UUV Magnetic and Electric Field Sensing Network II

Final Report

1/24/2022

Grant Number: N00014-20-1-2493

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Moscow Idaho 83844

Distribution Statement

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Project Summary

A copy of the annual RPPR for the project is attached for reference.

The major goal for the project was complete the assembly of the Riptide UUV and Stand-Alone Sensor Module (SASM) and be prepared to conduct Underwater Electric Potential (UEP) and magnetic signature measurements.

The Riptide UUV, shown in Figure 1, was assembled by combining the previously purchased sensor sections and battery sections from Riptide with the nose and tail cone purchased from BAE in the previous research project. Several technical challenges had to be overcome but with assistance and advice from BAE all the issues were eventually resolved. The UI research team integrated the WHOI modem and associated UI software to allow acoustic comms and navigation compatible with the UI UUV research subs. The software, firmware and hardware are ready for an in-water test. The emergence of COVID-19 and the associated restrictions prevented the UI researchers from being able to perform an in-water test at ARD or other locations with the Riptide AUV.

A finalized prototype of the SASM has been assembled and tested in our saltwater test tank, see Figure 2. The SASM is capable of recording six channels of 24-bit data at 2K SPS allowing simultaneous recording of a three axis Billingsley triaxial fluxgate magnetometer and three axis electric field sensor data. In addition, the SASM includes a Memsense IMU with a recording rate of 100 SPS. This system is powered by a minimum of four standard 9V batteries and can be installed on almost any UUV. The SASM measures 30 inches in length and 2.5 inches in diameter. Figure 3 shows salt-water test tank data

for the Ag/AgCl and carbon electrodes. The Ag/AgCl noise floor was 0.64, 0.68, and 0.58 uV/m and the carbon was 1.6 uV/m after 20 Hz low-pass filtering. The Electric Field sensor used the UI developed 3" sensor ball with 10mm Ag/AgCl electrodes and embedded amplifier shown in Figure 4. Schematics and documentation for the SASM are available to ONR upon request.

Equipment Status

The Riptide, SASM, Hydroid portable transponders and other equipment is currently stored on the UI campus in the Gauss-Johnson Engineering Laboratory. The buoys for the in-bay test range at ARD have been pulled and are currently in storage. The yellow-barge range and topside tracking systems are still deployed and used on other ARD projects.

Figure 1. UI Riptide assembled with instrumentation and battery sections.

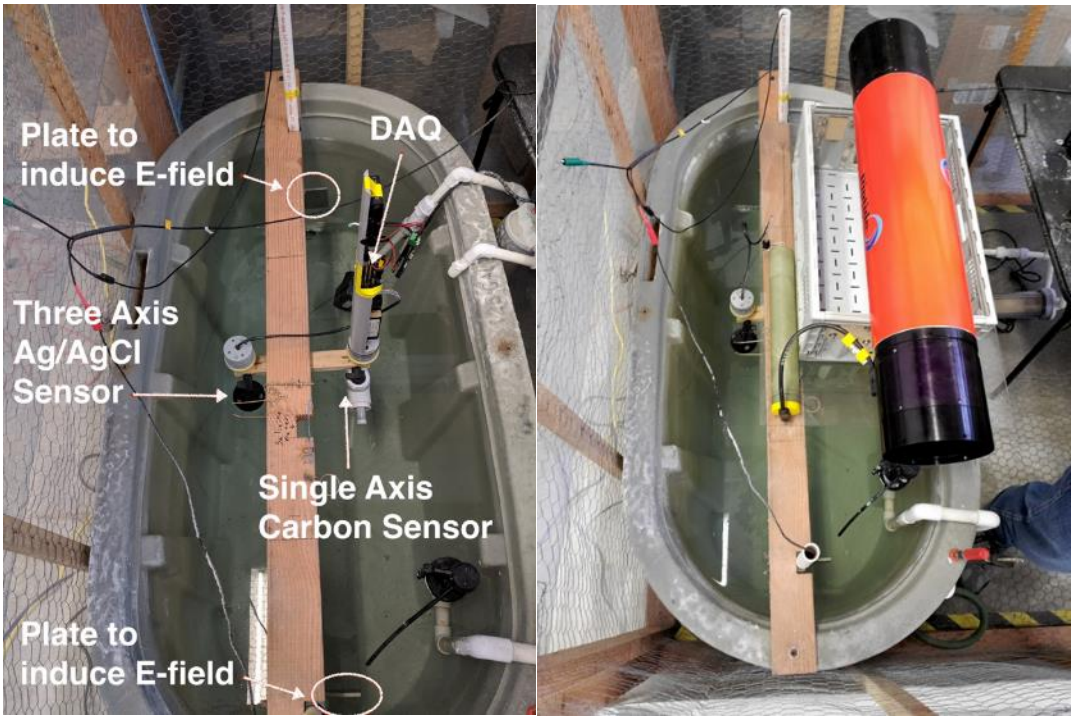

Figure 2. Saltwater test tank with SASM (left) and NIDAQ Riptide Section (right).

