High Definition Laser Scanning and Mining

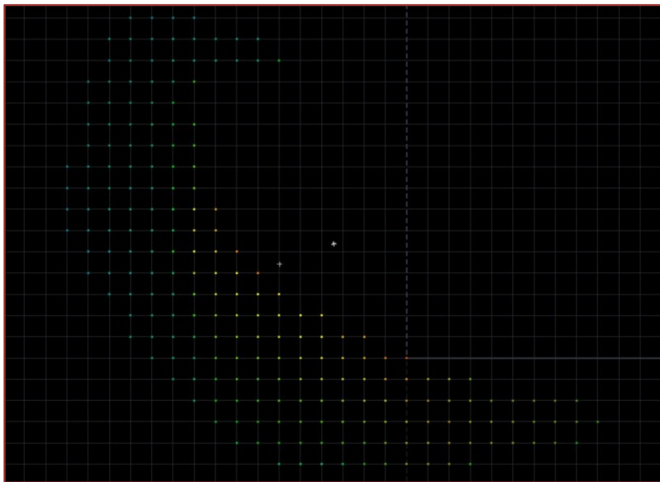
A Faster, Safer, and More Accurate Way to Monitor Mining Volumes

Traditionally, the calculation of volumes that were removed from mines was accomplished by counting loads as they exited the dig area. While this was accurate in totaling how many cubic yards were hauled it did not determine the volume removed due to the "fluff" or air that was added to the aggregate as it was blasted, and aerated by the various machines that moved the material off site. To remedy this, surveyors were used to create surface models that could be compared at regular time intervals to determine the actual volume that was removed from the dig area. These surface models are created from measurements that are taken every 50 to 100 feet across a quarry or stockpile. In order to take these measurements the surveyor must walk across the entire dig area in a grid pattern stopping every 50 to 100 feet to take a measurement of that spot's latitude, longitude, and elevation. While each spot that is measured is accurate, there are still some problems with this system.

Initially, the surveyor is required to walk all of the area to be measured. This is time consuming and can cause accuracy problems if each area is not completed in a timely manner as the topography in mines can change drastically from day to day. Secondly, this walk can be hazardous as the surveyor must dodge front loaders, dump trucks, trains and unstable soils, all while maintaining the grid pattern and taking measurements at the 50 to 100 foot intervals. Finally, the area in-between each of the measured spots is interpolated when the surface model is created. In other words, if there is a hole between the measured spots it is filled in. If there is a hill it is leveled as a direct line between the two closest measurements.

Fig.1 Laser Scanning Target at an Aggregate Mine

This can cause the resulting surface model to be far less accurate than each individual measurement would appear to be if analyzed statistically. For an illustration of just how much data is being interpolated and the effects of the interpolation on the surface models derived from each grid, see figures 2, 3 and 4 on the next pages. The difference is substantial, especially if your billing invoices are based upon the resulting volumetric calculations. Fortunately there is a single solution to all three of these problems. That solution is High Definition Laser Scanning.



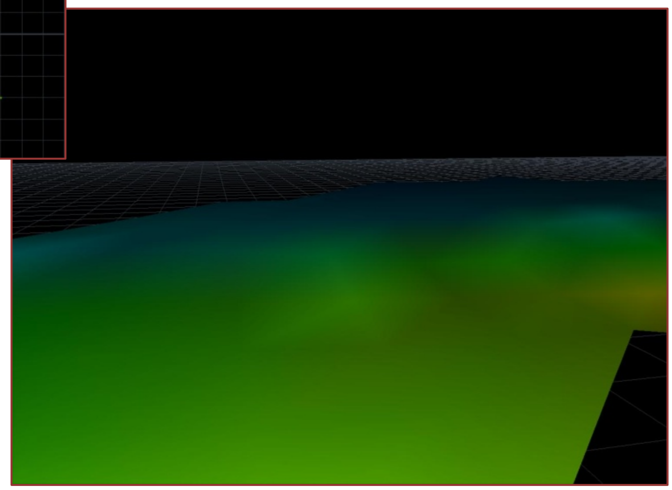
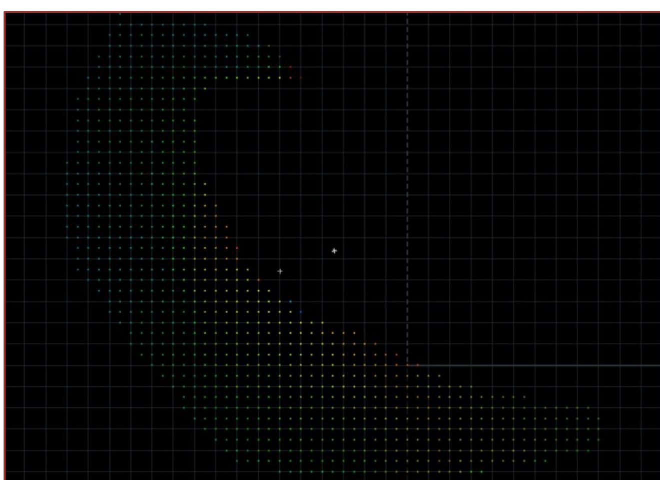


Fig.2

Above is an orthometric view of a sample area with a survey measurement taken at 100 foot intervals.

