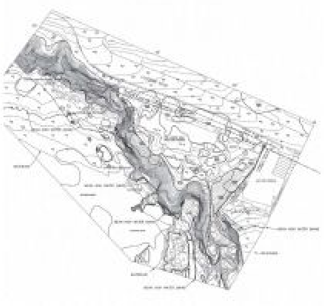
Full Frontal Mapping in 3D



Cliff surveys are traditionally performed with fixed-wing aircraft that collect nadir photos. However, one particular California bluff required the cliff's face to be surveyed for an erosion study. A photogrammetry company used the opportunity to test the viability of accurately triangulating oblique images and mapping them in 3D stereo. The company not only met tight data specifications, but also developed a new technique for cliff-face surveys.

Photogrammetry specialist Robert Lafica and his company, Central Coast Aerial Mapping, have been producing detailed 3D stereo-based topographic maps, orthophotos and orthomosaics and surface models since 1977. Although he has performed many traditional cliff surveys, he had never tried oblique image mapping.

“With oblique images, the land that’s closer to the camera is quite clear but it’s less clear the further away it is,” said Lafica. “I wasn’t sure if our photogrammetry software could calculate those odd angles to properly triangulate. And without precise triangulation, I couldn’t accurately map or mosaic the cliff.”

The unique project targeted a 12m-high bluff with a sweeping residence perched on top, located along Pacific Coast Highway 1 about 20 kilometres northwest of San Luis Obispo.

Lafica needed to produce a 0.5-inch (1.27cm) orthomosaic of the entire area of interest (AOI), a 1.2-in (3.04cm) 3D topographic contour map of the cliff face and top-of-bluff surface, and a vector-based digital terrain model (DTM) accurate to 1.2in. The topographic map needed to have 1-ft (30.4cm) contours and also clearly show the mean high water (MHW) line, which delineates private and public foreshore boundaries.

From All Angles

Lafica and a survey colleague, Paul Reichardt, surveyed the site, timing their arrival with the lowest tide window. Reichardt set out six ground control point (GCP) targets around the property and along the beach and then used his Trimble R8 GNSS receiver to measure their positions to within 0.04ft (1.22cm) accuracy. They also established four photo ID points around the AOI for quality control for the photo triangulation process.

Lafica flew the UAS and collected 158 nadir and oblique photos at an average ground sample distance of 0.5in. To capture the cliff side, he flew the UAS with the camera angled at 40 degrees. In parallel with the aerial survey, Reichardt used the Trimble R8 and 5600 total station to collect property corners and some top-of-surface elevations to integrate into the 3D topographic map.

The side view of the property perched precariously on top of the bluff.

New Technique

Back in the office, Lafica processed the nadir and oblique image sets separately to tie photos together and orientate the project.

Lafica loaded the 127 nadir photos, the UAS GNSS data and the GCP positions into Trimble’s Inpho UASMaster photogrammetric software to automatically triangulate the images. It processed the images in batches and automatically matched images to each other. After the initial triangulation, Lafica attached precise coordinates to each control point target in the image. With that additional georeferencing, UASMaster then connected all the imagery to the ground control and set the images in the correct positional accuracy for orthorectifying and mapping.

Lafica also created orthophotos and used Inpho’s OrthoVista module to mosaic the orthorectified images into a seamless orthomosaic of the entire AOI at a 2D accuracy of 1.2in. Lafica then repeated the same process with the 80 oblique images. UASMaster automatically deciphered the unique characteristics of off-nadir imaging and triangulated them in 45 minutes.

“One of the reasons we use UASMaster is because of its photogrammetric power,” said Lafica. “To accurately tie the oblique images together, the software needed to use different routines and algorithms to figure out puzzles like the camera lens distortion values. And it did. That was a level of smart I didn’t expect.”

About one week after the field survey, Lafica delivered the 3D topographic map, the orthomosaic and a vector-based DTM to the customer, definitively answering any questions around the uncertainty of mapping oblique UAS images in 3D.

The finished 3D topographic contour map of the site, including the mean high water line.