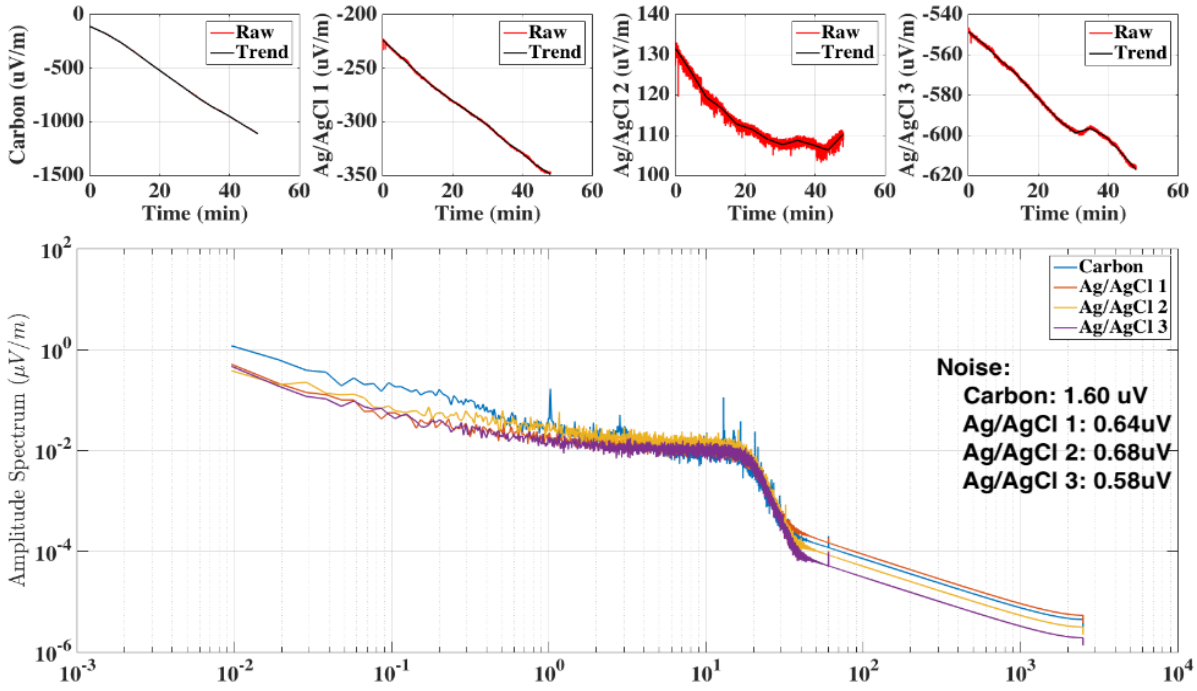

Figure 3. Three axis, 3” diameter Ag/AgCl ball electric field sensor and 1-axis carbon electric field sensor salt-water test tank performance measurements. The 1-axis carbon electric field and the Ag/AgCl sensors had pre-amplifier gains of 250x and 500x respectively.

Figure 4. 3” ball sensor with embedded UI pre-amplifier.

2021 Annual Report

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Major Goals

In our past research program, we proposed to use a commercially available UUV to perform magnetic and electric field signature measurements on cooperating naval vessels in an operational environment. The UUV that has been selected for this survey was a customized Riptide 7.5" diameter vehicle that has the ability to tow a magnetic sensor and includes a transponder for use in an ultra-short baseline (USBL) tracking system. The vehicle was to be purchased by ONR from Riptide and made available to UI researchers for development of the sensors and data acquisition systems for making the magnetic and electric field measurements. Unfortunately, Riptide had technical difficulties with the ONR vehicle and went bankrupt and prior to delivery of the vehicle. The UI had purchased an instrumentation section and battery section in preparation for use with the ONR Riptide. BAE purchased Riptide and the UI researchers purchased a nose and tail cone to go with the previously purchased sections to have a vehicle capable of making the proposed magnetic and electric field measurements. The major goals for this project are to complete the assembly of the Riptide AUV and the sensors and are shown below.

Task 1: Riptide Development. Task 2: Develop and Improve Sensor Modules. Task 3: Modeling and Data Analysis. Task 4. Project Management.

Accomplishments Under Goals

A functional commercial AUV was assembled by combining the previously purchased sensor sections and battery sections from Riptide with the nose and tail cone purchased from BAE. Several technical challenges had to be overcome but with assistance and advice from BAE all the issues were eventually resolved. The software, firmware and hardware are ready for an in-water test. The emergence of COVID-19 and the associated restrictions prevented the UI researchers from being able to perform an in-water test at ARD or other locations with the Riptide AUV. A finalized prototype of the Stand Alone Sensor Module (SASM) has been assembled and tested in our salt water test tank.

Plans Next Period

The grant has currently expired, and the equipment needs to be stored or returned to ONR or turned over to ARD. There is a potential for future research projects in this area and we would like to maintain our research capabilities in the event ONR decides to prioritize this research. The UI has developed a lot of intuitional experience making electric and magnetic field measurements with AUVs. The facilities at ARD on Lake Pend Oreille offer an excellent low noise large body of water that is well situated for making electric and magnetic field measurements for evaluation of equipment and sensors.

Results Dissemination

Nothing to Report

Honors and Awards

Nothing to Report

Training Opportunities

Nothing to Report

Technology Transfer

The University of Idaho office of technology transfer is interested in and currently seeking to establish intellectual property rights for the Stand Alone Sensor Module. Once documented, they intend to contact commercial vendors of oceanographic equipment to see if there is any interest in developing a product for commercial applications.

Participants

Name	Role	Person Months
Edwards, Dean	Faculty	1
Frenzel, James	Faculty	1
Canning, John	PD/PI	6
Marulanda Arias, Juan	Postdoctoral (scholar, fellow or other postdoctoral position)	6
Holt, Cory	Undergraduate Student	3

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14. ABSTRACT

The Riptide UUV was assembled and its software was modified to include the WHOI modem communications and navigation systems and to be compatible with the UI UUV systems. The Stand Alone Sensor Module was tested in the UI saltwater test tank and had electric field noise measurements under 1 uV/m after a 20 Hz low-pass filter. Covid-19 safety protocols impacted field testing opportunities and as a result no in-water testing occurred.

15. SUBJECT TERMS

UUV, Electric Field Sensors, Electric and Magnetic Field Measurements

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