# Wave Tank Testing and Model Validation – Lessons Learned

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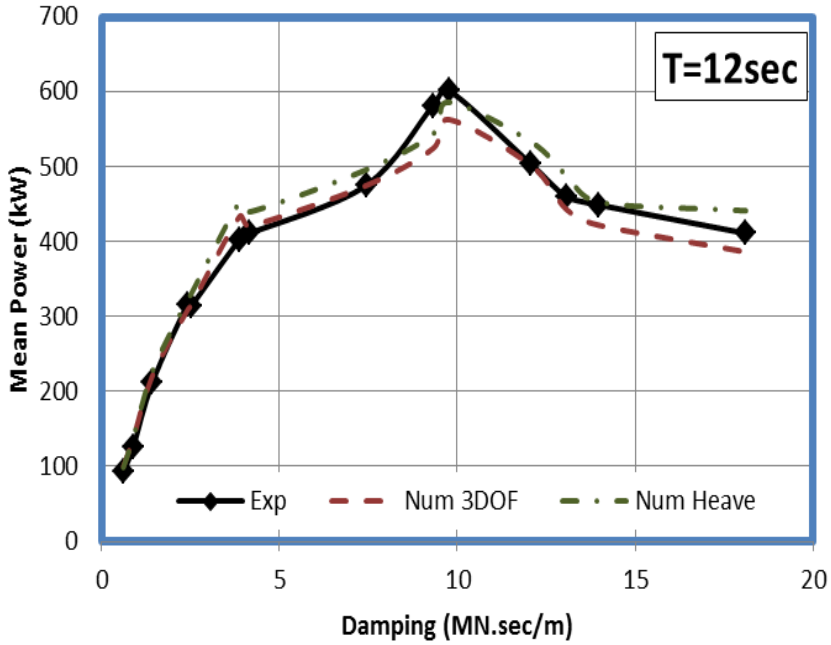
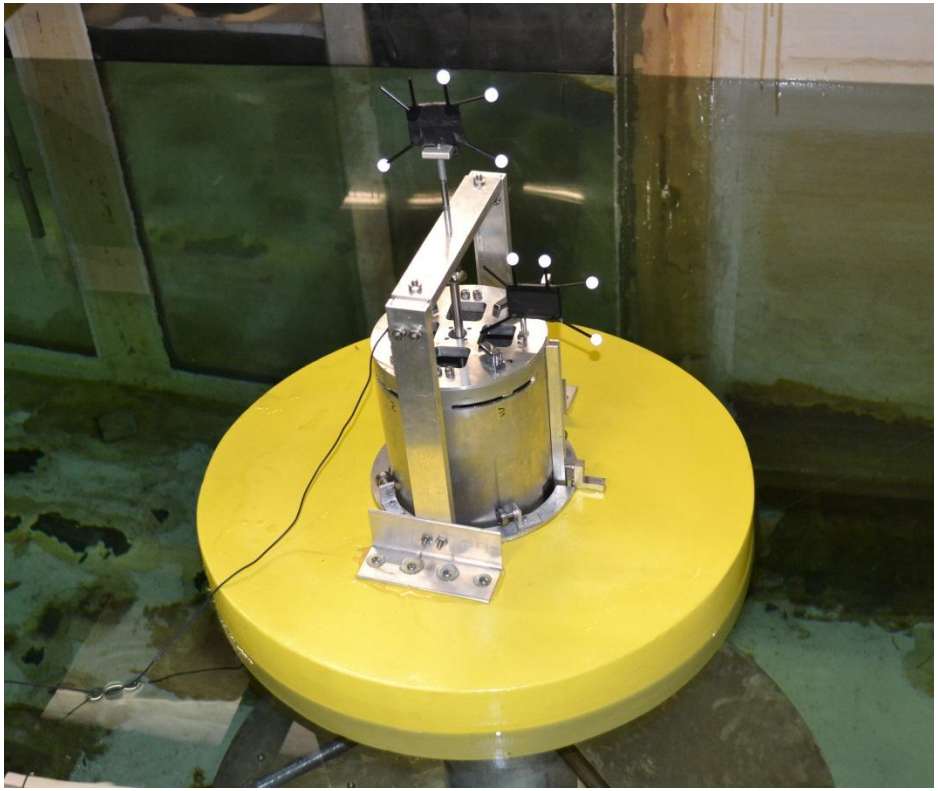
**7-7-12**



