High-level Data Fusion Software for SHOALS-1000TH
FY05 Annual Report

Grady H. Tuell
Optech International
7225 Stennis Airport Drive
Suite 400
Kiln, MS 39556
Phone: (228) 252-1004 FAX: (228) 252-1007 E-mail: gradyt@optechint.com

Steven E. Lohrenz
University of Southern Mississippi
Hydrographic Science Research Center
Department of Marine Science
Stennis Space Center, MS 39529
Phone: (228) 688-3720 FAX: (228) 688-1121 E-mail: steve.lohrenz@usm.edu

Award Number: *W912HZ-05-C-0061*
http://www.optechint.com ; http://www.marine.usm.edu

LONG-TERM GOALS

Optech International and the Department of Marine Science at the University of Southern Mississippi will partner to develop and apply data fusion techniques for application to environmental mapping problems in the shallow-water and coastal environments. This work will lead to: (1) a robust collaboration between industry and academia focused on the use of airborne remote sensing technologies for near-shore and coastal analysis; (2) the emergence of a data fusion paradigm wherein a larger community of researchers can understand and eventually contribute to this work; (3) dissemination of appropriate data sets into the larger community; and ultimately to (4) improved understanding of regional-scale coastal environmental processes which will be realized thorough the structured analysis of combined airborne lidar and passive spectral data.

OBJECTIVES

The objectives of this collaboration are: (1) develop a number of new data fusion algorithms and computer programs which will produce coastal and environmental information from SHOALS-1000TH data; (2) achieve increased accuracy of environmental information extracted from SHOALS-1000TH data by collection and application of *in situ* oceanographic ground truth; (3) facilitate the transfer of knowledge from academia to industry regarding the collection and use of *in situ* optical data; (4) facilitate the transfer of knowledge from industry to academia related to airborne laser technology and sensor and data fusion; and (5) facilitate the education of future researchers and workforce through the integration of these concepts into graduate level courses at the University of Southern Mississippi.

APPROACH AND WORK PLAN

The work will be accomplished in 3 tasks: (1) collect and apply in situ optical data to improve data fusion algorithms for shallow water benthic habitat mapping and characterization of the water column; (2) the development of data fusion algorithms for high-level fusion of lidar and passive spectral data; and (3) the extension of previous data fusion techniques to include applications on the shore.

In the first task, Optech International and USM will work closely with the Joint Airborne Lidar Technical Center of Expertise (JALBTCX) to identify a location for a data collection campaign, and will coordinate resources to collect the airborne and in situ data. These data will be shared within the team, and quickly disseminated to other interested researchers. Using the *in situ* data, the results of the algorithms will be tested and refined. Ms. Jen Aitken of Optech International will coordinate the overall data collection effort and supervise the collection of airborne data, and she and Mr. Vinod Ramnath of Optech International will process and distribute these data. Dr. Steven Lohrenz of USM will coordinate and supervise the collection of in situ data. Dr. J.Y. Park of Optech International will supervise the overall development of data fusion algorithms into a common package, and this will be accomplished in the IDL language. We anticipate the data collection will occur in the late spring of 2006, and will most likely be on the west coast of Oahu.

Over the past 3 years, Optech International has developed algorithms for the fusion of SHOALS bathymetric lidar with passive spectral data. These algorithms achieve fusion by constraining the inversion of radiative transfer equations for individual pixels in the passive spectral data, so as to produce spectral reflectance images on the seafloor. Other more sophisticated techniques are possible. Unfortunately, there is no accepted paradigm for the presentation, evaluation, or comparison of data fusion techniques as applied to environmental applicatons. This problem arises from the fact that most efforts to develop a data fusion paradigm have arisen within military contexts. In this project, we will develop and utilize a data fusion paradigm (based on the SIT data fusion model presented in the original proposal) which can be used to describe the functionality of data fusion algorithms within two contexts: the increasing abstraction of information from data; and the increasing abstraction of spatial data from discrete measurements towards spatial objects. We will then develop new data fusion algorithms for higher-level fusion which work at higher levels in both the information and spatial contexts. Dr. J.Y. Park and Dr. Grady Tuell from Optech International will lead this work.

Previous data fusion efforts for SHOALS-1000-TH data have been applied only to the submarine case. In this project, we will extend existing and new data fusion concepts onto the beach by combining topographic lidar data with passive spectral data. This work will lead to fusion-based land cover mapping and change detection, and automated shoreline extraction and characterization. This work will be performed by Dr. George Raber at the University of Southern Mississippi, in close collaboration with Dr. J.Y. Park at Optech International.

WORK COMPLETED

No work was accomplished in FY05. The project was awarded on September 30, 2005. Work began in October, 2005.

RESULTS

No results were produced in FY05 due to late award of the project.

IMPACT AND APPLICATIONS

National Security

This project has the potential to produce changes in how shallow waters and the coastal environment are mapped and monitored. One possible spin-off is that the active/passive data fusion approach will prove to be an effective way to find small objects on the beach and in shallow water.

Economic Development

This project will develop new tools for the commercial application of airborne remote sensing for mapping and monitoring the littoral zone. Also, the collaboration between industry and academia will facilitate development of a workforce educated in the use of these technologies. Together, these two impacts should improve the utility of this approach and increase the demand for active/passive systems.

Quality of Life

Data fusion techniques developed in this NOPP project will be of immediate value to the U.S. Army Corps of Engineers and NOAA for the regional-scale mapping and monitoring of coastal ecosystems. Ultimately, algorithms for airborne data will be improved through the use of *in situ* data. This work will also lead to the development of new algorithms for the mapping and monitoring of spatial distributions of water column constituents, and the development of a commercial capability for this purpose.

Science Education and Communication

At present, no university in the world has a program of instruction which covers bathymetric lidar in detail. This NOPP partnership strengthens the commitment made by Optech International to assist USM in developing this capability, and USM's commitment to become an academic leader in this area. Aspects of this work will be integrated into the curricula for the graduate Marine and Hydrographic programs at USM, and will be the focus of work for one or more graduate students. This, in turn, will lead to the presentation of these results at conferences and the publication of peer-reviewed papers.

TRANSITIONS

Quality of Life

As part of JALBTCX, the U.S. Army Corps of Engineers and NOAA presently operate an airborne system capable of simultaneously measuring airborne active and passive data. The algorithms and software developed in this NOPP project will improve their ability to combine, process, and analyze these data for regional-scale coastal mapping applications.

Science Education and Communication

The data fusion paradigm developed in this partnership, and the datasets generated, will be available to all interested researchers. Because data fusion is an active area of research at many universities, we expect these data to be used in a number of graduate theses and other research projects.

RELATED PROJECTS

Subsequent to the award of this NOPP project, Optech International received a contract from the U.S. Office of Naval Research (ONR) to use bathymetric lidar combined with passive spectral data for seafloor classification as it relates to the detection of mines. This project is named: Counter-mine Lidar UAV-based System (CLUBS). The two projects are distinct, but have some commonality. For example, the data fusion paradigm developed in the NOPP project will be used to formulate, present, and quantify the work in CLUBS. A number of personnel at Optech will work on both projects. Also, USM will serve as a sub-contractor to Optech International on CLUBS.