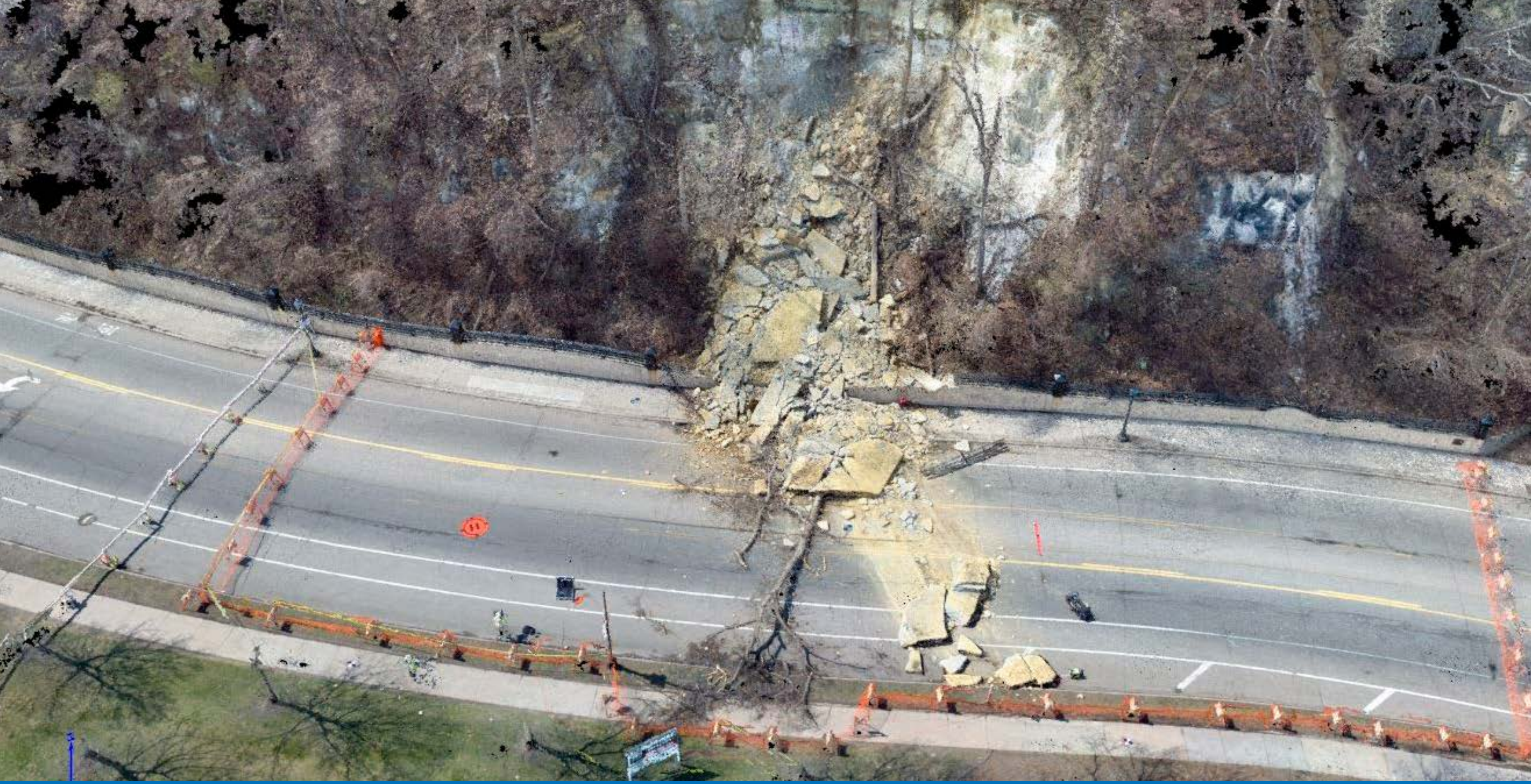


Wabasha Street Rock Slide Emergency UAS Investigation

St. Paul, Minnesota

SAINT PAUL
The Most Livable City in America

COLLINS ENGINEERS INC.

Overview

INTRODUCTION

On Saturday, April 28, 2018, at approximately 3:30pm, a rock slide occurred without warning and closed Wabasha Street in St. Paul, Minnesota. Despite happening in the middle of the afternoon in a dense urban environment, there were no injuries. The area was deemed unsafe and closed to the public until the site could be assessed by engineers and a plan to clean up and stabilize the bluff could be prepared. The City of St. Paul contacted Collins Engineers, Inc. to map the site with an unmanned aircraft system (UAS), or drone, to gather information needed to start the remediation effort.