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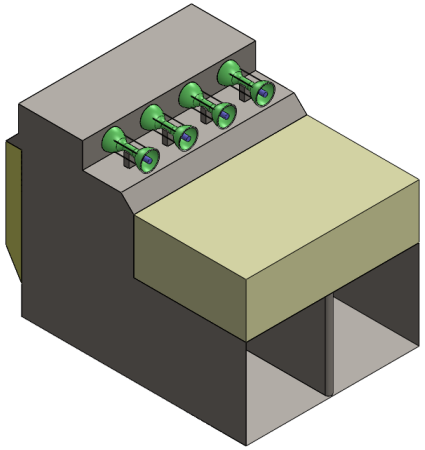
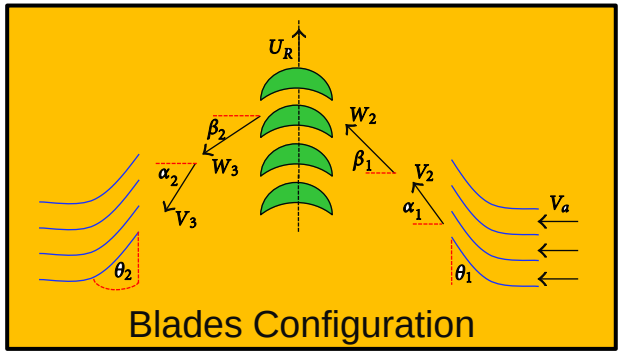
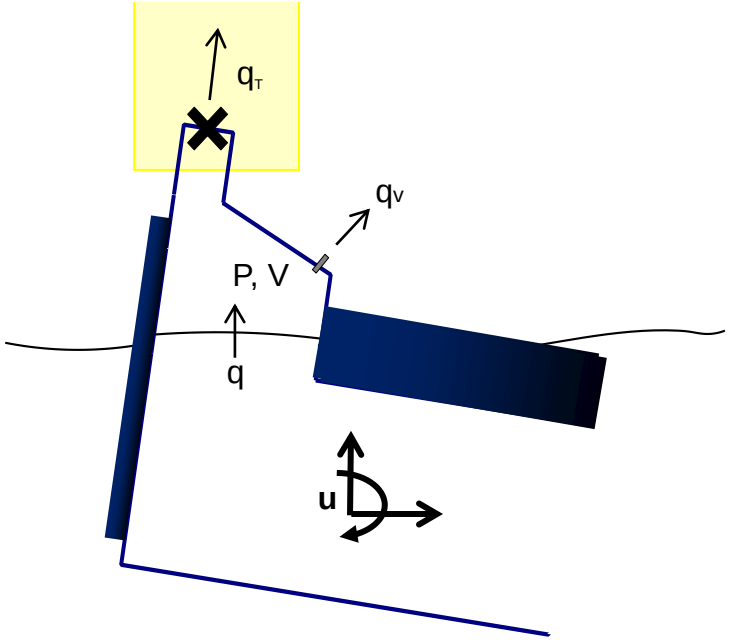
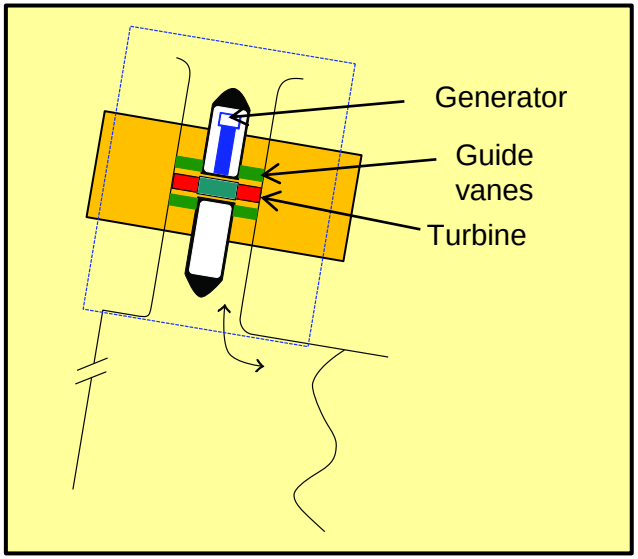
# Representing the Full-Scale System



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# Appropriate Modeling of Physics

Run-time is important to make a model useful as an engineering and/or optimization tool.

- Have to be selective about how the physics is represented in the model
- Different physical phenomena are important to different WEC devices

