Advanced Underwater Imaging

Mr. Jerry Neely
5600 U.S. Highway One North
Fort Pierce, FL 34946
Phone: (772) 465-2400, ext. 476 Fax: (772) 468-0071 Email: neely@hboi.edu

Mr. Charles Mazel
20 New England Business Center
Andover, MA 01810-1077
Phone: (978) 689-0003 Fax: (978) 689-3232 Email: mazel@psicorp.com

Award Number : N000140310562

LONG-TERM GOALS

The long-term goal of this project is to advance the state-of-the-art of underwater imaging by developing new systems that harness recent advances in laser, optical, computer processing and imaging technology. The primary application for these systems will be in imaging both natural and man-made objects in aquatic environments.

OBJECTIVES

The objectives of this project are
1) to develop two new underwater optical imaging technologies;
2) to demonstrate the capabilities of these instruments in both tank and field tests; and
3) to prepare a comprehensive survey of existing and emerging underwater laser imaging technologies, as well as solicit a wish-list of capabilities from the primary user communities (military, commercial, and scientific).

APPROACH

The tasks for this project may be organized into three categories: Hardware Development, Prototype Testing, and System Survey. The Harbor Branch Oceanographic Institution (HBOI) and Physical Sciences Inc. (PSI) will work in concert to achieve the following goals:

Hardware Development
1) HBOI will upgrade the 3D-LITES flying spot laser scanner to harness recent advances in electronics and lasers and to add a fluorescence imaging capability. The upgrades will include modifications of the sensor's receiving end to record both fluorescence and reflectance information, replacement of the existing laser source with a powerful DPSS blue laser and upgrades of the system's electronics to modern and space-conserving components. The new laser source would necessitate the addition of a separate underwater housing that will house the laser's power supply. Since the main goal of the modifications is to study the relevant parameters that are relevant to fluorescence based underwater imaging (excitation source, relevant fluorescence bands, detectability in turbid waters etc.) in a relatively short time, we are minimizing the system modifications to only that which is necessary.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 2003		

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Advanced Underwater Imaging	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)	8. PERFORMING ORGANIZATION REPORT NUMBER
PSICorp,,20 New England Business Center,,Andover,,MD, 01810	
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

The original document contains color images.

14. ABSTRACT

The long-term goal of this project is to advance the state-of-the-art of underwater imaging by developing new systems that harness recent advances in laser, optical, computer processing and imaging technology. The primary application for these systems will be in imaging both natural and man-made objects in aquatic environments.

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**		**5**	

Nevertheless, we also hope to increase the system's performance (frame rate, image resolution and Signal to Noise ratio) during the process. We plan our development efforts to achieve the main goals first, using a modular approach that would allow a smooth transition to a more powerful front end, which is already in the preliminary phase of design. It is possible that the implementation of the new front end would take longer than the current funding period allowed, nevertheless, our two-step approach would allow us to meet the project objectives as originally planned. This improved system will be called 3D-FLITES.

2) PSI will develop a field-deployable prototype of the Benthic Optical Probe (BOP), a seafloor classification system initially developed with SBIR funds. By emitting a rapid sequence of filtered flashes, the BOP collects fluorescence and/or reflectance data from a discrete spot on the seafloor.

Prototype Testing

1) Once constructed and installed in water-tight housings, performance tests of both 3D-FLITES and BOP will be conducted in the saltwater tank at HBOI's Biophotonics Center. These tests will include system calibration and sensitivity assessments for a range of water turbidity levels and types of targets. These tests will quantify the effective operating range, resolution, and target characterization capabilities of both systems. A team of HBOI and PSI staff will perform the tank tests.

2) Field tests will be conducted in and around the ship channels and docks at HBOI to assess system performance when imaging "real world" targets, such as seawalls, pilings, and ship hulls. These targets will provide 3D relief with natural surface growth and enable testing of system look-up and look-ahead imaging orientations. Both 3D-FLITES and BOP will be used to image the same series of targets. A team of HBOI and PSI staff will perform the field tests.

System Survey

1) A comprehensive survey of existing underwater laser imaging systems will be conducted by PSI with support from outside consultant Dr. Drew Carey of Coastal Vision. Dr. Carey was a member of SAIC's laser line scanner group and has extensive contacts in this user community.

