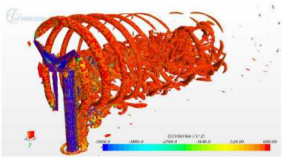


Fiber Braggs Grating for real time strain measurements



*Process for determining loads via load cases**





Dynamic and load characteristic simulations

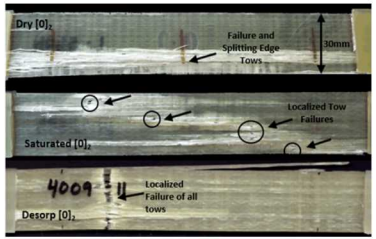
Design load $F_d = \gamma_f F_k$ < Material's strength $f_d = \frac{f_k}{\gamma_m}$

Industry needs for structural and mechanical load measurements

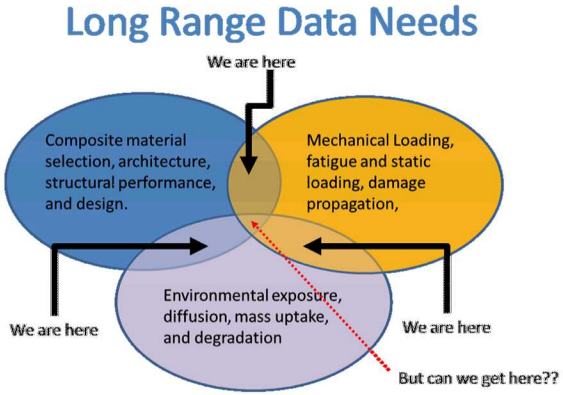
- Load measurement and verification is identified as the highest priority standard for development based on input and agreement from the National Committees"
- Cost effective and reliable means of accurately measuring structural loads in real time during ocean trials
- Load data during field operation to validate structural and hydrodynamic models, provide confidence in system reliability
- Predictive loads for mechanical designs and testing

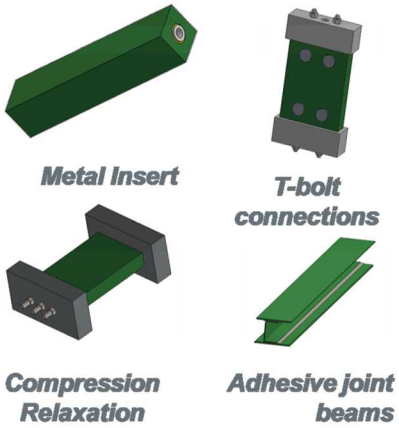
*IEC TS 62600-2 Design Requirements for Marine Energy Systems (https://webstore.iec.ch/publication/25634)

Where we are and What is to come



Coupon Mechanical Test Specimen





Coupon level study complete

- Effects of soaking and temperature
- Saturation under an applied stress
- Tension-Tension Fatigue
- Stacking sequence and partial saturation
- Altered damage mechanisms after saturation

Sub-scale element testing in progress

- Build on finding from coupon-level results
- Determine design loads for large subcomponent
- Instrument subcomponent with load sensors

Sub-scale element: bearing stress specimen

Develop and demonstrate subcomponent test methods

- Reduce the time and cost required for full-scale structural validation
- Provide near net-scale static and fatigue data on composite subcomponents of materials for MHK system