

3D Modeling for Area and Volume

Drones are one of the greatest technological advancements of the 21st century. With the advancements in camera technology, UAV's can be used for a wide range of commercial applications, combined with 3D mapping software, what was once a half- to a full-day job can now be accomplished in just a few hours. Drone mapping has huge potential for several applications. One, in particular, is the construction sector. Being able to have an accurate and clear model of your project or the materials to complete your project is very important because a drone can fly lower to the ground it can get higher quality images. Drones equipped with GPS, a digital camera, and a powerful computer; surveys can be accurate up to one centimeter. 3D mapping is accomplished by photogrammetry, this is the science of taking measurements from photographs. When a 3D map is made, multiple overlapping images (80% to 90%) of the ground are taken as the UAV flies on a predetermined flight path. To accomplish this as a pilot would be very hard. If your drone can fly by waypoints this can be accomplished, there are also several apps to make this easier. After the flight, the pictures need to be stitched together to make a model. To accomplish this, we use 3D mapping software and a powerful computer. The software used is Pix 4D. The images are loaded in, and the geographic location is established then the software does the rest for you. If someone tried to do this themselves it would not be as quick.

When an asphalt company resurfaces a road. They often grind up the old road to reuse the materials that go into the new road, this is called RAP. The RAP is stored in stockpiles as well as the new dry materials that go into the road. These stockpiles must be monitored for quantity purposes. Up until a few years ago, to do this a person had to go out and set up a total station as well as a rover unit, to survey the pile(s). Most of the time there is more than one pile. A person would have to walk around the pile(s) taking shots as well as the top of the pile to get a cross-section. Then they had to upload into a computer and create discon lines so they could get a quantity. This would have to be done for all stockpiles at the plant.

I had the opportunity to fly a stockpile and go through the modeling process to get the asphalt company a quantity on one of their aggregate piles. First off, at the time I did not have my pilot's license, so one of our pilots from another office accompanied me as the pilot in command. We have two different drones. We decided it would be a good time to see if there is much of a difference between the two drones. As far as the final numbers. The two drones are the Phantom pro4 v2 and the Phantom RTK. To make this the best possible flight, there had to be some preflight work/research. First off, I used Google Earth to get an idea of the location and the layout. Second, and this is where things start to go in different directions. For the Phantom 4 v2, you can use preparatory software to plan and execute your flight, such as the Pix4D app, Phone Deploy, etc. The RTK comes with preinstalled software that you are required to use, which is not as user friendly as the others. Next, I loaded it directly into the flight controller. I got on Google Earth pro and drew a polygon around the area I figured was the stockpile from the description. Then I uploaded it into the controller and planned the flight. However, I did not find out if you can use Google Earth to plan your flight for the RTK.

After arriving on-site, it was clear that since the time that Google Earth took that shot. The pit had changed a bit as far as size. The area we were in was very bad on cell service. Meaning, we could not get the overlying map to load or get an idea of where we were. Every time something loaded in, it showed us in the middle of a field. Well, after some driving around to try and get a better signal. I figured out the pit had grown. Here is a quick tip if you ever find yourself in this situation, you can walk around by the object you want to fly while holding the controller. It will draw a line you can use that line to get an idea of the area of interest. In my case, that is what I had to do. I started the controller and

3D Modeling for Area and Volume

drone. Then I walked around the piles a bit. It showed us in the middle of the field. So, we figured the pit had changed. We tried it and got a successful flight in the first shot.

While I was walking around, I noticed pieces of lath on the ground painted pink. Later, I found out that these are ground points that you shoot before you fly. There is a minimum of four to five. These are Ground Control Points or GCP's. This is how you would georeference your project. It also reduces errors in your project. They also create image geotags. Geotags are GPS coordinates for each image. When flying an RTK drone you don't have to take GCP's. Recently drone manufactures have integrated real-time kinematic (RTK). This allows 3D position detection within just a few centimeters. However, if you have the means GCP's are not a bad idea either. It does add time. Imagine doing a flight that is 6hrs away. However, if you have the means I would do it just to be safe. Imagine doing a flight that is 6hrs away, then getting back to the office to process, and you find out the drone lost connection to the ground station. Once I arrived at the office, I began the work of processing. This was my first time using Pix4D. After a little bit of trial and error and a lot of time, because it takes a while for the computer to process, I finally got a model set up in Pix4D. I can see how having a powerful computer makes getting the model done faster and easier. I did one using RTK and without RTK. The difference in X, Y, & Z error was quite different. Below, is an example.

