Exercise 1: Process drone data to model a large construction project

Technical note

This exercise requires the download of large amounts of data, and based on your individual system specifications, it can potentially take long periods of time to process the data. It is recommended to briefly review the exercise prior to downloading data. Additionally, please review ArcGIS Drone2Map Help: Hardware resources and performance to verify your specifications and to gauge performance expectations. A solution set or project file of results dataset is available of limited products generated if you determine that your system may take too long to perform the product generation.

Note: Due to individual system variables that cannot be accounted for, the estimated time to complete this exercise (40 minutes) does not include any of the download time for data nor the potential processing time to create the various 2D and 3D products in ArcGIS Drone2Map.

Software requirements

- ArcGIS Drone2Map 2023.1
- ArcGIS Pro 3.1

Introduction

ArcGIS is capable of using imagery from many sources, including unmanned aerial vehicles (UAV), or drones. With these sensors, high-resolution imagery can be captured and quickly added to your GIS to provide an updated view of your project site or construction site or for use in advanced analysis. Several ArcGIS Reality products can help manage your drone data, as described in the following table.

Managing your drone data	
Esri product	Capabilities and uses
ArcGIS Reality for ArcGIS Pro	ArcGIS Reality for ArcGIS Pro is an ArcGIS Pro extension that expands ortho mapping capabilities with high-fidelity 2D, 3D, and True Ortho product generation.
Site Scan for ArcGIS	Site Scan for ArcGIS provides the ability to program your drone's flight plan and then create imagery products in a cloud-based workflow.
ArcGIS Drone2Map	ArcGIS Drone2Map provides a desktop-based workflow for creating imagery products from drone data.

Additionally, ArcGIS Reality mapping in ArcGIS Pro can be used to create orthorectified imagery. Depending on the origin of the input imagery and the organization requirements, the choice of which application to use can vary.

Note: The exercises in this course include View Result links. Click these links to confirm that your results match what is expected.

Scenario

In this exercise, you have been provided with recent imagery of a building under construction (Building E) on the Esri Redlands, California, campus, which was collected by a drone. Imagine that you are a GIS analyst with the company providing aerial surveys of the construction site. Your task is to use the data to create 2D and 3D imagery products. These products will be used to show progress on the development to stakeholders, project engineers, and the construction team. You will use ArcGIS Drone2Map and the following workflow to create these imagery products.

Creating 2D and 3D products in ArcGIS Drone2Map follows a generalized workflow based on your AEC project needs and requirements. You can customize your workflow as necessary.

Estimated completion time: 40 minutes

Expand all steps | Collapse all steps

- Step 1: Install ArcGIS Drone2Map

Because you will be using ArcGIS Drone2Map, you will need to install the software before creating imagery products.

a Open a web browser in private or incognito mode.

Note: To learn how to enable private browsing, go to How to Enable Private Browsing on Any Web Browser (https://links.esri.com/HowToBrowse).

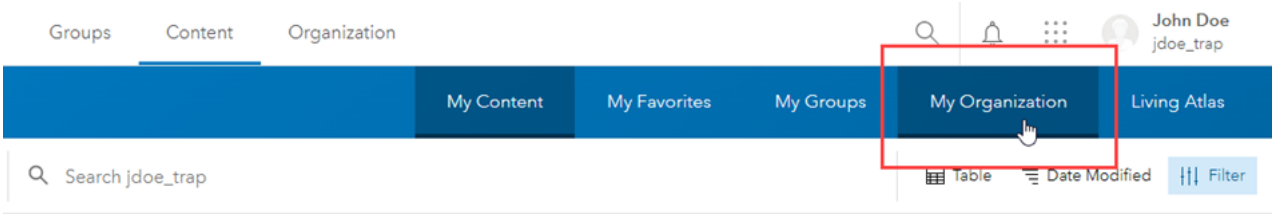
b In the address bar, type **www.arcgis.com** and press Enter.

c Click Sign In.

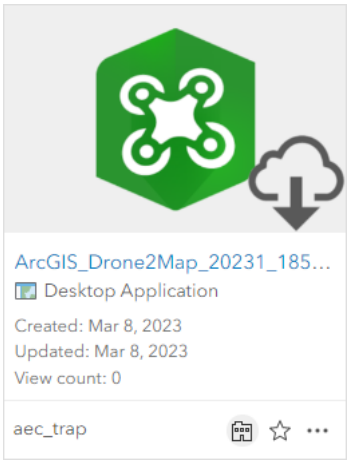
d Under ArcGIS Login, copy and paste or type your MOOC course ArcGIS username and password.

e On the Transform AEC Projects With GIS And BIM Home page, click the Content tab.

f Click the My Organization tab, as indicated in the following graphic.