Subscale modeling allows to help us understand and validate the models physics.

- Ideally we can isolate physical phenomena to properly debug theoretical model
- Focus is on validating fluid-structure interaction
- Scaling of mechanical systems needs to represent the physics of the full-scale system (i.e. mooring, power-take-off, control system).

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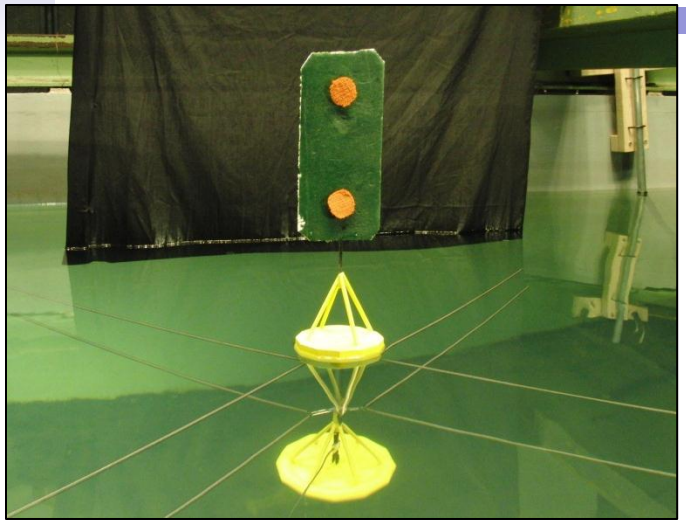
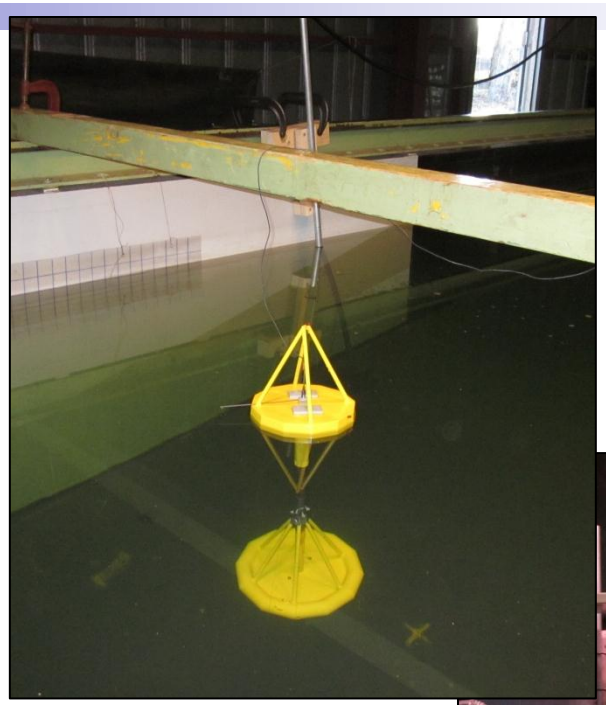
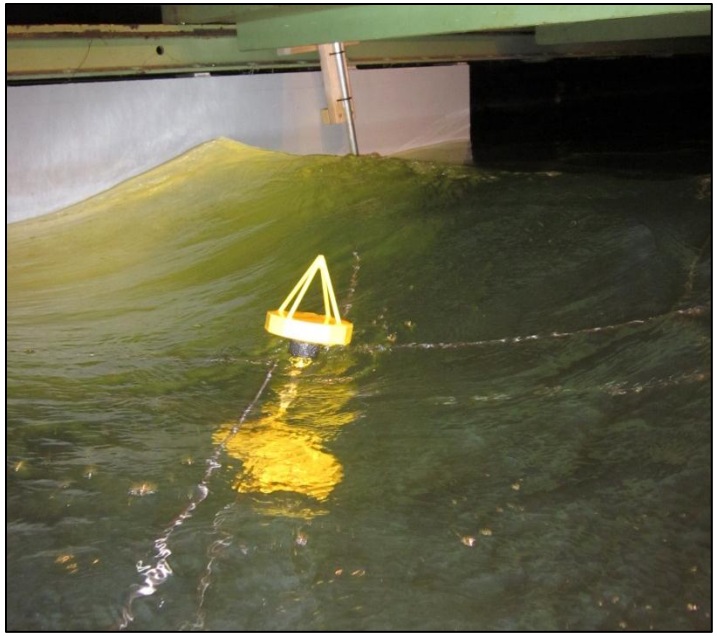
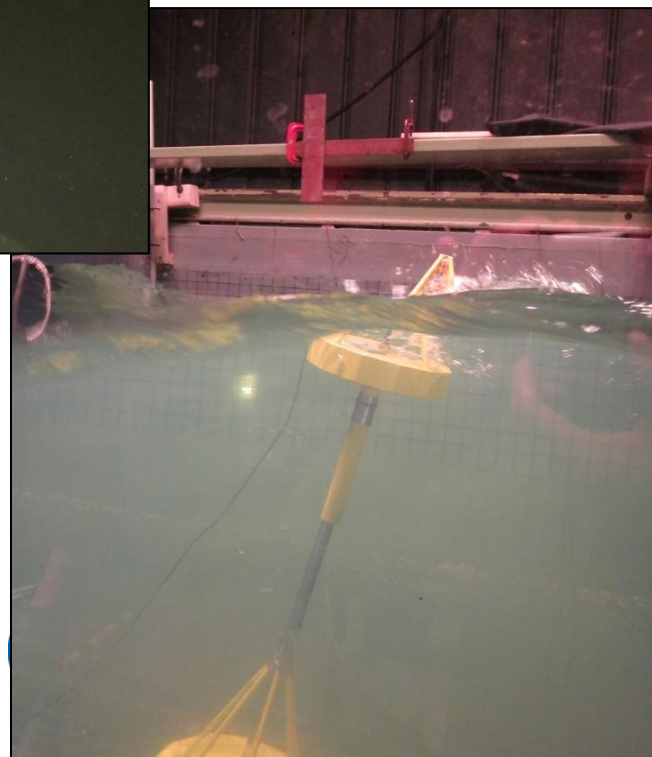
# Point Absorber 1/100th Scale & 1/46th Scale, November 2010

