# Development of a Next Generation Platform and Instrumentation for Continuous Ocean Observations (PICO)

Christian Meinig
NOAA Pacific Marine Environmental Laboratory, Seattle WA

## Table of Contents

1. Abstract ..... 2
2. Project Summary ..... 2
3. Scientific Accomplishments ..... 2
4. Education and Outreach ..... 7
5. Publications and Reports ..... 7

## 1. Abstract

NOAA's Pacific Marine Environmental Lab has developed and deployed critical technology to advance the state of the art for high-quality time series climate measurements that include both platforms and instrumentation. The advancements include a low-cost, easy to deploy mooring system (PICO) that can be deployed in full ocean depths off a vessel of opportunity. The PICO mooring is designed to be transferable to industry, easy-to-deploy and incorporates vandal resistant features. The instrumentation development includes a mooring profiler that is designed to replace discreet sensors such as those on the ATLAS moorings. The profiler or 'Prawler' uses energy harvesting to profile up and down the mooring line and includes robust inductive modem protocols for realtime data transmission and vehicle control. The Prawler was tested in Puget Sound in FY'09 and was shipped to Hawaii for an Oct'09 deployment in deep water. Sensor development for the Prawler includes a CTD, developed in partnership with Seabird and engineering sensors, but can be expanded to include other observations (currents, bio-geochemical, etc). For surface observations a stand-alone datalogger and telemetry system (Vaisala-SBD) incorporates the Vaisala WTX-520 sensor (wind, rain, AT/RH, baro) that can sample and report hourly for 400 days on 14 alkaline D-cells. Initial correlations with standard ATLAS sensors are very promising, except with RH, where calibrations need to be incorporated to improve accuracies.

## 2. Project Summary

The purpose of the Platform and Instrumentation for Continuous Observations (PICO) is to advance the state of NOAA's open ocean observation systems with the development of an easy to deploy and low cost mooring system which makes use of novel technology and commercially available sensors and instrumentation. The PICO project addresses critical issues regarding moored, deep-ocean observations: 1) reducing the total costs of high quality ocean observations, including realtime meteorological and sub-surface measurements, 2)improving data return rates in areas prone to vandalism. This effort is motivated by the need to develop a mooring,

instrumentation and concept of operations to replace and significantly improve upon the performance of existing ATLAS moorings used in NOAA's contribution to the tropical moored buoy arrays in support of climate research and forecasting. Users of this technology development effort are climate researchers, warning and forecast managers and industry. An updated web site containing videos and animations on the overall concept and results from system deployments can be found at: http://www.pmel.noaa.gov/pico/

## 3. Scientific Accomplishments

Project deliverables from the '09 Work Plan include three main projects: 1)PICO mooring development, 2)Prawler profiler development and, 3)Vaisala WTX-520 stand-alone datalogger and transceiver.

**Deliverables**:

***PICO mooring:***

*a. Build, test and deploy a complete PICO mooring with next generation Prawler in local waters and off-shore.*

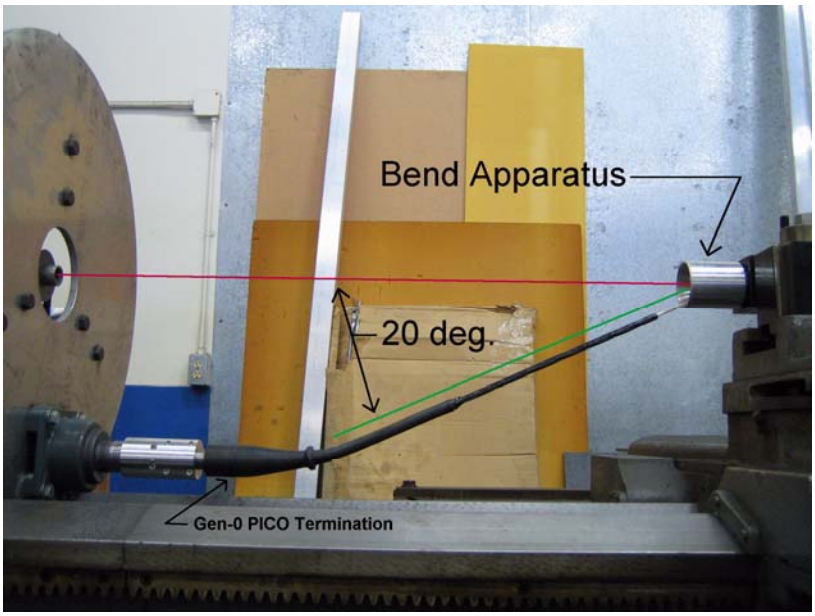
A PICO mooring was successfully deployed and tested in local waters in FY'08. The prototype was shipped in late Sept and deployed in early Oct '09 in deep-water tests off Hawaii. The experiment is currently underway with all moorings deployed

