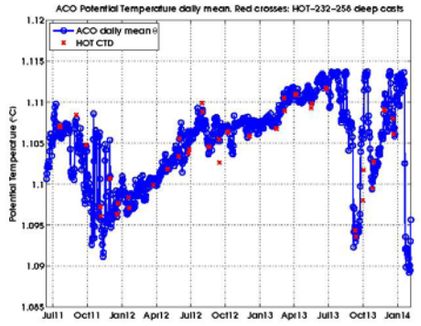
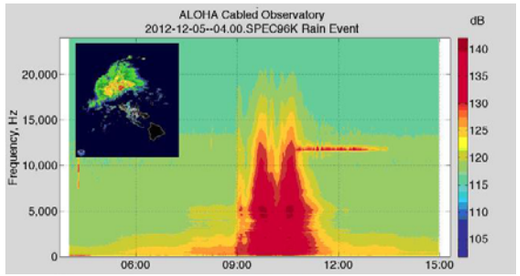
On-going science includes studies of deep-sea biology; abyssal circulation and mixing; and acoustic signatures of earthquakes, ships, marine mammals, wind waves, and rain.

To the right: A deep-sea lizard fish attacked an aristeid shrimp (and failed). Fifteen identified species were seen, and a number of unidentified ones, about two organisms per hour (J. Drazen and A. Fleury, UH).



To the left: Bottom temperature shows ~20 m°C cold bottom water overflow events with dynamic oscillations and slow recovery. Such events occur in many other abyssal locations and they have important implications for observing and understanding deep ocean dynamics and mixing, and impacts on climate.

Rainfall and wind waves are loud and easily detected even at the great depth of the ACO. The figure to the right is the acoustic spectrogram during an intense convective storm embedded in a cold front. The data is being analyzed in the context of the freshwater cycle at ALOHA.



New experimental uses of the ACO are anticipated and encouraged, with proposals in progress on predator-scavenger community dynamics, benthic community response to changing climate and food supply, and a mooring system sampling the full water column on a rapid, sustained and adaptive basis to address the carbon cycle, water column dynamics and mixing, and bio-physical interactions.

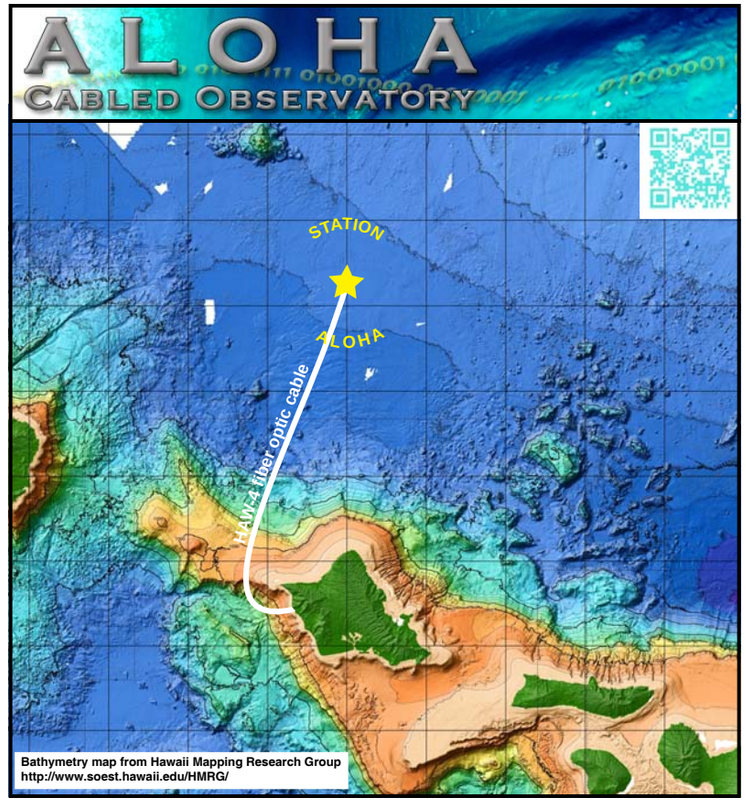
For more information on science and engineering at the ACO, contact Dr. Bruce Howe at bhowe@hawaii.edu

The ACO was made possible by the collaborative efforts of many individuals and organizations.
We wish to acknowledge and praise these important contributions.