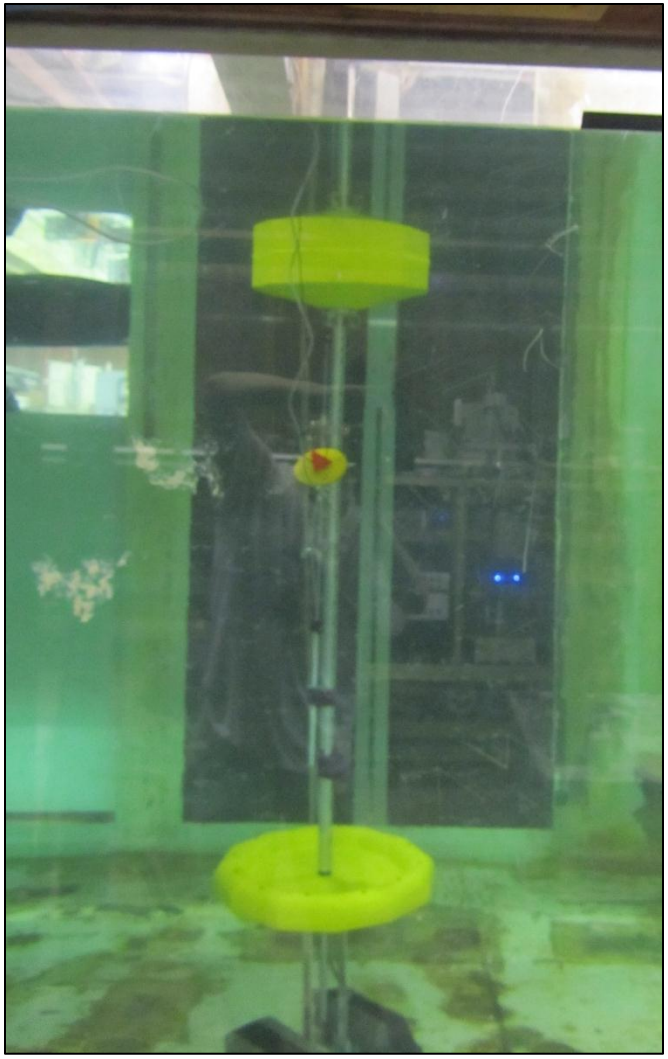


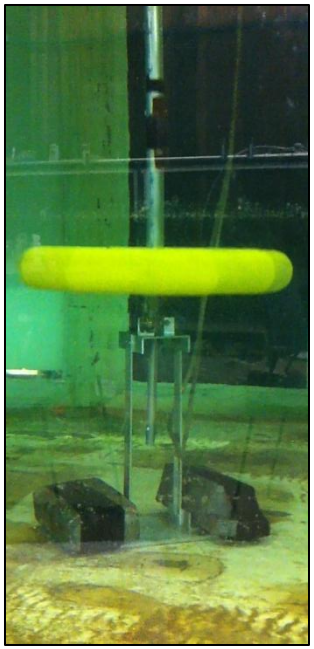


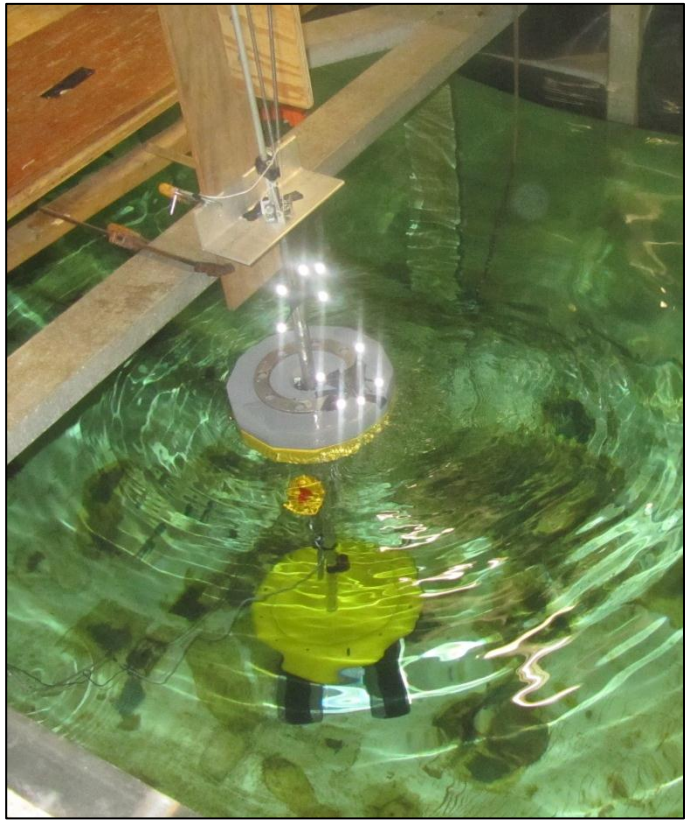




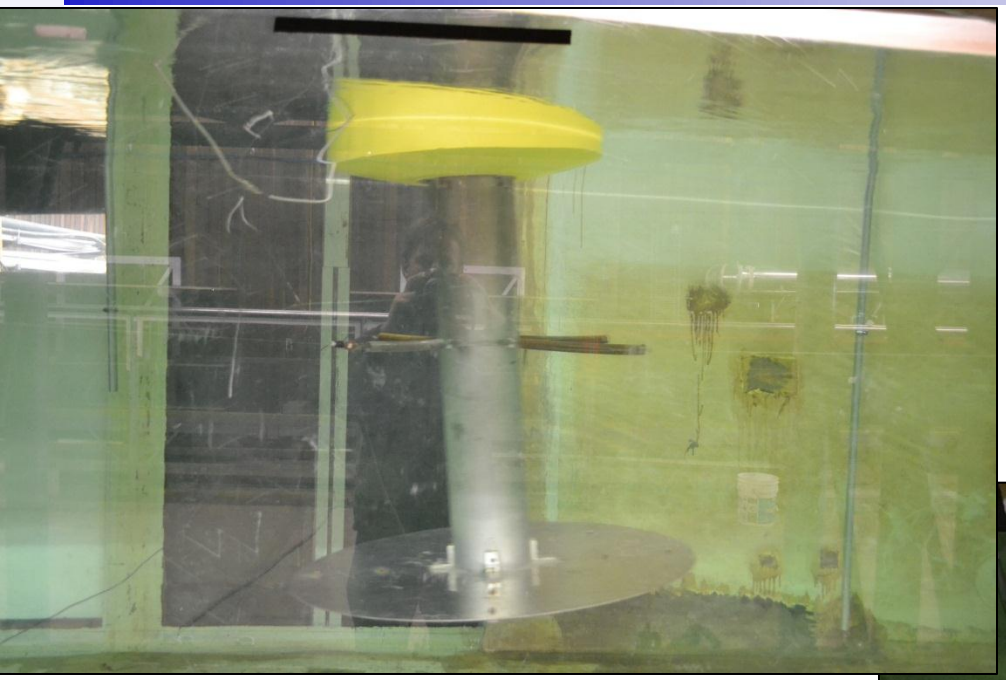
# Point Absorber 1/46th Scale, August 2011