*b. Modeling and laboratory testing of PICO terminations and transitional splices.*

In 2009 OCO funding allowed PMEL to begin an extensive analysis and redesign of the PICO mooring termination, this process involved:

1. Validation of PMEL's built Dynamic Line Tester (DLT) as a tool for accelerated PICO termination life cycle testing (see picture below). The DLT is a machine that PMEL EDD has developed for subjecting mooring line segments to accelerated cyclic loading and bending fatigue and to our knowledge is the only one in existence for these purposes. As part of this funding, jigs and tooling were designed and built for running the PICO termination on the DLT machine. PICO terminations subjected to cyclic bending and loading on the DLT machine were then carefully compared to the terminations recovered from 2008's in-situ Hawaii PICO deployments. These tests both validated the DLT machine as an appropriate tool for evaluating future termination designs (i.e. failure points were replicated), and highlighted several critical weaknesses with the Gen-0 design.
2. The PICO mooring termination was re-designed to address the weaknesses found in step 1. This re-design process involved the extensive re-work of the terminations bend-limiter design which included FEA modeling of the most promising termination designs, and a new approach to the manufacture of the bend limiter components which allows components to be cast while under tension.

3. Ongoing analysis of the Gen-1 terminator design. This year tooling and fixtures for the Gen-1 design were designed and built for the DLT. New potted socket mooring terminations and techniques were evaluated through a series of tension pull tests, and DLT life cycle tests are currently in-progress.
   Additionally, PMEL procured test sections of the transitional machine splices within the PICO mooring. These test sections are currently in-house and awaiting life-cycle testing on the DLT (once the Gen-1 termination tests are completed).

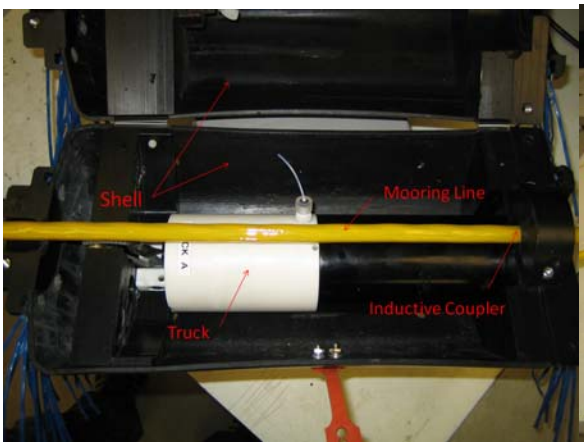


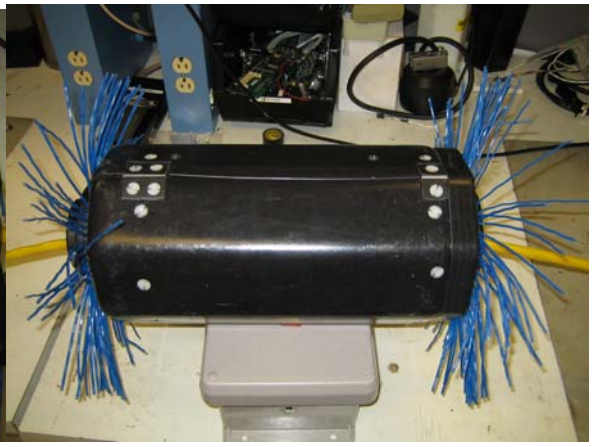

PMEL Dynamic Line Testing Machine with PICO bending strain relief in test.

