REGIONAL SEDIMENT MANAGEMENT USING HIGH DENSITY LIDAR DATA

Larry E. Parson[1], W. Jeff Lillycrop[2], Jennifer K. McClung[3]

Abstract: Assessing the performance of coastal projects requires determining how all the elements interact to define the behavior of the entire system. Recent technologies such as airborne lidar provides the ability to collect coastal survey data on a regional level, demonstrating a systems approach to sediment management in the coastal region. Since becoming available, airborne lidar (SHOALS) has performed numerous coastal surveys which demonstrates the concept of this new technology towards regionalized sediment management. Recognizing the need for regional sediment management, the State of Florida and U.S. Army Corps of Engineers have embarked on adopting a systems approach toward sediment management. The objective of this paper is to describe the airborne lidar capabilities and identify the concept of using this technology towards coastal project sediment management on a regional scale.

INTRODUCTION

Coastal projects are dynamic features in terms of littoral processes and play a major role in the variability and impacts on adjacent shorelines. All coastal projects are composed of several elements, i.e. navigation channel, structures, shorelines, tidal shoals, harbor areas, and longshore features and part of a functional system on both local and regional scales Each project and its elements contribute to the overall behavior of the entire system. Assessing the performance of a coastal project requires determining how all the elements interact to define the behavior of the system. Costly management

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1) Assistant Director, Joint Airborne Lidar Bathymetry Technical Center of Expertise, U.S. Army Engineer District, Mobile, 109 St. Joseph Street, Mobile, AL 36628 USA. larry.e.parson@sam.usace.army.mil

2) Director, Mobile, Joint Airborne Lidar Bathymetry Technical Center of Expertise, U.S. Army Engineer District, 109 St. Joseph Street, Mobile, AL 36628 USA. Jeff.lillycrop@sam.usace.army.mil

3) Joint Airborne Lidar Bathymetry Technical Center of Expertise, U.S. Army Engineer District, Mobile, jennifer.k.mcclung@sam.usace.army.mil

decisions for such projects are often based upon sparse data collected for one, or possibly two, elements without knowledge of how those elements are affecting the overall system. When evaluating the condition and performance of any project, it is important to understand the morphology and processes interacting with the entire system on both a local and regional scale. Such information is critical to aid in the design and maintenance of channels and structures, assessment of impacts on adjacent shorelines, and to provide a sediment budget and management for coastal projects. Irish and Lillycrop (1997) emphasized the establishment of a sediment budget as one of the most important tools that coastal engineers use to understand and provide sediment management for coastal projects. Dally (1993) has identified a need for technologies capable of collecting comprehensive survey data including both bathymetry and topography for the establishment of accurate sediment budgets.

Bathymetric surveying is one of the most widely used techniques for monitoring and predicting the behavior of coastal projects and investigating their effects on the coastal zone. However, bathymetric surveys alone do not provide the comprehensive and detailed information necessary to provide an understanding of processes occurring throughout an entire project (Parson and Lillycrop, 1993). Also, conventional bathymetry is not typically collected on a scale that would contribute to the overall understanding of the regional effects of coastal projects. Processes that effect coastal areas above the water is highly dependent on the nature of the adjacent bathymetry. Using topographic data without the associated bathymetry, would give only a partial picture of the pocesses at work for any given area. Collecting both topographic and bathymetric information is necessary for effective project management.

In the pursuit of new technologies to augment existing hydrographic surveying capabilities, the U.S. Army Corps of Engineers (USACE) began a cost-shared project in 1988 with the Canadian government under the U.S./Canadian Defense Development Sharing Program for design, construction, and field verification of the Scanning Hydrographic Operational Airborne Lidar Survey (SHOALS) system. The term “lidar” stands for <u>LI</u>ght <u>D</u>etection <u>A</u>nd <u>R</u>anging. The USACE accepted the SHOALS system in March 1994 following field testing which indicated that the system met or exceeded all design and operational specifications. Since then, SHOALS has surveyed over 250 projects (a/o Mar 1998). Applications range from navigation projects and beach monitoring, to coastal structure evaluation, to emergency response operations.

