Development of an "Adaptable Bottom Instrument Information Shuttle System" (ABIISS)

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1. Project Summary

The Climate Change Science Program has listed as a national priority the assessment of current climate change in the context of Earth's history and a determination of the likelihood of abrupt changes in this century. An integrated Earth system analysis capability, incorporating ocean now-casting, is needed to assess the current state of the climate system. Such capability would allow monitoring and analysis of rapid changes so that policy and decision makers can understand the risks involved and consider implementing programs to limit the impact of abrupt changes. A classic conundrum of physical oceanographic and climatic research has been how to measure the deep ocean and record data with instruments on the bottom of the ocean while also getting the data back to land quickly enough to be used in climate analysis and prediction. The existence of instruments able to telemeter the data to a ship on site was an advance towards the solution of the near real time problem. However, it increased considerably the cost of the operation due to the increasing cost of the vessels. The ocean environment is a particularly challenging and harsh one for the electronics that are the heart of modern measurement systems, and the deep ocean is typically even less forgiving. Recent scientific research has demonstrated, however, the critical need for data throughout the full depth of the ocean if society is to improve understanding and prediction of climate changes. Solutions to these challenges, therefore, must be sought. Funded through the 2009 OAR Assistant Administrator's Discretionary Fund (AADF) program, this AOML/PHOD project has sought to develop a cost-effective system utilizing expendable 'data pods' which would collect data from a central instrument, self-release at a user pre-programmed interval, surface and transmit their data back to land via satellite. The main advantage of the project is that deployments could be made in remote areas, with a substantial reduction of needed ship time. Instruments would be deployed from a research vessel. Data will be transmitted via satellite for up to 4 to 5 years, depending on the instruments used. At the end of this period, scientists will have to make the decision of whether recover or not the instruments base on a cost effective analysis. This conceptual design has the advantage of being adaptable to many different kinds of sensors and would serve not only the NOAA Climate Goal's needs but would also foster cross-goal and cross-line cooperative execution by addressing some needs of the Ecosystem Goal as well as the Weather and Water Goal.

This project proposed to develop an array of expendable glass tubes mounted around a frame housing an oceanographic instrument. The data will be ported from the instrument to an external data controller, which will then transmit the data by short-distance radio frequency (RF) to an array of expendable glass-tube data pods mounted on the anchor frame. The glass tube is a well-proven design for deep-ocean instrument housings. The cylindrical shape takes up less space on a mounting frame as compared to the glass sphere, allowing more data pods to be mounted on a smaller frame. The tubes can be designed to withstand full ocean depth to 10,000 meters. On a 5' diameter frame up to 18 glass tubes may be mounted. Under the system proposed here for development, these tubes would be released from the frame based on a user programmable time interval. As each tube is released it will contain the entire record from the instrument, not just the data obtained since the previously released tubes. This will guarantee continuity in the data set in the event that there is a failure in any of the tubes. The data will be transmitted to a base station via satellite. At the end of the deployment period, the instrument and data controller pod could be recovered, while the anchor frame would be expendable. The recovered nstrument and data controller could then be reused in subsequent deployments at minimal additional cost (primarily replacement of batteries and the anchor frame).

2. Accomplishments

Time line

- Initial tank testing of components began in January 2009
- Prototype data controller and data pod design completed and testing started in April 2009
- First open ocean test of the full system was completed in September 2009

Development of the prototype and initial test

Additional funding to support the one-day cruise in the Straits of Florida aboard the R/V F. G. Walton Smith was provided by the OAR Office of Climate Observations. The purpose of the cruise was to complete the first open ocean tests of the new deep ocean data retrieval system, which has now been named the "Adaptable Bottom Instrument Information Shuttle System (ABIISS)", a technology developed by AOML engineers.

