Evaluating the Accuracy of Volumetric Surveys using the Event 38 E384 Drone and Drone Data Management System™

Summary:

Using a drone resulted in a **60% reduction of man-hours** required to monitor stockpile volumes in a large sand quarry in southern Ohio. The customer was able to complete a survey without visiting or climbing each pile.

A study was conducted to compare the results of volumetric analysis of quarry stockpiles between three methods:

1) Manual measurement with GPS receivers
2) Aerial photogrammetry using an E384 and the Drone Data Management System™ (DDMS) with RTK-GPS ground control points
3) Photogrammetric analysis using DDMS on the same data set without the use of RTK GPS ground control points

The objectives were to determine the difference in measurement results between the three methods and to compare the resources required to complete each method.

Comparing the measurement results showed an error of 1.59% between manual measurement and RTK-GPS augmented photogrammetry. Without the use of GCPs, the same data produced measurements with an average of 2.80% error compared to the GCP-augmented data.

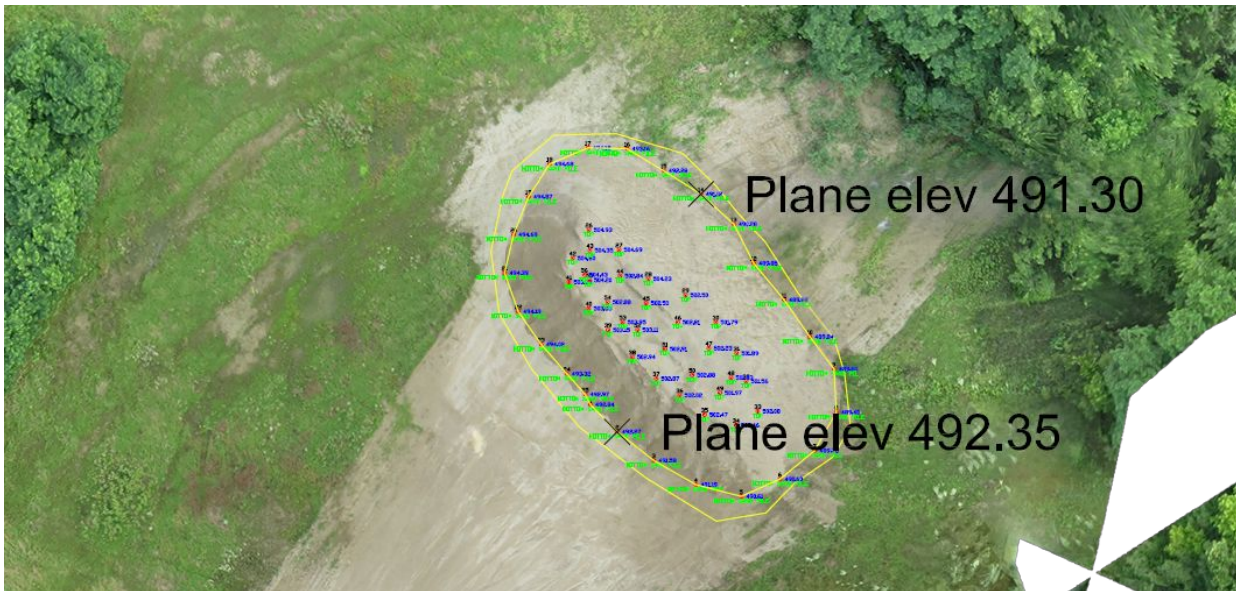
Data Collection Methods:

Prior to using the E384, the customer used an RTK GPS receiver and manually traced each pile to estimate its volume ("walking the pile"). To complete the estimate, an operator was equipped with an RTK GPS receiver in a backpack. He/she then physically visited each pile to be measured, first walking around the outside perimeter of the pile, then climbing to the top and walking the full flat top area.

With the E384, the customer is able to complete a survey without visiting or climbing each pile. First, operators drive around the site dropping targets for ground control points (GCPs). Once laid, one operator proceeds to collect an accurate location for each GCP using an RTK GPS receiver. At the same time, the other operator prepares the E384 and begins flying the pre-programmed mission. The same mission plan is often used without modification for repeat measurements of the same site. If permanent objects or structures exist on a site, they could also be used as GCPs without the need to lay or record their position on subsequent missions.

Processing Methods:

Prior to using an E384, this customer used Carlson Civil Suite to calculate pile volumes. Once all the data was collected, it was passed to an analyst who used the raw collection of GPS points to estimate the shape and elevation of the pile. A sample of the density of measurements used for this method is shown below. Processing in this way took an analyst approximately 2 hours for a 50-75 acre job site.



For comparison against this processing method, the raw image data from the E384 using an S110 camera and flight telemetry logs were processed using the Event 38 Drone Data Management System™ (DDMS™) both with and without the aid of Ground Control Points (GCPs). Volume is calculated on DDMS™ by first reconstructing the terrain in 3d using the Digital Elevation Model (DEM) app.

With the DEM, an operator outlines the base of the area to be measured using Map Viewer. The Volume App uses the provided outline to estimate the elevation and slope of the ground beneath the pile. It then iterates through each data point in the DEM and determines the relative height of the DEM above the estimated ground elevation. In this case, data was generated on a 9cm grid, resulting in approximately 121 measurement points per square meter. Knowing the grid spacing and the height of each data point, DDMS™ calculates the total volume of the sand pile based on the thousands of data points collected from high resolution imagery.