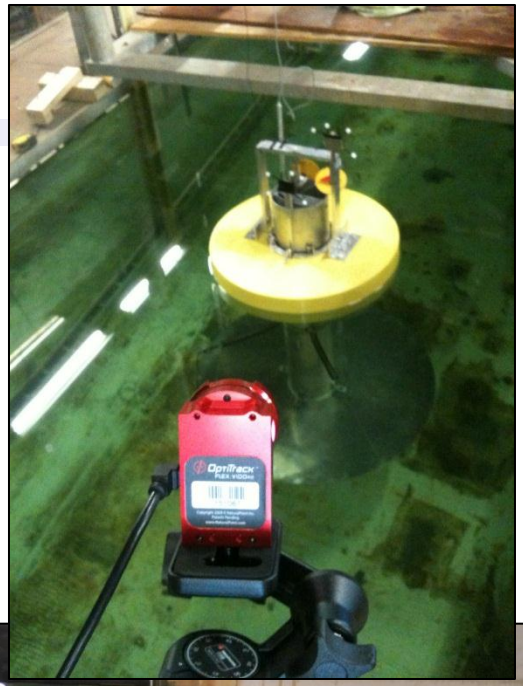


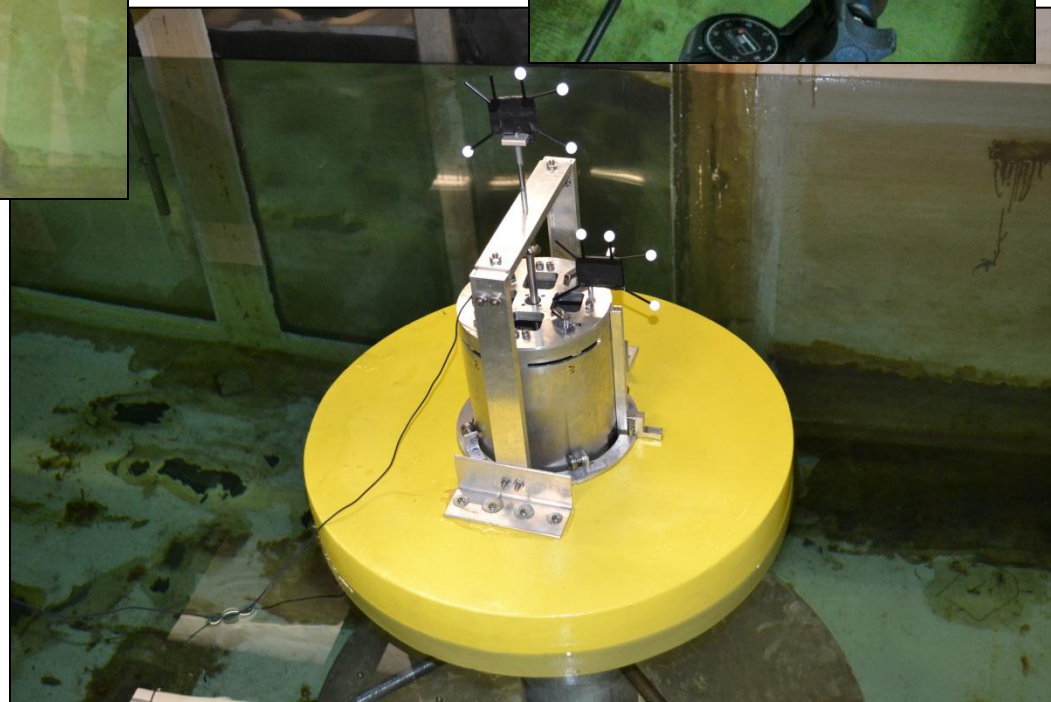




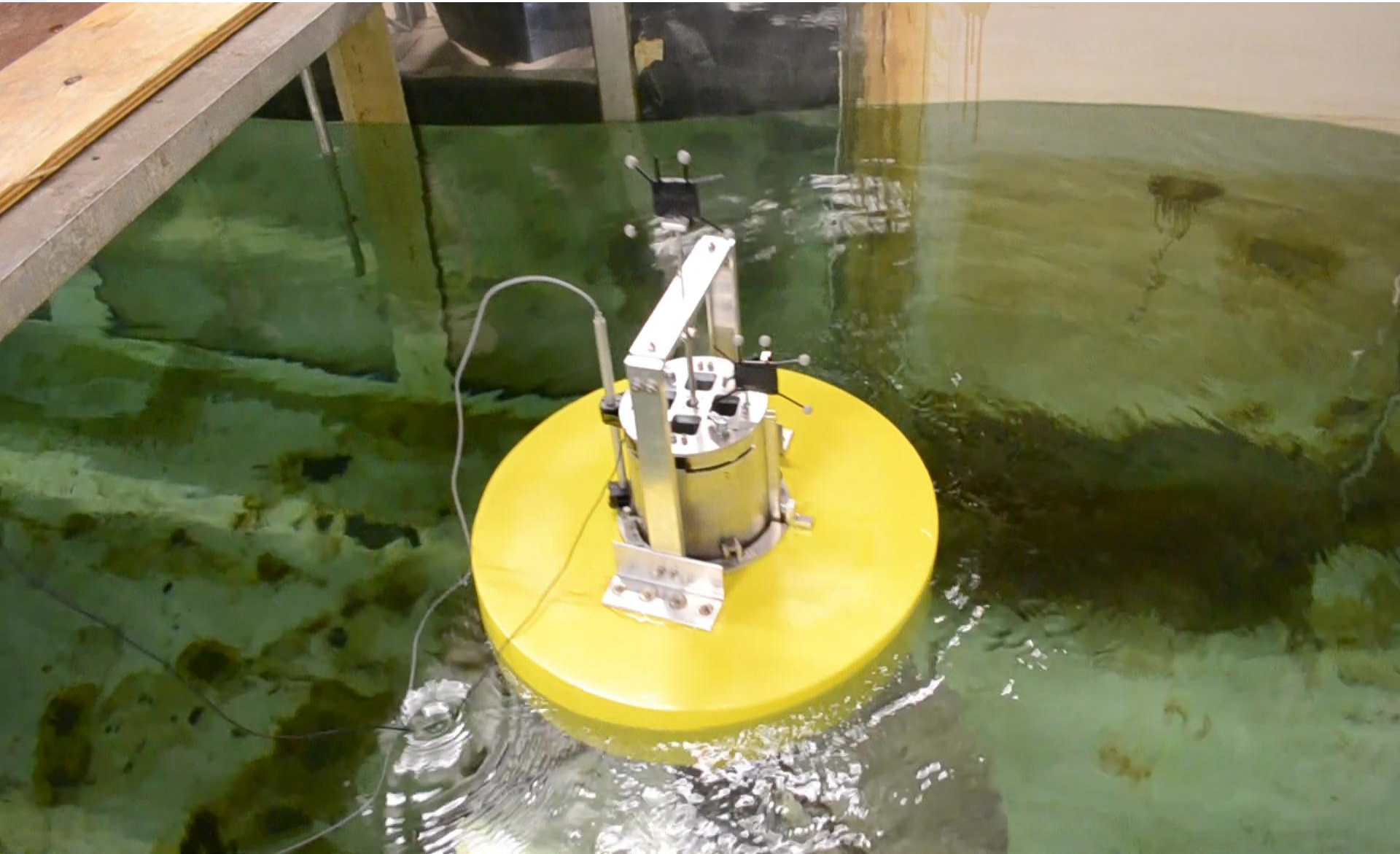
# Point Absorber 1:33 Scale, October & November 2011



