Optimal Exploitation of 3D Electro-Optic Identification Sensors for Mine Countermeasures

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LONG-TERM GOALS

The overall goal of this project is to utilize existing assets to address issues critical to the operational deployment of advanced electro-optic identification (EOID) mine countermeasure (MCM) sensors. EO identification of mines is specified as a requirement for the next generation of Navy MCM systems (e.g., AQS-20(X) and RMS). With maturing sensor technology like the Areté developed Streak Tube Imaging Lidar (STIL), a concerted effort is being undertaken to evaluate optimal sensor performance, predict sensor performance with advanced imaging models, and to make this EO sensor capability available to the fleet.

OBJECTIVES

This two-year collaborative effort, including teams from Areté Associates, Coastal Systems Station (NAVSEA/CSS), Metron Inc., Raytheon, and Northrop Grumman, will utilize existing sensor and sensor model assets to address issues critical to the operational deployment of subsurface EOID sensors. Under this task, Areté will integrate and field an existing STIL sensor for multiple at-sea experimental collections. STIL collected image data sets, as well as data sets from other participating sensors, will be analyzed and compared to each other and with data sets from previous collections. Actual data sets will then be compared with modeled results for a significant number of targets, backgrounds, and operationally relevant environmental conditions.

APPROACH

The Streak-Tube Imaging Lidar (STIL) is a compact, high-resolution, 3-D imaging sensor. It uses a blue-green pulsed laser transmitter with a fixed cylindrical lens to project a fan beam beneath the sensor vehicle onto the ocean bottom. Conventional imaging optics are used to image the illuminated area onto a slit photo cathode of the streak tube. Electrons released from the photo cathode are accelerated and electrostatically swept onto a phosphor anode, forming a 2-D range/azimuth image for

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14. ABSTRACT
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each laser firing. Two conventional CCD cameras then produce digital range/azimuth imagery. The along-track dimension is sampled in a push broom fashion by utilizing vehicle motion and successive laser firings. The resulting 3D image data is then processed to produce conventional contrast maps of the bottom and targets, as well as range maps which represent the height of objects above the surrounding background of the sea bottom.

In support of the experimental data collection phase of this effort, an existing STIL sensor, previously developed under ONR funding, was retrofitted and integrated into a larger CSS-developed tow body (shown in Figure 1). In addition to the STIL sensor, two laser line scanner EO sensors (developed by Raytheon and Northrop Grumman) were also integrated into the 36-foot underwater vehicle. Two experimental data collections under a variety of operationally relevant conditions utilizing this test vehicle are planned for FY01 and FY02. Analysis of data sets collected during these field tests will provide a means to further determine overall EOID system performance in various environmental conditions.

Figure 1: STIL, Processing System, and EOID Multi-sensor Tow Body
[Tow body shown dockside with STIL sensor integrated in small section ahead of the tow body wing. STIL CAD drawing. STIL Sensor in Laboratory. Topside processing system as deployed onboard ship]

Following successful sensor integration and deployment, data will be analyzed and directly compared with Arete's existing STIL imaging models to determine and assess overall model performance. Lessons learned will then be incorporated into these models, as necessary, to allow more accurate representations of actual STIL system performance over a wide range of operational and environmental conditions.

WORK COMPLETED

During early FY01, Areté reassembled the STIL sensor after several improvements were completed. Laboratory testing and calibration of the sensor were conducted in May of 2001. In early June, the sensor was shipped from Tucson, AZ to CSS in Panama City, FL. To verify sensor performance and test new components of the system, the STIL system was fielded in the AQS-20 prototype tow body. After successful completion of two days of at-sea testing aboard the R/V *Athena II*, the sensor was then integrated into the larger tow body and tested in the laboratory during early July. After the other two EOID sensors were successfully integrated and lab tested in July, EOID testing was initiated in early August. Numerous at-sea data collections were conducted with the three EO sensors during the month of August. These tests included a variety of standoff ranges, attenuation lengths, and speeds. Tests and demonstrations were conducted aboard the R/V *Mr. Offshore* off the Panama City, Florida coastline. Currently, Areté and other team members are analyzing data collected during this first exercise.

In addition to data collection efforts, Areté has initiated improvements to the existing STIL model and is in the process of comparing model results against actual data sets collected. Also under this task, Areté has participated in test planning and target design phases along with other team members.

RESULTS

Initial analysis results indicate that sufficient amounts of data in widely varying environmental conditions were collected for the August 2001 test. Sample STIL data from this first collection are shown in Figures 2 and 3. Figure 2 illustrates a mine-like object (MLO) as seen from the STIL during one of the collection runs. The left image in Figure 2 illustrates a contrast image produced by the sensor, and the right illustrates a range image. Both are standard products of the STIL system. The range imagery provides a unique capability of determining distance of an object from the sensor as well as the height of an object above the sea floor. Figure 3 illustrates some of the sample calibration targets designed for this test as seen from the STIL during another of the collection runs.

