ALOHA CABLED OBSERVATORY

PHASE 2 Installation Cruise

Preliminary Report

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Rev. 2
Summary:

The purpose of cruise TGT 226, was to install the 2nd phase of the ALOHA Cabled Observatory (ACO) using the JASON-2 ROV to plug in the observatory and associated experiments. A secondary project, time permitting, was to collect rocks and perform bottom surveys in selected areas of the Ka'ena Ridge.

Installation of the Observatory during this cruise was not possible because of the failure of cables and connectors supplied by Ocean Design, Inc.

Background

Installation of the ACO was divided into two phases. The first phase cut, moved and terminated the HAW-4 electro-optical cable at Station ALOHA, and lowered it to the ocean floor with a set of preliminary experiments (the Proof Module). Phase 1 was accomplished in February, 2007, by the USNS ZEUS. Real-time hydrophone and pressure data had been flowing continuously through the cable since that time. Phase 2 of the ACO, originally scheduled for November, 2007, was to use JASON-2 to install the main observatory. That operation was delayed for a year as a result of late delivery of defective pressure vessels.

The technology to plug in electrical and optical systems on the ocean floor has made it possible to consider building general-purpose observatories in the deep ocean. Ocean Design, Inc. (ODI, http://www.odi.com/) is the only ocean cable provider for suitable submarine wet-mate electrical and optical cables and connectors. Their cables were used in HUGO, H2O, ACO, and other observatories. Cables and connectors supplied to ACO by ODI have cost the project more than $200,000. Cabling for Phase 2 is shown in Figure 1.
Figure 1. ACO Phase 2 Cabling and Sensors. Cable assemblies, including cables and connectors and/or feed-throughs, A, B, C, D, D1, E1-E5, F, G, and H, and the Proof Module umbilical, B1, (not shown) were supplied by ODI.

Cables to experiments (E1-E5) were heavily modified by the SOEST ESF in 2007 to improve their mechanical characteristics and to operate better when using Ethernet signals. Cable assemblies A, B, C, H, and the Proof Module umbilical contain optical fibers.

Prior to sailing on the October, 2008 cruise, the system had been operated successfully for more than a year without significant problems. All cabling had been tested before Phase 1 through Cable A before it was spliced into the main cable. All fibers except fiber 2 in cable “H” showed normal attenuations at that time. Fiber 2 in cable H, which showed excessive attenuation, was not used in the final configuration.

A test system consisting of a version of the shore station electronics used at the Makaha Cable Station, where the cable comes to shore on Oahu, was used during testing both on shore and at sea. The only
significant differences between installed operation and test operation were the optical attenuation required to prevent saturation of the optical amplifiers, and the bypassing of cables C and B (Figure 1) which could not be tested because of the lack of an adequate test cable and connector.

The test cable necessary for end-to-end system testing through cables B and C was not supplied by ODI until a week before the cruise. Negotiations concerning this test cable were long and frustrating. Initially ODI wanted to charge more than $37,000 for purchase of the cable (which would only be used for testing). An alternative was then suggested where we would lease the cable for more than $5,000 per week. Eventually, ODI agreed to loan the cable at no cost if we then allowed them to have our ACO Phase 1 umbilical cable after we were done with it, with the option to use it again when needed. The test cable was finally received from ODI about 1 week prior to the cruise. Rather than the cable specified containing four fibers and two electrical connections, however, it was immediately recognized that the delivered cable contained four electrical connections and two fibers, rendering it incompatible for connection to cable C, and useless.

CRUISE NARRATIVE:

10/18/08 The cruise was delayed and shortened by one day so that the chief mate on the Thompson could be replaced at the last minute due to illness. The ACO system was set up the staging bay and tested, showing nominal operation.

10/19/08 After deploying long-baseline navigation transponders, the first JASON-2 dive, J2-376, located the cable termination roughly 150 m from the anticipated location. The cable termination and Proof Module appeared as expected, with the Proof Module floating above the cable termination and considerable white deposits covering the Proof Module sea water return (Figure 2).

