November 2012 Test Plan

Purpose

The test deployment planned for November 2012 has three purposes.

1) Test initial versions of the control algorithms that are under development for increasing the power capture capabilities of the wave-energy conversion device.
2) Collect data from a new sensor that measure buoy submergence for future use as in input to the power take-off control algorithms.
3) Continue longevity and survivability testing of the device. Every deployment uncovers weak points and only repeated deployments will allow a robust system to evolve.

Schedule

Deployment is currently planned for November 9th, 2012 with a mobilization day November 8th. Recovery is planned for one month later (December 7th, 2012) or earlier if conditions warrant.

Test Location

The testing is planned to take place 5.7 nautical miles south-west of MBARI (at a bearing of 215 degrees mag.).

- Latitude 36 degrees 44.67 minutes North
- Longitude 121 degrees 52.60 minutes West

A notice to mariners will be submitted to the coast guard describing the system, location, and duration of deployment.

Test Specifics

For this deployment there will be three control algorithms and the ability to switch between them remotely or on a schedule.

1. The same Resistive Loading scheme we deployed last time
2. A "Gain Scheduling" algorithm that is not a wave-by-wave scheme but instead adjusts the damping on a slow time scale (10's of minutes) to maintain a target standard deviation of piston motion. This could be a pretty big improvement over what we had since as the sea state changes (which it does a lot as can be seen from the last deployment) it should maintain a better impedance match between the wave energy and the conversion device. When the waves got small last time the motions essentially stopped because the damping was pretty high. This isn't as sophisticated as the wave-by-wave control that is envisioned, but is a necessary step and should be present in any latching scheme to set the damping during the times when the system is "unlatched".
3. A preliminary latching scheme that "latches" (actually just makes the damping as high as our power electronics can handle, which is pretty high) the piston when the force measurement is within some distance of the mean force. This should help drive the buoy motions out of phase with the incoming waves. The use of the load cell to determine the latching and unlatching points is a poor substitute

for a buoy draft sensor. For instance, when the power take-off ram is latched the forces change dramatically and nearly instantaneously whereas the buoy draft changes much more slowly. To work around this for this deployment a lock-out delay time will be used to keep the latching from oscillating one and off at a fast rate. The capability of this control scheme to drive the buoy out of phase with the incoming waves will depend on the relationship between the lock-out time and the incoming wave period. As such the lock-out time will be adjustable during the deployment. Although this is a sub-optimal scheme, it is expected that the data collected about the response of the system to power take-off latching will be useful.

Because a buoy draft sensor is needed to achieve the planned wave-by-wave control scheme, we've added a fairly high precision pressure sensor to the very top of the PTO. That should allow a measurement the depth of submergence of the buoy to be made to within a few millimeters. Without previous knowledge of what this data will look like, it isn't prudent to use it as a control system input. Instead, the concept is to gather data from that sensor on this deployment to provide sufficient confidence in its behavior to use it as a control input in the second deployment.

The three control schemes outlined above will be selectable from shore during the deployment. After manual testing of each one, the system will be set up to cycle between each on a 30 minute period that corresponds to the wave-rider sample period. Post processing of the deployment data will include a comparison of each scheme's performance relative to the sea state.

Safety Considerations

- These tests will use the R/V Shana Rae, run by Jim Christman out of Santa Cruz, California. On board the vessel Jim will have final authority on all matters involving safety of personnel, ship, and equipment. Jim will conduct a safety briefing each day before leaving the dock that covers life-save equipment and procedures, man-overboard procedures, fire-fighting equipment and procedures, liferaft locations and operation, and deck operations procedures and requirements for work vests, steel toed boots, and hard-hats during overhead operations. In the absence of guidance from the ship captain, standard MBARI ship-board safety procedures which include *International Safety Management* regulations.
- All on-shore work will be performed in accordance with the regulations outlined in the *MBARI Safety Manual* maintained by the MBARI Safety Officer (Norm Steinberg)
- Heavy equipment operations will be performed in accordance with procedures specific to the equipment (Forklift, Crane, and Scissor-Lift), maintained by the MBARI Safety Officer. In all cases equipment operators will have had safety training for the equipment being used.
- Diving operations (if needed) will be performed by divers trained to the standards of the American Academy if Underwater Sciences (2003) in accordance with MBARI scientific diving procedures as established and maintained by the MBARI

dive safety officer Kim Reisenbichler. A dive plan will be submitted to, and approved by, the dive safety officer prior to the test dates.
- Should assistance be required from the MBARI Division of Marine Operations during the testing, Steve Etchemendy is the point of contact on-shore.
- Francois Cazenave from the MBARI engineering team is trained and certified in First Aid and CPR procedures.
- Boarding the buoy at sea should not be necessary and is not recommended. If it becomes necessary, the stainless steel box with the power electronics and the yellow high-voltage cable should be avoided, these are the only two locations on the buoy where high-voltage is present.
- Relevant Contact Information:
    - MBARI Safety Officer – Norm Steinberg (831) 775-1711
    - MBARI Director of Marine Operations – Steve Etchmendy (831) 775-1902
    - MBARI Dive Safety Officer – Kim Reisenbichler (831) 775-1720
    - US Coast Guard – VHF Channel 16

Equipment Needed
- MBARI Grove crane November 8th and ~ December 7th, 2012.
- MBARI dock space, November 8-9.
- MBARI divers on standby (not expected to be required).
- PowerBuoy system.
- Wave-Rider buoy.