***Prawler Profiler:***

*a. Build a "truck" function module that will act as comms, locomotion, CPU and power management.*

A novel modular electro-mechanical instrument or 'truck' was designed, built and successfully tested. The truck incorporates communication, locomotion, processing and power functions into a single waterproof housing. The truck fits within a small overall shell that also can house the various sensors (temperature, pressure, conductivity, etc). The overall packaging size needs to be kept as small as possible to avoid placing too much stress on the mooring line and causing premature wear and mooring failure.



Interior View of Climate Profiling Instrument Complete Prawler –exterior view

*b. Work with Seabird to design and build a new CTD specifically for the Prawler.*

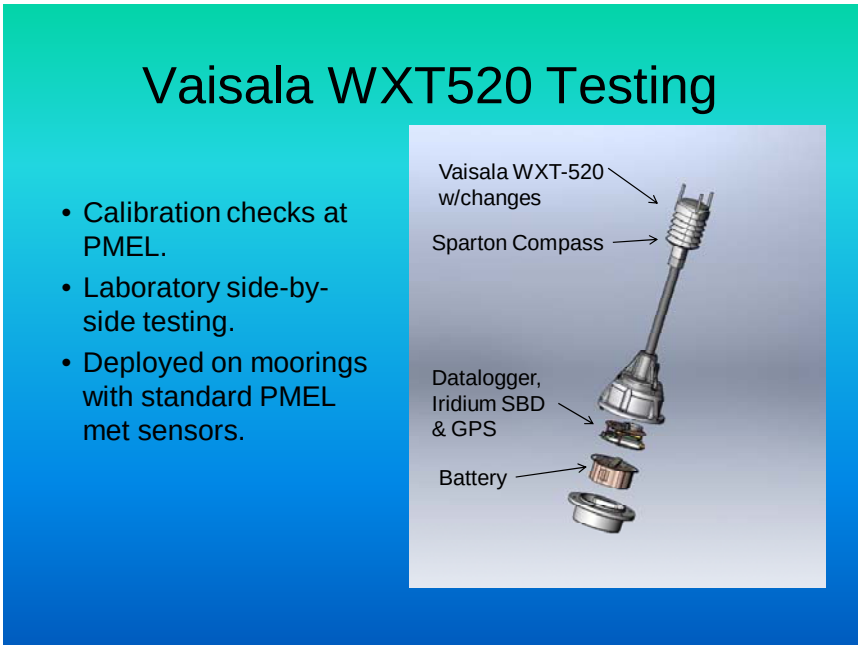
Two prototype low-powered CTDs were designed and purchased from Seabird electronics with Prawler specifications. This novel design is lightweight, robust and dovetails with the ultra-low power requirements of the Prawler. Lab and calibration tests have been very good and we are planning an ocean deployment in FY'10. The impact to the ocean research community is that there is now a standalone CTD available for mooring profilers that consumes 250mW when sampling at 1Hz. We learned that an additional low-power interface board is needed inside the Seabird CTD so that the unit can be turned off in between sampling and that sampling intervals can be varied by command. By employing such a scheme, we've found that we can get CTD 6ea profiles per day with 60 samples per 500m profile with higher sampling density near the surface. PMEL engineers and researchers worked together on this scheme and protocol and have found that it is more than sufficient for climate observations with the Tropical Moored Buoy Array. We will propose to deploy the truck with the Seabird CTD with the above scheme for FY'10.

Ultra low-power Prawler CTD development w/industry

***Vaisala WTX-512 for tropical moored buoys:***

a. Design, build, calibrate and deploy 3 units in tropical location, incorporating vandal resistant features and realtime telemetry.

A stand-alone Vaisala WTX-520 datalogger and Iridium telemetry system was designed, built, calibrated and deployed in 4 tropical locations. The system has been tested alongside standard PMEL sensors with very favorable comparison with winds, barometric pressure, rain and temperature. RH is the only sensor that at this point does not meet climate observation accuracy.

