Moored Array Technology: Mooring Design Investigation for the Autonomous Ocean Sampling Network Experimental Program

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LONG-TERM GOAL

The long-term goal of the Moored Array Technology program is the development and at-sea testing of new mooring and telemetry techniques for use in oceanography. Areas of concentration include mooring and buoy designs, in-water telemetry techniques, and application of emerging satellite and networking technologies.

OBJECTIVES

The specific objective for 1998 was the design and development of a coastal telemetry mooring to be used in conjunction with the Odyssey AUV to expand the AOSN concept and allow it to move toward true autonomy.

On the mooring component level the objective in 1998 and beyond is to expand the technology of stretch hoses and stretch conductors up to five times higher elongation levels. A stretch hose design with 150 percent elongation at maximum working loads is under construction. Such a hose will find applications for coastal telemetry moorings exposed to high sea states.

APPROACH

The AOSN concept [1] makes use of a variety of autonomous platforms to collect spatial and time series environmental data. These data need to be telemetered in near real time to the system users. One way to accomplish this telemetry is to moor surface buoys in the measurement area and use these buoys as platforms for RF links to either satellites or local nodes. A difficulty with this approach has been the cost, complexity, and special-purpose nature of these moored buoy systems.

Our goal in 1998 was to devise a very simple, low-cost coastal mooring system that combined flexibility and ease of use while providing the necessary telemetry links through the water and the atmosphere. Our approach was to use a small, rugged surface platform that contained an off-the-shelf RF modem that was integrated directly with one of our WHOI-developed acoustic modems, the UAM

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or Utility Acoustic Modem [2]. The telemetry buoys can receive and transmit acoustically as well as receive and transmit via RF. By concentrating on simplicity and ease of use, we were able to develop a coastal telemetry mooring with a cost of less than $10,000 including all materials, electronics, RF and acoustic modems, batteries, light, mooring, anchor, etc. Labor to assemble the system is just a few technician days. The mooring system (Figure 1) can be installed by two people from a small boat without any serious deck gear.

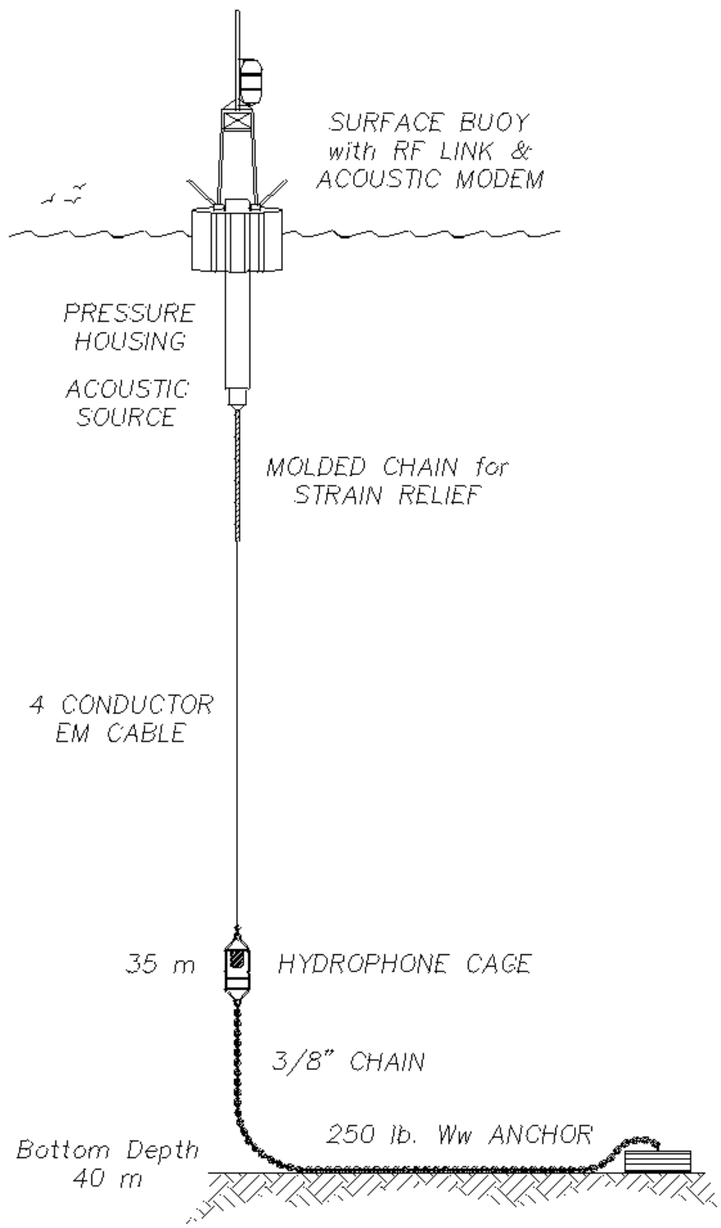

Figure 1. The low-cost telemetry mooring for coastal AOSN applications.