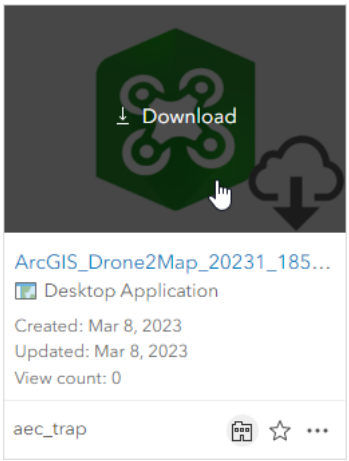


On the My Organization page, you will see a Desktop Application download button for ArcGIS Drone2Map.



*Step 1f***: Install ArcGIS Drone2Map.*

g On the My Organization page, click the ArcGIS Drone2Map graphic to download ArcGIS Drone2Map, as in the following graphic.



h Specify a download location for the ZIP file.

Note: ArcGIS Drone2Map requires 1.9 GB of disk space to download, so ensure that your download location has enough space to download and install Drone2Map.

i After the download completes, extract the file on your local computer.

This ZIP file contains the .exe file to install ArcGIS Drone2Map.

j After the extract is complete, double-click the .exe file

k Follow the installation instructions, accept the Master Agreement, and then accept the rest of the defaults.

l When you are finished, close the private or incognito web browser.

- Step 2: Download the exercise data files

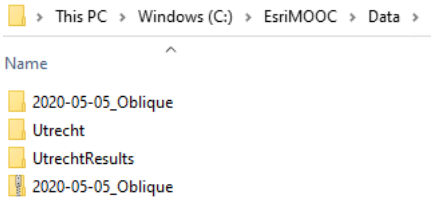
In this step, you will download the exercise data files.

a In a web browser, go to https://links.esri.com/2020-05-05_Oblique and download the 2020-05-05_Oblique ZIP file.

Note: The complete URL to the exercise data file is https://www.arcgis.com/home/item.html??id=b427ec7e091b4f17b768838a33ee4d6a.

Note: The size of this dataset is approximately 581 MB, so be sure that your computer has enough space to download the data.

b Extract the files to the **C:\EsriMOOC\Data** folder.



*Step 2b***: Download the exercise data files.*

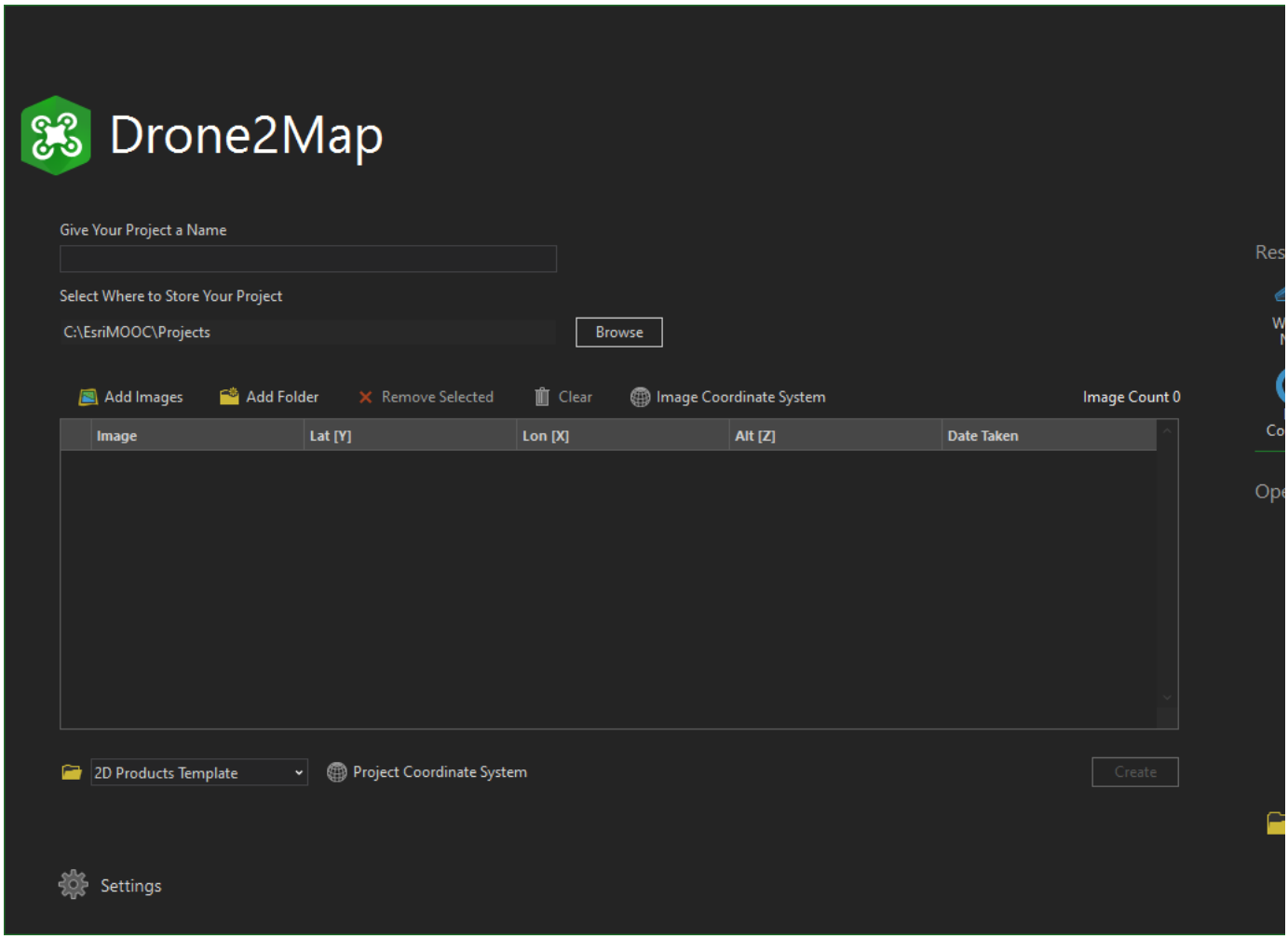
c When you are finished, close the web browser and File Explorer, if necessary.