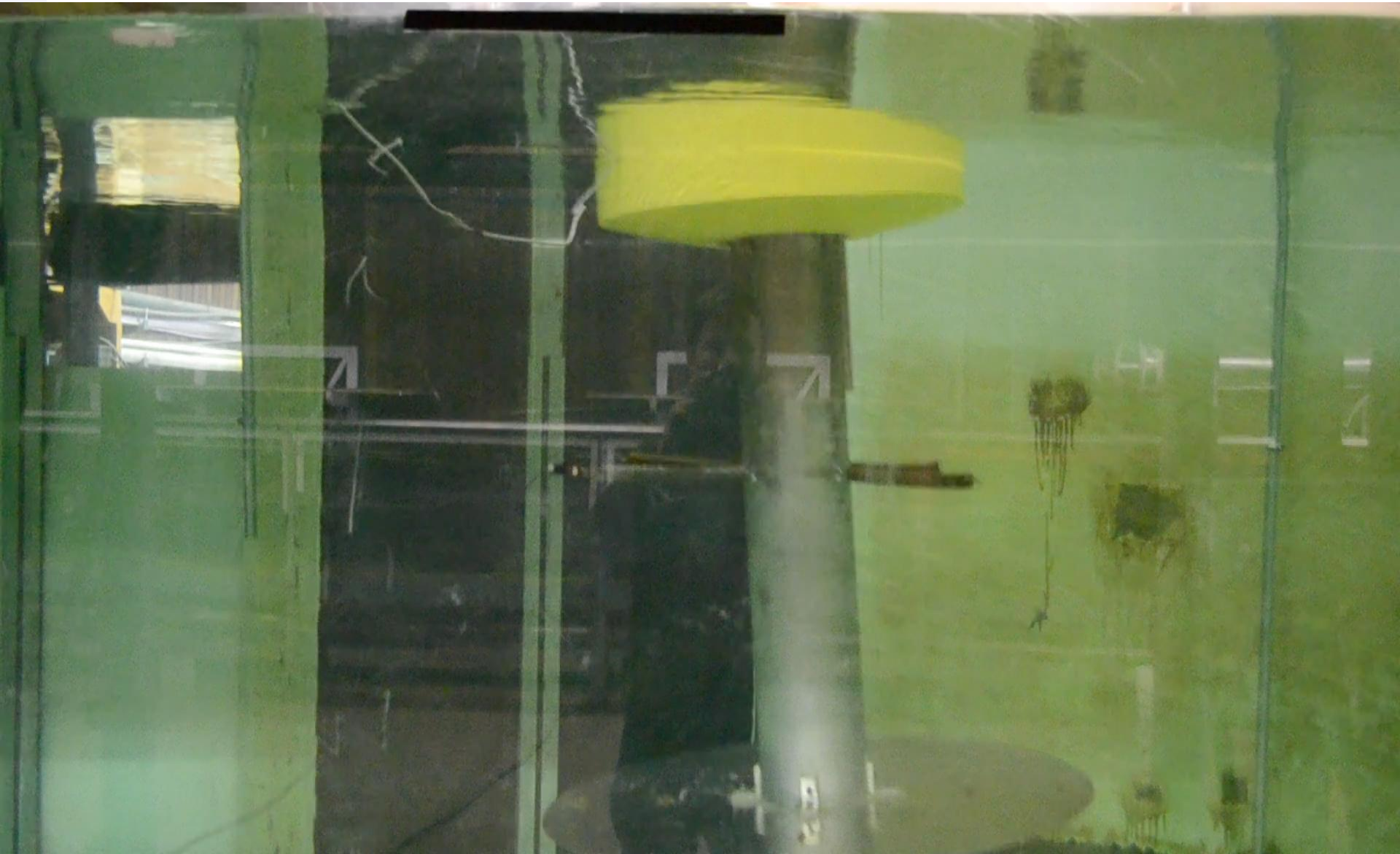


# Testing Video 1 – ISO View



# Testing Video 2 – Side View



# Testing Video 3 – Damping Plate Vortex Shedding

# Economics of Wave Tank testing

- Dayrates of wave tank facilities:
  - OSU wide basin $5k/day
  - OSU Flume $3.5k/day
  - Richmond $1.5k/day
  - Scripps $1.5k/day

Other Considerations:

- Tank Testing Support & Operation Staff: $500-$1000 / day
- Travel & Lodging for testing personnel: 2-4 persons @ $200/day
- Salaries for testing personnel: 2-4 persons @ $600/day

=> Burn-rate Range: $3600 - $9,200 for 8-10 hours/day => $360/hr - $1150/hr

Typically, at least a week of testing is required for any reasonable testing program. 2days setup, 2 days testing and 1 day take-down.

=> Each test costs between $18k and $46k

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# Infrastructure Issues

- Most wave tanks were not built for WEC testing:
  - Outdated hydraulic wave makers
  - Passive absorbing beach instead of active wave cancellation
  - Survival scale is too small in most cases (i.e. 1:100 scale)
- Primary issues:
  - Wave generation is inaccurate
  - Wave-maker unable to cancel reflected waves from model and beach
  - Water-depth is not easily varied
  - Extreme waves at scales that are too small
  - Schedule and Cost of existing facilities
- Solutions:
  - Design wave energy specific wave tanks (examples HMRC, Edinburgh)
  - Build and Manage facilities through competitive contracts to minimize cost

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# Sensors & Instrumentation

Non Issue:

- 6DoF motion measurement
- Wave probes
- Load cells
- Displacement measurements (linear or rotary)
- Data Acquisition and signal filtering

Challenging:

- Representing the PTO at scale
- Representing mooring system at scale
- Determining drag-terms in oscillatory flows

