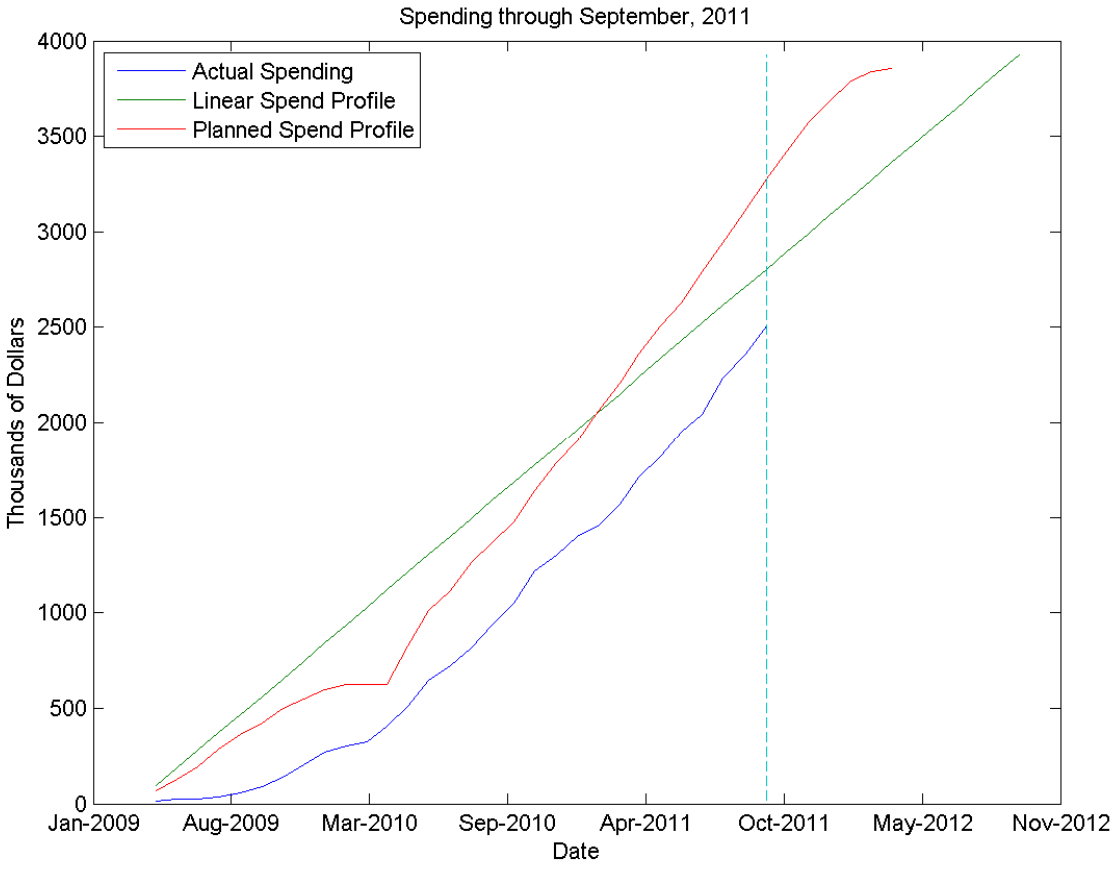
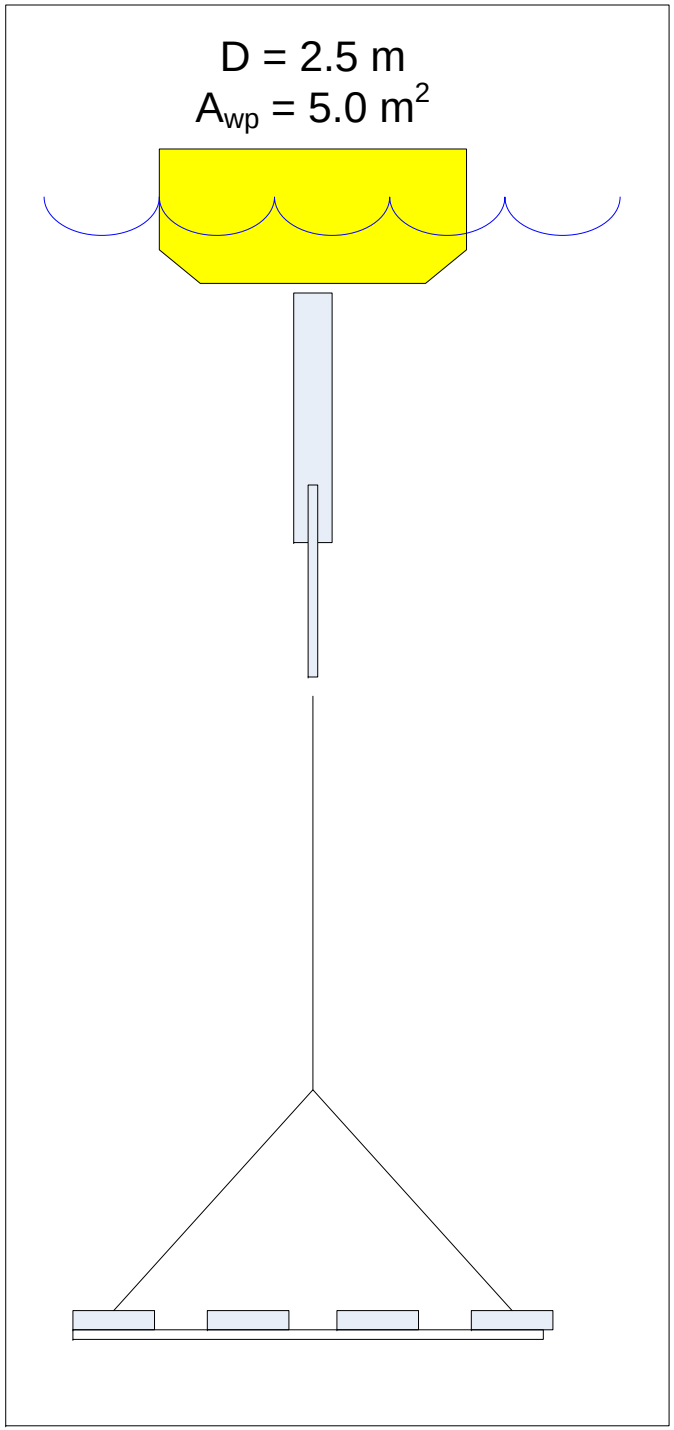