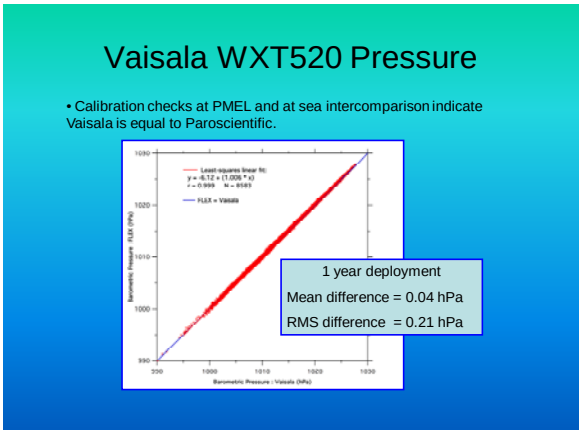


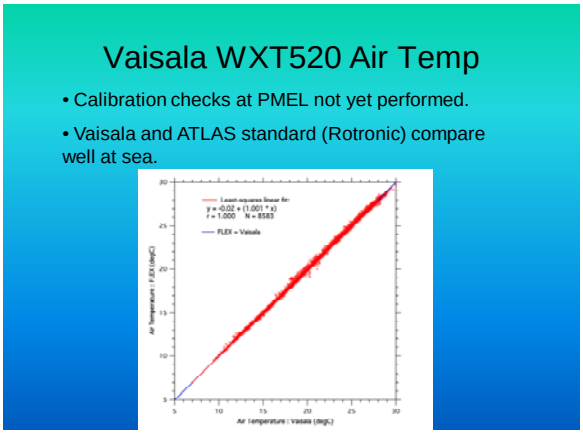

Some very important engineering challenges were overcome in this design including 1) minimizing the effects of the instrument electronics on the compass and, 2) developing an Iridium short burst data protocol that allows data delivery without requiring a server infrastructure. A Sparton digital compass was embedded with the Vaisala instrument housing by designing a custom circuit board interface and waterproofing the entire instrument. The off-the-shelf instrument is not suitable for ocean deployment without waterproofing the enclosure. We are working with the mfg to improve the watertight integrity of the instrument.

We've incorporated an ultra-low power processor within the datalogger and telemetry unit. For telemetry we are using an Iridium short burst data modem, that has the advantage of being able to email the data in realtime at low cost to any email address. At this point we've built several units and are working with researchers at PMEL to test them within the Tropical Moored Buoy Array.

b. Evaluate engineering and sensor data, document results

Engineering results on the WXT-520 sensor from a deployment with standard TAO sensors were evaluated and presented in Sept ’09 at the annual DBCP meeting in Paris. Examples from barometric pressure and temperature and shown below.




Two Vaisala-SBD units were also deployed within the RAMA array. Both systems prematurely failed after 20 and 45 days respectively for as yet unexplained reasons. We are currently investigating the nature of the failures and what the possible causes could be and have not been able to duplicate them at PMEL. We’ve had identical systems running for 3 months continuous outside at PMEL, without these types of failures. One buoy has since broken free of its mooring in what appears to be vandalism, but he other system at 1.5S/80.5E is still moored and we hope to recover within the next 5 months and perform diagnosis on the failure.

What we've learned from this is that the COTS (commercial off the shelf) WTX-520 sensors can be adapted with a simple PCB within the housing to add a Sparton compass that has calibrated and performed well.

## 4. Education and Outreach

Education and outreach was primarily accomplished thru an updated website www.pmel.noaa.gov/pico and a professionally edit video for the general public on this homepage. Additionally, talks have been on-going with the San Francisco Exploratorium, http://www.exploratorium.edu/ that is very interested in featuring realtime climate observations in the museum with PMEL technology.

## 5. Publications and Reports

As this is an engineering development effort, the focus has been on disseminating information at technical meetings and conferences. During this FY, a poster was presented at OceanObs '09:

"Low-cost, Robust and Easy-to-Deploy Surface Moorings for Tsunami and Climate Observations", Meinig et al.

An additional presentation was made at the DBCP '09 meeting in Paris including:

"Recent PMEL Climate Instrumentation Developments and Field Results", Meinig and Freitag