Instrumented Mines

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LONG-TERM GOALS

Our long-term goal is to provide the Navy with quantitative data on mine behavior. The Instrumented Mine will provide a means of measuring the interaction of a mine with its environment and how environmental factors influence mine burial. This information can be used to enhance mine burial models. Knowledge obtained from long-term measurement of mine dynamics in diverse environments will improve the U.S. Navy's tactical advantage when operating in mined waters.

OBJECTIVES

The objective of this project is to develop an Instrumented Mine that is capable of measuring and recording mine dynamics (roll, pitch, azimuth and 3-axis acceleration), temperature, pressure, percent burial, scour depth, and acoustic energy over a 1-year duration. Percent burial and scour depth will be measured using a unique acoustic method being developed in this project. The Instrumented Mine with Sediment Transport will include a mix of multi-frequency burial transducers for measuring suspended sediment concentrations and acoustic Doppler transducers for measuring water current flow rates thus providing for the calculation of sediment flux in the vicinity of the mine. The combination of these measurements will provide a comprehensive data set for analysis of the processes that affect subsequent mine burial. Our end objectives are to provide a scientific research tool to improve the understanding of mine burial and a fleet exercise tool for training and testing tactics on mine sweeping.

APPROACH

Omni Technologies, Inc. is currently working on two ONR projects associated with Mine Burial Prediction. Both deal with the advanced development and applied research for measuring in-situ mine burial parameters and the sensing of the processes which cause burial. The first project is designated as the Instrumented Mine and the second is the Instrumented Mine with Sediment Transport. Both Instrumented Mines designs will be similar except one system will attempt to measure in-situ Sediment Transport in addition to its other measurements. This will be accomplished using a set of 500 kHz

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14. ABSTRACT
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Doppler transducers and 1.5 MHz and 3.0 MHz suspended sediment transducers. Other measurements the systems will make are percent burial, scour, acoustic energy impinged on the mine, roll, pitch and azimuth, temperature, and acceleration. Both will be capable of responding to a coded pulse. The units are being designed to operate in up to 100 feet of water.

Omni Technologies, Inc. has proposed to develop instrumented, cylindrically shaped mines which have dimensions and weight similar to actual mines that is capable of deployments of up to 1-year. These units will be self-contained and require no external connectivity while deployed although the capability exists to connect to the system while deployed if so desired. Although quite unique in design, this approach is based upon work earlier developed by the Germans and more recently at the Naval Research Laboratory.

These Instrumented Mines will measure percent burial using one hundred and ten 1.5 MHz and 3.0 MHz acoustic transducers installed across the surface of the mine. These transducers will be mounted flush with the mine surface to insure minimal disruption of water flow across the mine surface. This is significantly different than previous instruments that used optical sensors that protruded from the mine surface causing disruption of water flow possibly affecting the burial processes. These sensors will detect the presence of sediment at the sensor surface out to 1 meter thus allowing them to be used to measure scour. Additionally, the acoustic returns will be used to calculate suspended sediment concentrations using methods developed by Peter Thorne and others (reference). The acoustic data from these sensors will be base banded and recorded in total for off-system analysis. This is to conserve battery power and storage space for acquisition purposes only. All the data will be processed by a software package developed for use on a workstation. Temperature is being measured for use with the acoustics for sound speed calculations.

Pressure measurements will be made for a few minutes over intermittent time periods to provide snap shots of wave activity during the deployment. This will allow for correlation of wave action with burial processes such as wave induced scour and liquefaction.

Acoustic energy measurements will be made with hydrophones to provide a means of determining when the system has been interrogated by a search SONAR, to support recovery and to support simple interrogation of the mine while deployed. Although the hydrophones have a broad bandwidth, only a narrow band will be sampled to reduce the long-term data storage requirements. The sampled bandwidth, however, will be user selectable prior to deployment over the entire range of the hydrophone. The hydrophone will also act as a transmitter when a coded signal has been received. This will allow for the user to locate the instrument and to monitor its operational state. In addition, this could be configured to respond during a sweep exercise thus allowing for real-time feedback to a SONAR operator.

The Instrumented Mine's roll, pitch, azimuth and 3-axis acceleration will be monitored to provide the user with information on the mine's dynamics while deployed. This information is important to determine significant events that occur during the deployment and for correlating the mines movements in relation to external forcing functions.

Bronze was select as the preferred construction material. A non-magnetic material was first required to provide azimuth measurements using simple magnetic methods instead of having to resort to expensive and power hungry optical compasses. Bronze, however, offered additional advantageous

characteristics that include corrosion resistance, anti-fouling, strength, mach inability, ready availability and desirable density.

Alkaline D-cell batteries are being used as the power source due to their energy density characteristics, cost, safety and ready availability. These will be housed in disk shaped, nylon battery packs. The battery packs will be reusable and should provide for quick and low cost assembly.