SITE INVESTIGATION GOALS

The overall project goal was to safely gather data to create a map and 3-D model of the rock slide area. Because the rock slide was considered an emergency, data collection and processing needed to be performed quickly so that the engineers could have information available for them to make the decisions on how to best proceed. Information was needed for the geotechnical engineer to assess the slide area and determine the stability for remediation and clean up. Information was also needed to determine if the extents of the slide affected nearby private property, especially near the top of the slide. Since the slide area was still potentially unstable, the data collection had to be performed without accessing the immediate slide area. The City of St. Paul decided that data collection with a drone could be an effective way to accomplish the project goals with minimal risk to the public and to field staff.

Wabasha Street Rock Slide

Execution

EQUIPMENT

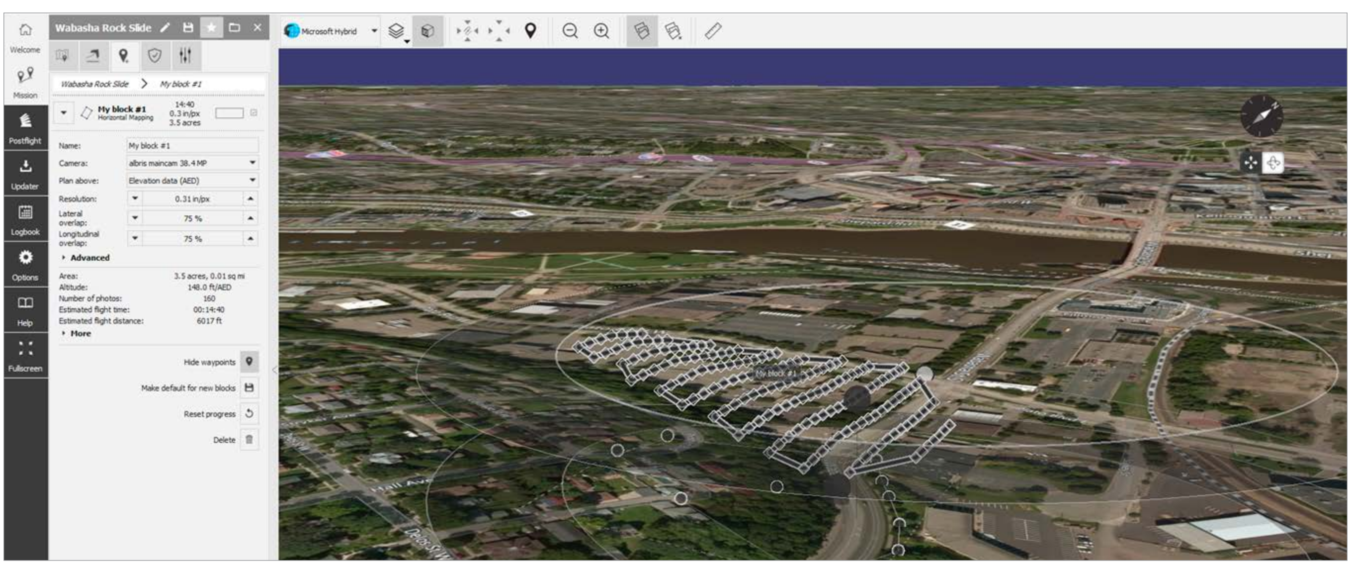
The team utilized the senseFly albris drone, which was designed for commercial inspection and mapping purposes. The albris UAS can be controlled interactively with a controller, or autonomously with a pre-programmed flight. Both flight modes utilize a laptop computer to control the UAS. The flight control software contains the UAS's settings, which includes a real-time map that displays the drone's location, live image views, and flight data. The UAS is approximately 22 inches x 32 inches x 7 inches and weighs 3.96 pounds. The propellers are protected by shrouds and, combined with its lightweight design, the drone poses very little hazard to the public.

senseFly Albris Drone and Propeller Aeropoint

The albris UAS imaging payload consists of a gimbal-mounted head containing a high-definition video camera, a 38 mega-pixel (MP) still camera, and an infrared camera. The 38MP still camera was the primary data acquisition tool for this effort. With pre-programmed or interactive flights, the albris UAS can take still images at regular intervals which can then be processed by software to produce high-resolution maps and models. The absolute horizontal/vertical accuracy of the UAS is from 3 feet to 16 feet without using ground control points and down to 0.04 inches when using ground control points.