Today, this technology provides comprehensive high density survey data, both bathymetric and topographic, required for accurate evaluations for an entire project area. The speed and coverage provided by an airborne system such as SHOALS result in survey capabilities never before available. Such information is being used as valuable input towards advanced data analysis and interpretation for coastal projects throughout the Corps of Engineers as well as other Federal and local agencies (Irish and Lillycrop, 1997 and Morang, Irish, and Pope, 1996). Sediment management performance and dredging needs can be determined using high density lidar data resulting in reduced manpower, time, and resource requirements in a more standardized and objective manner.

The improved information and analysis support decision making processes and assist managers in preparing maintenance plans, budgets, and schedules.

SHOALS SYSTEM OVERVIEW

SHOALS is a fully-operational bathymetric and beach survey system capable of surveying a variety of project types. SHOALS operates from the Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX), which is headquartered at the U.S. Army Engineer District (USAED), Mobile. The JALBTCX's mission is to operate the SHOALS system and to develop new products and applications. Additional goals for the JALBTCX include expansion of mapping and charting capabilities and the fusion of lidar bathymetry with auxiliary sensors such as muti-spectral imagery and Synthetic Aperture Radar (SAR).

SHOALS consists of an airborne data collection system and a ground-based data processing system. The system operates by emitting laser pulses 400 times per second while being scanned in a 180^o arc pattern across the flight path of the airborne platform, which is a Twin Otter DeHaviland DHC-6 (Figure 1). Each laser pulse travels from the airborne transmitter to the water where some light energy is reflected and detected by onboard optical sensors. The remaining light passes through the water column, reflects from the sea bottom, and returns to the optical sensors (Guenther, Thomas, and LaRocque, 1996). The time difference between the water-surface and sea-bottom returns indicates the water depth. Operating from an airborne platform at an altitude of 300 to 500-m and at speeds up to 70-m/s provides measurements on a 4 to 8-m horizontal grid, covering up to 35-km^2 per hour. Sounding densities can be adjusted by flying higher or lower, at different speeds, or by selecting different scan widths. Figure 2 shows the airborne data collection equipment installed in the fuselage of the Twin Otter.

Survey Products

SHOALS produces high density measurements that can be used for creating three dimensional digital elevation models from which navigation and shore protection projects can be monitored and managed. This is a unique product that allows the USACE engineers to manage sediment on a regional scale rather than individual components of a project. Standard products include: a) metadata file for compliance with the National Geospacial Data Regulations, b) plan view engineering drawings of an entire survey project, c) information and references pertaining to the SHOALS system, d) digital survey data files on CDROM composed of ASCII XYZ files, and e) geo-referenced color video of the surveyed sites.

Performance Specifications and Accuracy

Accuracy and data quality meet or exceed USACE Class 1 and International Hydrographic Organization (IHO) Order 1 standards. Through independent testing both the National Oceanographic Service (NOS) (Riley, 1995) and U.S. Navy have verified that SHOALS meets the IHO accuracy standards for nautical charting; the IHO being the organization that sets these standards. Canada, Sweden, Australia and private industry have similar airborne lidar systems that are being used for nautical charting surveys. In addition, the USACE has conducted extensive field tests to determine that SHOALS meets its Class I accuracy requirements, which are more stringent than the charting standards (Lillycrop, Parson, and Irish, 1996). The performance characteristics and accuracy specifications are listed in Table 1.

In response to USACE increased needs to map beaches, dunes, and above-water structures, SHOALS was enhanced with the capability to utilize kinematic GPS (KGPS). Since the need to use water surface as a vertical reference is eliminated, KGPS allows more extensive measurements of beaches and dunes. With the ability to collect both bathymetric and topographic (above water) survey data, SHOALS can simultaneously conduct complete navigation and shore protection project surveys.