- Step 3: Add drone data

In this step, you will create a new project and then add drone images of Building E collected in May 2020 that will be used in the project.

a Start ArcGIS Drone2Map.

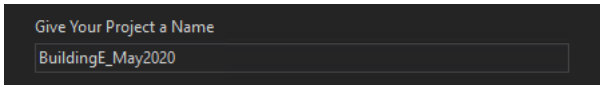
b When prompted, sign in to Drone2Map with your MOOC credentials.



*Step 3b***: Add drone data.*

Note: If you encounter problems signing in to Drone2Map with your MOOC credentials, uncheck the Automatically Sign-In option and try again.

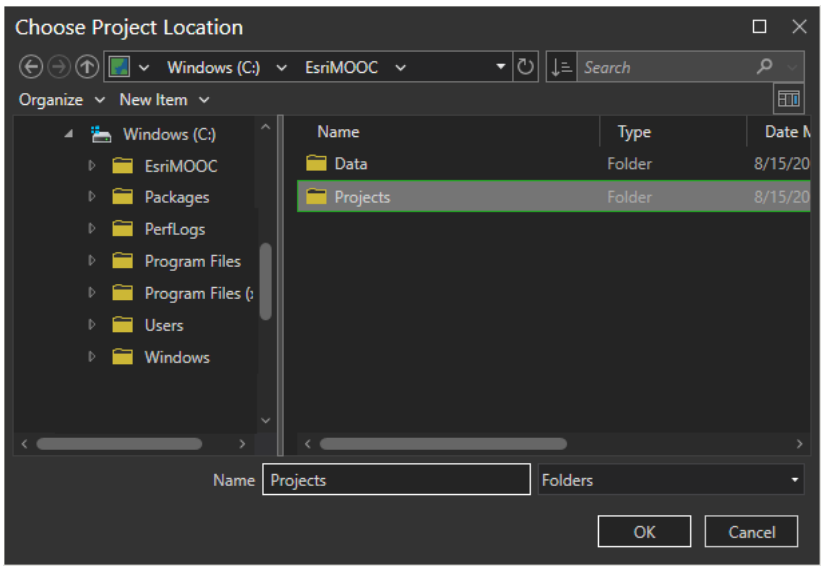
c In the Give Your Project A Name field, type **BuildingE_May2020**.



*Step 3c***: Add drone data.*

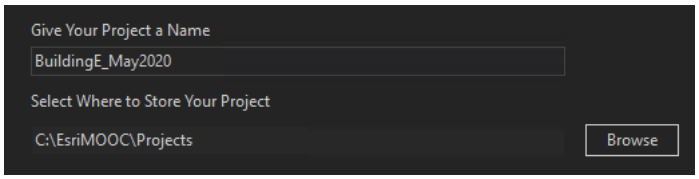
d For Select Where To Store Your Project, click Browse.

e In the Choose Project Location dialog box, browse to **..\EsriMOOC** and click the Projects folder to select it.



*Step 3e***: Add drone data.*

f Click OK, and then notice that your new project name and the location have been updated.

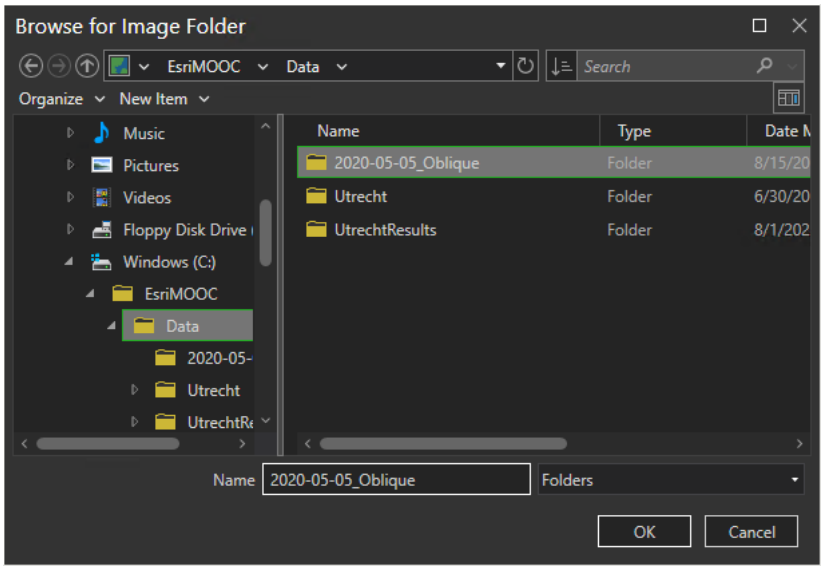


*Step 3f***: Add drone data.*

Now you will add the drone images to your project.