The graphic to the right is a screenshot of a surface model (TIN) that was derived from the survey measurements that are shown above.

While the above model may look sufficient, it is what you cannot see that is most important. With 100 feet between each survey point much more data is being interpolated than actually measured! Next we see the same area with double the density of the collected measurements (which will, of course, increase the time and cost needed to complete the data capture) but the increase in resolution to a 50 foot grid should be noticeable.



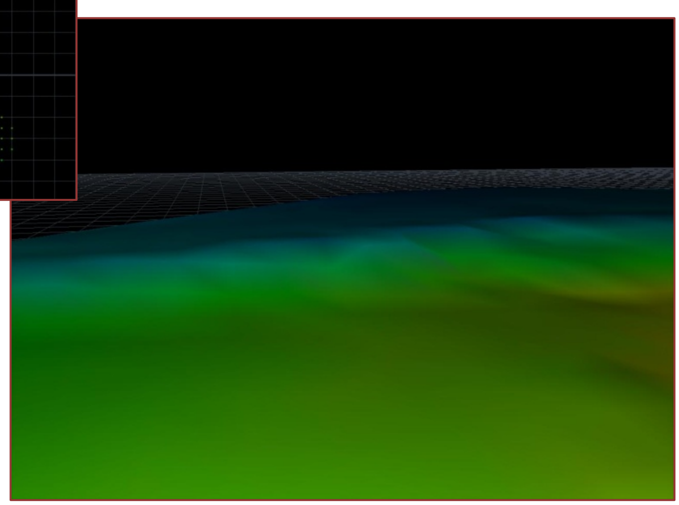
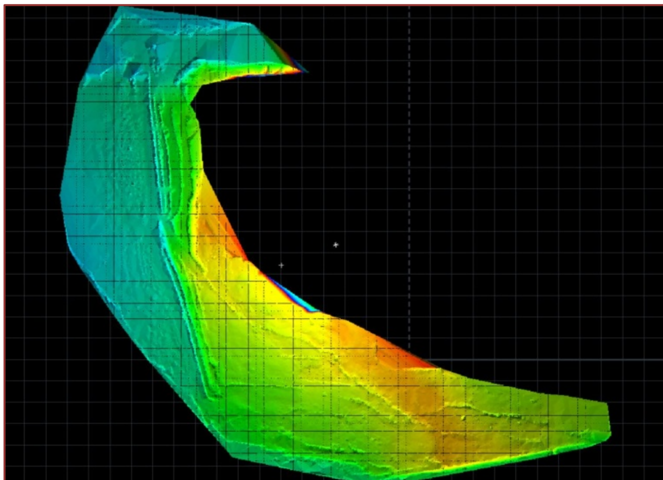


Fig.3

Above is an orthometric view of the same sample area with a survey measurement taken at 50 foot intervals.

In this screenshot we can see that what looked like a slight hill in the surface model from the 100 foot grid is actually a cut bank with a steeper incline than the rise interpolated by the surface model in fig. 2.

While the increase in definition is easily seen we are still interpolating more data than we are measuring. So, why not keep increasing the grid density? When using traditional survey tools this becomes cost prohibitive. However, with a High Definition Laser Scanner extremely high collection densities can be achieved at current market rates. In fact, while it is not necessary for this application, collection grids can be as tight as one survey point every 6 mm. In this final example we used the laser scanner to collect a measurement on a 3 foot grid. The screenshots speak for themselves.