Initial development of this system, has mainly utilized a pressure-equipped inverted echo sounder (PIES) as the primary instrument for which data must be transmitted. The original design called for 16 to 18 data pods. On September 8, 2009, AOML completed a successful proof-of-concept field-test of a new deep ocean data retrieval system. The first prototype was developed and tested with only four data pods. (*see Figure 1*).

The PIES is contained in the yellow hard-hat in the photo, while a data controller is located beneath the PIES inside the orange protective structure. The vertical white structures are protective housings containing glass tubes which are the data pods themselves. A PIES makes two measurements, round-trip acoustic travel time and bottom pressure. These measurements are made on a predetermined schedule; for this test, measurements were made every 10 minutes. Once the PIES made a measurement the data was delivered to the data controller via an RS-232 serial cable that comes standard with the PIES. The data controller then retransmitted the data via radio-frequency signals along wires laid along the frame. It is important to note that the wires

that transmit data to the data pods do not penetrate the glass tubes – this is critical to avoid potential binding during release of the data pods. The data pods were programmed to release one hour and three hours after deployment, and when they reached the surface they transmitted the data through the Iridium Satellite System back to land (*see Figure 2*). Several different satellite transmission systems are being investigated in order to determine optimal cost-effectiveness.

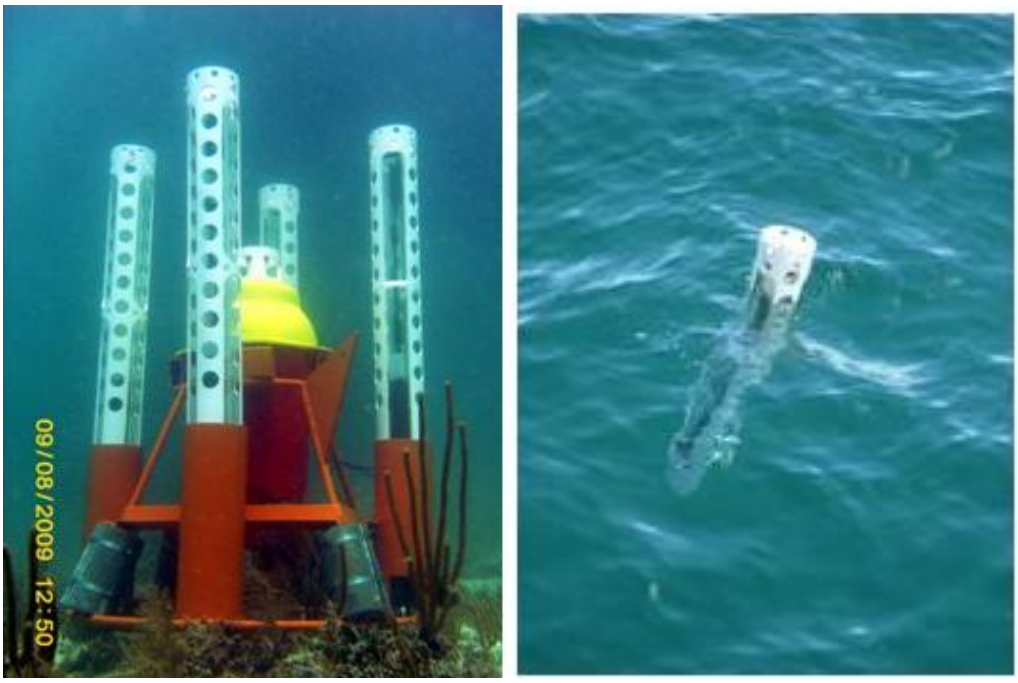

Figure 1*: Left: Photo of prototype ABIISS system with a PIE in the Straits of Florida. For the prototype testing only four data pods were built. The PIES was set to sample travel time and bottom pressure every ten minutes. Right: Data pod transmitting data via satellite after release*

No modifications are required to adapt any oceanographic instrument for use with the ABIISS system. The first open ocean test was extremely successful. Initially a problem was detected with the release mechanism. The burn wire mechanism successfully burned the wire but the data pods had to be released with the assistance of scuba divers. The mechanical problem stemmed from the design of the spring-assisted release system. This minor design flaw was corrected onboard the ship and the second deployment proceeded flawlessly. The data pods released as programmed, and once they reached the surface the data was transmitted via the iridium satellite system and received onboard the ship via email.