g Above the Images field, click Add Folder .

h In the Browse For Image Folder dialog box, browse to **..\EsriMOOC\Data** and select the 2020-05-05_Oblique folder.



*Step 3h***: Add drone data.*

i Click OK.

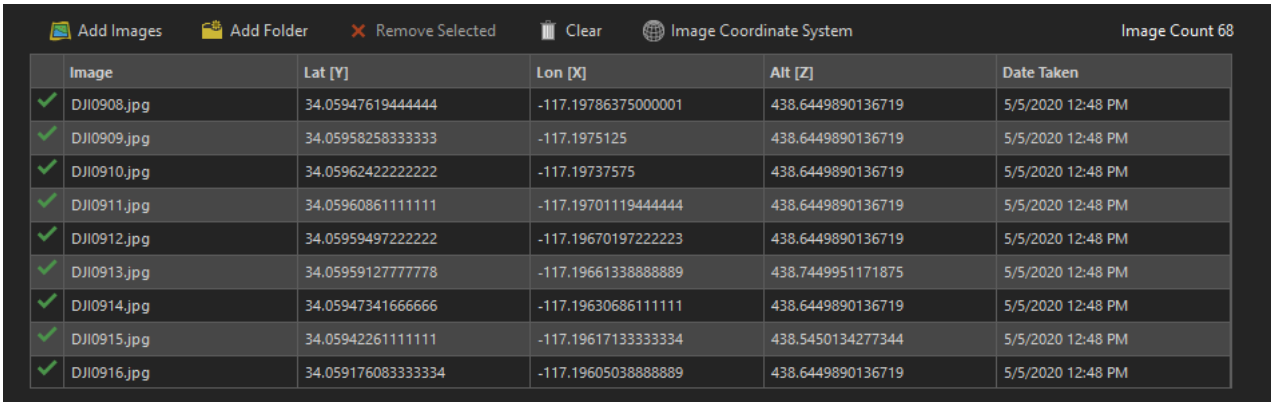


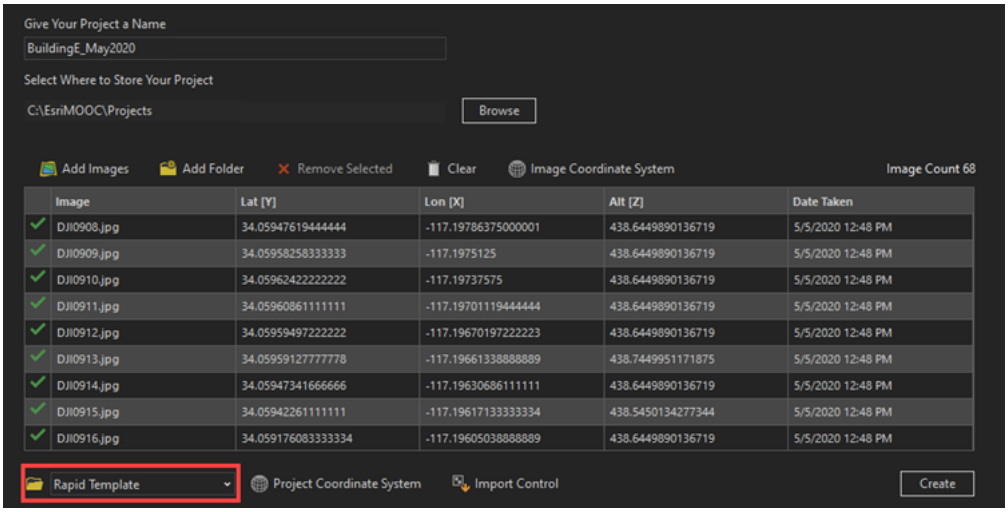
Image	Lat [Y]	Lon [X]	Alt [Z]	Date Taken
DJI0908.jpg	34.05947619444444	-117.19786375000001	438.6449890136719	5/5/2020 12:48 PM
DJI0909.jpg	34.05958258333333	-117.1975125	438.6449890136719	5/5/2020 12:48 PM
DJI0910.jpg	34.05962422222222	-117.19737575	438.6449890136719	5/5/2020 12:48 PM
DJI0911.jpg	34.05960861111111	-117.19701119444444	438.6449890136719	5/5/2020 12:48 PM
DJI0912.jpg	34.05959497222222	-117.19670197222223	438.6449890136719	5/5/2020 12:48 PM
DJI0913.jpg	34.05959127777778	-117.19661338888889	438.7449951171875	5/5/2020 12:48 PM
DJI0914.jpg	34.05947341666666	-117.19630686111111	438.6449890136719	5/5/2020 12:48 PM
DJI0915.jpg	34.05942261111111	-117.19617133333334	438.5450134277344	5/5/2020 12:48 PM
DJI0916.jpg	34.059176083333334	-117.19605038888889	438.6449890136719	5/5/2020 12:48 PM

*Step 3i***: Add drone data.*

There are now 68 oblique drone images collected of Building E under construction added to your project.