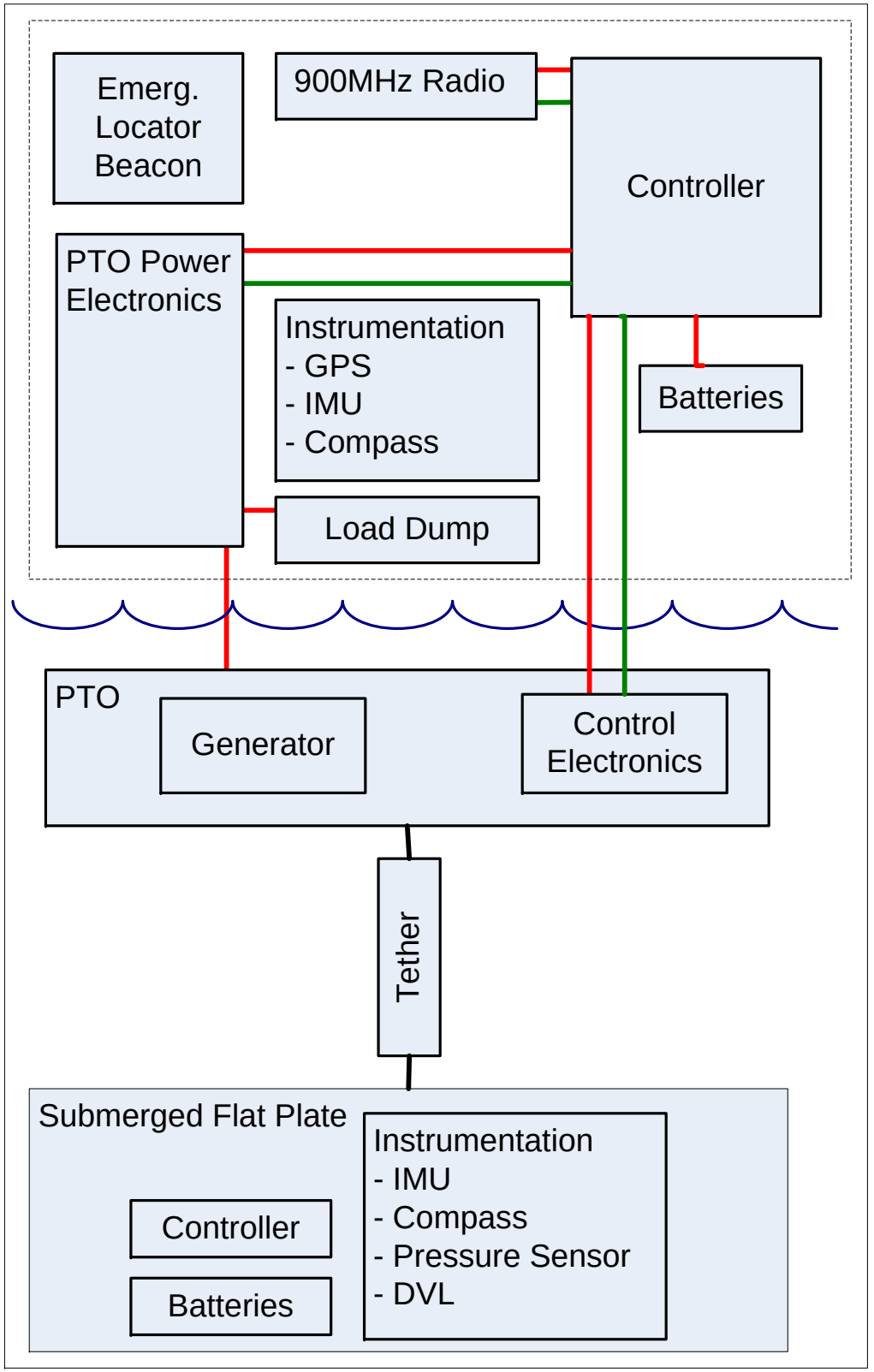
Financial Progress through September 2011

