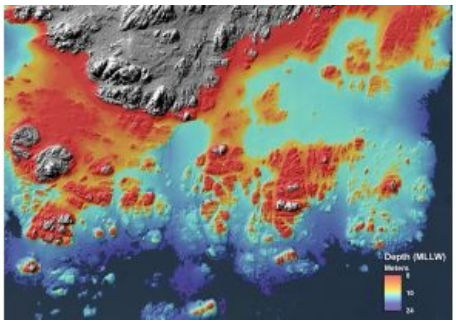
NV5 MAPS CHALLENGING ALASKAN COASTAL ZONE FOR NOAA USING LEICA GEOSYSTEMSÂ€™ AIRBORNE BATHYMETRIC & TOPOGRAPHIC LIDAR SYSTEM

Lidar technology shines along the Alaska coastline



The National Oceanic and Atmospheric Administration (NOAA) contracted NV5 Geospatial to define the shoreline in an extremely complex area of south-east Alaska as part of the NGS Coastal Mapping Program. The shoreline mapping required NV5 to collect subsurface bathymetric measurements as well as nearshore elevation data. NV5 deployed its integrated airborne Leica Chiroptera 4X and Leica HawkEye 4X Lidar sensors from Leica Geosystems, part of Hexagon, to capture the onshore topographic and shallow-water bathymetric datasets. Despite Alaska's famously turbid water and poor flying conditions, the project successfully captured seafloor details to depths of 16 to 20 metres.

The Alaska Coastal Mapping Initiative is driven by the 2019 Presidential Memorandum on Ocean Mapping of the US Exclusive Economic Zone and the Shoreline and Nearshore of Alaska. The long-term goal is to create a seamless coastal map of the state by 2030, with a focus on the connection between the inland terrain and the offshore subsurface environment. The programme places an emphasis on the use of bathymetric Lidar technology.

The Alaska coastline has been poorly mapped due to the local conditions, including frequent rain and cloud cover, dramatic tidal swings and turbid waters caused by dynamic wave action. The advantages of accurately mapping the shoreline are many – safer ship navigation, more efficient coastal resource management, better modelling of storm surges and coastal flooding, and improved benthic habitat stewardship. The airborne data collection would immediately impact the coastal mapping project, as the nearshore bathymetric measurements would be supplied to the sonar-equipped vessels also taking part in the survey initiative to keep them operating in deeper waters. "NOAA is trying to get very accurate and precise data to promote the safety of all the vessels working in these complicated environments," said Andres Vargas, technical expert at NV5 Geospatial.

The selection of NV5 to map one of the most challenging parts of the state was a natural one, since the firm based in Corvallis, Oregano is an experienced user of Leica Geosystems' airborne topographic and bathymetric Lidar sensors, which are capable of acquiring onshore terrain and offshore water depth data simultaneously – representing a significant time saving in environments where suitable flying conditions are limited.

NOAA assigned NV5 two project areas, including about 630 miles of rugged shoreline in the Revillagigedo Channel near Ketchikan, Alaska, totalling 350 square miles in an extreme fjord-filled landscape.

Topobathymetric Lidar point cloud coloured by RGB imagery on land and depth underwater.

Project specifications called for capturing the aerial bathymetric Lidar points with a minimum density of three points per square metre (ppm) within two hours of low tide. Also requested to precisely delineate the land-water boundary was 25-centimetre four-band multispectral optical imagery at low tide within 30 days of Lidar operations. The target acquisition window was between May and October

2021.

NV5 deployed its Leica Chiroptera 4X and HawkEye 4X integrated Lidar system to Alaska aboard a Cessna Caravan. The Chiroptera 4X is a dual laser, designed specifically for simultaneous collection of high-resolution terrestrial elevation and shallow-water bathymetric points. The bathymetric laser operates in the visible green portion of the spectrum, which penetrates the water column to a nominal depth of 30 metres with 0.15-centimetre vertical accuracy at a five ppm density in clear waters and during ideal surveying conditions. The near-infrared topographic laser has a typical vertical accuracy of 15 centimetres.

While the Chiroptera 4X is a stand-alone system, Leica Geosystems designed the HawkEye 4X module as a companion device to collect deeper bathymetric data when integrated with the Chiroptera. The complementary HawkEye typically adds 40–50% depth penetration, with an accuracy exceeding IHO Order 1. Integration of the sensors enabled NV5 to acquire onshore, shallow-water and deeper-water data in a single flight – maximizing the handful of good flying days available.

Leica Chiroptera 4X & Leica HawkEye 4X.

Leica LiDAR Survey Studio

Capturing data in extreme conditions

In preparing for deployment, NV5 knew the harsh conditions in Alaska would be a challenge that required special procedures. Most notable were the low-lying clouds that limited flight operations and nearly relentless winds that kept the waters dynamic and turbid. Another issue was the dramatic terrain of the fjord landscape, which sees the shoreline in many places rising several hundred feet vertically out of the water.

Finding flat ground for the placement of survey control markers was difficult in the rugged topography covered by dense vegetation in many areas. The team surveyed 164 points, including the mooring of buoys in the water. These buoys not only served as control points but also monitored water clarity and relayed these measurements to the NV5 team. This information proved critical in deciding daily where water conditions were suitable for airborne Lidar operations.

Windy weather created choppy waters, which increased turbidity, and the flight planners quickly noticed patterns in the wind-turbidity conditions. Winds from certain directions roiled the water more severely than from others. In fact, the wind direction was nearly as important as wind speed in reducing water clarity. Meteorological predictions helped give the crews an edge in planning the next day's flights based on expected wind conditions.

An unexpected challenge that required an on-site modification of airborne operations was related to the extreme terrain and cloudiness. NOAA specified the collection of ground elevation measurements for a half mile inland from the shore. Unfortunately, in that half-mile distance, the fjord walls rose so precipitously that flights over the land would have to be conducted at a much higher altitude than over the water. "With flights already limited by clouds, we decided to operate the Chiroptera/HawkEye system only over the water in some areas to focus on acquisition of bathymetric data," said Vargas.

Even in steep fjords, the oblique scanning angle of the Chiroptera terrestrial laser successfully captured the shoreline, which was critical to the mapping project. But for surveying farther inland, NV5 brought a second aircraft on-site with a dedicated terrestrial Lidar to capture the additional data at the higher altitude – when weather allowed.

Hill shade model of the topobathymetric Lidar-generated DEM, coloured by depth to highlight areas shallower than 10 metres. Submerged rocks and a steeply rising coastline make this area dangerous and difficult to map with survey vessels.

Conclusion

Once the flight operations were completed, NV5 delivered the data to its Oregon headquarters for processing. The Leica Lidar Survey Studio software was used to extract and correct the elevation points for each flight line. NV5 then ran the data through a custom workflow to generate the point clouds and normalize the Chiroptera and HawkEye data sets for integration.

A key aspect of this process was finding relatively flat seafloor surfaces in the overlap area between the Chiroptera shallow data and the deeper HawkEye measurements. Technicians used this as the cut line where the two point clouds were merged to create a seamless bathymetric data set from the shoreline down to a maximum of about 20 metres in depth, where the Lidar penetration ended.

This bathymetric 'extinction line' at 20 metres depth was critical to the next and ongoing phases of the Alaska Coastal Mapping Initiative,

explained Vargas: “Thanks to the highly accurate bathymetric and topographic Lidar data, NOAA will be able to carry on with the collection of multibeam sonar [aboard vessels] in a safe manner,” he said. “This was a very successful collection where the sensors performed admirably and characterized many complexities in the channel.”