This mission was processed by DDMS™ in 5 hours elapsed time, start to finish. This time can vary depending on internet connection and size of the mission area. Because DDMS™ automates the ortho-mosaic and DEM creation steps, **the total analyst time needed to process was less than 1 hour.**

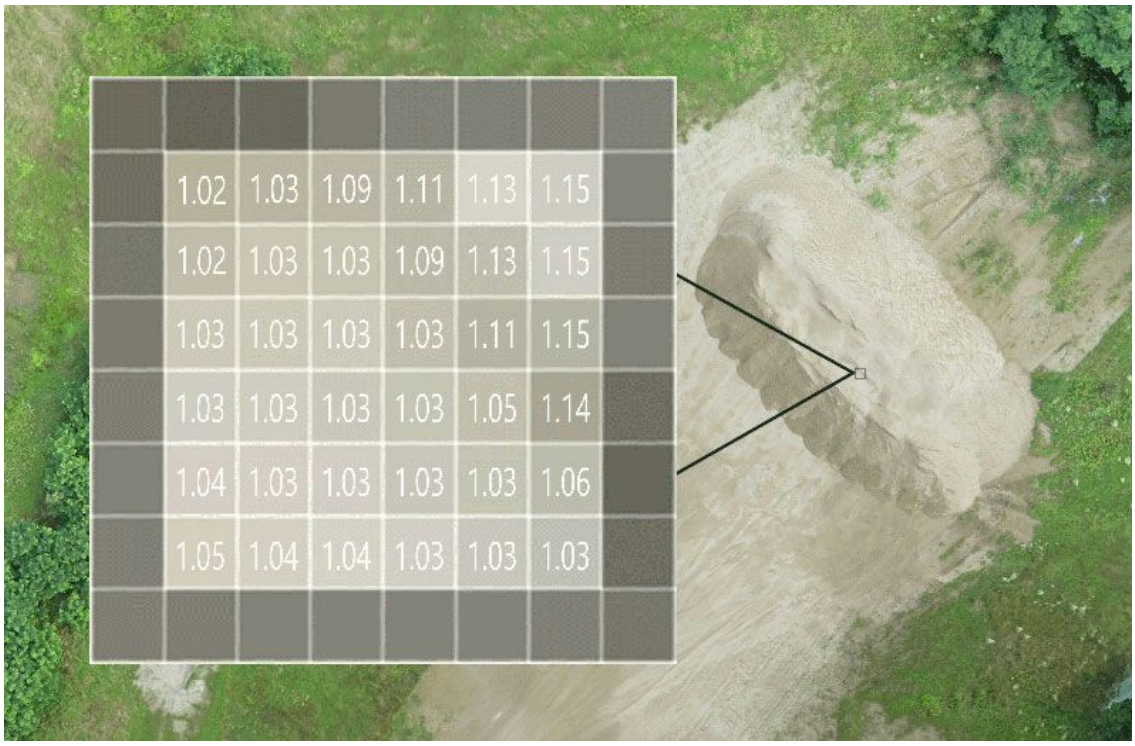


Illustration of relative pile elevations above estimated ground elevation for each point on the DEM

Results:

For direct comparison against walking the piles, only one pile's data was available. The volume of this pile as calculated from the three techniques is listed below.

Measurement Technique	Volume (cubic yards)
Boundaries Shot with RTK GPS Receiver by Foot	1336.60
E384 & DDMS™ Measurement with GCPs	1315.32
E384 & DDMS™ with Intellishoot onboard GPS	1293.32

We found that the customer's new measurement technique – using an E384 with GCPs and DDMS™ - resulted in a **volume measurement within 1.59%** of the traditional method of walking the pile manually.

Although this customer always uses GCPs to increase the accuracy of the mosaic and DEM, we also processed the same mission again using only the onboard GPS tags provided by the Intellishoot system on the E384. Using The DDMS™ Volume Calculator app and the Intellishoot-tagged data, a result within 3.24% of the 'walking the pile' method was achieved. Further comparisons between the Intellishoot and GCP-based data are below. A maximum discrepancy of 4.93% with an average error of 2.80% was achieved.

(Cubic Yards)	Pile 1	Pile 2	Pile 3	Pile 4	Pile 5	Pile 6
Measured w/GCP	6967.03	1471.66	625.45	18124.45	12154.79	19816.06
w/o GCP	7169.45	1438.26	637.00	17574.68	11934.07	20792.90
Error	-2.91%	2.27%	-1.85%	3.03%	1.82%	4.93%

The old method of manually walking each pile for this quarry site could take a total of 8 man hours. Using the E384 and DDMS™ reduced the resources taken for the same site down to just 3 man hours on site. Adding in post-processing analyst time of 2 hours for the old method and 1 hour for DDMS™, **switching to the E384 and DDMS™ reduced this customer's total operator time from 10 hours per site to 4 hours.**

Conclusion:

Using a drone and the DDMS™ resulted in a **60% reduction of man-hours** required to monitor stockpile volumes and the customer was able to complete a survey without physically visiting each pile. Collecting ground control points does improve the accuracy of volumetric measurements. Where possible, GCPs should be marked permanently for repeated use.