The graph below shows the projects actual spend profile through the end of September 2011. The red line shows the originally spending plan (from the original proposa), the green line shows the linear spend rate from the project inception to an end date that reflects a six month extension in the period of performance. The blue line shows the actual spend rate and shows the increased spending rate resulting from the build and test of equipment.




D = 2.5 m
A_{wp} = 5.0 m^2


Emerg. Locator Beacon
900MHz Radio
Controller
PTO Power Electronics
Instrumentation
- GPS
- IMU
- Compass
Batteries
Load Dump
PTO
Generator
Control Electronics
Tether
Submerged Flat Plate
Instrumentation
- IMU
- Compass
- Pressure Sensor
- DVL
Controller
Batteries

November 7-11 2011 Test Plan

Introduction

The tests planned for November 7-11, 2011 are the first deployments of this project that include the conversion of wave energy all the way through to electrical energy. The surface buoy, submerged plate elements, computer systems, and some elements of the power take-off device have all been tested and deployed before, new to this deployment are the hydraulic-electric power conversion elements and the load control electronics. The week long testing plan includes several individual deployments lasting between 4-24 hours depending on weather conditions.

Test Goals

Specific goals of this testing are:

- Deploy and test at sea the new power take-off electro-hydraulic system
- Collect performance data on the power-take off system in an at-sea deployment.
- Collect incident wave data to allow post-test numerical model validation and calibration.
- Evaluate effectiveness of tether guide solution.
- Log data about the sub-surface plate and water motions to inform AUV docking effort.

Activities/Schedule (subject to weather)

Monday November 7th

- Load all equipment (submerged plate, wave-rider, and support computers and radios) on Shana Rae dockside at MBARI.
- Put buoy and PTO assembly in the water
- Ensure all computers are running and reporting data as expected.

Tuesday, November 8th

- Ensure data is being collected and sufficient battery charge exists for planned tests (Buoy system and wave-rider buoy).
- Transit to location with water depth greater than 120 meters.
- Deploy submerged plate from Shana Rae A-frame
- Deploy wave-rider buoy and attach to submerged plate pick-up float.
- Stand by and monitor behavior for 3-4 hours.
- Recover system and return to MBARI
- Evaluate data and plan changes for subsequent deployments

Wednesday-Thursday, November 9-10

- Repeat tuesdays operation, or alternatively leave system out overnight if weather conditions warrant.

Friday, November 11th

- De-mobilize.

Test Location

The testing is planned to take place nominally 5 nautical miles west of Moss Landing. A notice to mariners has been submitted to the coast guard describing the system and the possibility that it will be in that area un-attended.

Calm Weather Contingency Plan

In the case of very calm waves (as occurred Jan 25th, 2011) we will be set-up to perform a tow test from the Shana Rae to evaluate the power required to move the system through the water at various speeds.

Safety Considerations

- At no point should the stainless steel box containing the high-voltage electronics be opened at sea or at any time which the hydraulic ram is able to move.
- 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.
- Steel-toe boots and life-vests on deck and hard-hats around crane operations as per MBARI policies.

Equipment Needed

- MBARI Grove crane November 7th and November 10/11.
- MBARI dock space.
- MBARI divers on standby.

Activities for final year of project

In the case that the November 2011 testing produces the expected results (power generation and AUV homing), the project is in a good position to achieve several significant milestones in the final year of the effort. This document outlines the activities planned to enable the final two-week deployment of a system in August 2012 that captures wave energy, charges batteries and delivers power to a docked AUV. Although the list is long, it appears that much of it is achievable in the year long time-frame because the project has achieved good efficiency after 2.5 years of work, the team is working well together and much of the hardware needed exists already.

