# MIMO Transceiver Systems on AUVs

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Award Number: N00014-08-1-0756

## LONG-TERM GOALS

The long-term goal of the project is to improve data rate and reliability of data communication on autonomous underwater vehicles (AUV) or other submerged platforms.

## OBJECTIVES

The project objective is to:

1) Develop a versatile, mobile acoustic MIMO communication testbed on a small AUV at the frequency band of 8-50 kHz for data communication studies, and
2) Make this system capable of use on various submerged platforms (e.g. ROVs, moorings, fixed observatory nodes, etc).

## APPROACH

The acoustic communication work that we have done to date has focused mainly on high-end, surface-ship mounted transponders and fixed mooring transponder systems [1-3]. In order to provide an enhanced communication system, we must strive to deliver the same capability on an autonomous vehicle that can move about freely within the marine environments. The MIMO transceiver system on the AUV is designed for ease of use and low-cost deployment during at-sea experiments. The system under design can be attached to the AUV or potentially other platforms. It is capable of conducting acoustical sampling with or without single-element or multi-element source transmission. The system consists of three components: data transmission/acquisition electronic unit, a hydrophone array, and a

# Report Documentation Page

*Form Approved*
*OMB No. 0704-0188*



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

| 4. TITLE AND SUBTITLE | 5a. CONTRACT NUMBER |
|---|---|
| **MIMO Transceiver Systems On AUVs** | 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) **University of Delaware,College of Marine and Earth Studies,107 Robinson Hall,Newark,DE,19716** | 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
**code 1 only**

14. ABSTRACT
**The long-term goal of the project is to improve data rate and reliability of data communication on autonomous underwater vehicles (AUV) or other submerged platforms.**

15. SUBJECT TERMS

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT | b. ABSTRACT | c. THIS PAGE | | | |
| **unclassified** | **unclassified** | **unclassified** | **Same as Report (SAR)** | **5** | |

multi-element source. The electronic unit, housed in a payload module of the AUV, will conduct acoustic sampling from up to eight (8) hydrophones and provide analog waveforms to four (4) transducers.