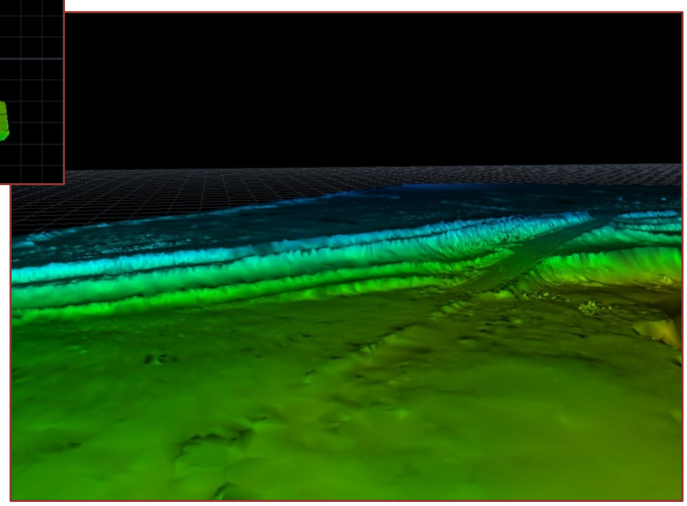


Fig.4

Above is an orthometric view of the same sample area with a survey measurement taken at 3 foot intervals.

Finally we have the surface model from the 3 foot grid laser scanner data. Now we see that the embankment is actually a cut bank that is bisected by an access road.

When you consider the fact that the access road that we were unable to see with the lesser collection grids is used by large dump trucks, the amount of product that may have been under or over estimated comes into focus. Exactly how much this improvement in accuracy translates to in bank feet is dependent upon site conditions. However, using the same dataset as that used in figures 2-4, we performed a volumetric analysis of the site in comparison to a laser scan taken 37 days later. First we will explain the methodology used to perform the volumetric analysis with a High Definition Laser Scanner and then we will take a look at the results of the test comparison.

Exactly how is High Definition Laser Scanning faster, safer, and more accurate than traditional surveying techniques? Laser Scanning works similar to a traditional total station; however, there are significant differences. With a laser scanner it is no longer necessary to walk the area being measured. This significantly increases the level of safety afforded the operator. The scanner can be set up in a safe location away from equipment traffic, unstable stockpiles or cliff faces.

The unit then uses a “time of flight” laser to capture measurements of visible objects and the surface at any grid spacing the operator wants. All of this data is instantly recorded to a laptop computer in the field. From a single position the laser scanner can capture all of the visible area within a 100 yard radius of the unit. At our test grid pattern of 3 foot, this can be accomplished in under an hour. Multiple positions are then tied together using a control network. The control network allows all data to be oriented to the client’s desired coordinate system. This also allows for comparisons of the same area over a timeline (see figures 5-7). It is through these timely comparisons that the volumetric analysis is performed.