WORK COMPLETED

The two Instrumented Mine projects began at different times and so are in different phases of completion. The first project is 10 months into an 18-month project and the second project is 5 months into an 18-month project.

1. Omni Technologies, Inc. has completed the system design.
2. Omni Technologies, Inc. has completed all the mechanical development except for minor changes discovered during electronics system development and those changes that will be required to add the acoustic Doppler sensors on the 2nd mine.

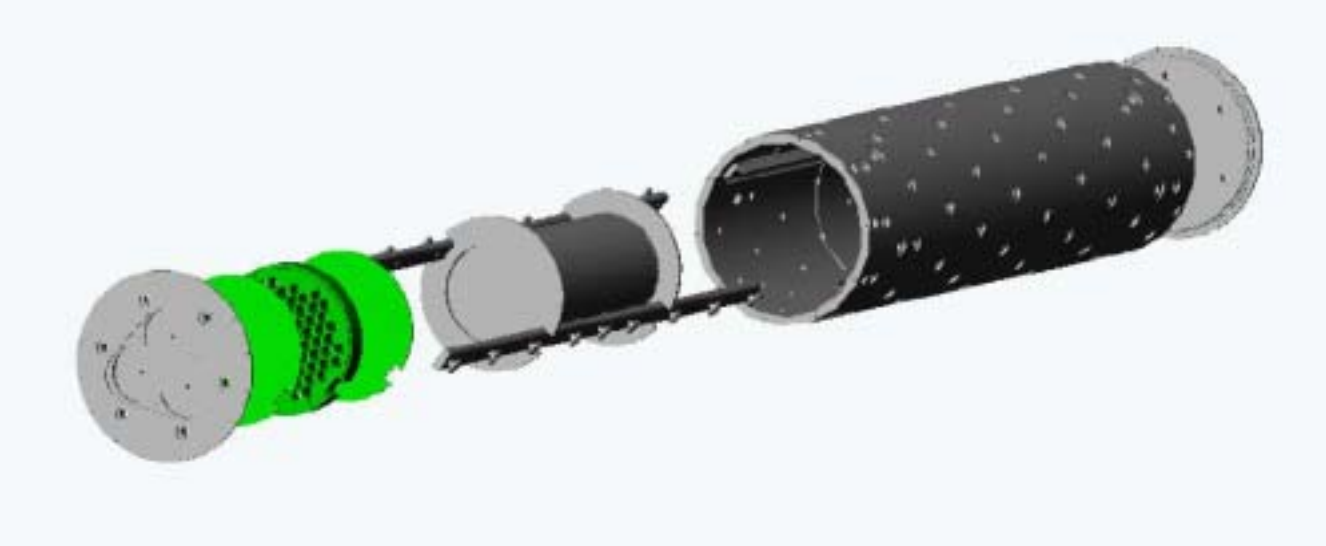

Figure 1. The Assembly Drawing of the Instrumented Mine showing sensor hole patterns, the internal electronics canister, end caps, and a single battery pack.

3. The bronze cylinder and end cap castings are in the process of being made. The bronze stock for the sensors and other parts is also being made.
4. Approximately 70% of the electronics design has been completed. The back plane electronics is designed, fabricated and being tested. The hard drive interface electronics is designed, fabricated and tested. The DC-DC converter board is design and in the process of fabrication. The cache controller is designed and is in lay out. All the analog electronics have been designed. All the processors have been selected and have been received. The wiring infrastructure has been completed. The power system design is completed. All the COTS

sensors have been selected and purchased. All the connectors have been selected and purchased.

5. The hydrophone design is complete and 10 sensors have been completed. In-house testing of these has been completed.
6. A number of 1.5 MHz burial transducers were built but failed in-house testing. It has been discovered that the urethane potting is damping or absorbing the acoustic energy. We are in the process of resolving this issue.
7. The pressure sensor design is completed and many parts purchased.
8. The battery packs have been designed and are in the process of being fabricated.