These activities are:

- At-sea testing of electrical generation
- Power converter design, build, integration and test
- Control enhancements and system hardening for two week deployment
- Dock stabilization and power pass-through to submerged plate
- AUV homing to “mock-dock”
- Marketing meeting – January 9th
- AUV dock design, build and test on stationary mooring.
- AUV docking test to wave-energy buoy
- Propulsion testing
- Two week demonstration deployment
- Final analysis and final report preparation
- Numerical model packaging for general use

At-sea testing of electrical generation

Testing to be performed the week of Nov 7-11, 2011. All equipment is in house and is currently undergoing pre-deployment testing. Should we have bad luck and not have sufficient wave conditions during this test, we’ll leave everything assembled on the dock and wait for a weather window in the following few weeks.

Power converter design, build, integration and test

Currently, the wave-energy buoy that will be deployed the week of November 7th, 2011 generates electricity in an unregulated fashion, at voltages ranging from 0 to 400 volts. This power is not stored but is instead dissipated in a specialized resistor bank that optimizes the generator loading for peak energy capture. To be stored this power needs to be converted to a battery voltage level (24 volts), while maintaining the optimum generator loading. The design of this power converter is underway, an initial prototype will be lab-tested by the end of 2011 and an at-sea version will be ready by March 1st, 2012.

Control enhancements and system hardening for two week deployment

A small amount of control enhancements and an unknown amount of system hardening are required to enable a two week long deployment. The November 2011 tests will shed light on the performance and longevity of the system at sea.

Dock Stabilization and power pass-through to submerged plate

The docking concept under development will be limited to smaller sea-states without some active dock stabilization, and will require an electrical conductor path through the power take-off

device that does not exist in the current system. The design of the power take-off device has anticipated both these needs and it is a relatively small job to include these features, with the dock stabilization component being higher risk. The dock stabilization activity consists of the integration of commercially available electrical components and should be relatively straightforward. Components have been identified and testing of this feature is scheduled for February 2012.

AUV homing to "mock-dock"

Initial homing tests to a stationary submerged "mock-dock" which consists of a PVC pipe structure covered in a cargo net will occur the weeks of October 17th and November 7th. This testing will wring out the details of the MBARI AUV docking software since it's been ported to a new system.

AUV dock design, build and test on stationary mooring

An AUV dock based on previous docking experience at MBARI is underway and will begin fabrication in December 2011. This dock will be first tested on a stationary mooring in March 2012

AUV docking test to wave-energy mooring

The AUV dock will be moved to the power-buoy system in May 2012, this introduces new challenges because the target is now moving vertically, and there is possible interference from the submerged plate.

Propulsion testing

The wave-energy buoy is currently a purely drifting system. It has been long imagined that a propulsion system could provide some station-keeping capabilities that will increase the utility of the system. As a replacement for the preferred approach (flapping foil), a simple thruster could provide decent performance but would need to be tested to examine the possibilities. Although power hungry, this solution may not significantly limit the power generation capabilities of the system since we currently dissipate excess energy that can not be stored as heat. This activity is in the concept stage at this time and several approaches are being considered. Testing is possible in April 2012 if the design approaches appear viable.

Two week demonstration deployment

The project culminates in a two week long demonstration deployment in which energy is harvested, stored, and delivered to and AUV. This testing is planned for August 2012.

Analysis and final report preparation

The final month of the project will be dedicated to creating a comprehensive report summarizing the analysis, testing, and results from the project.

Numerical model packaging for general use

The numerical model developed for this project has proved to be a useful design tool and it would be nice to write a user manual and make this tool available to other researchers. This is out of the scope of the original project and would ideally be a small follow on activity.

Schedule and Cost

Activity	Date	Labor (weeks)	Material Cost	Ship Costs	Total Cost (Burdened)
At-sea testing of electrical generation	8-Nov-11	8		$8,000	$62,907
Power Converter Design, buld, integration, and test	March 2012	24	$20,000	$8,000	$194,760
Control Enhancements System Hardening	August 2012	12	$25,000		$113,990
Dock Stabilization and Power Pass-Through	February 2012	12	$20,000	$8,000	$118,520
AUV Homing	8-Nov-11	2			$12,707
AUV Dock Design and Fabrication	March 2012	20	$30,000		$172,367
AUV Dock Test to Stationary Mooring	April 2012	16	$12,000	$4,000	$125,813
AUV Dock Test to Wave-Energy Buoy	June 2012	16	$15,000	$8,000	$136,383
Propulsion Testing	June 2012	12	$15,000	$8,000	$110,970
Two-week Demonstration Deployment	August 2012	16	$12,000	$10,000	$134,873
Numerical Model Packaging for General Use	TBD	10			$72,197
Analysis and final report preparation	25-Sep-12	4			$28,879
10% Contingency		15			$119,258
Total		167			$1,403,622

Time-Line