UNMANNED AERIAL SYSTEM LIDAR SURVEY OF TWO BREAKWATERS IN THE HAWAIIAN ISLANDS

Jessica H. Podoski, P.E., USACE Honolulu District, jessica.h.podoski@usace.army.mil
Thomas D. Smith, P.E., USACE Honolulu District, thomas.d.smith@usace.army.mil
David C. Finnegan, Ph.D., USACE Cold Regions Research and Engineering Laboratory, david.finnegan@usace.army.mil
Adam L. LeWinter, Ph. D., USACE Cold Regions Research and Engineering Laboratory, adam.l.lewinter@usace.army.mil
Peter J. Gadomski, Ph. D., USACE Cold Regions Research and Engineering Laboratory, peter.j.gadomski@usace.army.mil

INTRODUCTION

The U.S. Army Corps of Engineers (USACE), Honolulu District (POH) is responsible for the operation and maintenance of 26 navigation projects within the State of Hawaii and the U.S. Pacific territories. The majority of these deep-draft and small-boat harbors include breakwaters that are consistently exposed to a substantial and varied Pacific Ocean wave climate, requiring POH to maintain a rigorous structure condition inspection program to ensure safe and efficient operations at all of its navigation projects. As part of its constant efforts to improve the quality and efficiency of this inspection program, POH has joined with the USACE Cold Regions Research and Engineering Laboratory (CRREL) Remote Sensing and GIS Center of Expertise to utilize an Unmanned LiDAR Scanning (ULS) system to collect LiDAR (Light Detection and Ranging) spatial data and coregistered imagery of breakwaters at Hilo Deep Draft Harbor on the island of Hawaii, and Kaumalapau Deep Draft Harbor on the island of Lanai.

BACKGROUND

Hilo Deep Draft Harbor is located on the northeast coast of the island of Hawaii and serves as one of the two main commercial ports for the island. The breakwater is an approximately 10,080 ft-long (3.1 km) structure constructed in 1924 to provide protection and access to a 35-foot (10.7-m) deep navigation channel. It is primarily a rubble-mound structure, with an approximately 900-foot (274-m) section composed of tribar concrete armor units. The length of the structure, as well as its regular exposure to open ocean swell, has made previous efforts to quantify the structure's condition by visual and non-contact methods (such as marine-based multibeam and LiDAR surveys) challenging.

Kaumalapau Deep Draft Harbor is a naturally deep port on the southwest coast of the island of Lanai, protected by a 220 ft-long (67-m) breakwater constructed in 2006. The harbor serves as the only source of deep draft access for the small island and its residents. The breakwater was constructed of 35-ton Core-Loc armor units, due to its deep water foundation and potential exposure to hurricane generated waves (Figure 1). Inspection of this structure is also challenging due to the large size of the armor units and the difficulty in tracking movement of armor units by visual methods. Post-construction monitoring of the structure was successfully completed using terrestrial LiDAR scanning (TLS) and has been documented in Podoski, et al. (2010). These previous TLS collections will be compared to ULS-derived data to determine improvements to coverage and quantify changes to the subaerial breakwater in the years following construction.

OBJECTIVES

This presentation seeks to document the results of coastal structure inspection and monitoring utilizing a ULS as an alternate method for acquiring high-resolution LiDAR terrain data and coincident RGB imagery. The different features of each breakwater (length and armor layer material) will enable a thorough evaluation of the applicability of this system for this purpose. Survey of the Hilo Harbor breakwater will test the range of the system and its ability to operate in a marine environment. The Kaumalapau Harbor breakwater survey will allow evaluation of the system's accuracy and coverage on a highly reflective and irregular structure surface.

Figure 1 – Kaumalapau Harbor Breakwater, Lanai, Hawaii

APPROACH

This effort will utilize a Riegl RiCopter ULS system that is capable of acquiring high-resolution 3-D topography of the above water portions of each breakwater. Maximum operating range from a single location with the RiCopter is a 3280 ft (1Km) radius, which is sufficient to ensure multiple passes of each breakwater. The ULS system includes: Riegl VUX-1UAV laser scanner, Applanix AP20 IMU, Sony Alpha 6000 digital camera (x2), UAV platform, and flight planning and data acquisition software.

The resulting high-resolution point-clouds will have an average point density of 580 points/m^2, with an estimated accuracy of 2cm. The ability of the ULS system to make multiple overlapping flight lines at varying headings will result in a more complete representation of the breakwaters compared to previous TLS surveys limited by static scan positions and line-of-sight obstructions. This will result in a ULS dataset that has more complete coverage than the TLS collection, with comparable point density and accuracy.

REFERENCES

Podoski, et al., (2010): Post-Construction Monitoring of a Core-Loc Breakwater Using Tripod-Based LiDAR, Coasts, Marine Structures and Breakwaters, Thomas Telford, vol. 2, pp. 448-459.