MacKay Sposito

Case Study: UAV Photogrammetry Aids SR 503 Repair Plan

In mid-March of 2017, the Washington State Department of Transportation (WSDOT) contacted MacKay Sposito about an emergency response UAV flight to respond to a landslide on SR 503 near Speelyai Recreation Road. The call came on a Tuesday evening and we were able to review flight restrictions, plan our flights and necessary ground survey control, and mobilize for the flight within 48-hours, as determined by weather conditions.

Issue

Both directions of SR 503 near Speelyai Recreation Road (milepost 33.6) west of the community of Cougar is closed due to a landslide of rock, trees, and debris, blocking travel across both sides of the roadway. Initial evaluations deemed that the slide was likely to continue to spread, halting travel through the area indefinitely.

Analysis of Alternatives

The unreliable state of the landslide made it inadvisable for traditional surveying methods to be used on the 200ft span of land, making UAV technology a smart choice to address the situation safely.

Recommended Solution

After reviewing WSDOT's needs, we determined that the flight along SR 503 was heavily vegetated with large stands of tall trees. This, along with the nature of the slide and steep slopes, required that we fly the project with our DGI Phantom Pro Plus quadcopter. The landslide was active, and access to the area was restricted due to safety concerns.

The goal was to develop high-definition photography and 4k video of the slide area so that WSDOT's geotechnical engineers could determine the nature of the slide and ongoing safety of the area. The goal was also to provide an accurate 3-dimensional model of the slide so that earthwork volumes could be developed and explosive charges planned (for addition slope removal).

Implementation

MacKay Sposito provided deliverables, which included a digital design (DGN), Digital Terrain Model (DTM), point cloud, and a georeferenced orthomosaic.

Licensed Pilot, Adam Wise, flew a DGI Phantom Pro Plus quadcopter to acquire 4K video and photos for 2D orthomosaic imagery and 3D point cloud data.

Project Manager, Cory Dopp, PLS, facilitated communication between WSDOT and our team. Additionally, he created a digital DGN, DTM, point cloud, and a georeferenced orthomosaic. Dopp verified accuracy between our collected survey points and the DTM and found it to be 0.1 ft accuracy on the roadway.

Party Chiefs, Gabe Emery, LSIT, and Rob Sumrall manually surveyed the areas to the east and west of the slide utilizing a 5 second Trimble S6 Robotic Total Station and Trimle R8 Dual Frequency Receivers. An independent Opus Static primary control point was established to control this survey. Secondary control was established using RTK GPS methods. The survey points gathered were used to help control our data for post-processing. The overlap of these two crews proved essential to the accuracy of the final deliverables.

Process

Our original plan encompassed a review of a 200 ft span, where the bulk of the landslide was currently active. Because of the nature of the landslide, and the possibility of additional damage, WSDOT asked that we complete a full 2,000 ft review of the road wall. This process took 5 hours to capture, with turnaround deliverables presented within 4 business days.

Close-up inspection of unstable area (photo)

Aerial targets (GCPs) are set at strategic locations along the flight path, which will control the project. These targets must be located with survey quality equipment. For this particular project a point was set in a random location and static data was collected for submittal to NGS OPUS to obtain a NAD83 (2011) coordinate. A Trimble R8 dual frequency receiver and a Trimble S6 robotic total station were used to establish survey grade coordinates on the aerial targets.

A total of 1,780 images were taken in order to generate the requested data, which was loaded into our processing software for initial analysis of coverage and overall quality. Since this project was flown on two separate days, the processing was split into east and west. The west side had an initial processing time of 3hrs 7m and the east side had initial processing time of 54m.

In the second stage of processing, 14 survey quality ground control points (GCPs) were identified within the individual photos and the project was reoptimized to place the flight in a geolocated position. After analyzing the GCP quality report for accuracy, we were able to process the point cloud and orthomosaic photo.

