Long Endurance Testing of a REMUS Docking Station, Duplicate Copies and Off-Site Support - An Expansion of N00014-02-C-0278

Thomas Austin
Woods Hole Oceanographic Institution
Bigelow Lab 303 MS # 10
Woods Hole, MA 02543
Phone: (508) 289-2894 fax: (508) 457-2104 email: taustin@whoi.edu

Ben Allen
Woods Hole Oceanographic Institution
Bigelow Lab 302 MS #10
Woods Hole, MA 02543
Phone: (508) 289-2930 fax: (508) 457-2104 email: ballen@whoi.edu

Award Number: N00014-02-C-0278

LONG-TERM GOALS

To transition a field-deployable, self-powered, autonomous docking system for the REMUS/SAHRV vehicle that will support long-term reconnaissance operations in littoral waters.

OBJECTIVES

The objective of this research is to demonstrate the capability to perform repeated coastal reconnaissance and harbor penetration missions with a REMUS/SAHRV Autonomous Underwater vehicle (AUV).

Technological objectives that are required include:

- the development of a self-powered, modular seafloor docking station that permits the vehicle to leave the dock to perform periodic surveys of the coast; to penetrate harbors and rivers; and to return to the dock for protection, battery recharging, data off load, and reprogramming between missions;
- the development of a docking module for the REMUS vehicle system;
- the development of an energy source to power the dock and to recharge the vehicle;
- the development of acoustic, radio frequency, and satellite communication systems for the dock and the vehicle;
- the development of navigation and control software that supports the vehicle docking objective;
- the development of software and hardware that supports the autonomous operation of the dock;
- the development of a periscope video camera module for the SAHRV/REMUS vehicle to support harbor penetration missions.

The major subsystems of the autonomous docking system are depicted below in Figure 1.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 2008**	2. REPORT TYPE	3. DATES COVERED **00-00-2008 to 00-00-2008**

4. TITLE AND SUBTITLE **Long Endurance Testing of a REMUS Docking Station, Duplicate Copies and Off-Site Support - An Expansion of N00014-02-C-0278**	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,Bigelow Lab 303 MS # 10,Woods Hole ,MA,02543**	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

