APPLICATION OF BATHYMETRIC LIDAR DATA TO NOAA NAUTICAL CHARTS

Abstract

NOAA is responsible for providing hydrographic survey data to support safe navigation in the U.S. Exclusive Economic Zone (EEZ). The EEZ comprises 3.4 million square nautical miles and extends 200 nautical miles offshore. NOAA's Office of Coast Survey's (OCS) objective is to, increase efficiency while maintaining the quality of data portrayed on NOAA nautical charts. To accomplish this NOAA's OCS continually looks for new and emerging technology capable of meeting this goal. OCS has been involved in testing of bathymetric lidar systems since the 1990s. These systems have demonstrated their ability to accurately acquire shallow water bathymetry and perform shoreline reconnaissance to International Hydrographic Organization standards. The success of these tests gave rise to NOAA's first bathymetric lidar contract in the fall of 2003. Over the past several years, efforts have been made to fully integrate bathymetric lidar into the hydrographic survey pipeline to support nautical charting. Lidar has demonstrated several advantages over traditional hydrographic survey techniques, particularly in complex near-shore areas. NOAA utilizes these advantages by providing lidar to field units and contractors surveying in near-shore areas to help increase efficiency with respect to bathymetry, feature identification, and reconnaissance. This allows NOAA to reduce the time its field units and contractors spend operating in potentially hazardous coastal environments. In addition, collaboration within NOAA has expanded the uses of lidar to support other program missions, such as tsunami inundation mapping and benthic habitat characterization.

The process of implementing lidar for hydrographic surveys, from planning and acquisition, to review, dissemination, and application to the nautical chart has evolved significantly over the past several years. For example, lidar deliverables are in the process of being standardized in order to provide the field units with a clear and concise data package. Each new project is analyzed and changes are adopted to create a valuable tool to support the Nautical Charting program. These efforts have increased the efficiency of ship based operations that use lidar to provide the near-shore data which is often difficult to obtain using traditional hydrographic multibeam surveys. In addition to data collected through the existing contracts, lidar acquired from other contractors and government agencies has been reviewed and applied to NOAA nautical charts.

Over the last three years, NOAA has contracted a series of near-shore hydrographic surveys using bathymetric lidar as traditional methods of surveying in shallow waters are time-intensive, less complete and are frequently a dangerous undertaking for survey vessels and crew Conventional hydrography is much more efficient in open water, where less maneuvering is required and the water is deeper. OCS has also worked to increase collaboration with other NOAA offices, academia, government agencies, and private industry involved in the use of this technology to better understand the potential

applications and make more efficient use of existing systems. Through analysis of individual case studies NOAA's integration of lidar into its existing hydrographic survey pipeline continues to evolve.

The projects which have focused on the use of bathymetric lidar for nautical charting applications have met with varying degrees of success. One challenge has been the impact of environmental variability on lidar data. There is now a better understanding of the conditions that contribute to the success of a survey and NOAA has become increasingly proficient in determining when and where this technology may be applied. Additionally, NOAA is improving data delivery methods to increase efficiency of data processing, review, and use by NOAA vessels. In the future, NOAA plans to begin a comparative analysis to more accurately determine lidar's capabilities. From these results NOAA expects to establish new standards that will serve a broader range of applications.

Background

In 2003, NOAA awarded its first Lidar Hydrographic Surveying Services and Related Support Services Contract to support NOAA's nautical charting program. The contract was awarded to Tenix LADS, Inc. Within the life of this contract nine task orders were identified and assigned to perform surveys in Alaska, Connecticut, Oregon, and Puerto Rico.

A significant component of the contract was the requirement to produce a bathymetric lidar survey to meet IHO accuracy standards. In addition, the lidar survey had to function as a stand-alone survey with all the requirements of a traditional hydrographic survey. In doing so, the lidar surveys could then be combined with traditional hydrographic surveys to update the NOAA suite of nautical charts.

Data from other contractors and government agencies has been made available to NOAA to apply to nautical charts. NOAA has acquired lidar data through coordination with Joint Airborne Lidar Technical Center of Expertise (JABLTCX) and Fugro Pelagos, Inc.

Project Selection and Planning

There are multiple environmental factors that may affect the success of a lidar project: water clarity, sea surface conditions, weather, and terrain. During the planning process collecting as much information as possible and evaluating the project area in detail before survey operations commence increases the likelihood of success. OCS determines the most beneficial area to use lidar by analyzing data acquired over the past several years.

OCS Hydrographic Survey Projects (Case Studies):

In a three-year period, from 2004 to 2006, a wide range of data was collected from Puerto Rico to Alaska. On average, NOAA conducts between two to three lidar projects per year, in coordination with NOAA field parties or other NOAA funded projects. During that time period, 11 projects were assigned under the lidar contract (nine in Alaska, one

on the East Coast, one in Puerto Rico and one in the Pacific Northwest). As this was NOAA's first contract requiring lidar to serve as a registered surveys for nautical charts, many of these projects where used as test cases to refine the integration of lidar into the charting process. This paper will review some of the challenges and benefits of these projects and discuss what was learned and carried forward for future work.

Integrating Lidar into the Hydrographic Data Pipeline

The process of integrating lidar bathymetry and associated feature information into the hydrographic survey pipeline, from acceptance and review at NOAA's processing centers, to the field units, and eventually onto the nautical chart has been a complex challenge, which has evolved considerably over the past several years. Lidar is only one of multiple outside sources of data (i.e. prior surveys, nautical charts, photogrammetry, satellite imagery and digital shoreline) used to compile and create a survey. Integrating new sources of data into an established pipeline is often difficult without clear guidance to the user. Upon delivery of the first of lidar surveys questions were raised from NOAA field parties regarding establishing multibeam sonar junction points, standardization of file formats, and receiving specific guidance dealing with areas of sparse coverage.

In order to move forward, NOAA needed to develop a better understanding of the problem of integrating this new data and to address some of these issues. During the 2005/2006 field season a series of site visits were arranged between NOAA personnel and the lidar contractors at Tenix LADS, Inc. NOAA personnel were given the opportunity to speak with Tenix hydrogaphers, received tours of their lidar platform (de Havilland Dash-8 aircraft), and were given an opportunity to oversee on-site processing techniques. Hydrographers from Tenix LADS, Inc. accompanied NOAA Ships RAINIER and FAIRWEATHER to observe during lidar junction operations. In addition, contractors visited both NOAA's Atlantic and Pacific Hydrographic Centers to better understand the data submission and review process. The end result was a better understanding of the issues and increased discussions over possible solutions.

Conclusion

NOAA's use of bathymetric lidar has evolved considerably over the past several years. Increased knowledge that follows each new project has improved NOAA's understanding of the capabilities and limitations of lidar systems. OCS's objective is to establish lidar's role as an effective survey tool as well as improve its integration into NOAA's hydrographic surveying pipeline.