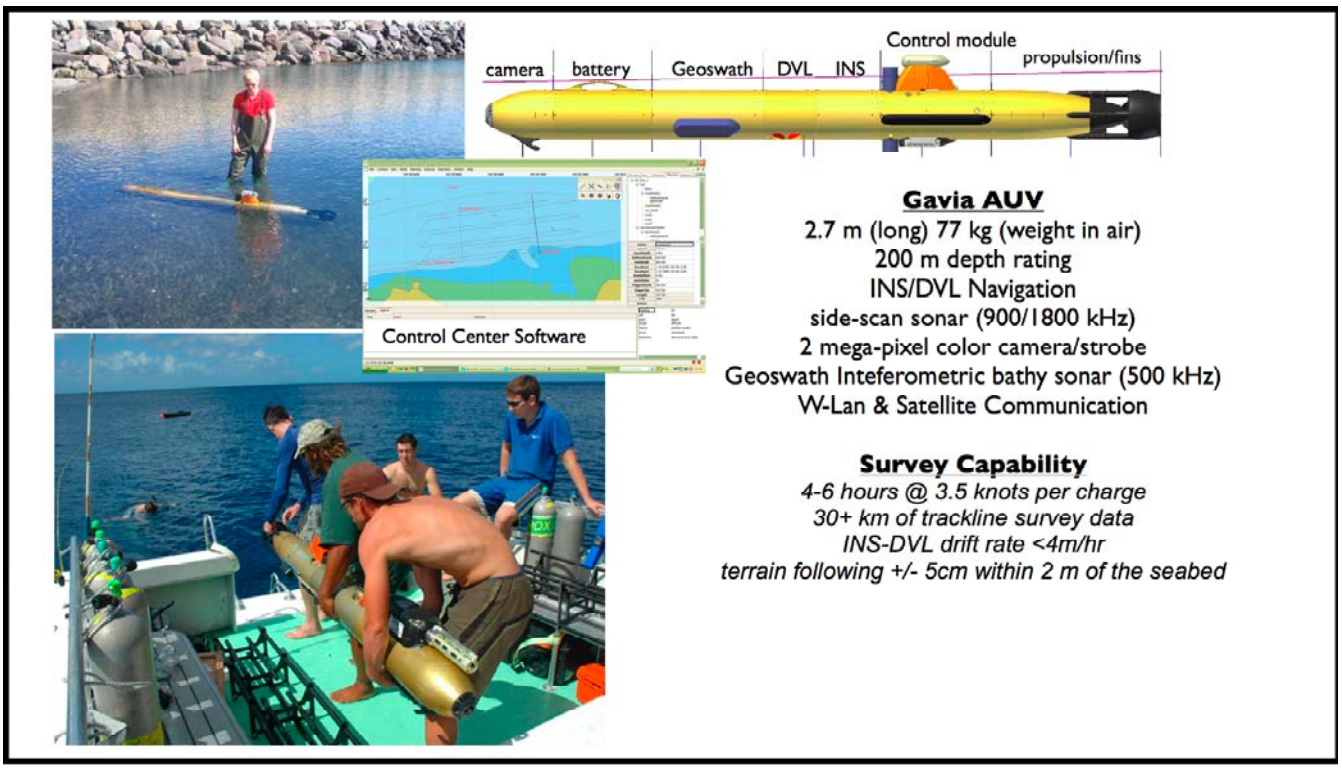


***Figure 1. The University of Delaware's DORA vehicle – a Gavia class AUV.***

Our approach involves several inter-related tasks: AUV evaluations, development of data transmission/acquisition electronic unit, placement of transducers and hydrophones, AUV integration, laboratory tank studies, and field ground-truth tests. Some of these tasks were pursued independently; the results of the independent efforts are being brought together through continued analysis.

## WORK COMPLETED AND MILESTONES

A close collaboration has been established between the two laboratories involved in this project, the Ocean Acoustics Laboratory (OAL) and Coastal Sediments Hydrodynamics & Engineering Laboratory (CSHEL) both at the University of Delaware, which includes many field cruises and exchanges of equipment and personnel over the last several years. Our efforts this year have focused on the design and construction phase of a new MIMO system and the integration of this system into an AUV (The University of Delaware's DORA vehicle – a Gavia class AUV) , which is shown in Fig.1. Our approach was to test the capability of the AUV while at the same time designing and ordering the components for the MIMO system in order to integrate the MIMO system into the AUV for subsequent tank and field testing. The completed and scheduled tasked are listed as below:

1) *AUV Evaluations*. Our emphasis for this part has been on testing the AUV in diverse coastal oceanographic settings to allow a broad assessment of the vehicle as a sensor platform. To that end, field surveys with the Gavia AUV have been conducted in 2008 in settings including shallow and deep carbonate platforms. The field campaigns include: i) January 2008 Bonaire- carbonate reef surveys in depths from 2 - 220 m of the insular shelf surrounding this island in the Netherlands Antilles; ii) July 2008- New Hampshire- tank tests; and iii) July 2008- Delaware Bay both inside the bay and on the adjacent inner shelf (Fig. 2) . Results from initial field tests imply that within limits the AUV may offer a robust platform for acoustic communications.