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)**	**6**	

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

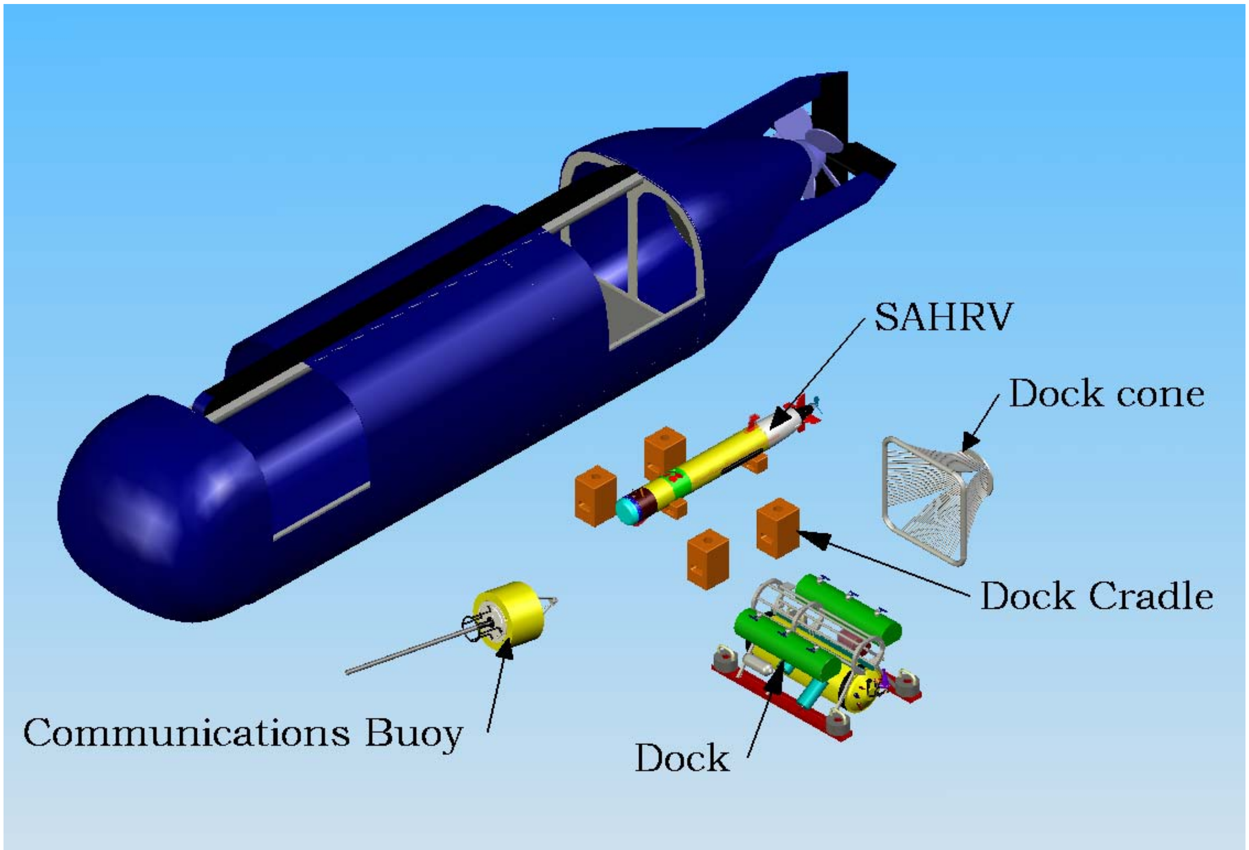

Figure 1: Major components of the SDV based REMUS/SAHRV docking system

APPROACH

The Woods Hole Oceanographic Institution (WHOI) Oceanographic Systems Lab (OSL), under the direction of Tom Austin, uses a team approach to field a well-engineered system. Ben Allen, and Thomas Austin will be Co-principal Investigators for this proposal. The engineering staff of the Oceanographic Systems Laboratory and other staff of the Woods Hole Oceanographic Institution will assist them. Specifically, Ben Allen and Mike Purcell will address mechanical issues; Tom Austin, Rob Goldsborough, and Ned Forrester will address electrical issues; Roger Stokey will address software and control issues; Marie Basile and Jane Hopewood will address documentation and administrative matters; and Greg Packard and Amy Kukulya will provide technical support in both electrical and mechanical assembly and testing.

WORK COMPLETED

The following tasks are in progress or have been completed during FY08.

- The docking station has been successfully tested in shallow stagnant waters off the WHOI dock to monitor biofouling, corrosion, and sediment accumulation.

- The docking station was modified to implement a “sleep” mode instruction set to allow very low power drains on the hotel system. System wake-up can be via a timed sleep duration or acoustic command. Also, a digital ranger feature was implemented to allow range tracking of the vehicle distance from the docking station during runway approaches.

- The docking station was installed outside Hadley Harbor for further long-term measurements of environmental factors on the dock.

- Vehicle missions with a non-inertial navigation REMUS have successfully navigated into the docking station using a magnetic north seeking compass.

- The duplicate copy of all the docking station components are complete and are now in final assembly and testing.

- A duplicate copy of the communications/camera buoy is being fabricated for delivery to NPS.

RESULTS

Battery design: The power source for the REMUS dock is an assembly of lithium-ion batteries. Each battery in the assembly is constructed from sixty-three 3.6 Volt, 2.0 Amp-hour industry standard 18650 cells, configured as 7 Series of 9 parallel. Thus, each battery provides 26 Volts nominal and about 17 Amp-hours, for a total energy of about 450 Watt-hours. Up to 20 of these batteries are configured in parallel to provide a total energy of 9 kWh. This is sufficient to fully charge a REMUS vehicle six times, allowing for the inefficiencies in the charging process. Approval for the transportation of these batteries must be obtained. One 4.5 kWh pack has been assembled and tested at WHOI. Sample battery packs from this assembly have been submitted for testing. Testing was completed in 2006 resulting in an approval letter from NOSSA for use of these batteries on the docking station at Panama City.

Ultra Short Base Line Array: This is a potted assembly consisting of a four-channel planar hydrophone receive array, acoustic baffle, and receive processor. The receive processor in the array includes four channel signal conditioning, digitization, and digital signal processing, capable of performing the signal detection and carrier phase estimation of each received signal. A 2-D beamformer algorithm then computes the resultant bearing in azimuth and elevation. The data is made available via the RS-232 interface to the vehicle CPU for the final coordinate transformation using the vehicle’s attitude and heading sensors. Further modification of the firmware resulted in reliable navigation of the vehicle into the dock.

Dock Design: The vehicle dock is depicted in Figure 4. The dock consists of an open aluminum frame to which the major components of the system are attached. The removable entry cone is mounted on the front of the dock, after it is deployed by divers from the SDV. During transit, the cone is removed from the dock, so all components will fit in the SDV. Two buoyancy tanks are included. These tanks may be filled with air so the dock is near neutral when divers remove it from the SDV. Once in place, the air is vented from the tanks, so the dock becomes heavy and rest securely on the seafloor. Additional weights may be added as shown in Figure 4. The yellow cylinder in the middle of the dock houses the vehicle electronics and the two 4.5Wh battery packs. Two actuators are also included. One actuator clamps the vehicle into the dock. The second actuator is used to move an underwater matable electrical connector, so a reliable connection is established between the vehicle and the dock.

