

Case Study

Volumetric and Feature Mapping for Surface Mines

Using Trimble UX5 Unmanned Aerial System



Volume measurements

Traditionally, volumetric survey calculations involve one or more of the following processes:

- RTK GPS (Real-Time Kinematic - Global Positioning System)
- Total Stations
- Surveying GPS
- Automatic Laser Scanners
- Aerial Flyover Laser Data.

All of these methodologies involve significant setup and processing time.

With the advent of UAS survey technology, volumetric workflow can be significantly shortened and simplified.

According to Steve Talbot, a surveyor with Sibelco Australia, using a UAS system resulted in a considerable savings in cost, time, and increased safety for surveyors .

Read full report here:
<http://uas.trimble.com/quote/sibelco>

Periodic unmanned aerial system (UAS) survey of mining operations can generate very timely and highly accurate volumetric measurements, change detection, and GIS planimetric maps, at a fraction of the cost of traditional aerial or ground survey. The UAS survey can be scheduled regardless of cloud cover, and using integrated software results in meaningful data within a few days of data collection.

The examples below detail a small aggregate mining operation in which was imaged by CompassData Inc. (<http://www.compassdatainc.com>) using a Trimble UX5 system and UAS Master software. The resulting detailed ortho imagery and Digital Surface Model (DSM) took about 10 man hours to generate, and were then used to capture the volume of the gravel piles.



Picture taken right before launch of UX5 system. Light rain and wind gust up to 32 MPH.

Instead of having expensive surveying equipment set up and exposing surveyors to safety risk, the UAS can be launched from a distance away, without the need for coordinating with or interrupting the mine operations.

See "Quarry and mine site surveying" <http://uas.trimble.com/quote/geocom>

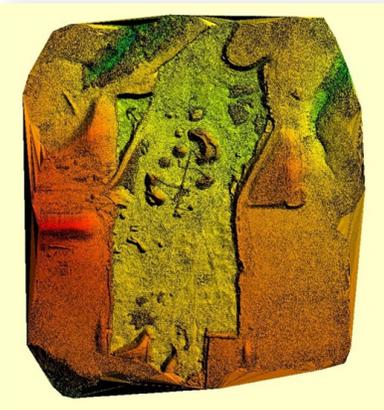
Digital Surface Model Accuracy and Density

The DEM resolution can be customized; in this example, the DSM had a resolution of about 14x14 cm (6x6 inches) resulting in a volumetric unit of 0.003589 cubic yards, or .0027 cubic meters - very precise!

The absolute horizontal accuracy of the DSM is dependent on the accuracy of the base imagery. These accuracies don't affect volumetric accuracy but are important if accurate planimetric mapping is desired.

The base accuracy depends on the strength of the GPS signal during the aerial survey and how rigorous the imagery triangulation was (tie point calculation). Without ground control points (GCPs), the absolute horizontal accuracy is in the range of meters.

With the use of GCPs, the imagery can be corrected to within 2-3 times the pixel size (for this example about 9 cm CE 95%).



Digital surface model showing the gravel mine extent, and piles on the floor of the mine.

Pixel Size

Notice how detailed the imagery below is. This specific image has an approximate pixel size of 2.5 cm, allowing details of the machinery to be seen, identification of tree and bush species, wetlands delineation, and easy mapping of the extents of the pit. The UX5 camera has – unlike a traditional compact camera – a large imaging sensor that captures very sharp, color-rich images, even in dark or cloudy conditions. The 16.1 MP camera and its custom optics give the UX5 the ability to capture data down to 2.4 cm (0.94 in) resolution.



Close up of 2.5 cm resolution image showing trucks and flatbed trailer.

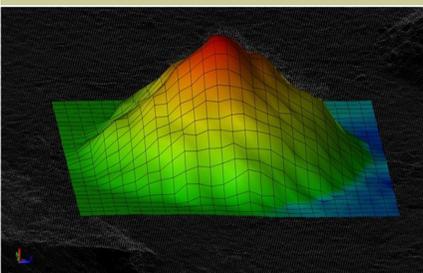


Volumetric result for one of the gravel piles. Measurement determined by drawing a polygon around pile and setting zero value for bottom of pit. Ortho image of the mine draped over the DSM and tilted for perspective view to the NW.

Additional Applications

Multiple applications can be performed, using various software, after the initial UAS data capture and processing. For example, the following analysis can be performed using UAS imagery and UAS generated DSM:

- Contours generated at every meter
- Volume calculation of the stock pile
- Visual site inspection
- Height pile monitoring
- Profiling
- Surface calculation and analysis
- New road projections
- Monitoring plants, pools and other mining facilities



Simplified surface grid used to calculate the volume of one of the gravel piles.

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Technical Details

For a detailed discussion of how digital photogrammetry, like UAS imagery, can result in detailed volume measurements see M. Yakar and H.M. Yilmaz article "USING IN VOLUME COMPUTING OF DIGITAL CLOSE RANGE PHOTOGRAMMETRY" (http://www.isprs.org/proceedings/xxxvii/congress/3b_pdf/22.pdf).

They wrote: "It is important to know cutting and filling volumes in many survey, engineering and mining works. Volume calculation, generally, are completed with classic surveying methods. The trapezoidal method (rectangular or triangular prisms), classical cross sectioning (trapezoidal, Simpson, and average formula), and improved methods (Simpson-based, cubic spline, and cubic Hermite formula) have been presented in the literature. Geodetic surveying methods have been insufficient for situations when the volume calculation of the objects need to be calculated in a short time or in a risk areas, or unreachable areas. In this case digital close range photogrammetry is an alternative method to volume calculation. Digital close range photogrammetry is a method which has been used for 3D surveying of objects for many years. By the development of digital techniques, digital close range photogrammetry used in many fields such as engineering surveying, topographic surveying, architectural surveying, archeological surveying, etc. has become productive, faster and an economical method."



Digital orthophoto of mine draped over UAS generated elevation point cloud. Notice that tree height, areas of large rocks, and machinery can easily be observed and mapped.

Summary

CompassData has three Trimble certified UAS remote pilots, and three Trimble certified UAS master image processors. Imagery collection can be scheduled independent of cloud cover, at a fraction of the cost of contracting an aerial survey, at resolutions tens of times more detailed than satellite images, and with custom collection areas editable up to minutes before flight time. Volumetric calculations and other custom, elevation and imagery derived solutions, are relatively easy to create using the accurate DSM. Small and large mining, oil and gas, and other land management applications will quickly realize a decrease in cost, time, and complexity, while increasing accuracy and data interpretability.

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