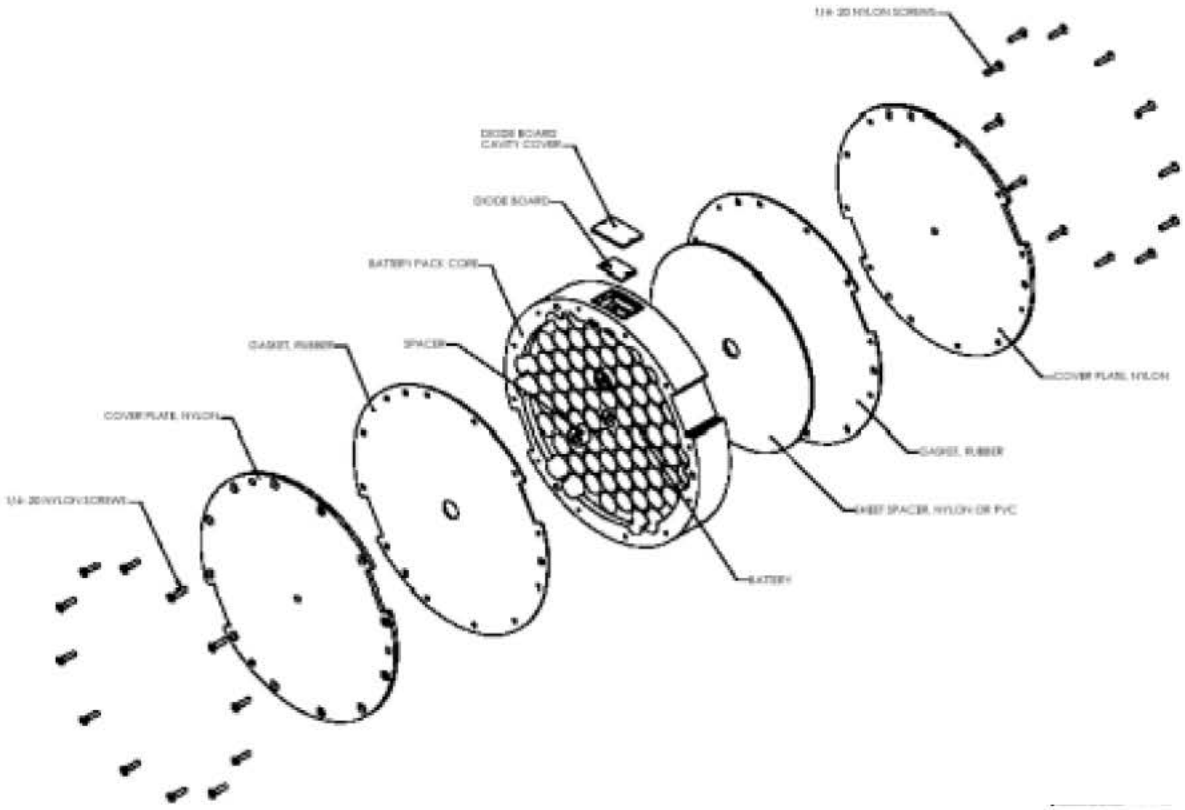

Figure 2. Assembly Drawing of a Mine Battery

RESULTS

Since these projects are only 50% and 25% complete, we have not had the opportunity to obtain significant results during a system deployment or in-house sensor testing. Results should be forthcoming in FY2002.

IMPACT/APPLICATIONS

The sensors and techniques being developed and integrated into the Instrumented Mines will provide the Navy the information necessary to predict mine burial and to correlate mine burial with the hydrodynamic processes and sediment types that affect burial. This will support the effort to develop and validate mine burial models for use in strategic and tactical Mine CounterMeasures (MCM) planning and operations. Omni Technologies, Inc. also sees a significant advancement in capabilities to the Navy's current exercise mines and believes these Instrumented Mines will provide better information to analyze the sweep exercises.

TRANSITIONS

No transitions at this time have been made although there is significant potential. The main transition will be as a fleet exercise mine

RELATED PROJECTS

The only closely related projects that I am aware of is the work OTI is doing on an SBIR project titled the "Weighted Oceanographic Registration Mine", the work that the Germany agency Forschungsanstalt der Bundeswehr für Wasserschall und Geophysik (FWG) is doing with their optical burial measurement mines, the Naval Research Laboratory's optical Instrumented Mine experiments, the Naval Research Laboratory's impact burial mine experiments and the Naval Research Laboratory's next generation Instrumented Mine project. Omni Technologies, Inc. has been involved with much of the development and experimentation associated with the projects except for the German systems. We have, however, participated in joint experiments with the German's when these systems were deployed.

REFERENCES

1. Richardson M.D. and K.B. Briggs. 2000. Seabed-Structure Interactions in Coastal Sediments. *Proceedings of the 4th International Symposium on Technology and the Mine Problem.* Naval Postgraduate School, Monterey California, 13-16 March 2000.

2. Michael Richardson, Philip Valent, Kevin Briggs, John Bradley, and Sean Griffin. 2001. NRL Mine Burial Experiments. *Proceedings of the Second Australian-American Joint Conference on Technologies of Mine Countermeasures*, Sydney Australia, 27-29 March 2001. Defence Science and Technology Organization

3. Thorne, P.D. and Taylor, J. "Acoustic measurement of Boundary Layer Flow and Sediment Flux", J. Acoustic Society of America 108(4), October 2000.

PUBLICATIONS

1. Griffin, S., Bradley, J., Richardson, M. D., Briggs, K. B., and Valent, P. J., "Instrumented Mines for Mine Burial Studies", Submitted to Sea Technology, Publication should be in November 2001 issue.

PATENTS

No patents have been applied for at this time.