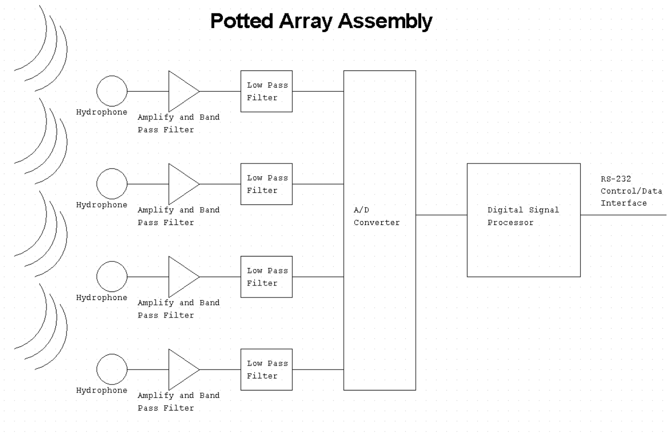

Figure 2. Block diagram of the Ultra Short Base Line Array (USBL)

Figure 3 Photo of the USBL array showing the locations of the electronics, and acoustic receive array.

Periscope Camera: A second-generation periscope camera has been designed and is currently being fabricated. Figure 8 depicts the new design. This concept utilizes a scissor jack that is activated by a lead screw, which expands and drives the camera up and out of the vehicle. Using this concept, the camera can be lifted 10 inches out of the water. The overall length of the assembly is 12 inches.

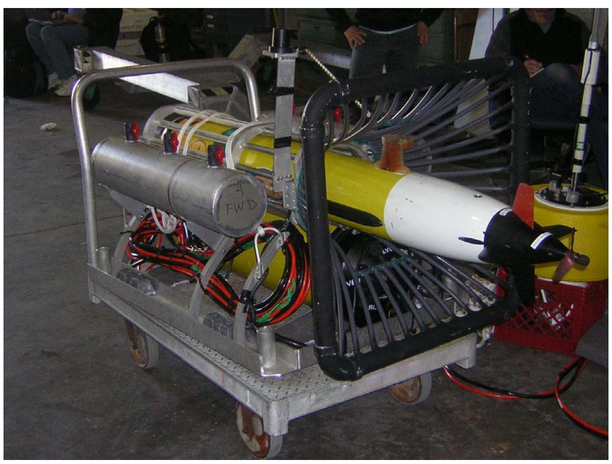

Figure 4. REMUS/SAHRV docking system with buoyancy actuators and 9.6 kWh battery packs.

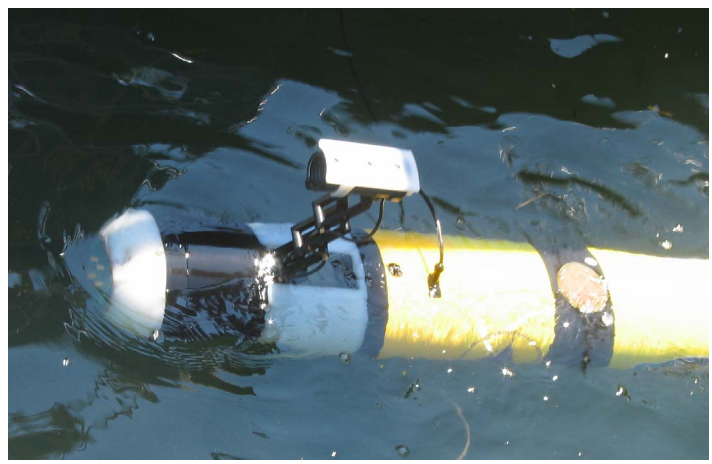

Figure 5. Photo of the extended periscope camera. The camera is mounted on a scissor jack assembly that permits it to be raised 9 inches above the vehicle. The camera is mounted at an angle of 5 degrees looking up. Camera electronics with recording system are housed forward of the camera.

IMPACT/APPLICATIONS

The UUV technologies developed under this program provide operators with new tools that enhance their productivity, improve the quality of the data they obtain, reduce the time it takes to acquire the data, and offer the promise of being able to eliminate the need to send divers and/or mammals into some very hazardous situations. The approach has proven to be affordable and reliable without burdening the operator with unnecessary complications. In short, these tools will be valuable to operators in the theater. This fact indicates that rapidly deployable robotic systems will impact the way in which autonomous operations will be conducted in the future.

TRANSITIONS

The primary transition point for this program is Navy Special Forces. EOD is also tracking the development closely. A duplicate copy of the docking station has been fabricated for the Naval Postgraduate School. The modular payloads being developed under this program will also be of interest to larger vehicle systems. These payload sections include the:

- docking module, including a ultra shore base line homing array;
- 9 kilowatt hour rechargeable Li-ion battery packs;
- persiscope camera module.

Additionally, a Communications/Camera buoy was developed for remote communications and video observation of the vehicle entering the dock.

RELATED PROJECTS

This work is related to EOD User Operational Evaluation System program and the SAHRV program.

PUBLICATIONS

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