the American Surveyor

FEBRUARY 2016

PHOTOGRAMMETRY

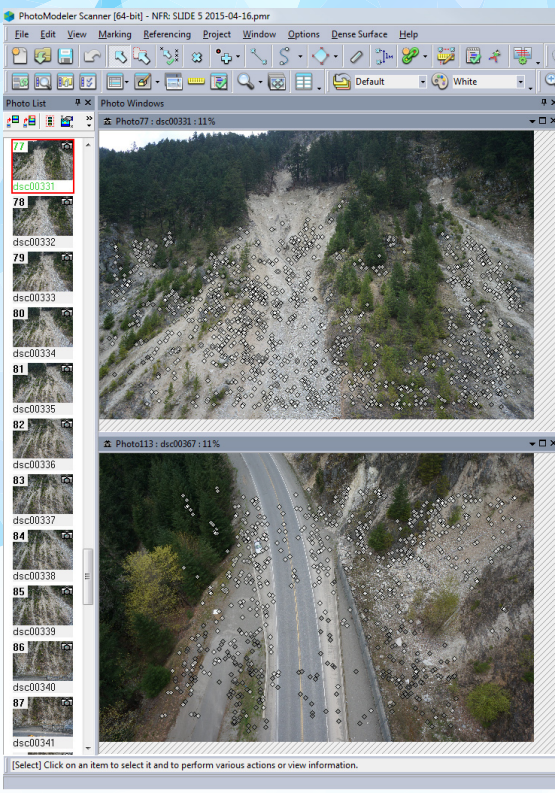
Elevation Certificate
The latest from FEMA

Complex BIM Project
Requires mix of tech

Software & Fieldwork
Pays off for students

PHOTOGRAMMETRY

Helps Surveyors Save Time and Improve Accuracy



Aerial view of a debris slide catchment area. This photo shows the catchment area before the contractor has removed the debris and is one of many that will be imported into PhotoModeler to calculate the total debris volume of the slide.

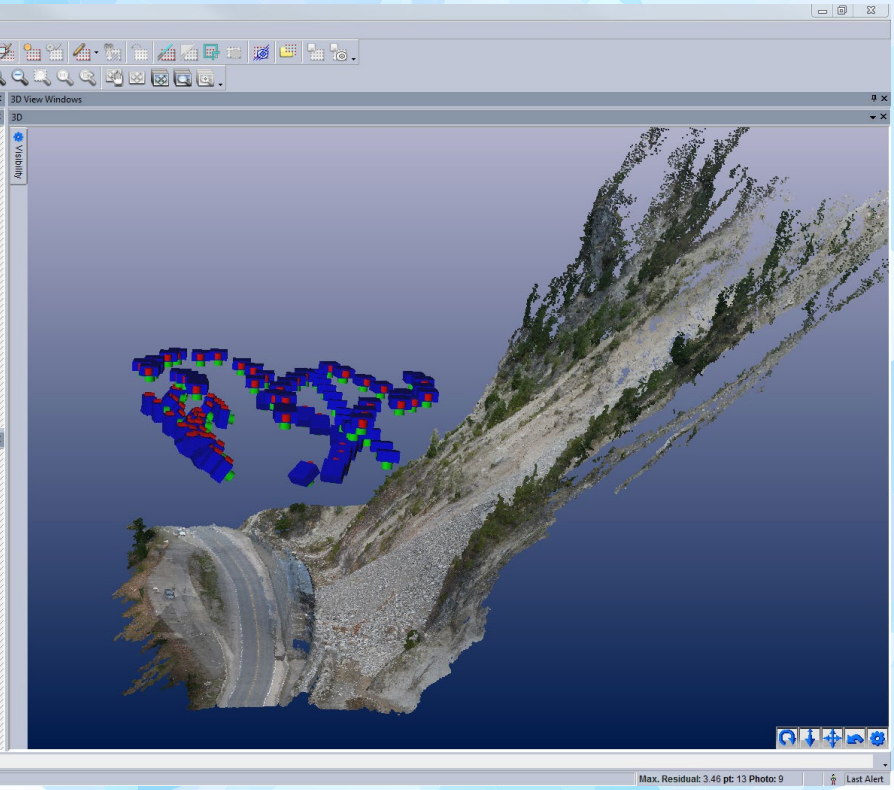
Surveying is a time and labor intensive process that requires extremely high levels of accuracy. Two North American surveyors are addressing this challenge by using photogrammetry to increase the number of points surveyed by several orders of magnitude while reducing field time by half or more. Photogrammetry is the process of generating measurements and models from photographs. "Photogrammetry helps us win more jobs by providing more competitive pricing," said Paul Lepine, Senior Geotechnical Technician for exp Services Inc., Burnaby, British Columbia. "Photogrammetry provides much more accurate measurements since every point is created in 3 or 4 photos and these photos are reconciled together to obtain closure for the entire model," said Eric Blackburn, President of EBI Surveying, Tampa, Florida.