The region within 100 m of the cable termination was surveyed on 10 m lines and clear quadrants to the NE, NW, and SW from the termination were found suitable for experiments.
10/20/08 JASON was recovered from the first dive and the observatory was lowered to the bottom on the 9/16” trawl wire together with a navigation transponder, acoustic release, and a pinger for bottom detection. The navigation transponder imploded as the package approached the bottom, and the package was returned to the surface (but not recovered to the deck). The transponder was replaced and the package lowered again. The Edge Tech acoustic release failed to release on this lowering, and the package was again returned to the surface and the release was replaced with a Benthos release. On the 3rd lowering, the release was triggered after many attempts, and the package settled to the bottom only 2 m closer to the cable termination than planned, an accuracy of 0.04% of the water depth, an excellent feat of navigation and ship control (Figure 3). Note that the ACO sled had been cycled to 4700 meters three times at this point.
where a stream of oil bubbles was visible coming from the Proof Module umbilical connector, indicating that the cable was leaking oil (Figure 4).

The main umbilical (Cable B in Figure 1) was very difficult to plug in. The connector was finally connected after more than an hour of trying, including tipping the cable termination on its side at one point. Similar problems had been observed with this cable while plugging it in during testing in the lab, and ODI was contacted concerning the problem, but offered no advice. It was found that the connector would sometimes connect with little difficulty and at other times not be connectable with more than 100 lbs of force.

After connection was finally made, the cable power was restored and the system tested by Jim Jolly and Jim Babiniec at the Makaha Cable Station. They reported that while cable power drain was as expected, there was no communication over the optical data link. The clock pulse generated in the JBox was present, however, indicating that there was communication with the JBox, but not to the Observatory. After more testing and discussions with Mark Tremblay in New Jersey (one of the AT&T designers of the original cable system and instrumental in the design of the optical communications used by ACO), it was determined that the ACO must be brought back on board so that optical levels could be tested.
We also decided that the Proof Module should be returned to the surface so that it’s umbilical could be used in the testing in lieu of the test connector that was to have been provided by ODI. JASON cut the rope to the Proof Module using their “hedge clipper”, and it surfaced about 100 m from the ship 95 minutes later. JASON was recovered at 03:00 UT on 10/23/08.

10/23/08 16:40 UT. JASON and Medea were rigged for recovery of the ACO and sent to the bottom (Dive 3, J2-378). The “Sky Hook” was dropped from Medea and connected into one of the recovery ropes on the ACO sled. About 2000 m from the surface, the ACO sled dropped off in large swell with signs of snap loading in the wire tension. When recovered, the recovery rope had parted at a poorly-made splice (made by Duennebier). JASON was again rigged for recovery of the sled and sent to the bottom (Dive 4, J2-379, 10/24/08 06:00 UT) to run a search grid. Luckily, the sled was located (on its side) within 1.5 hours after reaching the bottom and returned to the surface without further incident. The dive ended at 10/24/08 14:00 UT. There was damage to one of the ADCP pressure transducers (possible only related to pressure), minor damage to one of the micro-Cats, and one of the ADCP covers was missing, but all else appeared normal.

Initial testing of the recovered ACO sled on deck (through the Proof Module umbilical plugged into “C” in Figure 1) showed the same symptoms as were observed at Makaha, i.e. proper electrical power draw and clock, but no communications between the test setup (called “mini-Makaha”) and the Observatory going. Between 1/2 and 1 cup of oil was found in the Proof Module indicating that the high-pressure seal in the Proof Module umbilical connector (B1) had at least partially failed.

The situation changed rapidly, and it was soon impossible to power the system through the Proof Module umbilical, with the electrical power draw indicating a partial short circuit. While testing on deck, Duennebier received an electric shock while touching the ship and the Proof Module umbilical connector. This should not have happened, and it was determined that there was a partial short between the Proof Module connector and the power conductor, indicating salt incursion into the oil-filled cable. The JBox was removed from the ACO sled and opened. It
was found to be dry and normal. The Proof Module umbilical and main observatory umbilical were bypassed by opening the JBox pressure vessel and powering the system directly into the JBox. This restored the correct power draw, indicating an electrical fault in the B1 cabling, but we still could not communicate between the JBox to the Observatory module to control the observatory power supply and experiment ports.

By this time it was obvious that we were dealing with serious problems, far more serious than incorrect optical attenuations. It was decided to move the observatory back into the staging bay and do a rock dive with JASON on Ka’ena ridge while the system was evaluated (Dive 5, J2-280 begun 10/25/08 17:00 UT).