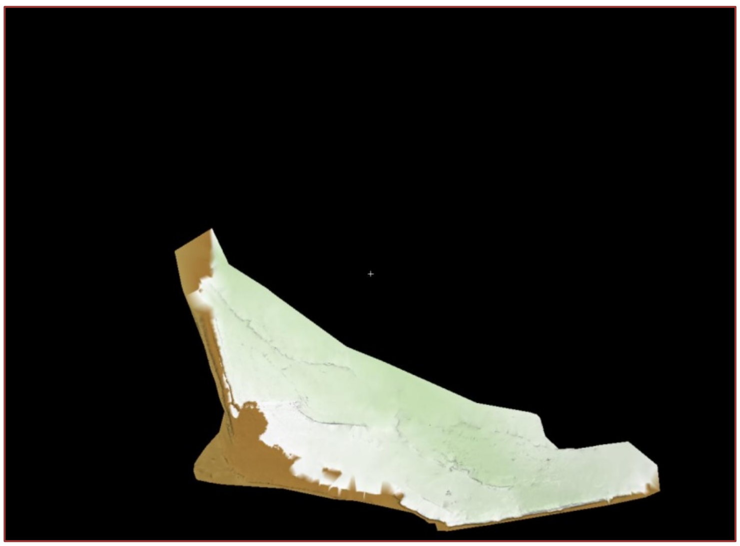


Fig. 5 Surface model of Laser Scanning Data from April

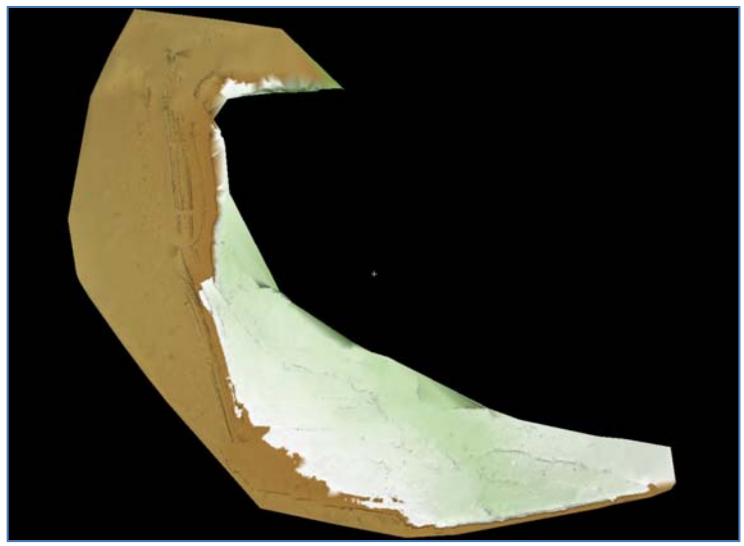


Fig. 6 Surface model of Laser Scanning Data from May

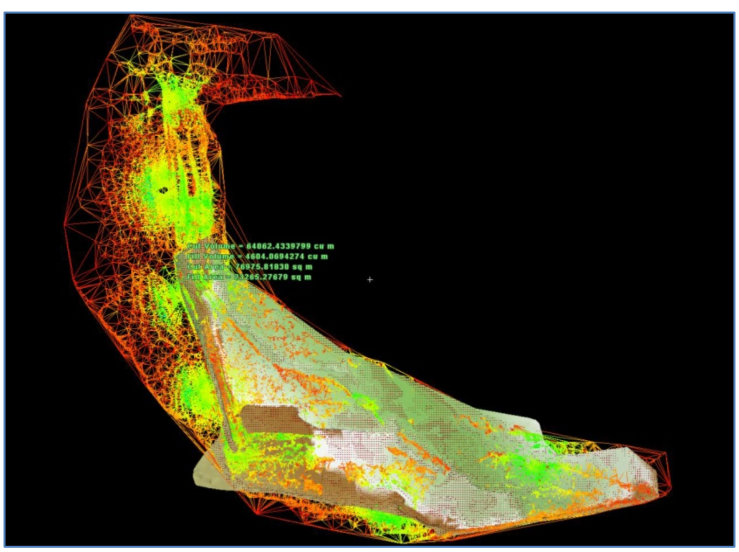


Fig. 7 A comparison of the two surface models to derive the common area and the elevation differences between April and May

The result is a simple, easy to read and analyze table of volumes and areas measured. This data can be used to judge performance of in house excavators and haulers or to verify invoicing of 3rd party contractors. As with all projects from GDM the deliverables can be customized to meet the needs of each client. Below we have tables 1 and 2 with the results of the volumetric analysis from April to May.

Sample Volumetric Data

table 1	**Cut Volume**	**Fill Volume**	**Volume Removed**
Cubic Feet	2262343.461	162591.161	2099752.3
Cubic Yards	83790.498	6021.894	77768.604
Cubic Meters	64062.433	4604.069	59458.364

table 2	**Cut Area**	**Fill Area**	**Total Common Area Surveyed**	**Total Area Surveyed (09.Apr)**	**Total Area Surveyed (16.May)**
Square Feet	828557.491	250424.343	1078981.834	1151417.861	2310843.965
Square Yards	92061.943	27824.927	119886.87	127935.317	256760.440
Square Meters	76975.818	23265.276	100241.094	106970.648	214685.289
Acre	19.021	5.748	24.769	26.433	53.049

In fact, the client for whom GDM produced the above tables discovered a discrepancy between our analysis and their hauler's invoice. The contractor claimed removal of roughly 85,000 banked cubic yards of material. Using our month to month volume measurements, our client could show verifiable evidence that the contractor's estimates were erroneous. This saved our client $9000.00 in haulage fees in a one month period.

Finally, we come to the numbers for our accuracy case study. Using the same methodology as that described above, GDM performed a volumetric analysis using the surface model from the 100 foot grid and the 3 foot grid respectively. When compared to the April base scan the model from the 100 foot grid shows a removal of 73,397 banked cubic yards. As the above table reflects, the model from the 3 foot grid shows a removal of 77,768 banked cubic yards. That is a difference of 4,371 cubic yards or in this case 176 cubic yards per acre! At that rate it does not take long to see a difference in accuracy translated to a difference in your bottom line.

Geophysical Data Management, Inc. provides mapping services of all types and is an industry leader in the field of High Definition Laser Scanning. With Offices in Austin, TX; Dallas, TX; and Nashville, TN we can quickly allocate personnel and resources to sites worldwide. For more information on High Definition Laser Scanning or our many other services visit our website at www.GPDMinc.com or contact us at the number listed below.

Faster, Safer and More Accurate… all at a price that is comparable to traditional methods. For a demonstration of how High Definition Laser Scanning can improve your bottom line, contact Geophysical Data Management, Inc. today.

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