WORK COMPLETED

Coastal Telemetry Buoy. The MURI-AOSN project (program # ONR-322 OM/AOSN N00014-95-1-1316) led by MIT (J. Bellingham, P.I.) conducted a 10-day field trial of AOSN vehicles and related technologies in Cape Cod Bay in September 1998. We built three of our coastal telemetry buoys for use on this effort. Two of the moored systems were deployed in 30-45m of water during this cruise and were used to test acoustic communication systems installed on the Odyssey AUV and to test communication algorithms that were transmitted from the R/V Oceanus to the buoys. Of these two systems, one worked perfectly and we established a reliable acoustic link from the ship to the buoy over a 10-Km distance. The data rate for these tests was 200 bits per second using a frequency-hopped FSK technique designed for maximum reliability at moderate baud rates.

The second system suffered a cable failure on deployment that resulted in the loss of the hydrophone signals. The RF and acoustic hardware worked fine, but the mooring was unable to detect acoustic transmissions. The third system illustrated the flexibility of the design. It was used as an emergency replacement for the AUV dock mooring surface buoy that flooded during the experiment. After recovering the original surface telemetry buoy, which was configured with an onboard computer, two-way satellite link and several other telemetry systems, we made a few modifications to the wiring of the low-cost coastal buoy and from a small boat we reconnected it to the dock mooring. We were back on the air immediately and this allowed the vehicle operators to continue their operations without serious delays.

Prototype Active Mooring. We built a prototype Active Mooring (Figure 2) in 1997, which is designed to act as a subsurface mooring most of the time, but has the capability of surfacing to telemeter data on a schedule. The system operates by filling an internal bladder with seawater to submerge the buoy to a pre-selected depth. The bladder provides corrosion protection and minimizes gas exchange in the buoy, which could result in the development of a partial vacuum and subsequent system malfunction. The system is designed for 100 ascent/descent excursions in coastal waters on a single alkaline battery pack. It uses a simple chain mooring to accommodate changes in mooring length.

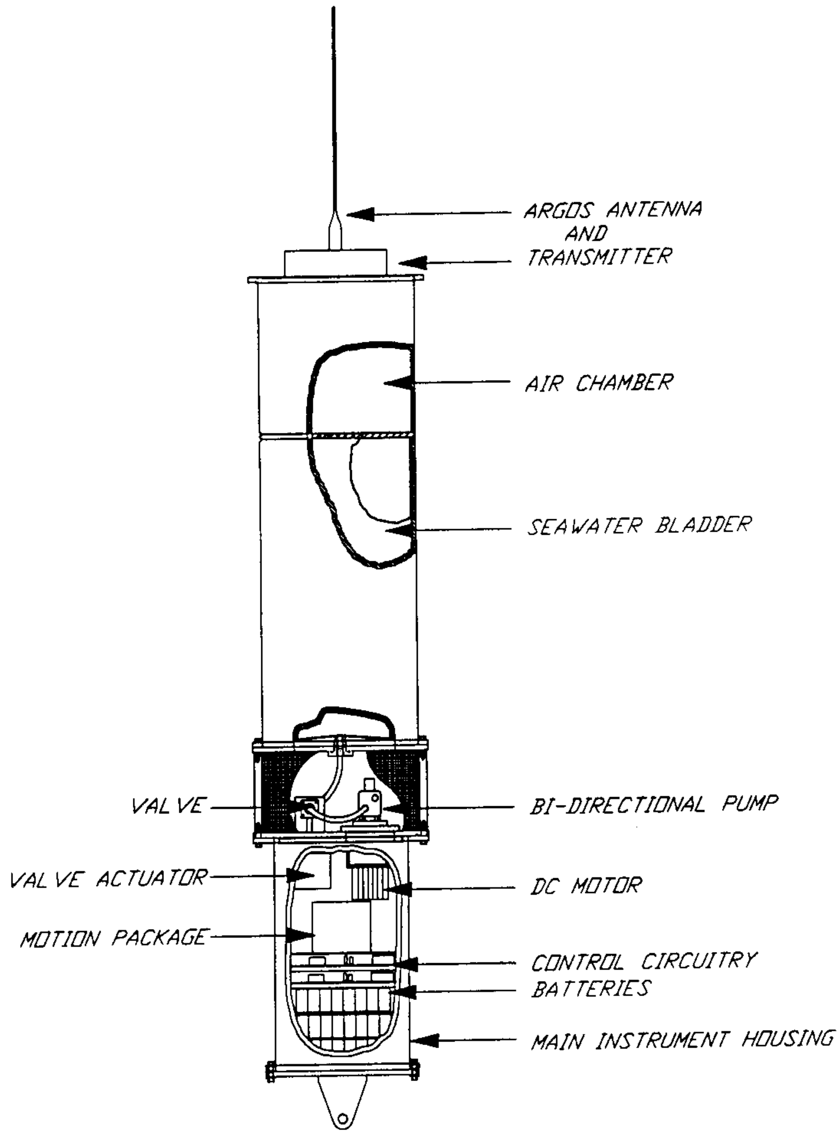

Figure 2. Active Mooring Vehicle

In 1998 we conducted several tests of the prototype Active Mooring. The latest of these was conducted in Buzzards Bay in August 1998. We have a two-week test planned for November 1998 at the Buoy Farm near Woods Hole (40m of water). The prototype Active Mooring is equipped with a dynamic motion instrument so that mooring motions and tilts can be correlated with sea state and local currents.

