AOSN MURI:Docking for the Autonomous Ocean Sampling Network

Principal Investigator:
Hanumant Singh
Blake 206, MS #7,
WHOI, Woods Hole, MA - 02453-1109
Fax (508)-457-2191
email hanu@whoi.edu

Co-Principal Investigator:
Dana Yoerger
Blake 206, MS #7,
WHOI, Woods Hole, MA - 02453-1109
Fax (508)-457-2191
email dyoerger@whoi.edu

Program #:
ONR-322 OM/AOSN N00014-95-1-1316

WWW address:
http://www.whoi.edu/DSL/hanu/

LONG-TERM GOALS

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 (AOSN).

Our work specifically relates to the aspects associated with docking AUVs within an AOSN.

OBJECTIVES

The docking component of an AOSN consists of several tasks that must be accomplished autonomously. These tasks include homing the vehicle to a dock after its mission is completed; offloading data from the AUV and transferring it back via satellite to remote users on land; charging the vehicle in preparation for its next mission and undocking at the start of a new mission.

APPROACH

Our approach to docking is illustrated in Figure 1. The AUV is driven onto a pole such that a latch on the front engages and holds the vehicle onto the pole. A motorized assembly then aligns inductive cores on the AUV and the dock to allow for an inductively based mechanism for data and power transfer. A controller on the dock accomplishes these operations autonomously. This controller also talks to a surface expression that allows two way communication between remote users, the dock and thus the AUV via satellite.

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: Docking for the Autonomous Ocean Sampling Network**		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)**	**5**	

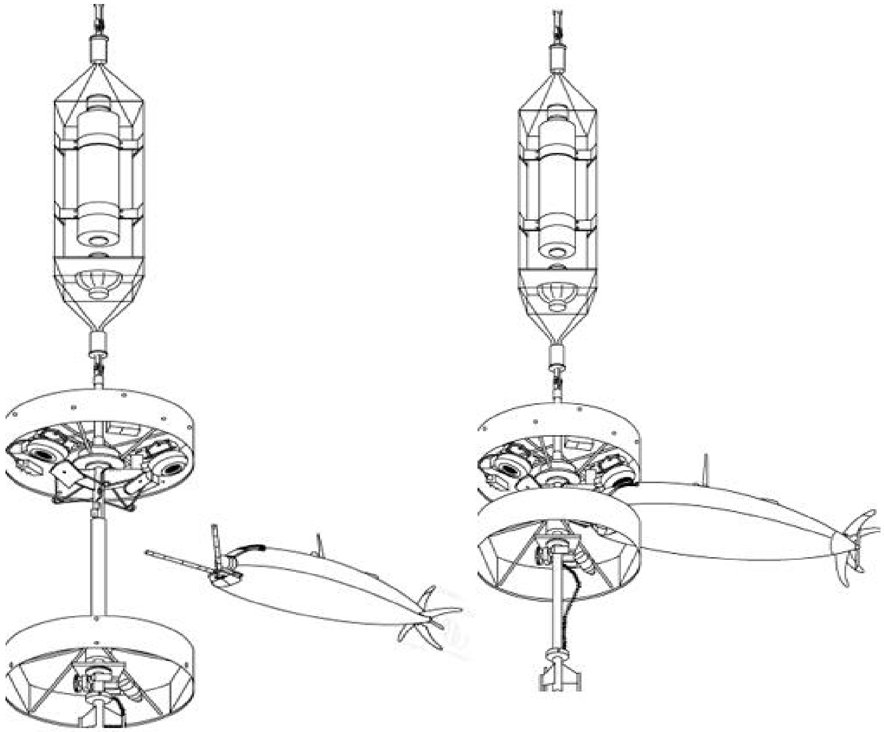

Figure 1. An Omnidirectional Approach to Docking

WORK COMPLETED

Software Implementation

The emphasis in the current year was on implementing the software for completely autonomous operations. The basic algorithmic structure follows a linear progression starting with the vehicle latching onto the dock. The dock detects the presence of the AUV, runs its actuator to align the inductive core on the AUV with the inductive core on the dock before beginning a transfer and archive of the AUV's data. The dock also obtains a suitably compressed representative set of the scientific data to pas along to remote users via a satellite link on the surface. It then starts the longer process of recharging the AUV's batteries. Once the vehicle is recharged, the dock depends upon a multiple input mission scheduler to decide when to launch the vehicle. While the vehicle is on its mission the dock tries to track the vehicle until it safely returns and this cycle continues.

