AOSN MURI: AOSN Mooring Development And Operations

Daniel E. Frye
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
Phone: 508-289-2759
Fax: 508-457-2195
Email: dfrye@whoi.edu
Award# N00014-95-1-1316
http://seagrant.mit.edu/~auvlab.mit.edu

LONG-TERM GOALS

The long-term goal of the AOSN MURI is to create and demonstrate a reactive survey system capable of long-term unattended deployments in harsh environments. We refer to such a system as an Autonomous Ocean Sampling Network [1]. The particular elements of the AOSN addressed by this project are the moored docking and telemetry subsystems that allow data to be forwarded from the ocean's interior to investigators on shore. Our goal is to develop these systems so that they are reliable, cost effective, and applicable to a variety of ocean measurement problems.

OBJECTIVES

Our objective was to build, test and deploy a pair of moorings in the Labrador Sea capable of supporting the AUV docking system and providing a reliable connection to a surface buoy equipped with 2-way satellite telemetry links. This objective was modified prior to the January 1998 cruise to deploy a single mooring. The second mooring was then designated a spare.

APPROACH

A subsurface mooring with an S-Tether surface link (see Figure 1) was designed and modeled using a static mooring model [2] to account for currents, component weights and component stretch under tension. This design was further analyzed using a dynamic model [3] to look at the effect of surface buoy motion on dock stability. Specific attention was paid to the following elements which were unique to the Labrador Sea requirement.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **1998**	2. REPORT TYPE	3. DATES COVERED **00-00-1998 to 00-00-1998**

4. TITLE AND SUBTITLE **AOSN MURI: AOSN Mooring Development and Operations**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Woods Hole Oceanographic Institution,Woods Hole,MA,02453**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM002252.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**4**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

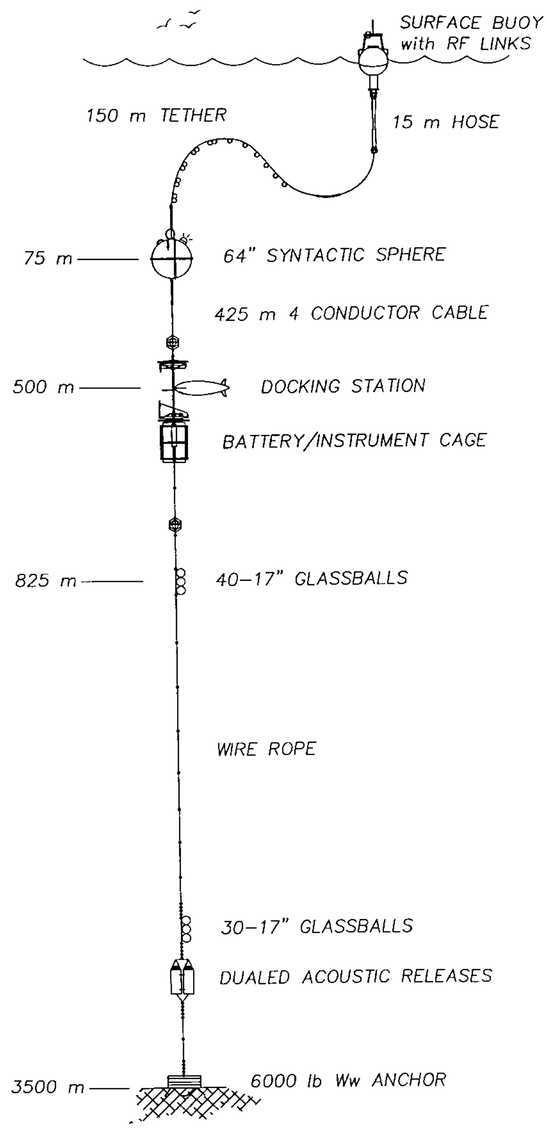

Fig. 1 AUV Telemetry Mooring Deployed in the Labrador Sea

1) Icing potential--We tried to make the surface buoy and antennas as low profile as possible to minimize icing.
2) Surface buoy submersion--Our design was able to accommodate up to 300m submersion of the surface buoy. This allowed for submersion during deployment as well as under the influence of very strong currents.
3) Extreme sea conditions--Winter conditions in the Labrador Sea are known to be extreme. We designed the surface buoy and its connection to the subsurface buoy to be extremely rugged. A specially designed stretch hose was used beneath the surface buoy to protect the electrical and mechanical cables in the surface transition region. A special jacketed tether connected the hose to the subsurface buoy and provided compliance to wave action.