In order to achieve a good relative accuracy (local) and absolute accuracy that corresponds directly to GPS coordinates, the team utilized Aeropoint ground control points (GCP) in addition to the city ground control. The propeller aeropoints have built-in GPS, solar panel, battery, and WiFi. Each unit collects GPS data while fieldwork is being performed and the data is automatically uploaded to a server where it is adjusted via a correction network to attain up to 2 cm accuracy. A report is generated which gives each GCP's survey grade location and the accuracy that can be expected for each point.

eMotion Flight Management Software Plan



The site is challenging due to the large elevation change and the need to map not only the horizontal surfaces but also the vertical surfaces of the bluff face.

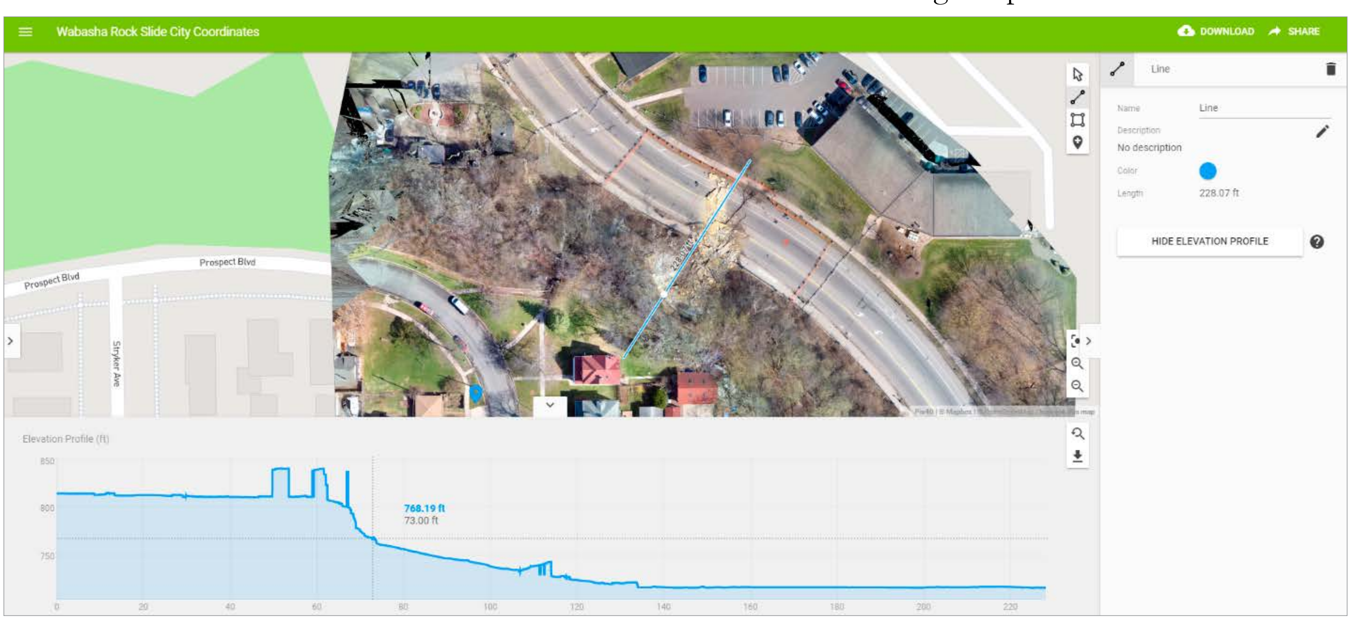
FIELDWORK

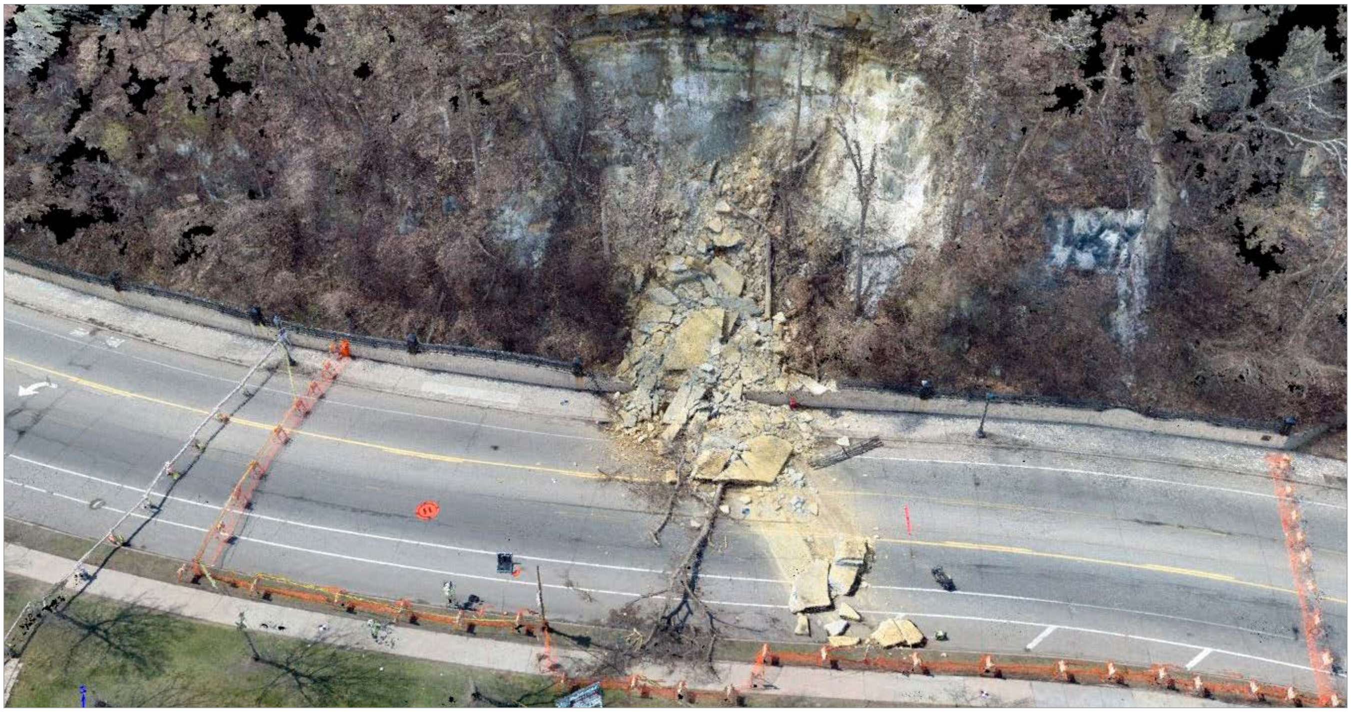
The City of St. Paul contacted Collins on May 2nd in the afternoon and a field crew was mobilized and on-site the following morning. The City of St. Paul communicated with nearby property owners to inform them of the planned work. The field crew consisted of two professional engineers certified as small UAS pilots. One field member flew the drone while the other acted as a visual observer. Fieldwork consisted of distributing ten Aeropoint ground control points throughout the site. The City of St. Paul surveyors also set ground control points to ensure the resulting location data was correct. The points were well distributed to ensure accuracy with half being placed on the upper part of the bluff and half being placed near the bottom of the site by Wabasha Street.

Although the area is near Homan Field and is considered restricted airspace, Collins had an FAA airspace waiver in place that allowed inspection work to be performed under the FAA's Part 107 Small UAS Rule. The project area was flown from two locations, one at the top of the bluff and one near the bottom of the bluff. High resolution images were collected using a preprogrammed autonomous mapping mission, and interactive flights where the pilot was manually flying the drone. The interactive flights utilized the drone's cruise control and image auto-trigger feature to collect images of the face of the bluff and slide area.

The site is challenging due to the large elevation change and the need to map not only the horizontal surfaces but also the vertical surfaces of the bluff face. Moderate wind at the site was accelerated at the top of the bluff and approached 25 miles per hour. The drone was able to handle the wind but the vegetation became hard to process because it was moving during the flights. Even with the challenges, the data was successfully collected in less than four hours including setup.