=> Many of the above systems could be modularized

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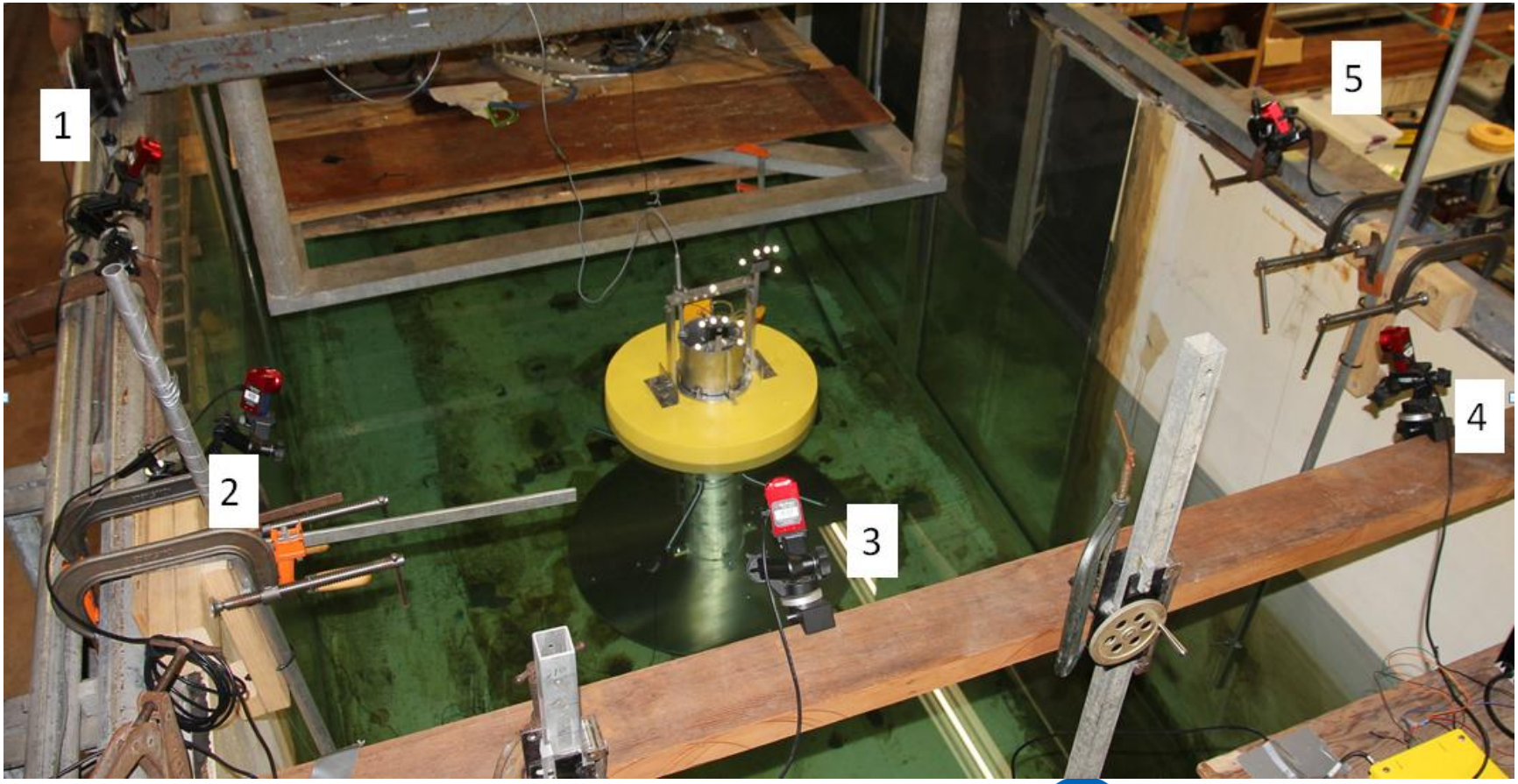
# Motion Tracking System

OptiTrack System used to record the 6 DOF motions of the model

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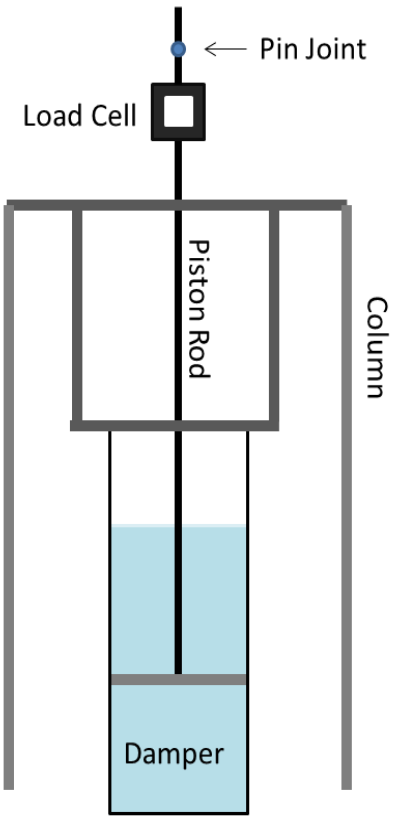
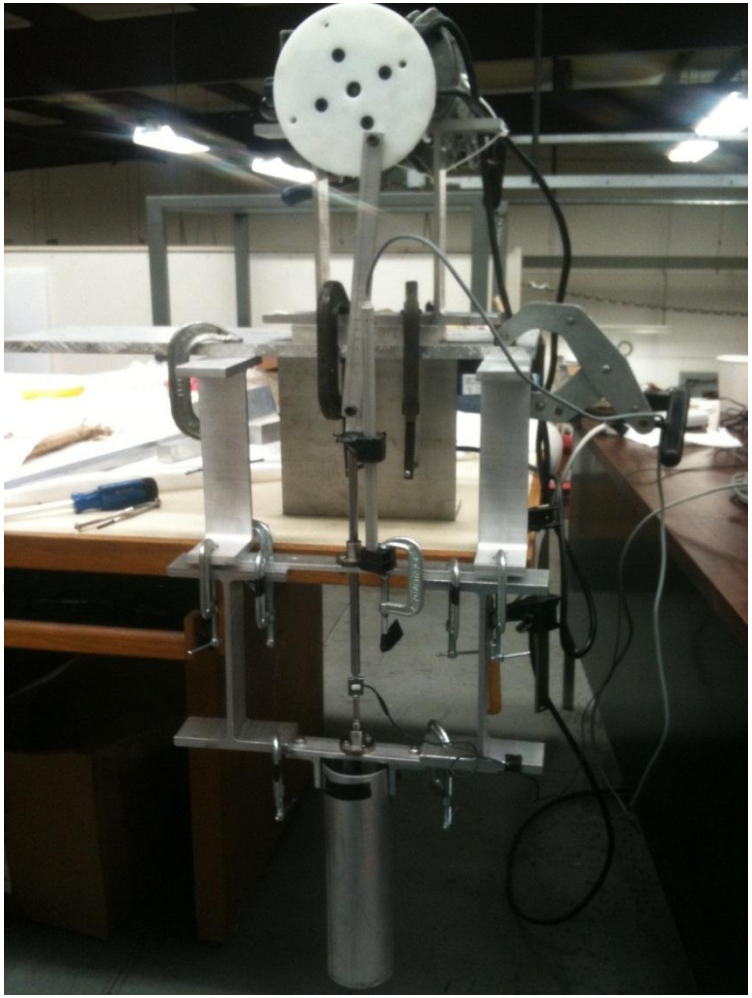
# Model Power Take-Off