» JERRY FIREMAN

Rock slope surveys

exp specializes in performing rock slope surveys that are required when rock slope remediation systems are built alongside highways. The company surveys the rock slopes and calculates the amount of mesh required to cover the slope and also proposed locations for metal stanchions used to secure the mesh. The company also estimates the required rock scaling—the removal of loose rock from slopes—and shotcrete—concrete that is sprayed onto the rock slopes. One of the critical areas in the survey is at the joint planes formed by breaks of natural origin in the continuity of either a layer or body of rock. Water often invades cracks at the joint line or fracture. Later as the temperature drops and freezes the water, its volume expands. This expansion pushes the rocks on either side of the joint apart, breaking off pieces of rock that may fall onto the road.

Below: 3D point cloud (right) of the debris slide seen in previous image. This point cloud, used to determine the total volume of the debris, was created in PhotoModeler from about 90 individual photos of the slide. SmartMatch points can be seen dotting the actual site images on the left.



View of catchment area of slide after contractor's removal of the debris.

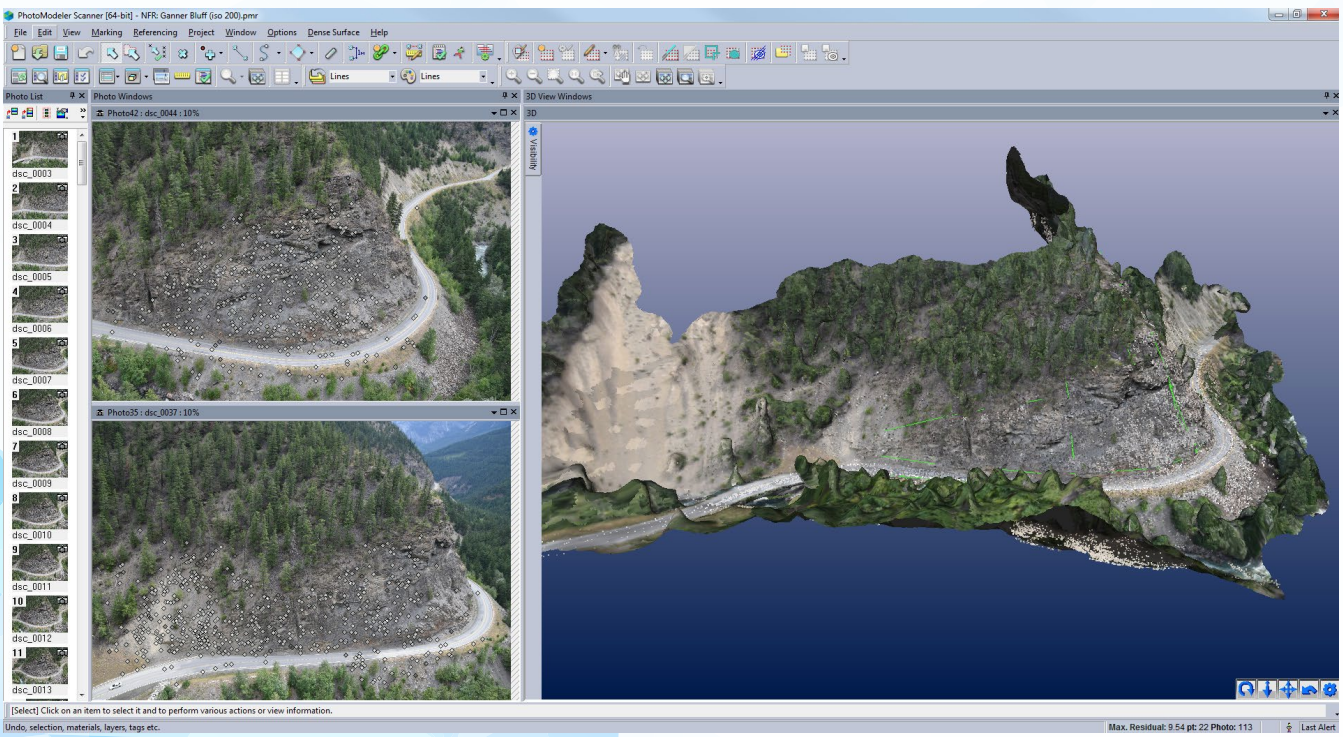
In the past, exp surveyors used a total station to survey a few thousand points on a typical 100 meter long rock slope. This process normally took three days. One of their challenges was that the two-lane highways are typically only 15 meters wide and the rock slope cuts are commonly 30 to 50 meters high and sometimes up to 100 meters. "It is very difficult to take measurements that high and to find safe and appropriate total station setups while surveying by the highway," Lepine said.