Fields	RTK (99% fixed)			Standalone		
	Error X [m]	Error Y [m]	Error Z [m]	Error X [m]	Error Y [m]	Error Z [m]
CKP_02	-0.018	-0.014	0.034	0.821	-1.377	-1.814
CKP_03	0.009	0.018	0.008	0.541	-0.842	-2.884
CKP_09	0.038	0.017	0.054	-0.004	-0.864	-4.366
CKP_10	0.014	0.045	0.051	0.214	-0.473	-3.555
CKP_11	0.036	-0.027	-0.016	-0.136	-1.540	-3.875
CKP_12	0.051	-0.028	-0.013	0.035	-1.669	-3.500
CKP_16	0.014	-0.014	0.013	0.259	-1.502	-3.358
CKP_18	-0.001	-0.002	0.011	0.427	-1.065	-3.395
CKP_21	0.005	0.027	0.024	0.362	-0.591	-3.332
CKP_23	0.017	0.012	-0.004	0.035	-0.643	-4.235
CKP_24	0.043	0.011	0.005	-0.057	-1.161	-4.335
Mean [m]	0.019	0.004	0.015	0.227	-1.066	-3.514
Sigma [m]	0.020	0.022	0.022	0.278	0.397	0.701
RMS Error [m]	0.027	0.022	0.027	0.359	1.138	3.583

After creating the model. I used the volume function in Pix4D to draw around what I wanted the software to calculate the area of. I did one with the RTK and my coworker did a model with the Phantom 4 V2. The results were close, the difference in results could have been due to the way we drew our boundaries.