The ACO development and deployment was supported by research and instrumentation grants from the National Science Foundation to the University of Hawaii, to the Applied Physics Laboratory of the University of Washington, to the Monterey Bay Aquarium Research Institute and to the Woods Hole Oceanographic Institution. NSF and the Office of Naval Research provided support for the USNS Zeus to recover, cut, terminate and relocate the HAW-4 cable to Station ALOHA in 2007. AT&T transferred the HAW-4 fiber optic telecommunications cable to the Research Corporation of the University of Hawaii for a nominal fee. The video camera was provided by funding from the Gordon and Betty Moore Foundation to David Karl (UH/CMORE). The University of Hawaii School of Ocean and Earth Sciences and Technology provided significant engineering, networking and other personnel support for development and deployment of the ACO. The SOEST Engineering Support Facility and Fred Duennebier provided significant design and construction support. Mark Tremblay (AT&T, retired) and Dave Harris (UH) spent many very long days in the Makaha Cable Station, troubleshooting the shoreside and underwater fiber optic connections. Captain Rick Meyer and the crew of the *R/V* Kilo Moana provided outstanding support of the cruise and the ACO deployment operations. Captain Ross Barnes and the UH Marine Center staff worked hard to accommodate the demanding logistics. The Jason group from the WHOI Deep Submergence Laboratory, led by Matt Heintz, were exceptionally professional, hardworking, and innovative in contributing to the successful deployment of the ACO. The SOEST Ocean Technology Group worked hard to support our work, especially with many deck operations in rough weather and at night.

And, the many research and support individuals who made the ACO possible.

We thank the following organizations for their substantial support and/or in-kind donation



ALOHA Cabled Observatory

University of Hawaii
School of Ocean and Earth
Science and Technology

http://ALOHA.manoa.hawaii.edu/ACO

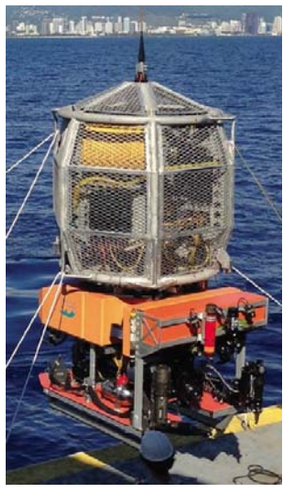
SCHOOL OF OCEAN AND EARTH SCIENCE AND TECHNOLOGY
UNIVERSITY OF HAWAI'I AT MĀNOA

The ALOHA Cabled Observatory (ACO) provides the deepest (4728 m) electrical outlets and Internet connection on the planet. It serves science at Station ALOHA, the site of the Hawaii Ocean Time-series program and others that have that has been studying

variability since 1988. The ACO provides infrastructure for continuous, interactive ocean sampling enabling new measurements as well as a new mode of ocean observing that integrates shipboard, autonomous and cabled observations. The NSF-funded project began in 2002. In 2007, the retired AT&T HAW-4 submarine fiber optic cable was cut 100 km north of Oahu and a "proof module" (hydrophone and pressure sensor) attached. A general purpose "node" was connected in 2011 with instrumentation transmitting measurements of temperature, salinity, currents, acoustics and video. New projects facilitated by the ACO are expected to span the water column addressing air-sea interaction, the carbon cycle, near surface plankton blooms, turbulence and mixing, abyssal ecosystems and more.

Engineering / Architecture

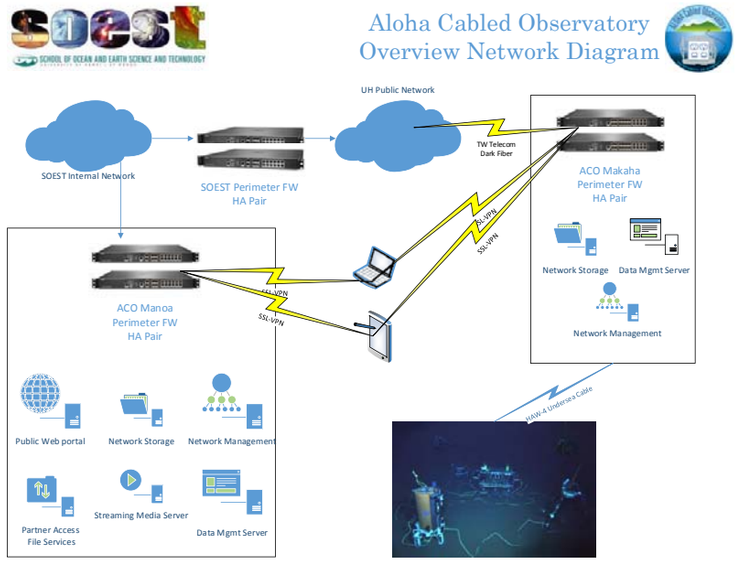
The AT&T Makaha shore station provides power to the system (up to 1200 W) and connects the subsea equipment via the retired HAW-4 cable (at 100 Mbs) to the UH Manoa campus and the Internet. Connecting to the ACO requires using a remotely operated vehicle (shown on the right) to position instruments and mate the underwater connectors. On the main Observatory "node" are eight user ports that provide access to the 100 Mb/s underwater Ethernet and (4 ports) serial communications, and a GPS-synchronized pulse per second. Six ports provide 48 V (5 at 150 W and 1 at 500 W) and two provide 400 V (300 W). Additional ports are provided by a secondary node (1@400 V, 3@48 V). ACO staff are ready to assist users with interfacing their instrumentation.