Several years ago, exp began using PhotoModeler photogrammetry software from Eos Systems. exp originally used a different software package but switched to PhotoModeler when it was discovered that PhotoModeler could be purchased for the amount that it cost to rent the other software for one month. When Lepine first began using photogrammetry, he placed photo control targets on the rock and surveyed the 3D coordinates for those points in order to provide the proper scale rotation and translation for the photographs. He then walked along the rock slope and took pictures with a digital camera, taking care to obtain at least a 60% overlap between adjacent pictures. This process took only one day for a 100 meter long rock slope.

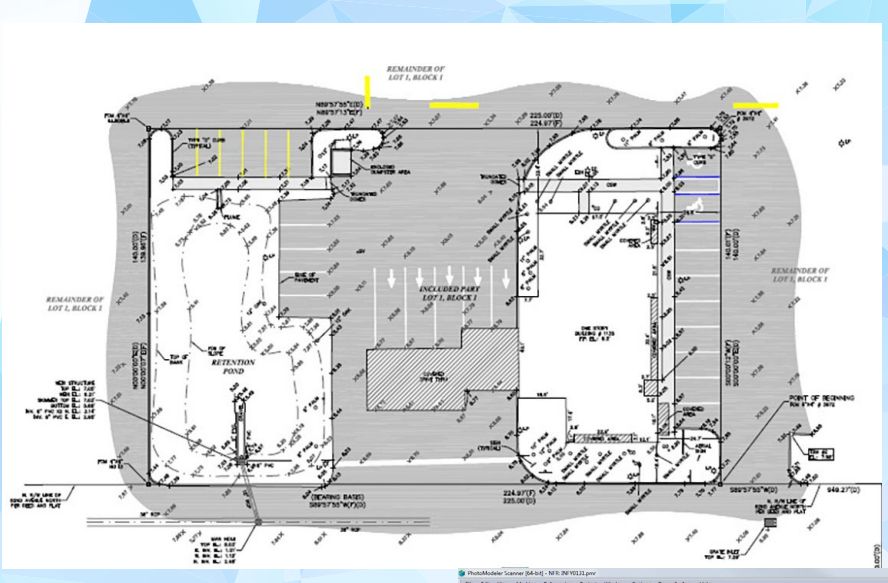
Photo of a bluff requiring rock slope remediation. Part of a government remediation project, this photo will be one of many used to calculate the mesh area and other requirements.