Point Cloud before vegetation removal

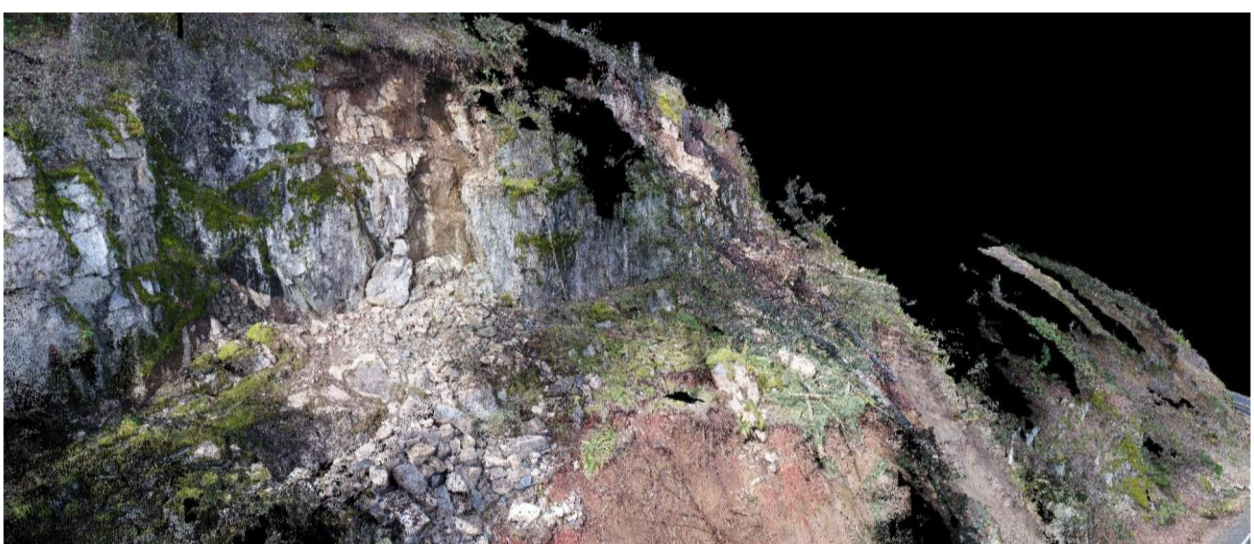
Point Cloud before vegetation removal

The point cloud processing took 3hrs 22m on the west side and 33m on the east; 30,618,838 3D densified points were generated on the west side and 9,007,801 on the east. Comparing the point cloud to conventional survey points (confidence points) the overall quality of the east side on the hard surface (road) was around 0.1ft. This confidence level exceeded some manufacture's stated accuracy level. The quality checks on the surrounding areas, including the slide area were within acceptable tolerances, typically 0.4ft. This is attributed to minimal control outside the roadway, which typically will cause the software to have a pull effect on the 3D point cloud data. The original point cloud was tiled into segments to allow for smaller file size.

The orthomosaic on the west side took 1hr 9m to process and the east 22m. The image of the main corridor was fairly clean and crisp. A few areas did have a blurred effect on the steep walls due to the photo angles in the processing. Along the edges of the orthomosaic, the quality is poor, which was expected. This is due to the close proximity of the photo to the tree canopy. The east and west orthomosaics were merged together and cropped to remove some of the undesirable effects. The final orthomosaic was tiled into segments to allow for smaller file size.

The East and West point clouds were merged together and prepared for vegetation removal. Due to the heavy vegetation and complexity of the terrain, this process is 40% automated and 60% manual. Generally the software will look at a small area within the point cloud and determine if any points fall outside or inside a given criteria. If they do, they will be classified as ground or non-ground points. From this classification, a detailed analysis can be made to further weed out the non-ground points. This final "ground" point cloud consisted of 26,557,715 3D points, which were used to generate a DTM. The final point cloud was tiled into segments to allow for small file size.

A Microstation DGN file was created showing 2 ft contour lines, roadway linework, and site control. A comparison was made between the orthophoto and the final DGN. The georeferenced image fit perfectly.