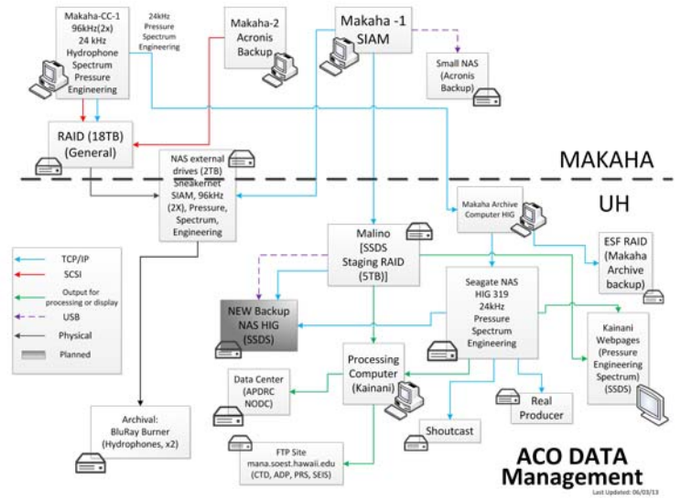
ACO Network and Data Management

For the ACO Network, we started with twin high availability pairs of enterprise grade firewalls by Sonicwall to create two islands; one at the AT&T Makaha Cable Landing station and the second in a SOEST data center. Set up as a high-availability "failover pair" we can upgrade the firewalls without interrupting the data streams. The two facilities are linked via an IPsec VPN tunnel so that devices in the SOEST data center can "reach across" the VPN link to access Makaha and the underwater resources. An integrated SSL-VPN supports remote access to equipment in a secure manner from almost anywhere in the world. This system meets full FIPS (Federal Information Processing Standards) and in most cases exceeds DoD requirements for unclassified data security.

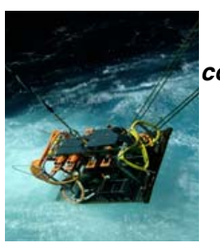
Active monitoring is provided by AdRem's NetCrunch for network equipment health monitoring using SNMP/ICMP/layer7 app tools along with profile-based intrusion detection; TotalView by PathSolutions monitors inter-device links for jitter, latency, and other path-related issues.



Building on the ACO network, a robust real-time control and data management system for the ACO was developed. Standard oceanographic data are acquired and managed by the MBARI-developed SIAM and SSDS software systems, compatible with standards for data and metadata being developed by the OOI. ACO data management is conducted using various computers and storage devices located at the AT&T Makaha cable station and at the University of Hawaii. At least three copies of each dataset are made and two copies stored in a separate locations.



Details of the equipment and software used for data management can be found in the schematic above. Real-time data are available online at http://ALOHA.manoa.hawaii.edu/ACO. Raw data and intermediate QC'd products are available via ftp. High-bandwidth hydrophone and video data files are acquired and managed by proprietary systems. An acoustic stream is provided in real-time, however due to their size, archived acoustic and video data are only made available by request. An ACO master data catalog is provided at http:// aloha-data.soest.hawaii.edu/repository. Data are also archived at data distribution centers (eg. NODC).



For more information on ACO Engineering, contact Dr. Bruce Howe at bhowe@hawaii.edu

For more information on the ACO network, contact Brian Chee at chee@hawaii.edu

For more information on ACO data management, contact Dr. Roger Lukas at rlukas@hawaii.edu or Dr. James Potemra at jimp@hawaii.edu