When Lepine returns to the office, he uploads the photos into the photogrammetry software and uses a feature called SmartMatch to automatically detect and match features across multiple overlapping photos. The software then computes the position of each point in the images in 3D space. "SmartMatch saves a considerable amount of time compared to the previous process of manually matching common features between the photos," Lepine said. "The time required to orient the photos is reduced from a few days to a few hours. The result is a dense point cloud consisting of millions of points that defines the topography of the rock slope to a much higher level of accuracy than was possible in the past." Accurately depicting the 3D geometry of the rock slope is critical because contractors prepare their bids for the remediation work based on this geometry.

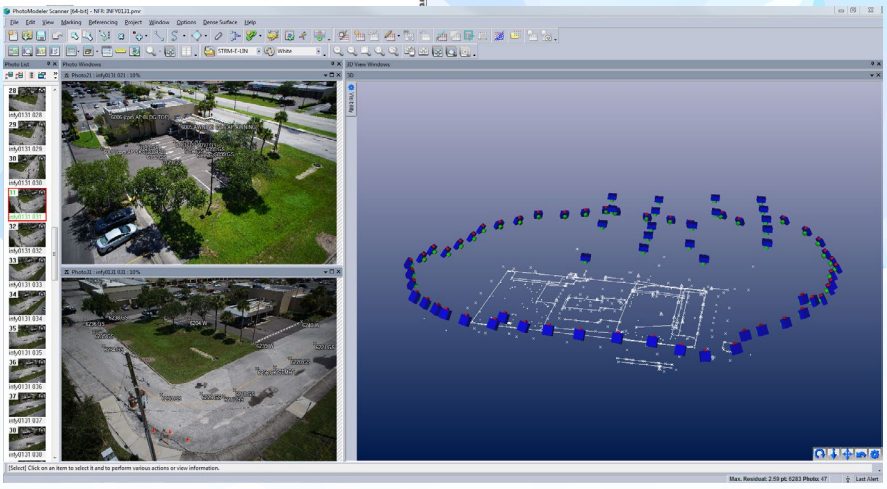
More recently, exp has further improved the survey process by using a DJI S900 Hexacopter drone with a Calibrated Sony NX5T camera to take the photos. Lepine



Rendered 3D surface model (right) of the bluff in previous image. The individual photos taken at the site are shown in the two images on the left. PhotoModeler surface drawing tools were used to outline the area of proposed slope mesh (green lines on surface model). The surface model with 3D lines outlining proposed slope mesh areas are imported into AutoCAD Civil 3D to calculate mesh surface areas and produce final drawings.



Survey of bank site. Anchor points set up around the survey site will later be used by the software to determine the correct position and angle for each shot.



Bank site in PhotoModeler. On the right is the set of georeferenced 3D point locations which will be exported to AutoCAD software. Two of the 40+ images taken of the survey site can be seen on the left.

commands the drone to hover and moves the gimbal into position for the shot of the rock slope. This method allows for better survey coverage of the rock slope than photos previously taken along the highway by hand. As with the manual photos, he overlaps each photo with the preceding shot.

Exp's governmental customers typically markup photos of the rock slope with lines drawn to indicate the outline of where they want the mesh. Lepine then makes a 3D model of the mesh using the surface drawing tools in PhotoModeler. At this point, the model is exported to AutoCAD Civil 3D where Lepine calculates the area of each section of mesh, creates annotations and generates separate surface models of each mesh. These deliverables are then provided to exp's client.

Sometimes the client requests modifications and when the client is satisfied Lepine produces a final drawing that is included in the package provided to the contractors for bidding. Often, when the construction is being performed, contractors may propose changes, such as extending the mesh to cover additional areas of the rock slope. In this situation, exp returns to the site after the construction is completed and performs an as-built survey using PhotoModeler that is used to determine the contractor's payment.

Redevelopment surveys

EBI Surveying based in Tampa, Florida is another company that has moved from conventional surveying to photogrammetry. The company focuses on surveying properties prior to redevelopment. It produces a map of the site that shows each of the improvements, such as buildings, pavement, signs, fences and inlets, as well as the topography of the site. In the past EBI measured each individual feature with a total station which took between two and three days for a typical one acre commercial site. The accuracy that could be achieved by this approach was limited by the fact that each measurement was independent of the others so the dilution of precision could not be calculated.