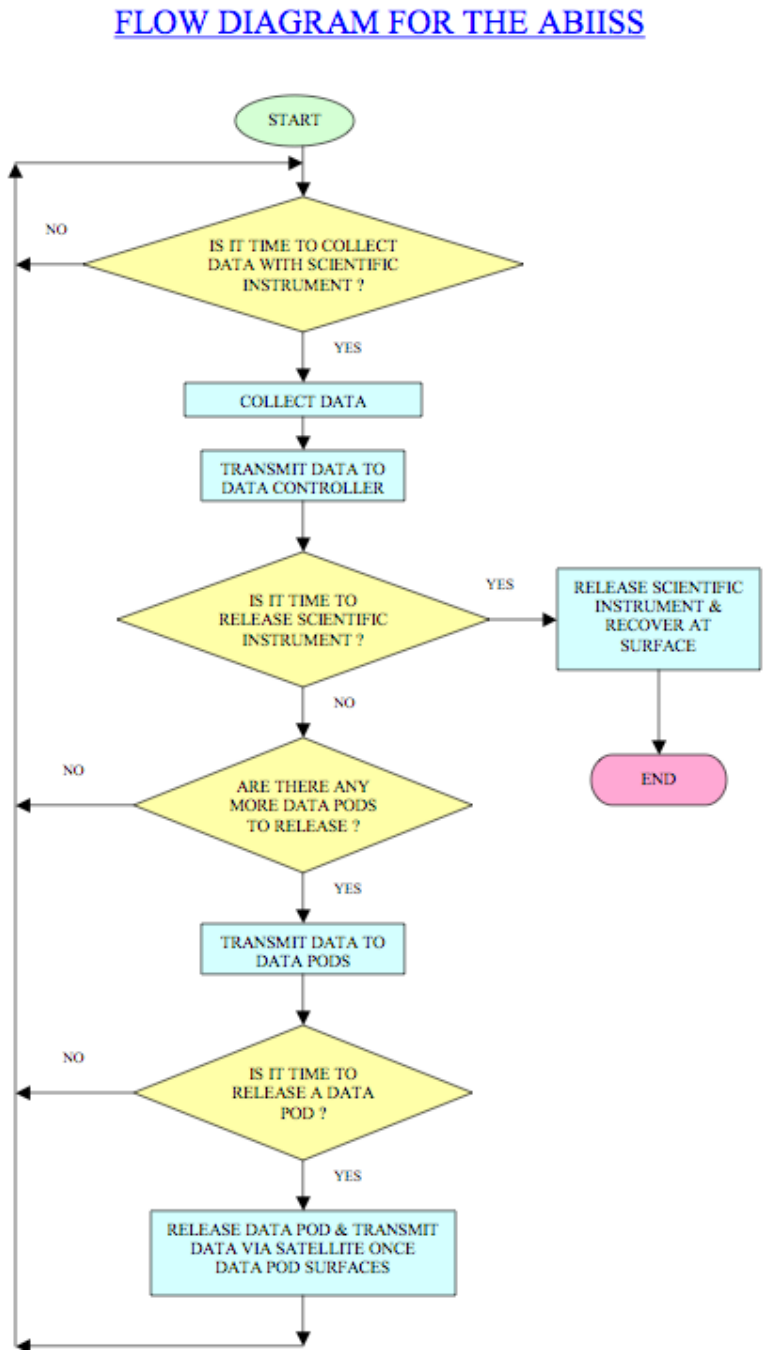

Figure 2. *Flow diagram for the data pod system.*

Additional photos and videos of the data pod system can be found at:
www.aoml.noaa.gov/phod/instrument_development