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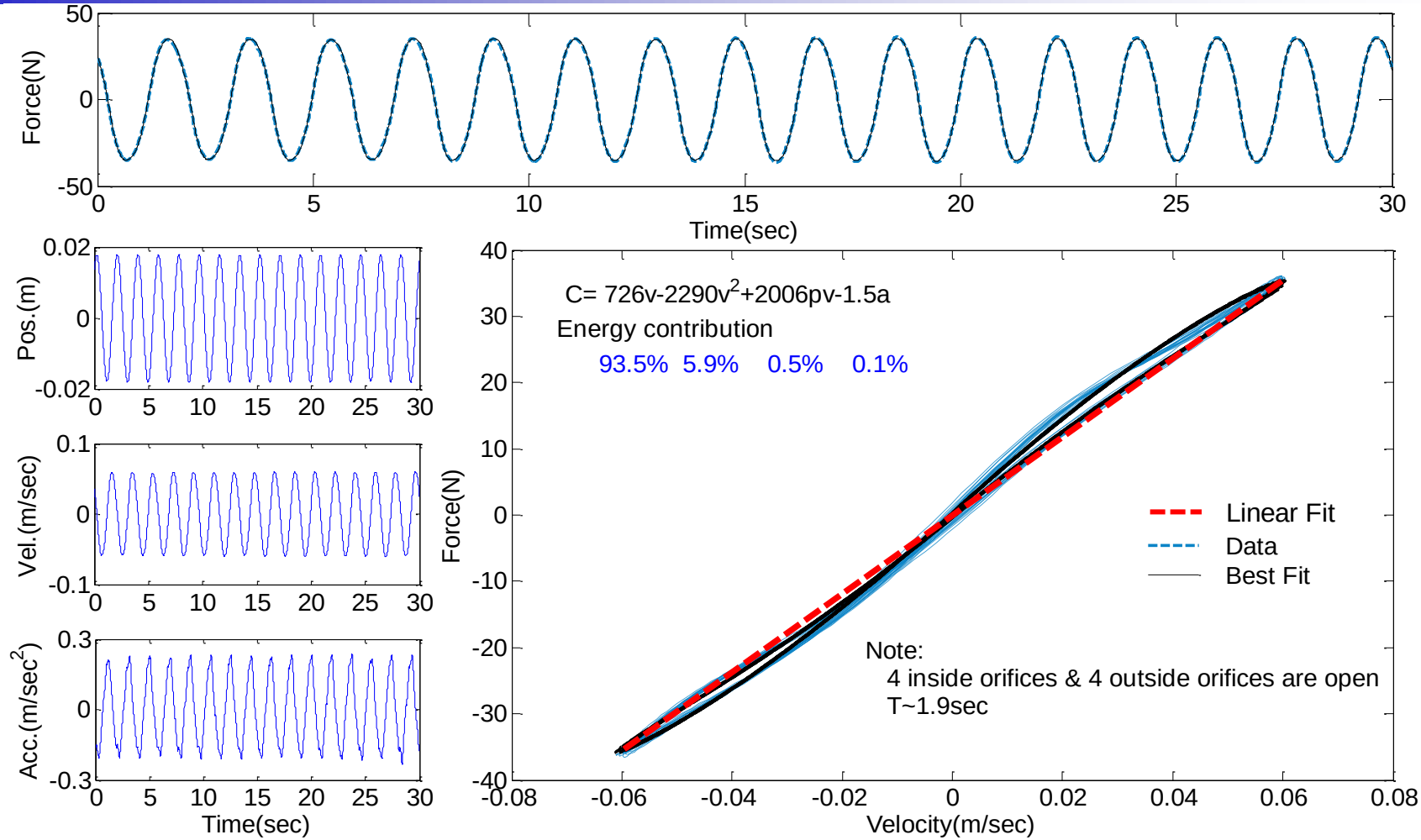
# Model Power Take-Off Calibration Results

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# Programmable Power Take-Off

Requirements:

- Low Weight to allow direct integration in scale-models
- Rapid variation of reaction force (positive and negative)
- Digitally controlled
- Stand-alone => can be shipped

Key challenge:

- High-force / low-speed
- Form-factor and weight for direct integration with model
- Accurate representation and control over of forces

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# Real-Time Measurement Correlation to Model

Problem

- Tank Testing Time is Expensive
- Data quality is critical to testing success
- Identifying issues early in the process is important

Solution

- Run Simulation while tank testing is being conducted
- Requires theoretical model with appropriate run-time (< 5 minutes)
- Model the test. I.e. represent the wave tank and the 'actual' wave surface elevation i the model
- Model can be used to reduce the number of test-runs => Improve efficiency

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# Determination of Drag-Terms in Oscillatory Flows

Problem:

- Viscous drag forces in oscillatory flows are frequency and amplitude dependent.
- Most models (Orcaflex, AQWA) represent viscous drag as a linear or quadratic term

⇒Models are only valid for a limited subset of wave conditions.

Potential Solution:

Forced oscillatory motion testing to quantify KC dependency of drag terms. Potential use of CFD and/or model test.

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