Next, you will set the template to use as the default output product template for your project. Drone2Map includes several templates that you can use, allowing you to quickly create output products based on the needs or requirements of your project. However, if you choose to, you can modify the output products required for your individual needs. In other words, if you select the 2D Products template but decide while working in your project that you want to create 3D products, you have the ability to modify the processing options to reflect your requirements. For this project, you will be creating both 2D and 3D products to show project progress. You will start with the Rapid template to quickly verify that your drone collection importing of your imagery was successful.

j In the 2D Products Template field, click the down arrow and choose Rapid Template, as indicated in the following graphic.



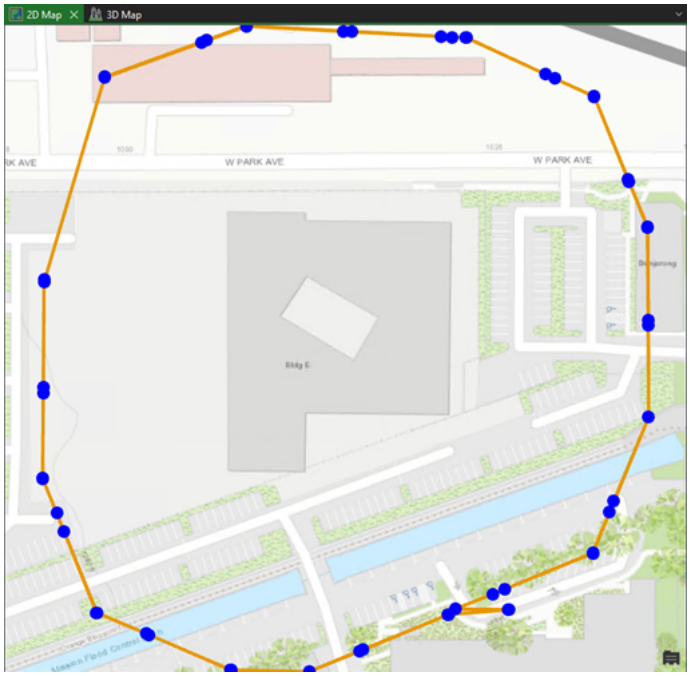
For more information on the default project templates available in Drone2Map, including the output product type and example uses, go to ArcGIS Drone2Map Help: Work with project templates.

All your input options to create your project and add images are now set.

k Click Create.

The Drone2Map project is created, and a 2D map is displayed, showing the construction project site.

l If necessary, from the Home tab, in the Layers group, click Basemap and select the Topographic basemap.



*Step 3l***: Add drone data.*

In Drone2Map, you will see 2D and 3D maps added to the display. The flight line pattern in the 2D map will be visible based on the arrangement of the input data.

m On the left side, review the Contents pane that shows the layers added to the map.