Conducting Nylon Rope. A double-braided nylon rope with three conductors was built in FY96. Double wedge custom terminations for the rope were built in FY97 and modified in 1998. The terminated rope sample passed limited cyclic stretch tests (40% elongation) at WHOI without problems. The assembly is currently starting cyclic tension fatigue tests at an outside test facility.

High Stretch Mooring Hose. The currently used rubber stretch hose supports applied tensions through load sharing by the embedded nylon cord reinforcement and by the rubber hose wall. Higher stretching can be achieved by changing the reinforcing cord geometry. A test hose sample is currently being built which allows 100 percent rubber stretch at a tension of 1000 lbs. before engaging the hose reinforcement, see Figure 3. The reinforcement works like a stop rope. Once engaged the hose acts as a much stiffer spring, thereby avoiding excessive hose stretch levels.

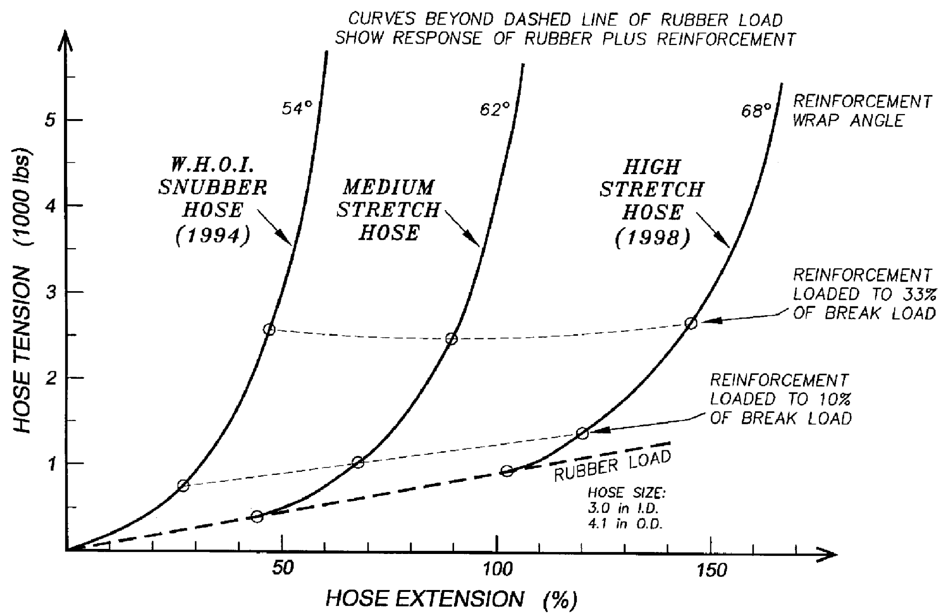

Figure 3. Hose stretch versus tension for several cord geometries.

Buoy Workshop. The second ONR/MTS Buoy Workshop was organized and held in San Diego in April of this year. The theme was the impact of new two-way telemetry systems for oceanographic buoys. The lively two-day sessions covered the full spectrum of oceanographic buoy technology. A 1998 Buoy Workshop Record has been compiled and printed and will be mailed at the end of October.

RESULTS

We have designed and successfully tested a new, low-cost coastal telemetry mooring that can provide two-way communication between AUVs and investigators on shore. It uses an integrated RF and acoustic modem and a simple mooring design that brings the total system cost below $10,000. It can be deployed from a small boat by two people.

IMPACT/APPLICATIONS

Coastal Telemetry Moorings

As described above, three coastal telemetry moorings were built and deployed on the September 1998 AOSN field trials in Cape Cod Bay. These systems, with a few modifications, are scheduled for use on the May 1999 AOSN experiment.

We are also using a similar design as the basic system approach for the NOPP project titled, “Low-Cost Modular Telemetry for Coastal Time-Series Data,” Grant # N00014-98-1-0816. We are planning to use several of these systems in Massachusetts Bay beginning in the summer of 1999.

A third application for at least parts of this system is on J. Preisig’s DURIP, “High Frequency Acoustic Testbed,” Grant # N00014-98-1-0429, where we are planning to use two of these systems for the surface component of this acoustic testbed.

TRANSITIONS

Coastal Telemetry Moorings have been transitioned to MURI-AOSN Grant #N00014-95-1-1316.

Coastal Telemetry Mooring designs are in the process of being transitioned to NOPP and DURIP Grant #'s N00014-98-1-0816 and N00014-98-1-0429, respectively.

Rubber stretch hoses and related mooring components were a key technology used for the Labrador Sea AOSN mooring.

RELATED PROJECTS

Multidisciplinary University Research Initiative: “Real-Time Oceanography with Autonomous Ocean Sampling Networks: A Center for Excellence.”

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