4) Distributed flotation was used to balance the weight of the large battery cases located below the dock. These cases and the wire rope beneath them had to be balanced without allowing overall mooring tensions to exceed the safe working load of the wire.
5) The massive dock battery was housed in two specially design 16" aluminum tubes rated for 1000m depth. Each tube held 2,000 alkaline D cells and weighed just 300 lbs. in water. They were bolted into a lightweight aluminum cage that acted as a strength member in the mooring.
6)

WORK COMPLETED

Two complete mooring systems were built and tested, including the large battery cases with frames and the surface buoys with electronic payloads. A test deployment was successfully conducted during the October 1997 Site D test cruise. The mooring was installed in 2700m of water and operated as designed. It was recovered without incident.

Two moorings were then taken to the Labrador Sea on the R/V Knorr in January/February 1998. One mooring was deployed on January 29, 1998 and operated as designed until it was recovered on February 10, 1998. On recovery it was found that the docking pole had suffered a bend of a few degrees on deployment and this apparently caused problems with the dock articulation. The second mooring was not used.

Parts of the dock mooring were again put to use during the September 1998 AOSN test cruise in Cape Cod Bay. Since the water was only 30m deep in the bay, only the dock and subsurface and surface buoys were used. On this deployment the surface buoy flooded due to a pinched O-ring and was successfully replaced with one of the new low-cost Coastal Telemetry Buoys developed for AOSN communication needs.

RESULTS

The important result of the Labrador Sea mooring work was the successful demonstration of a new capability. We developed a system that combined a stable AUV dock with real time satellite telemetry. We deployed the system at two open ocean sites and it worked as designed, even in the extreme environment found in the Labrador Sea in the winter. Our conclusion was that if we could design a successful system for the Labrador Sea, then we could expect to be successful most places in the ocean. We did not have severe icing problems, probably because the surface buoy was frequently awash. The surface buoy submerged to 140m during deployment (see Figure 2), but this was not a problem because our design depth was 300m. The 2-way satellite links and the surface-to-dock telemetry systems worked as designed and appeared to be robust.

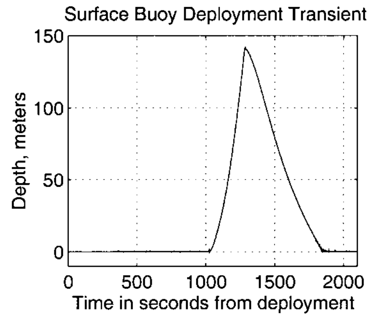

Fig. 2 Pressure record from the surface buoy during the deployment in the Labrador Sea

IMPACTS/APPLICATIONS

The mooring design, an S-Tether [4] with stretchable hose connection to the surface buoy is a general design that is applicable to a large class of measurement systems. Subsurface moorings with real-time telemetry requirements can utilize this approach for long term measurement applications.

TRANSITIONS

RELATED PROJECTS

This project is part of the Multidisciplinary University Research Initiative, "Real-Time Oceanography with Autonomous Ocean Sampling Networks: A Center for Excellence."

REFERENCES

[1] Curtin, T.B., J. G. Bellingham, J. Catapovic and D. Webb, "Autonomous oceanographic sampling networks," Oceanography, 6(3), p.86,1993.
[2] Moller, D., A computer program for the design and static analysis of single-point subsurface moorings systems, NOYFB, WHOI Tech. Rpt. WHOI-76-59, 106p., June 1976.
[3] Gobat, J. I., M. A. Grosenbaugh and M. S. Triantafyllou, WHOI cable: time domain numerical simulation of moored and towed oceanographic systems, WHOI Tech. Rpt. WHOI-97-15, 100p. November 1997.
[4] Frye, D. E. and W. B. Owens, "Recent developments in ocean data telemetry at Woods Hole Oceanographic Institution," IEEE Journal of Oceanic Engineering, Vol. 16, No. 4, pp. 350-359, 1991.

PUBLICATIONS

1) Von der Heydt, K., D. Frye and M. Johnson, "A moored system for data telemetry and control of autonomous underwater vehicles," to be published in proceedings of the Ocean Community Conference, Baltimore, November 1998.

2) Kemp, J. and D. Frye, "A rugged telemetry mooring for Labrador Sea AUV operations," presented at the ONR/MTS Buoy Workshop, San Diego, April 1998.