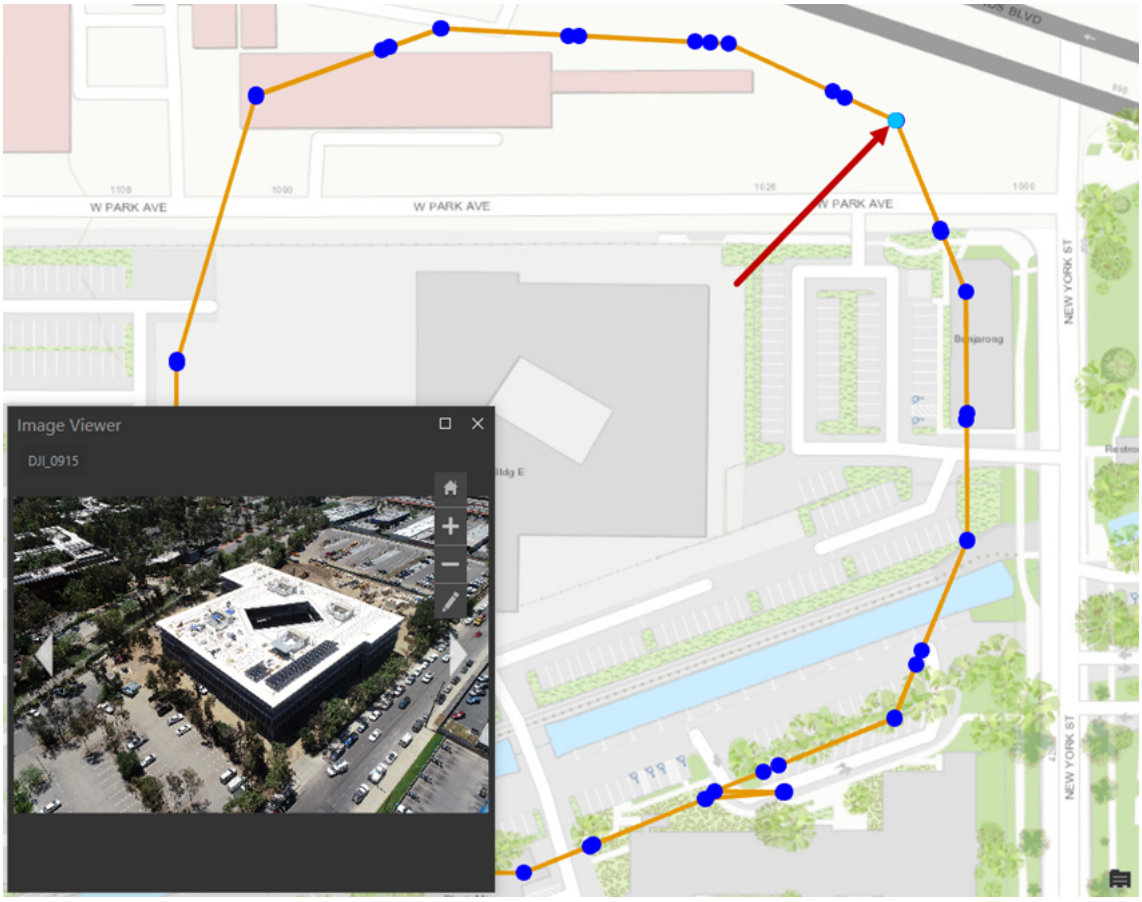
? What does the orange line represent?

- Answer
The orange line represents the flight line, or flight track, of the drone during collection.

? What do the blue dots represent?

- Answer
The blue dots are the enabled images that you added to the project and represent the point where the image was collected.

n In the map, near the upper-right (northeast) corner and along the northeast part the flight line pattern, click the blue dot for image DJI_0915, as shown in the following graphic.



The Image Viewer appears in a new window, showing the image that you just selected from the map. The purpose of the Image Viewer is to review input images before imagery products are created. You can add notes to images or even remove them if they are not needed for your project.

o On your own, examine a few of the other images in this collection of images.

p Close the Image Viewer.

Now that you have added images to a new project and examined the flight track and a few images, you are ready to configure the processing options.

- Step 4: Select processing options

ArcGIS Drone2Map is capable of producing many different imagery outputs. For this exercise, your specific construction project requirements indicate that you must create a True Ortho, various digital elevation models (DEMs), including both a digital surface model (DSM) and a digital terrain model (DTM), and a 3D point cloud and two 3D meshes.

In this step, you will select options for the 2D and 3D imagery products necessary to monitor the progress of the building construction.

a From the Home tab, in the Processing group, click Options.

The Options dialog box opens, where you can choose the products that you want to create and the parameters to use during the processing.

b In the Options dialog box, click the 2D Products tab.

c In the Image Collection section, for Orthorectification Method, click the down arrow and choose Solution Points.

d In the True Ortho section, confirm that the Create True Ortho box is checked.

