Connecting an Ocean-Bottom Broadband Seismometer to a Seafloor Cabled Observatory: A Prototype System in Monterey Bay

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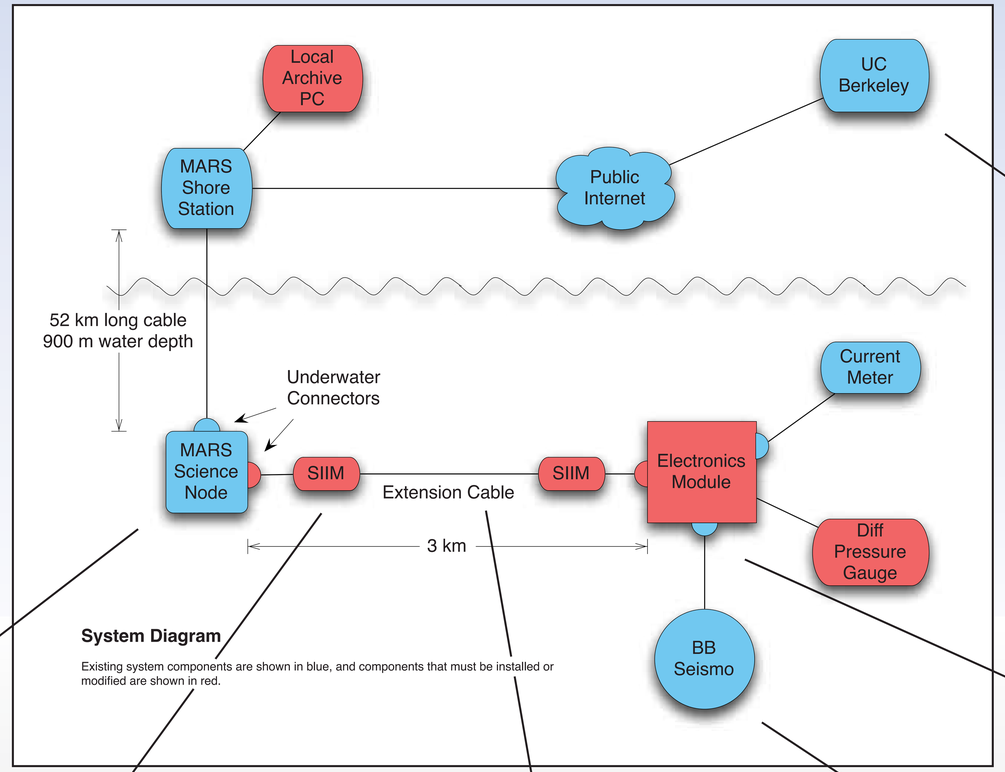
Overview

The Monterey Ocean-Bottom Broadband (MOBB) seismic station was installed in April 2002, 40 km offshore from the central coast of California at a seafloor depth of 1000 m. It comprises a three-component broadband seismometer system (Guralp CMG-1T), installed in a hollow PVC caisson and buried under the seafloor; a current meter; and a differential pressure gauge. The station has been operating continuously since installation with no connection to the shore. Three times each year, the station is serviced with the aid of a Remotely Operated Vehicle (ROV) to change the batteries and retrieve the seismic data.

In January 2009, the MOBB system will be connected to the Monterey Accelerated Research System (MARS) seafloor cabled observatory. The NSF-funded MARS observatory comprises a 52 km electro-optical cable that extends from a shore facility in Moss Landing out to a seafloor node in Monterey Bay. The node can provide power and data to as many as eight science experiments through underwater electrical connectors. The MOBB system is located 3 km from the MARS node, and the two will be connected with an extension cable installed by an ROV with the aid of a cable-laying toolsled.

The electronics module in the MOBB system is being refurbished to support the connection to the MARS observatory. The low-power autonomous data logger has been replaced with a PC/104 computer stack running embedded Linux. This new computer will run an Object Ring Buffer (ORB), which will collect data from the various MOBB sensors and forward it to another ORB running on a computer at the MARS shore station. There, the data will be archived and then forwarded to a third ORB running at the UC Berkeley Seismological Laboratory. Timing will be synchronized among MOBB's multiple acquisition systems using NTP, GPS clock emulation, and a precise timing signal from the MARS cable.

The connection to the MARS observatory will provide real-time access to the MOBB data and eliminate the need for frequent servicing visits. The new system uses off-the-shelf hardware and open-source software, and will serve as a prototype for future instruments connected to seafloor cabled observatories.

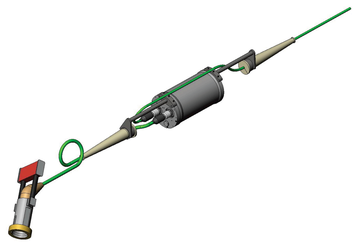


System Diagram

Existing system components are shown in blue, and components that must be installed or modified are shown in red.

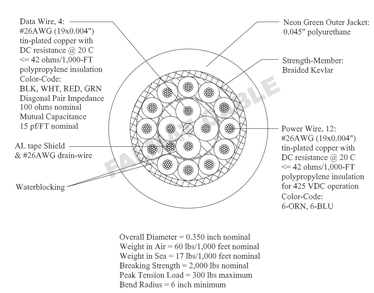
MARS Science Node

The node contains power supplies to convert the 10 kW at 10 kVDC provided from shore to lower voltages for use by science instruments. It also converts the data on the shore-cable's optical fibers to copper-wire Ethernet. The node has eight science ports, each of which supply 375 VDC, 48 VDC, 100 Mbit Ethernet, and a 1 PPS timing pulse to attached instruments.