3D Modeling for Area and Volume

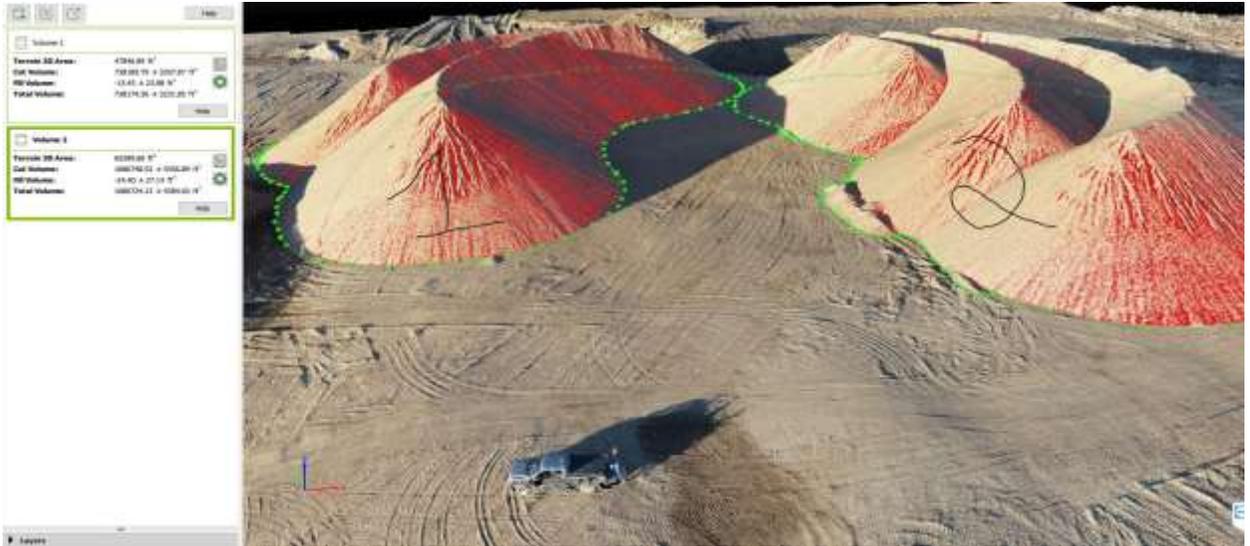


Figure 1

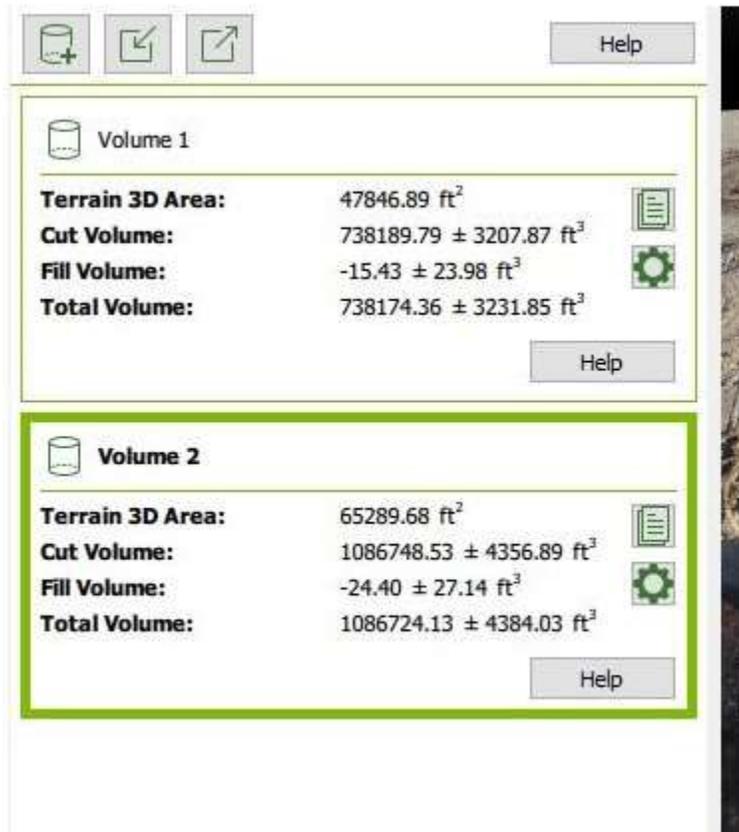


Figure 1.2: Phantom 4 V2 (non-RTK) with GCP's

3D Modeling for Area and Volume

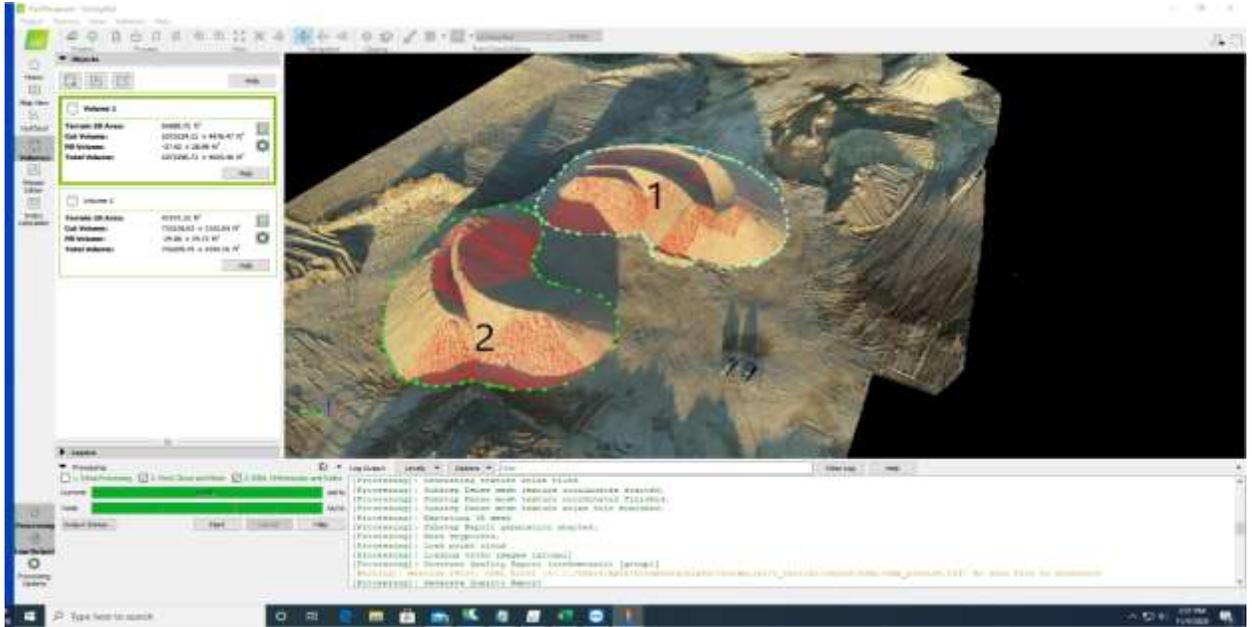


Figure 2

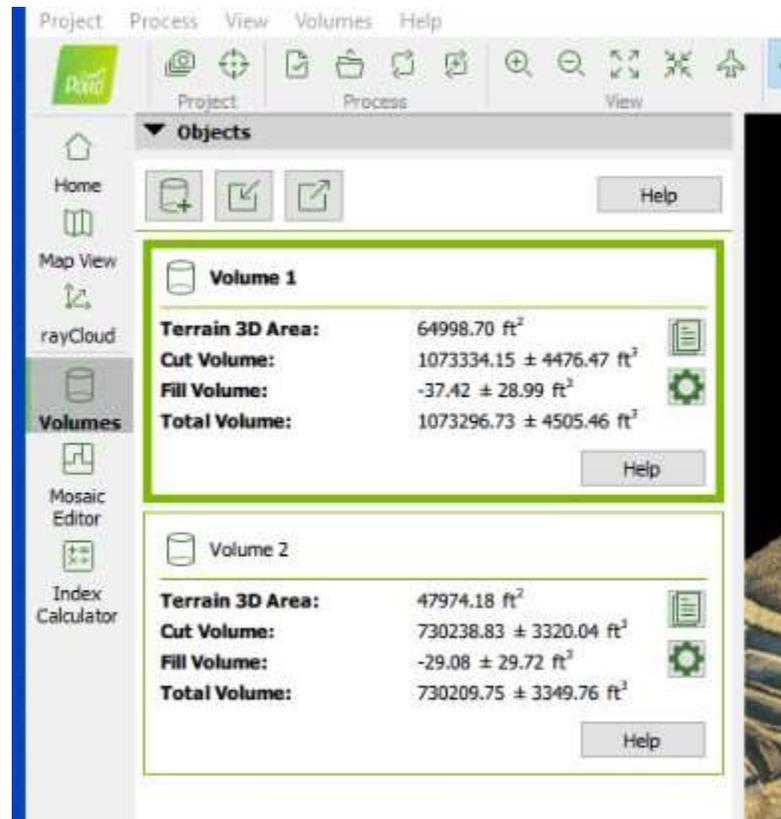


Figure 2.2: Phantom RTK

3D Modeling for Area and Volume

As you can see there were 2 piles to fly and two separate volumes needed. We both modeled the same piles at once. Both flights were performed at a 60m altitude to insure good ground distance. With the volume tool, you can draw a perimeter around the area or areas you wish to get an area or volume for. The volume from 1.2 number one. Goes with Figure 2.2 number two. This is due to the way I drew out the perimeters.

Most maps today are made with photos from an airplane. To accomplish this work, in the same manner, would be very time consuming and expensive. Drones are relatively inexpensive, so it is very cost-effective in the field. This was a fun little project, like everything, there is going to be a learning curve. I look forward to gaining as much knowledge as I can, the more I get to fly.

Bibliography

Corrigan, F. (2019, August 28). *Introduction to UAV Photogrammetry and Lidar Mapping Basics*. Retrieved from Drone Zone: <https://www.dronezon.com/learn-about-drones-quadcopters/introduction-to-uav-photogrammetry-and-lidar-mapping-basics/>

Taddia, Y., Stecchi, F., & Pellegrinelli, A. (2019). Using DJI phantom 4 RTK Drone for Topographic mapping of costal areas. *int. Arch Photogramm. Remote sens. Spatial Inf.*, 625-630.

Terwiller, B., Ison, D., Robbins, J., & Vincenzi, D. (2020). *Small unmanned aircraft systems guide*. New castle: Aviation Supplies & Academics, Inc.