Elevation Profile of Wabasha Street Rock Slide



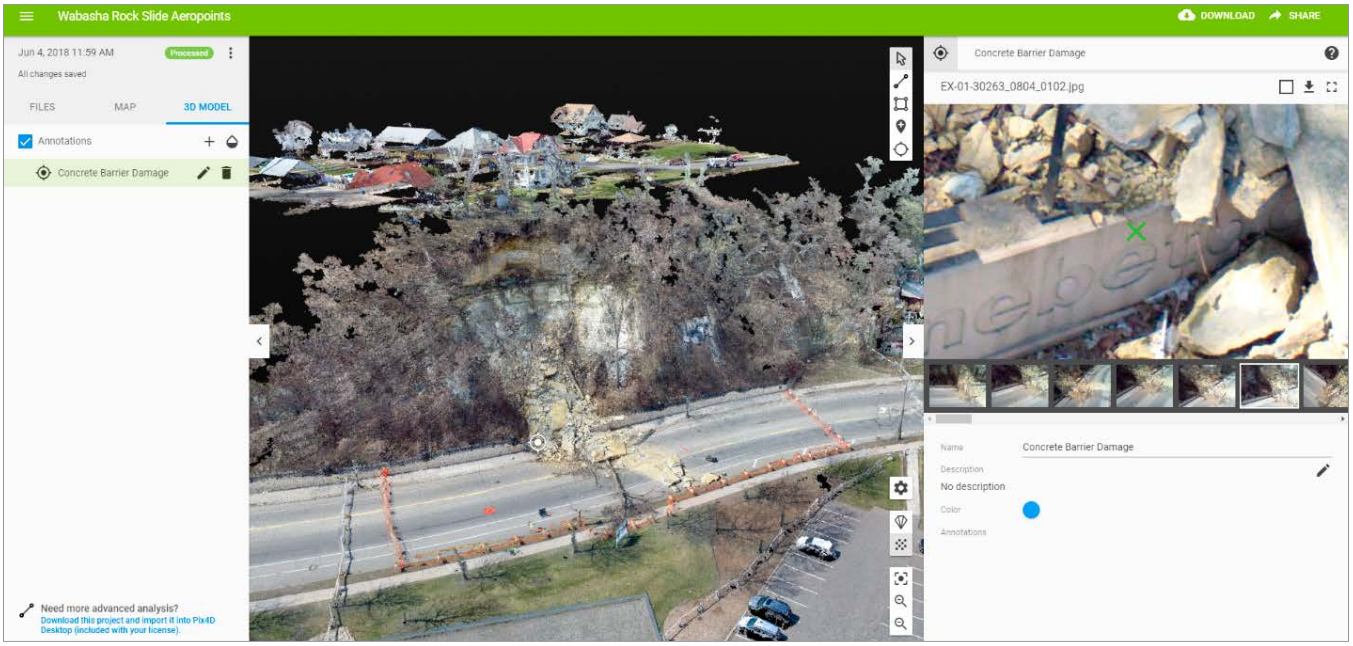


3-D Point Cloud of Wabasha Street Rock Slide

DATA PROCESSING

The high-resolution images were post-processed using Pix4D Software to create the project deliverables. The Aeropoint GCPs and the City surveyor GCPs were incorporated into the model to ensure both relative and absolute accuracy. Deliverables included an orthomosaic map of the area, a point cloud, and a triangular mesh model of the site. The processing was performed locally on a computer and also on Pix4D's cloud processing service.

Orthomosaic Map of Wabasha Street Rock Slide



Virtual Inspector Tool

RESULTS

The field investigation proved to be an efficient and safe way to collect and process a large amount of data efficiently and cost effectively. The entire data collection effort was accomplished without any staff having to enter areas that were considered unsafe or unstable. The resulting maps and models of the area were useful to engineers involved in the project in several ways. The profile of the bluff was easily determined at various locations without the need for any manual surveying of the slide area. The 3-D model and point cloud was used by the geotechnical engineer to determine the geometry of the slide area.

The orthomosaic map of the area was used to compare the extents of the slide to property lines to determine whether private property was affected by the slide. The map is dimensionally correct and was used to measure distances and convey the extents of the slide. Pix4D includes a cloud version which enables the sharing of the map and models without the need to transfer large amounts of data and without the need for the end user to have Pix4D software. The cloud version has a virtual inspector tool that serves as a three-dimensional photo log of the inspection. Once the model is created from the images, the photos are linked to the model. If a particular area of the project site needs to be reviewed, the user can click on that point on the model and all of the photos will be displayed of that particular element being inspected. The cloud version also includes annotation tools to communicate results more effectively.

While the original goal of the project was to collect data to help technical staff with the repair project, one lesson that emerged was that the 3-D modeling also became an effective communication tool. It was used to communicate the impacts to the City Council, senior City staff, and affected property owners. By viewing the 3-D model and area map, the extent and impact of the slide could be quickly understood without making a site visit.

PROJECT STATISTICS

438 High Resolution Images

Time in Field: 4 Hours

Field Work and Data Processing Cost: $5535

Model Processing Time: 18 Hours

3D Model Points: 6,6039,598

Total File Size: 13.2 Gigabytes

Data/Model on the Cloud: https://cloud.pix4d.com/pro/project/304433/3d?shareToken=4548e50ce69f494cbf2b7e96d7dad6f6

Pix4D Propeller Aero Sensefly: https://www.sensefly.com/software/pix4d/

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