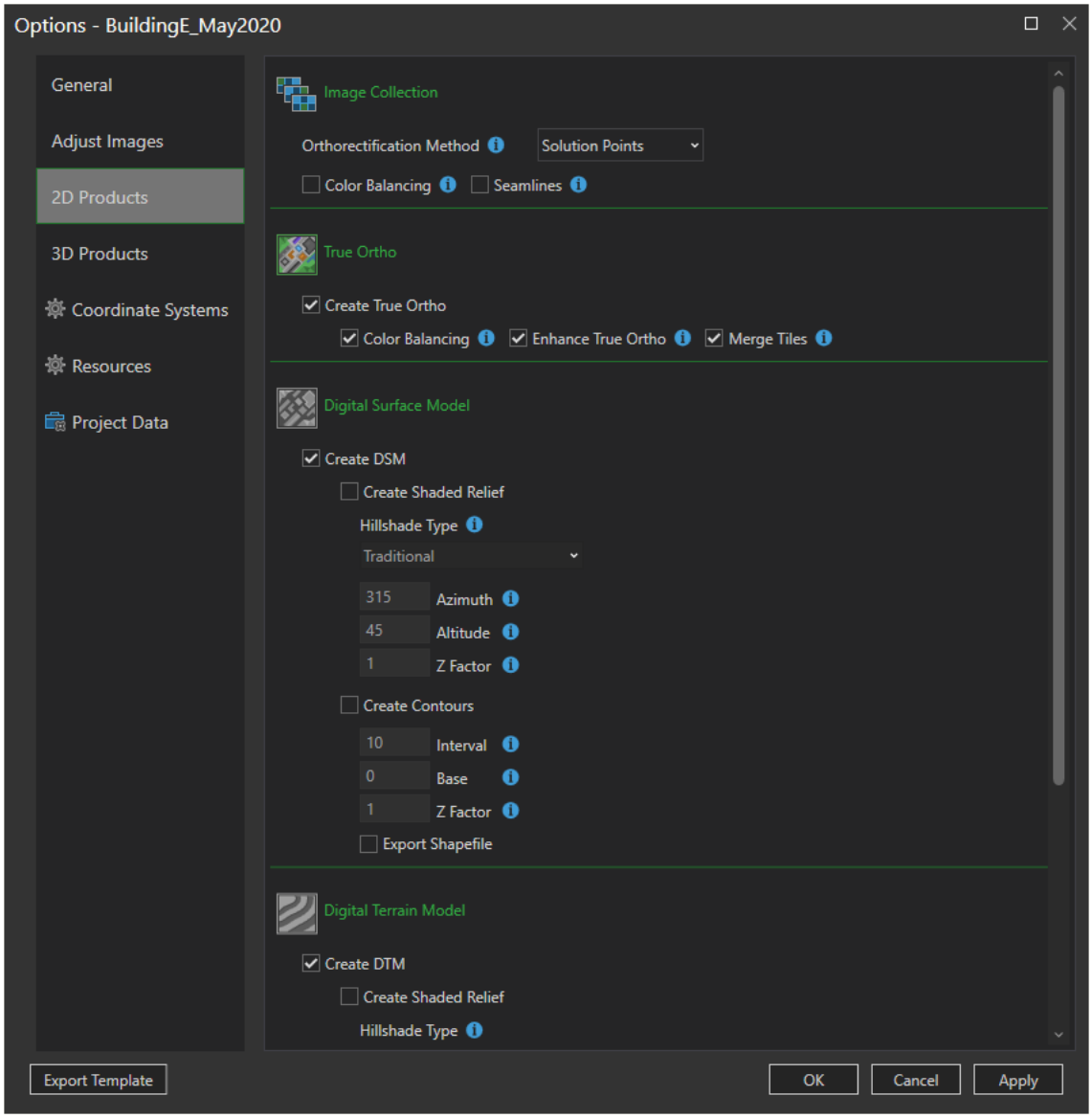
e In the Digital Surface Model section, check the box for Create DSM.

f In the Digital Terrain Model section, check the box for Create DTM.

- Hint

  You can point to the Information icon to see a detailed description of the individual parameters and settings.

g Verify that your parameters look like the following graphic.



For more information about the 2D Products options, go to ArcGIS Drone2Map Help: Processing options – 2D products.

Now you will set the processing options for the 3D products that you want to create. You will select options to create scene layer packages (SLPK) for the DSM and 3D textured meshes. Additionally, you will create a LAS point cloud. The LAS point cloud is a set of points that represents coincident locations in the project area where several pixels from various input rasters are the same. These keypoints are then used to create a point cloud that can be used to model different elevation imagery products.

h In the Options dialog box, click the 3D Products tab.

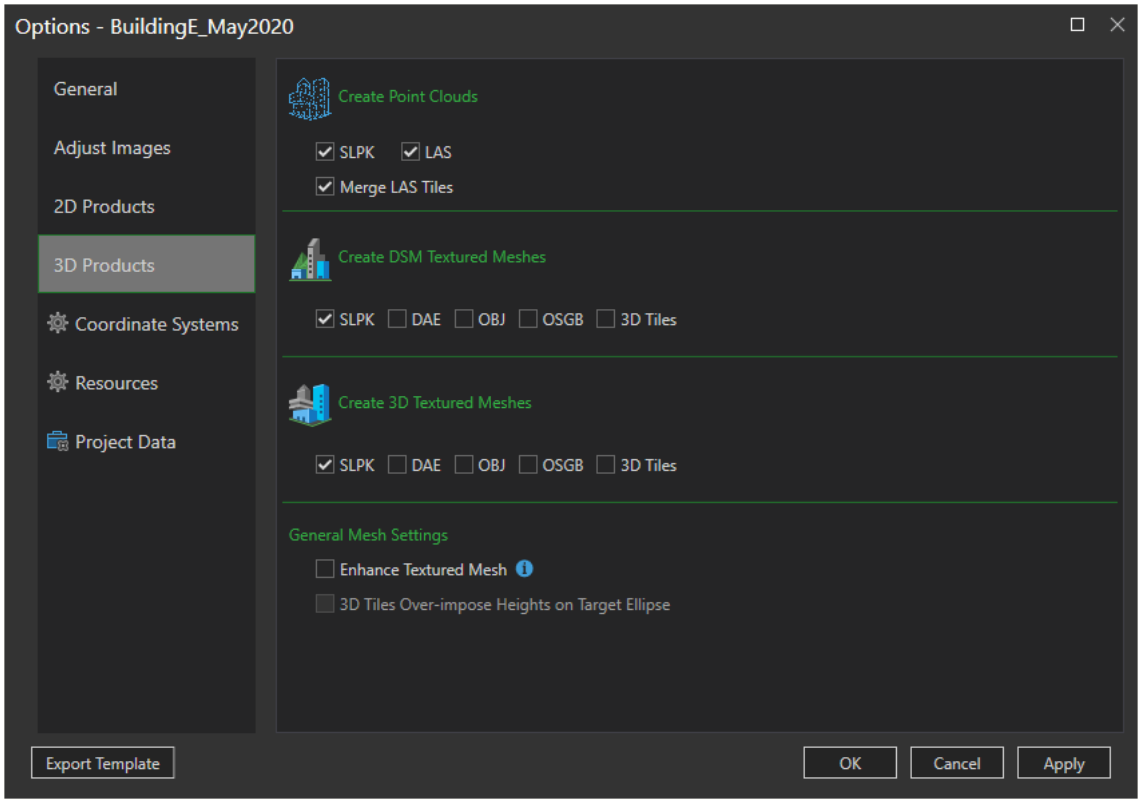
i In the Create Point Clouds section, check the boxes for SLPK, LAS, and Merge LAS Tiles.