2) A comprehensive survey of emerging technologies that are applicable to underwater laser imaging systems will be conducted by PSI. This study will address new and forthcoming technological advances in lasers, optical components, and detectors relevant to improving underwater optical imaging systems.

3) PSI in association with Dr. Carey will solicit input from the military, commercial, and scientific user communities regarding desired imaging capabilities to better support their mission needs.

By developing a clear understanding of what systems are currently in use, what relevant technological advances are in the offing, and what capabilities the user communities desire, we will provide the necessary information for making rational investment decisions regarding future underwater laser imaging systems.

WORK COMPLETED

In the first six months of the project, significant progress has been made in the Hardware Development and System Survey task categories.

Hardware Development

PSI is currently evaluating three alternative BOP designs, which are largely defined by their respective light sources. These options represent different tradeoffs between cost and system performance. The candidate designs are based on either LEDs, strobes, or lasers (Q-switched or CW) as the excitation sources and PMTs as the receivers. At this point all of the designs involve a source-receiver separation to reduce near-field fluorescence and backscatter in the case of reflectance measurements. Doing so eliminates the need for fast gating electronics. Additionally, for the laser-based design, this separation offers the possibility of collecting target range information via triangulation.

Harbor Branch Oceanographic is currently retrofitting many of the old 3D-LITES components. A high power blue LASER has been purchased which is necessary for making fluorescence measurements. The optical sensor package is being developed in a two step approach. During the first step the sensor's front end that is currently in the system would be used with modifications made to control the gain setting of the image intensifier externally, which together with a 5 station filter-wheel apparatus will enable acquisition of fluorescence and reflectance images. A new interface board is developed for this modified front end to connect it to the rest of the newly upgraded electronics of the system. The second step, would incorporate a new design of the front end that is predicted to increase system performances. Both the modified and the new front end modules would have the same interface to connect to the rest of the system and are predicted to be swappable. All of the computer equipment necessary for control of the device has been upgraded to today's standards. New controller boards are being laid out which will also utilize smaller and upgraded electrical components. New user friendly software based on the Windows platform will be developed in parallel with all other work.

System Survey

The comprehensive review of past and extant laser imaging systems has been completed. This document provides an historical background and presents the genesis of the systems currently in use. In addition, a briefing has been prepared that reviews the concepts behind the common types of underwater laser imaging systems (*i.e.* range-gating, flying spot scanning, etc.), as well as the advantages and limitations of each approach. This briefing is intended to foster discussions with potential users who are only casually familiar with laser imaging technologies.

RESULTS

Design and construction of both the 3D-FLITES and BOP prototypes is progressing as planned. Experimental results are expected to be obtained in FY04.

The system survey of available underwater laser imaging systems has been completed and includes a concise history of these systems stemming from pioneering efforts in the late 1980s. This document will provide a valuable perspective when considering where to place future development emphasis.

Complementing the system survey, a presentation has been developed that provides an overview of the three most common underwater laser imaging approaches, namely, range-gating, flying spot scanning, and projecting a line. Implementations of each approach are presented, along with sample imagery. The intent of this presentation is both to educate those with only a casual awareness of this technology and to stimulate new application ideas for these systems.

IMPACT/APPLICATIONS

This project has the potential to impact the operational Navy in two significant ways. First, new imaging sensors are being developed that will enhance the Navy's ability to image underwater surfaces, irrespective of their orientation (*e.g.* benthic targets, vertical pilings, ship hulls, etc.). The BOP will support automated environmental characterization through computer analysis of multispectral fluorescence and reflectance signals from the seafloor or other targets of interest. For more detailed target interrogation, 3D-FLITES will raster scan a region of interest from a stationary position and produce a high resolution, three dimensional range map with corresponding fluorescence or reflectance data. Both instruments are intended to function in an orientation-independent manner and be deployable from AUVs and ROVs. With these capabilities, BOP and 3D-FLITES will be able to investigate targets by looking up, down, or ahead. Second, information will be compiled regarding recent advances in laser and detector technologies, which will provide guidance for developing the next-generation of underwater laser imaging systems.

TRANSITIONS

Given the early stage of this project, the two new imaging systems under development are not mature enough to warrant technology transfer to outside parties.

RELATED PROJECTS

None.

REFERENCES

None.

PUBLICATIONS

None.

PATENTS

None.

HONORS/AWARDS/PRIZES

None.