The ODI multi-mode 4-fiber dry-mate optical cable (H in Figure 1) between the observatory and the JBox had showed heavy attenuation with one fiber (2) in early lab testing, but that fiber was not used. Testing of the remaining fibers showed new high attenuations that explained the lack of communication between the Observatory and the JBox. This cable had been operating normally during on-board testing before deployment and it had not been disconnected since weeks before the cruise. Observation of the male connector on the JBox shows that the fibers extend to different lengths, indicating that the attenuation may be caused by lack of contact. Testing of the fibers in this cable indicates that the attenuation in the cable itself is negligible, thus the problem appears to be in the JBox connector and possibly in the connector on the end connected to the Observatory pressure vessel. The failure of cable H after deployment was directly responsible for the system failure.

It was now obvious that the problems with the cabling made it unreasonable to install the observatory, and it was decided to make some changes to the Proof Module and reinstall it. Changes included changing the data format from Manchester encoding to Ethernet and adding a high-frequency hydrophone. The Proof umbilical also needed to be drained of oil, cleaned, and re-filled with oil. While this would not repair the Proof Module umbilical, it was hoped that it might survive long enough to provide valuable data.

While Harris, Howe, Duennebier, and later Snyder worked on the
conversions of the Proof Module, the thermistor array was rigged for autonomous deployment at Station ALOHA, rather than as an ACO experiment (See TAAM cruise report). In this configuration, the thermistor array will collect near-bottom temperature values for about two years or until it's acoustic release is triggered and it is recovered during a HOT cruise. The thermistor array was rigged and deployed without incident.

Leakage resistance values of about 5 KOhms were observed between the connector and the power conductor in the Proof umbilical. Nominal resistance should be infinite. After draining the oil from the Proof umbilical cable, alcohol was used to clean the connectors inside the cable and the cable was dried with helium. After cleaning, resistance was too high to measure as expected, and the cable was refilled with mineral oil supplied by the JASON team.

While the Proof Module and Thermistor array preparations were underway, JASON Dive 6 (J2-381, 10/27/08 15:00 UT) was made for more rocks at Ka'ena Ridge and to visualize the bottom roughness in the area where a mooring had been placed by Jerome Aucan. Both rock dives were very successful.

After two 16-hour days of work by Dave Harris, Bruce Howe, Jefrey Snyder, and Duennebier, the Proof Module was ready to drop over the side for plug-in by JASON at 0800 on October 28, 2008. At this time the JASON team asked for an hour hold for weather, with winds increasing and heavy swell - by far the worst weather we had seen. After an hour we were informed that JASON would not be able to dive, and weather was not predicted to improve for several days. We thus left the site and headed for Honolulu, docking at 08:00 HST on 10/28/08.

Failure summary:

Test Connector: The failure to provide the correct test connector (received and determined faulty one week prior to cruise) required us to return the Proof Module to the surface to use it's umbilical for testing of the system. Had we not been required to recover the Proof Module, we would likely still be collecting ACO Proof Data.
Proof Umbilical (Cable B1): This cable system connects the cable termination to the Proof Module. Although this cable operated successfully for 20 months as part of the ACO Proof Module system, the high-pressure seals in the Proof umbilical failed, allowing oil to enter the Proof Module feed-through end, and to leak oil from the other (wet mate connector) end. When brought to the surface, salt water had entered the cable shorting out the connector.

Cable “H” multi-mode fiber whip: This cable system provides communications between the JBox and the Observatory. This cable was tested before and during the cruise prior to emplacement, but the optical attenuation in the optical path increased beyond what was necessary to support communication between the JBox and the Observatory when deployed. Failure of this cable and its connectors was responsible for the failure to install the ACO.

In addition, cable B may also have failed, although we have not tested it independently. It is certainly suspect, as it has the same design as the Proof Umbilical.

In testing to date, we have found absolutely no problems with the electronics and optical systems except for the ODI cables and connectors, and we do not know of any tests we could have performed prior to the cruise that would have detected these faults. These failures have cost far more than the value of these cables, as the costs of the cruise were essentially wasted and delay of at least one year is inevitable before resuming operations and completing the ACO.