Hardware Implementation

While this progression does, at a simplistic level, capture the essence of all the tasks that are required of the dock it does not address a number of issues which impacted the actual hardware implementation. These issues include the power budget associated with a deployment that lasts several months, the reliability of the entire system in the event of subsytem failure, the protocols for dock and AUV interactions, and the precise nature of remote access for users onshore

Power for the dock was supplied by a collection of ~5000 alkaline D-cells. These were arranged in two housings connected to the dock controller. The computing engine on the dock is an i486 based PC-104 system. If we consider typical mission scenarios such as the one outlined for the Labrador Sea the requirements were for running vehicles for six twelve-hour-long missions. Considering that the overall deployment was to last for a period of over four months it becomes obvious that the majority of the time had the dock and vehicle idle. Trading off this idle time with a need to check the health of the dock as well as log the data from the sensors on board the dock we settled on a cycle such that the entire system would come alive once every two hours before shutting down, if a mission was not scheduled for the next time period. The typical time to boot up, make contact with the subsystems and transfer data between them was of the order of two minutes. With the entire suite of sensors running on the dock it the dock uses 35W of energy. However in the sleep state it uses only 100mW

.

Mission Schedule

Three mechanisms were implemented for scheduling a mission. It may be scheduled a priori, downloadable from operators on shore, or it may be triggered based on sensor input on the dock. The a priori mission schedule is an ascii file that resides on both the dock station and the vehicle and contains the time to start a mission, the name of the mission and its duration. This allows the dock to prepare for launching the vehicle at the right time as well as lets it know when to expect the return of the vehicle. Additionally it serves as a fall back mechanism should communication between remote users and the dock fail for any reason. The downloadable mission schedule is identical to the a priori mission schedule except that the ascii mission file has been received from remote operators via satellite and sent to the vehicle via the dock. A program on the dock also monitors sensors located on the dock and may make a decision to start a vehicle mission based on its input. This protocol has a mechanism built in so that it may be armed or disarmed by users on shore.

Dock, AUV and Satellite Interactions

Various hardware mechanisms were implemented for remote users to interact with the dock and the AUV. All interactions take place along a chain from the user, via satellite (Inmarsat C or Argos) or local RF link, onwards to the surface expression, from there via a four wire redundant RS-485 interface to the dock, and eventually via inductive coupling if required go to the AUV.

Every two hours the vehicle wakes itself up a few minutes before the hour and goes through a self check, the results of which it stores locally. On the hour the dock wakes up and communicates to the vehicle via ftp. It goes to the local data directory on the vehicle and checks for the existence of a specific file which contains a list of data files which the dock transfers over via FTP. The data from the AUV consists of archival data that is logged on the dock, highly compressed data that is transferred back to remote users via InmarsatC, as well as vehicle status information that the dock concatenates with its own status information into a bit stream suitable for Argos transmission.

As part of its wakeup cycle the dock also communicates with the surface expression. It queries the surface expression for sensor data, for time because the surface is set to GPS time, as well as for any incoming messages that the surface may have received via its inmarsat link. The incoming messages may be of several types. They may consist of mission files which the dock keeps a local copy before passing onto the vehicle, they may be specific files destined for the dock, or they may be files that are specific to the vehicle. The dock transmits a very compressed data packet for transmission over the Argos link as well as short snapshots of status and data for transmission over the InmarsatC link. An acoustic communications link also exists between the dock and the AUV. This serves to keep the dock informed about vehicle position when the AUV is on a mission as well as lets the dock know when the AUV thinks it is latched onto the docking pole.

Figure 2. The Docking Components on the Deck of the R/V Knorr

RESULTS

We participated in two cruises over the previous year. The first was off of the R/V Knorr in the Labrador Sea in January of this year where the dock was deployed on a deep water mooring. The second was off of the R/V Oceanus as part of the AOSN MURI and LOOPS efforts in Massachusetts Bay. In these and previous efforts we have so far demonstrated the following. The ability of the MIT Odyssey class AUV to omnidirectionally home in into a dock, the ability to bring two inductive cores into close contact to enable a complete implementation of the TCP/IP protocol for data transfer, the ability to very efficiently transfer power across the inductive cores, an integrated satellite link to provide remote connectivity, data and mission scheduling, and to do all these operations in an autonomous manner for extended periods of time.

IMPACT/APPLICATIONS

We have successfully demonstrated all the individual components required, from a docking standpoint, to create a reactive survey system, capable of long-term unattended deployments in harsh environments. We hope to demonstrate a complete integrated system with high reliability in the coming months.

TRANSITIONS

While the individual components of the docking system have been tested and verified, the reliability and robustness of the entire system will be tested extensively in upcoming cruises. These include a cruise on the R/V Gyre as part of a demonstration for NAVOCEANO and operations associated with the MURI and LOOPS program in Massachusetts Bay in the spring of next year.

RELATED PROJECTS

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

PUBLICATIONS

1. Singh, H., Lerner, S., Von Der Heyt, K., Moran, B., "An Intelligent Dock for an Autonomous Ocean Sampling Network", IEEE Oceans98 conference, Nice, France, 1998.