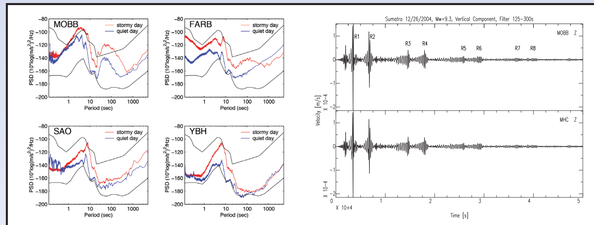
SIIMs

The Science Instrument Interface Modules at each end of the extension cable convert the MARS node's Ethernet signals, which can travel only 100 m, to DSL (Digital Subscriber Line) signals, which can travel many kilometers over a single twisted-pair cable. The SIIM on the MOBB end converts the DSL signals back to Ethernet. The MOBB-end SIIM also contains a power supply that converts the 375 VDC provided by MARS to 28 VDC at up to 150 W to power the instruments.



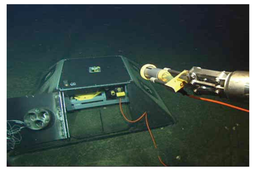
Extension Cable

The 3.6 km extension cables carries power and data between the MARS network and the MOBB instruments. The cable is 20% longer than the straight-line distance between the MARS node and the MOBB site to allow for uncertainties in laying the cable. At this distance, the DSL signal between the SIIMs can maintain a data rate of 1.152 Mbits/sec. In its current configuration, this type of cable is capable of delivering 550 W-km of power, i.e. 550 W over 1 km, 225 W over 2 km, 183 W over 3 km, etc.



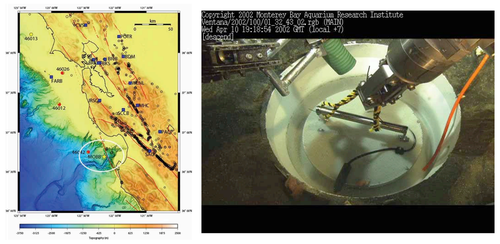
Seismic Data

Data from the MOBB system will continue to be analyzed and archived at the Berkeley Seismological Laboratory's Northern California Earthquake Data Center. The set of four **lefthand panels** shows observed background noise PSD at MOBB, FARB, SAO, and YBH (see map below for station locations). Shown are the Z-components on a stormy (red; Dec.16,2002) and on a quiet day (blue; May 23,2002). The USGS high- and low-noise models for land stations are shown in black. Increased noise level for periods between 20 and 500 sec, due to ocean currents and infragravity waves, is observed at MOBB, as well as at the island station FARB. The noise level at MOBB between 30 and 100 sec on a quiet day is comparable to the noise level at the island station FARB on a stormy day. The noise level at MOBB between 10 and 20 sec is comparable to the land station YBH, one of the quietest stations of the BDSN. The **righthand panel** shows the magnitude 9.3 Sumatra earthquake in 2004, as recorded by both the MOBB system and a land-based seismometer located on Mt. Hamilton in California. These filtered data reveal the Rayleigh waves recorded on the MOBB and MHC vertical components. The earthquake is seen multiple times as the seismic energy continues to circle the Earth; odd numbers indicate minor-arc arrivals and even numbers indicate major-arc arrivals. The horizontal scale spans almost 14 hours of time.



Electronics Module

The **lefthand panel** shows the removeable MOBB electronics module in its trawl-resistant steel frame 20 m away from the buried seismometer. Shown in the **righthand panel** during laboratory testing, the electronics provide an interface between the extension cable and the various MOBB instruments. A PC/104-based computer (Arcom Vulcan) runs a flash-memory-based Linux operating system and accepts serial data from the seismometer (Guralp CMG-1T) and the current meter (Falmouth Scientific 2D-ACM). A 24-bit A/D converter (Quanterra Q330) digitizes and time stamps the analog signal from the differential pressure gauge (Scripps Inst. of Oceanography DPG). These three instruments demonstrate the MOBB system's ability to accept data from RS-232 serial, analog, and Ethernet sources. The module also contains a supercapacitor-based backup power supply that maintains system power for up to two hours if power from the MARS cable is interrupted.



Broadband Seismometer

The Guralp CMG-1T seismometer is located 40 km off the central California coast in Monterey Bay. The **lefthand panel** shows the MOBB instrument's location (circled), as well as the locations of other instruments in the Berkeley Digital Seismic Network. The **righthand panel** shows the seismometer in its titanium pressure housing as it was installed into a 40 cm-deep caisson excavated in the sediment at 1000 m water depth. After seismometer placement, the caisson was backfilled with 0.8 mm glass beads until the beads were level with the sediment surface. The resulting configuration minimizes the effects of water currents on the extremely sensitive seismometer.

More Information

MARS Cabled Observatory
http://www.mbari.org/mars

Monterey Ocean Bottom Broadband Seismometer
http://www.mbari.org/mars/general/MOBB

The Northern California Earthquake Data Center
http://www.ncedc.org