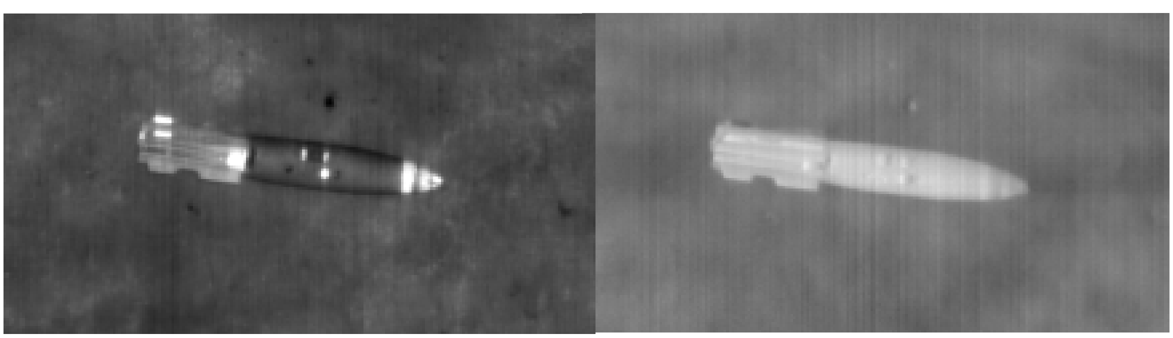

Figure 2: Mine-like Objects
[The left image is a contrast image of a mine-like object, and the right image is its corresponding range image. Lighter color indicates that the object is closer to the sensor]

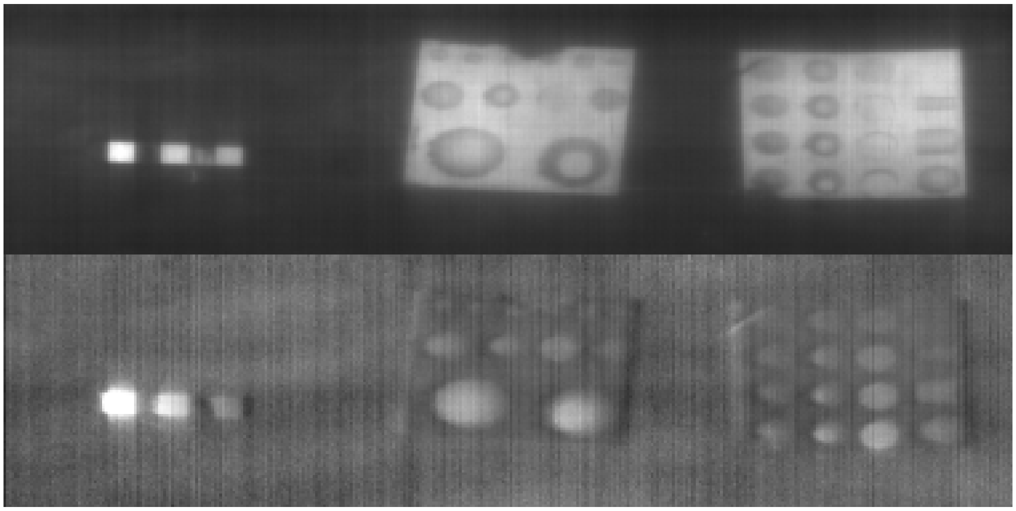

Figure 3: Special Target Panels
[The upper image is a contrast image of special panels with various shapes (e.g., cones, spheres, steps). The lower image is the corresponding range image.]

IMPACT/APPLICATIONS

The exploitation of high-resolution 3D imaging will have a significant impact on the ability to positively identify mines, reduce the likelihood of false target identification, and will result in appreciable improvements in MCM clearance effectiveness. The STIL EOID sensor allows rapid mine identification at various speeds and standoff ranges. This broad operational envelope will provide extended utility over a wide range of environmental conditions.

TRANSITIONS

As a result of the successful integration and testing of the STIL EOID sensor, this technology was selected for integration into the AQS-20(X) system. Two Engineering Development Model systems are currently undergoing final integration and acceptance testing under NAVSEA contract N00024-99-C-6337 for the Airborne Mine Countermeasures program (PE 0604373N) under PMS 210, PEO Airborne Mine Defense. The AQS-20(X) system with integrated EOID capability will also serve as the sensor system for the Remote Minehunting System (AN/WLD-1).

An airborne system, based on an adaptation of the EOID design (four receivers, and a higher power laser), was also selected for the Airborne Laser Mine Detection System (AN/AES-1). Three Engineering Development Model systems are being developed and tested under NAVSEA contract N61331-99-R-0022 for the Airborne Mine Countermeasures program (PE 0604373N) under PMS 210, PEO Airborne Mine Defense.

In addition, several organizations have requested and received STIL sensor data during FY01. These recipients of data are listed in Table 1 below.

Table 1: STIL Data Transfers during FY01

STIL Data Type	Year Data Collected	Data Description	Receiving Organization	Point of Contact
Raw sensor Data	2000	Data collected in the Gulf of Mexico	NAVSEA/CSS	Andy Nevis
Full Frame data	2000	Data collected in the Gulf of Mexico	NAVSEA/CSS	Michael Strand
Raw sensor Data and Processed Data	2001	Data from first multi-sensor experiment in the Gulf of Mexico	NAVSEA/CSS	Mary Hulgan
Raw sensor Data	2001	Data from System health checkout in Gulf of Mexico	NAVSEA/CSS	Andy Nevis
Raw and Processed Data	2000	Various data sets to work with in on-going modeling effort	Metron Inc.	Tom Stefanick

RELATED PROJECTS

This project has been performed in collaboration with Coastal Systems Station, Panama City, Florida, and several other contractors. The existing STIL EOID sensor will be maintained for additional ocean testing in FY02 and beyond.

In parallel to the EOID STIL development, a large aperture STIL system has been developed for underwater ocean measurements as part of a separate ONR initiative (N00014-96-C-0198).

During FY00, several Phase I SBIR contracts were awarded by multiple DoD agencies to investigate further use of STIL technology for other applications. A Phase II SBIR was also awarded by the Marine Corps to demonstrate STIL as an obstacle avoidance sensor for the Advanced Amphibious Assault Vehicle. This system has completed an initial demonstration during FY01.

REFERENCES

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