"After making the decision to give photogrammetry a try, I took a look at several different software packages and found they were bulky and difficult to use," said Eric Blackburn, President of EBI. "But when I tried PhotoModeler I found that its developers had taken a lot of time to develop an interface that makes sense to the user. The program works and feels a lot like Microsoft Office or AutoCAD so it's easy to understand. One of my favorite features is the 3D viewer which I keep open while I am marking and referencing the photos so I can easily keep track of which areas have been completed and which ones still require work."

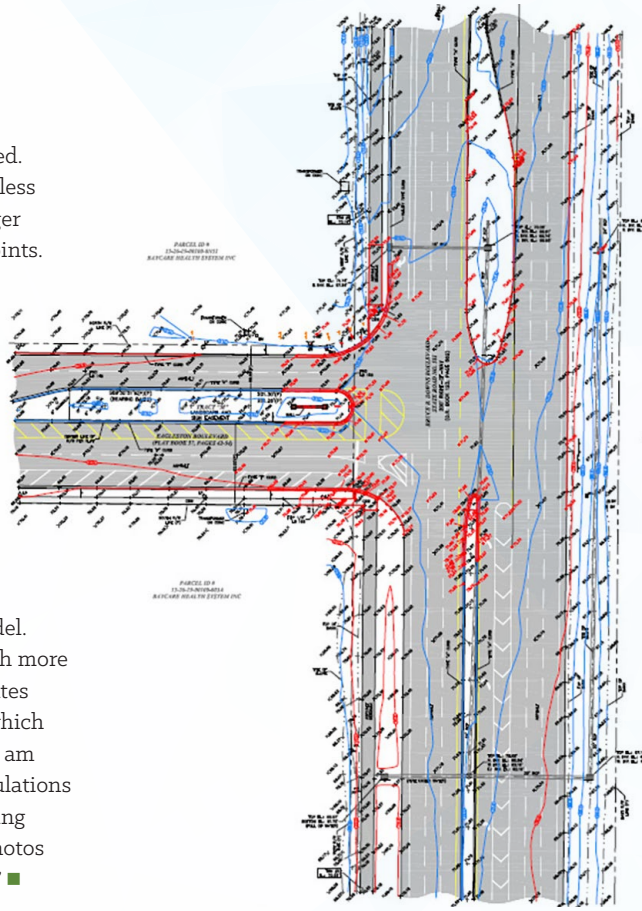
Blackburn now begins the survey process by setting anchor points around the site that will later be used by the software to determine the correct position and angle for each shot. He then sets up a camera on a 50 foot high telescoping pixie pole and takes 40 to 100 photos of each site, indexing the camera field of view about 15 feet for each shot to

achieve 60% or greater overlap between shots. There are still some improvements that can't be measured with photographs because key dimensions are hidden from view. For example, Blackburn must open manhole covers and take a measurement to the bottom of the pipe. However, in total eliminating the need to measure every point manually has reduced the field time required for a property from 15 to 20 hours in the past to only 6 to 8 hours today.

