CHARTS: AN EVOLUTION IN AIRBORNE LIDAR HYDROGRAPHY

James B. Heslin, W. Jeff Lillycrop, US Army Corp of Engineers District-Mobile
R. W. Pope, Naval Oceanographic Office
Joint Airborne Lidar Bathymetry Technical Center of Expertise

ABSTRACT

The Navy's first operational airborne lidar hydrography system, the Compact Hydrographic Airborne Rapid Total Survey (CHARTS) system will be field-tested during summer 2003. The US Navy through the Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX) awarded a contract for development of CHARTS through Technology Partnerships Canada to Optech, Inc., of Toronto, Ontario. This latest evolution of airborne lidar hydrography systems, CHARTS, is focused on fusing multiple sensors into one synergistic remote sensing system to better characterize coastal dynamics and update shallow water charts. The sensors that are being fused are a hydrographic laser system, topographic laser system and digital camera, with a future option being a hyperspectral imager.

THE CHARTS SYSTEM

The CHARTS system, being built by Optech Inc., demonstrates an evolution in airborne lidar hydrography based on the experiences gained from over nine years of operation of the US Army Corps of Engineers' Scanning Hydrographic Operational Airborne Lidar Survey (SHOALS) system. The CHARTS system is the integration of three major sensors, a 1,000-Hz hydrographic lidar, a 10,000-Hz topographic lidar, and a 1-Hz digital camera integrated into a compact airborne package, shown in Figure 1. Each component provides a piece of information needed to efficiently map the coastal zone, though historically these sensors have most often been flown on separate platforms, and most often at different times. The specifications of the CHARTS system major components are listed in Table 1.

Figure 1. Layout of CHARTS system airborne components.

Parameter	CHARTS Requirements
Depth Measurement	To 50 meters
Maximum depth	Kd>3.0 (daytime)
Minimum depth	To as shallow as 0.1 meter
Operational Altitude	Hydro: 200 m < alt < 400 m Topo: 300 m < alt < 700 m (10kHz)
Aircraft Speed	125 to 175 knots (nominal)
Laser spot spacing	2x2, 3x3, 4x4, 5x5 meters
Scan swath width	70% of the altitude
Vertical accuracy of Soundings & Elevations	IHO Order 1
Horizontal positional accuracy of Soundings & Elevations	IHO Order 1
Laser Operation	Hydrographic >1,000 Hz (nominal) Topographic >10,000 Hz (nominal)
Post Processing and Validation	Depths – 1.0:1.0 (processing:collection) Hazards and obstacles – 1.0:1.0

Table 1. CHARTS System specifications.

While the improvements in the data collection hardware are the most easily quantified, evolutions have taken place in all aspects of the CHARTS system, including the processing and survey management software. Special considerations were given to the real-time and post-processing algorithms, survey planning software, and a seamless data flow in the data processing software. A major feature of CHARTS is the utilization and automation of the existing SHOALS depth extraction algorithms needed to speed post-processing, enhance depth coverage, and minimize the need to manually analyze laser waveforms. An improvement in the CHARTS system is the incorporation of an improved algorithm to consistently discriminate between land and water returns in the presence of whitewater (Sosebee 2001). Survey-planning software will better characterize and monitor the full extent of survey flights to provide a more detailed report of survey. This will be achieved with an enhanced survey planning function and its added capability to estimate survey times and conduct mission optimizations by altering flight parameters such as swath width, flight speed and spot spacing. Once data are collected, the CHARTS system will have an integrated data processing flow from removal of the data from the hard drive computer disks or stripping airborne data, to auto-processing of lidar waveforms and topographic elevations and image cataloging, to 3-D editing and hazard investigations. The status of all flightlines and collected data will be tracked by data management software to provide detailed data management and accountability reports. These evolutions are necessary to keep the processing to collection ratio at less than 1:1 while reducing the operational field personnel requirements to a minimum.

The CHARTS design benefits greatly from Optech's knowledge of topographic lidar systems. The CHARTS' 10,000-Hz topographic lidar system will provide an output of latitude, longitude, elevation and intensity for the first and last lidar returns. This will provide elevations of both vegetation and bare earth. With ever-improving 3rd party classifications software CHARTS will provide comprehensive surveys of the coastal zone, both below and above water.

The digital imagery capability of the CHARTS system greatly expands the down-looking analog video capability of the SHOALS system. The digital imagery collected during a survey will be tagged with a GPS timestamp with the end result being a geographic position. This will provide a visual record of environmental conditions at the time of survey for later use in identifying coastal features or anomalous returns. The digital imagery has =20-cm on-ground resolution and is a value-added georeferenced imagery product that accompanies the lidar bathymetric and topographic data. When mosaiced, the imagery will provide a base map of conditions during a survey and can easily be incorporated into applications such as GIS, shown in figure 2.

Figure 2. Imagery with topographic and hydrographic lidar survey of the coastal zone.

ADDITIONAL SENSORS

The international requirements and direction of airborne coastal mapping and charting is discussed in Lillycrop et al 2000, which expresses the need to incorporate other airborne sensors to better quantify the coastal zone. Hyperspectral imagery was identified at the 2nd & 3rd Airborne Hydrography Workshops (sponsored by the JALBTCX) as a complement to SHOALS data for quantification of water column properties, such as sediment concentration, as well as improved navigation hazard identifications. Merging SHOALS data with hyperspectral imagery has provided such valuable information as bottom typing in Sarasota Bay and offshore of Key Biscayne in Florida (Wozencraft et al. 2002). More recent research focused on using hyperspectral imagery with SHOALS data to aid in accurate delineation of the land/water interface (Tuell and Lee 2001). Current research supported by the JALBTCX includes the fusion of hyperspectral imagery with SHOALS and topographic lidar return intensities, in preparation for the integration of a hyperspectral imager with the other sensors of the CHARTS system, which is scheduled for summer 2003.

CONCLUSION

The development of CHARTS is an evolutionary advancement in airborne coastal mapping and charting. The integration of bathymetric and topographic lidar with digital georeferenced imagery capability in the CHARTS system will provide a full description of the coastline and upland topography, near shore water depths, and any hazards to navigation in a survey area, shown in figure 2. Increased operating speed will allow a homogenous union with other remote sensing systems like the hyper spectral scanners, thus providing a cost effective capability for comprehensive coastal mapping and charting.

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