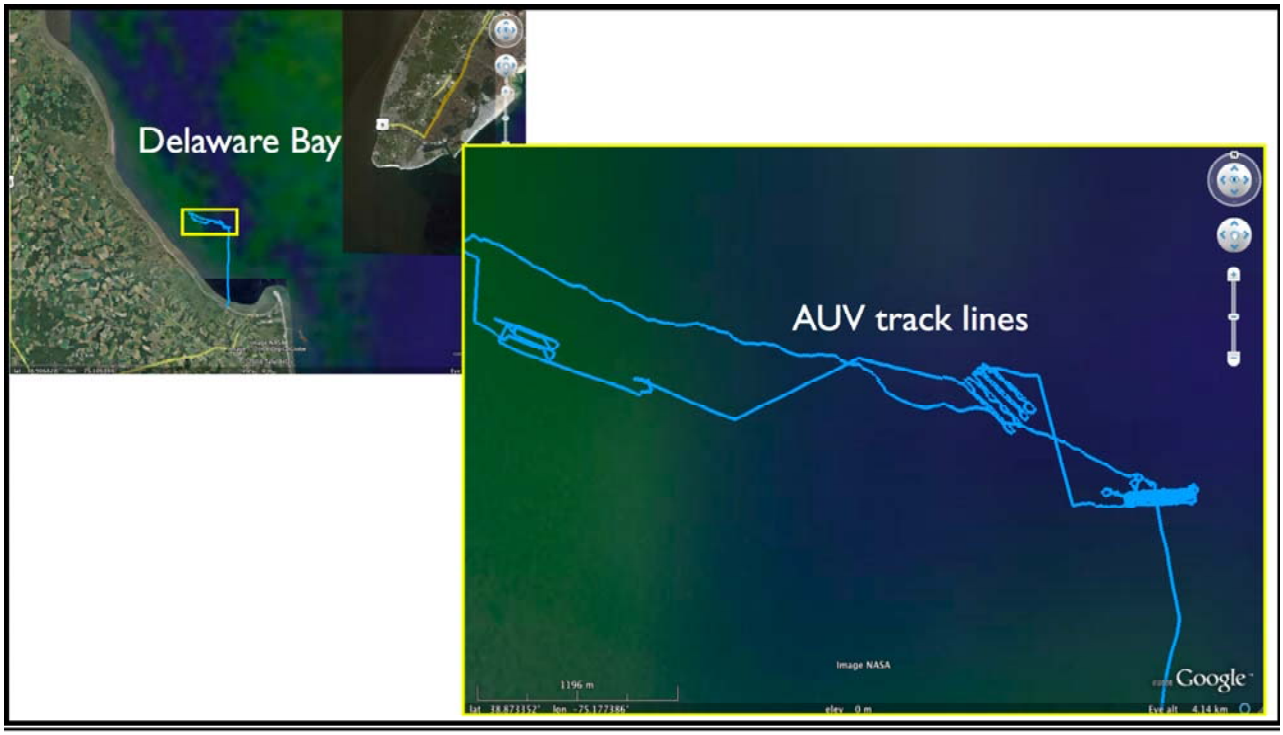


***Figure 2. AUV field survey tracklines from July 2008 inside the mouth of Delaware Bay.***

2) *Development of Data Transmission/Acquisition Electronic Unit.* The data transmission/acquisition electronic unit is to fit in the payload module of the AUV. The electronic unit is based on the existing design from OAL that has been proved robust in past high frequency acoustic experiments [2]. Now it is being re-designed into the PC104 form with much smaller size. The software for the PC104 structure is to be developed and the expected completion date for the baseline software is December 2008. The PIs have been working with the AUV vendor, Hafmynd Inc., to customize a payload module to house the electronic unit. Now it has been purchased and will be delivered to CSHEL in the fall of 2008.

3) *Placement of Transducers and Hydrophones.* With the electronic unit in the payload, the transducers and the hydrophone array are to be properly placed or attached to the vehicle. The hydrophone array can be towed. Hafmynd Inc has conducted towed cable trials and concluded that

the towing of a 12 m array will not have excessive negative effects on the navigation of the vehicle [4]. With a flooded section and a noise cone already purchased for the project, the transducers might be attached to the body of the AUV. The design of the towed array and the transducer placement has started. The design process should continue evolving even after lab testing or field trials.

4) *AUV integration.* During the acoustic measure, autonomous AUV operation is achieved either by command from the AUV mission control computer, or using pre-set parameter files loaded prior to start of mission. After AUV retrieval the data is downloaded via Ethernet to the shore processing computer for data editing, post processing, and report generation. The raw acoustic data files are recorded directly to the MIMO unit. Files are then transferred either via wired or wireless LAN in order to apply the processing algorithms [3] being developed at OAL. Certain supervision and communication is needed for the control/operation of the MIMO system when the vehicle is underway. For example, the MIMO system needs the positioning/timing information from the vehicle to tag the acoustic data. The vehicle might need the MIMO status for system management, for example shut-down protocol. The AUV integration is to be completed by the spring of 2009.

5) *Laboratory/Field Tests.* The PIs are seeking laboratories to test the MIMO system on the AUV. The objectives of the lab tests include i) measuring the self noise of the system; 2) calibrating of the acoustic source and receiver; and 3) testing the communication between the vehicle and the MIMO system. After lab tests, the system will be tested in the field for mechanic stability and initial acoustic measurements. These results might be used to improve the system design. It is expected that there will multiple lab/field studies during the end of 2008 and the beginning of 2009.

## IMPACT/APPLICATIONS

Results from initial tank and field tests indicate that the AUV may offer a robust platform for acoustic communications. If this continues to be proven true, the development of an AUV-deployed MIMO system will offer high rate acoustic communication capability appropriate for tactical applications.

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