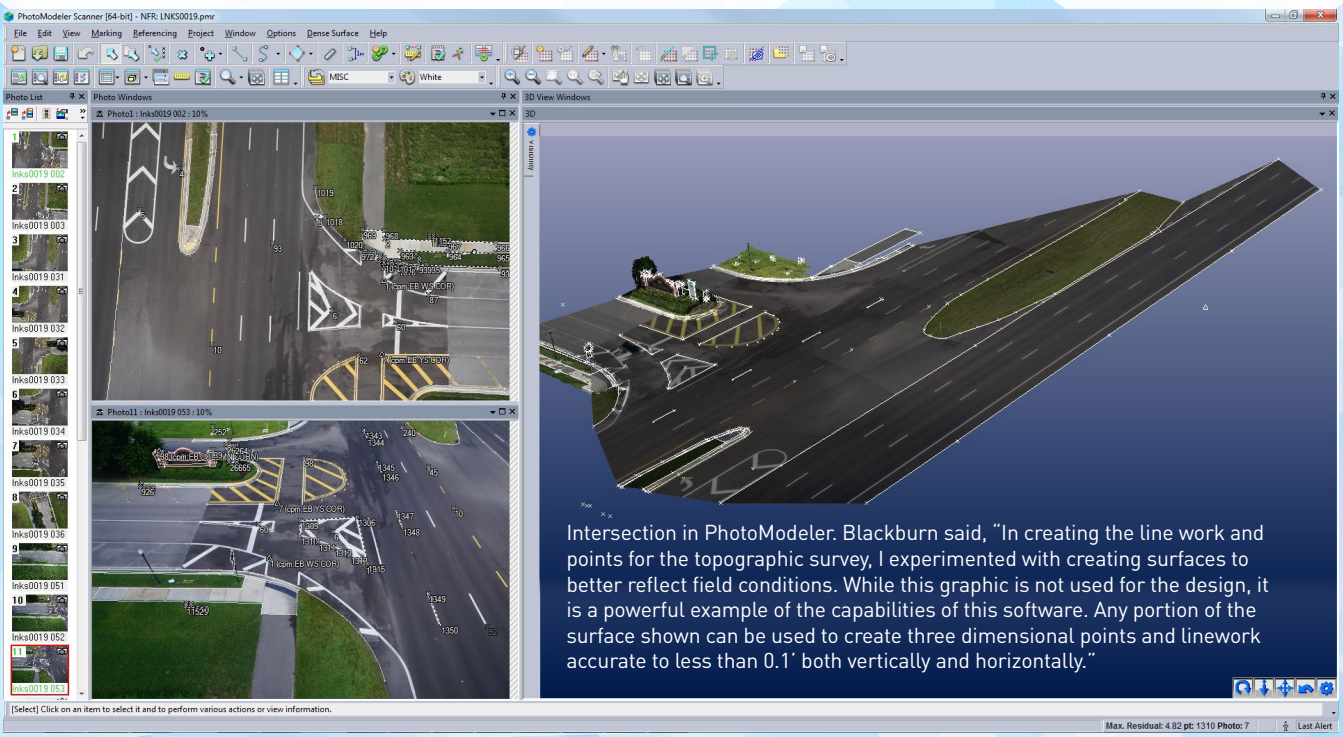
Blackburn brings the camera data back to the office and loads the photos into the photogrammetry software. He opens up photos and manually selects an anchor. The software then automatically finds each additional occurrence of that anchor point in other photos so Blackburn only needs to open up one photo for each anchor point. "I actually requested that this feature be added to the software," Blackburn said. "In fact, I have made several requests for improvements to the software and have often seen those changes reflected in subsequent program updates." Once Blackburn has marked and referenced the photos, the software generates a set of georeferenced 3D point locations which are then exported to AutoCAD software. This is delivered to the customer.

"Photogrammetry offers major advantages both in time savings and quality improvements," Blackburn concluded. "We find that we spend 60% to 70% less time in the field because we no longer have to measure most individual points. Another advantage is that we no longer have to worry about the possibility of missing an improvement that should be included on the survey. In the past when this happened I needed to go back to the site to take additional measurements. Now that we take photos of the entire site the client can easily measure the position of any improvements based on the 3D model. Photogrammetry also provides much more accurate measurements and calculates the potential error for every point which is from 1 to 3 hundredths of a foot. I am eagerly awaiting the time when regulations permit the use of drones for surveying because the ability to take higher photos will improve the quality of surveys." ■

Jerry Fireman is the President of Structured Information (*www.strucinfo.com*) and has spent more than 30 years writing about nearly every type of technology. To date, he has written more than 10,000 articles that have been published in over 3,000 trade journals, technical journals and mass media around the world.



This resulting map was created using Photomodeler. An entire second set of data was acquired using conventional methods as a comparison. On average, a difference of less than 0.1' was observed between the elevations of asphalt and concrete established by Photomodeler and the conventional data.



Intersection in PhotoModeler. Blackburn said, "In creating the line work and points for the topographic survey, I experimented with creating surfaces to better reflect field conditions. While this graphic is not used for the design, it is a powerful example of the capabilities of this software. Any portion of the surface shown can be used to create three dimensional points and linework accurate to less than 0.1' both vertically and horizontally."