Point Cloud after vegetation removal

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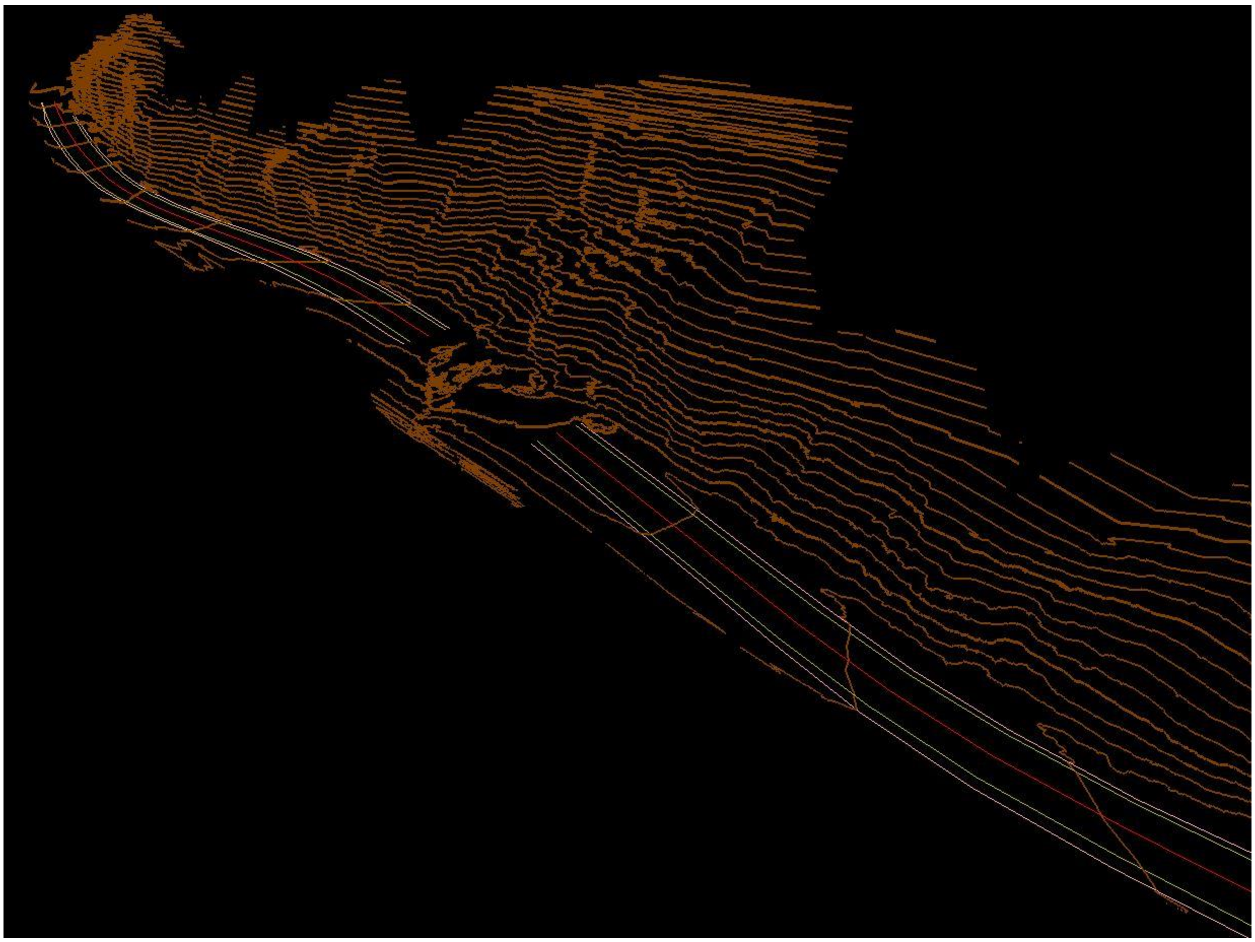
Results

The use of UAV technology was instrumental in completing this project safely, as traditional land surveying methods would have put those involved in probable danger. The severity of the landslide, coupled with the possibility of further movement, necessitated that the surveying method be one that allowed our professionals to gather data outside of the danger zone. By utilizing UAV photogrammetry, our team was able to access areas that were unstable, working around the areas of the landslide in a productive way. Additionally, the cost-savings of this technology allowed for a smaller team of professionals to gather the necessary data, rather than relying on a larger team of individual specialists.



Digital Terrain Model (DTM) showing contours at 5' intervals