The textured mesh options will create an object that can be viewed in three dimensions. The meshes can be used to model what the project area looks like as if you were on the ground looking around at the features.

j In the Create DSM Textured Meshes section, check the box for SLPK.

k In the Create 3D Textured Meshes section, check the box for SLPK.

l Verify that your parameters look like the following graphic.



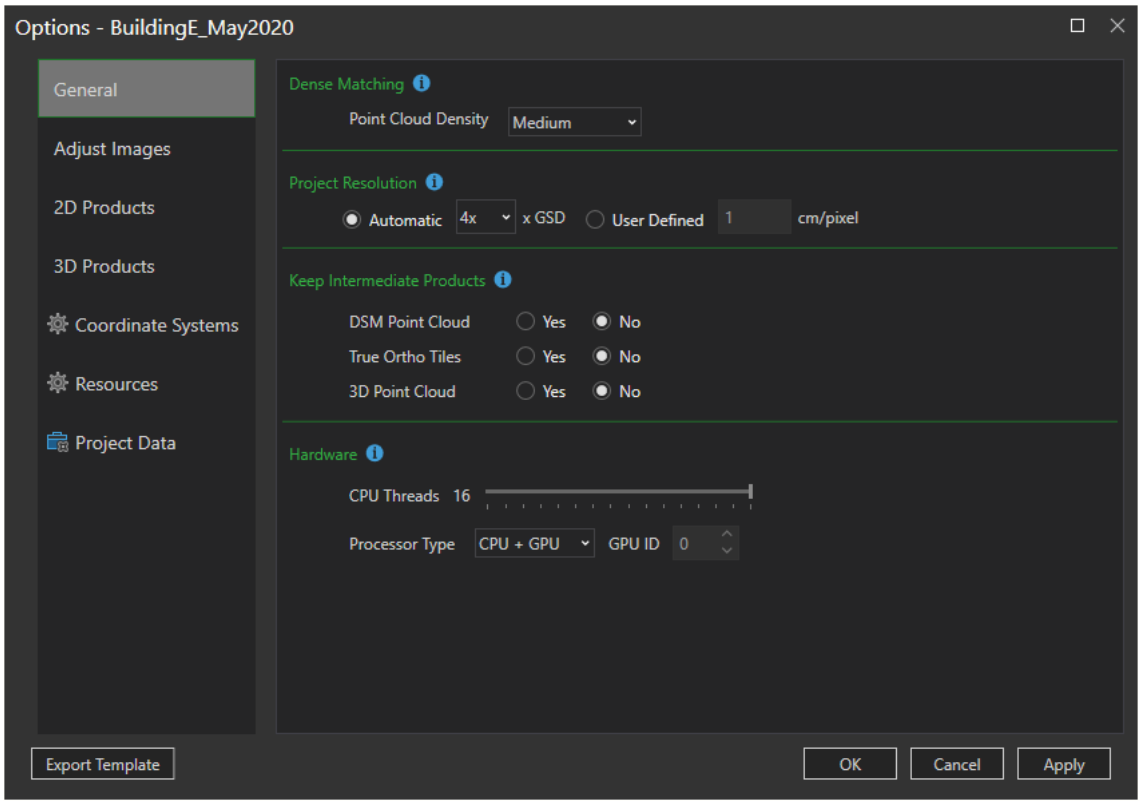
For more information about the 3D Product options, go to ArcGIS Drone2Map Help: Processing options – 3D products.

m Click the General tab, and then ensure that Point Cloud Density is set to Medium and Project Resolution: Automatic is set to 4x.

If you are working on a computer that is GPU-enabled, Processor Type is set automatically to use both CPU and GPU processors to maximize processing speeds. For more information on different factors that can influence processing speed of your drone collections, go to ArcGIS Drone2Map Help: Hardware resources and performance.

n If possible, in the Hardware section, for CPU Threads, set the slider bar to the maximum number available for your machine.

o If possible, and if necessary, in the Hardware section, set the Processor Type to CPU + GPU.



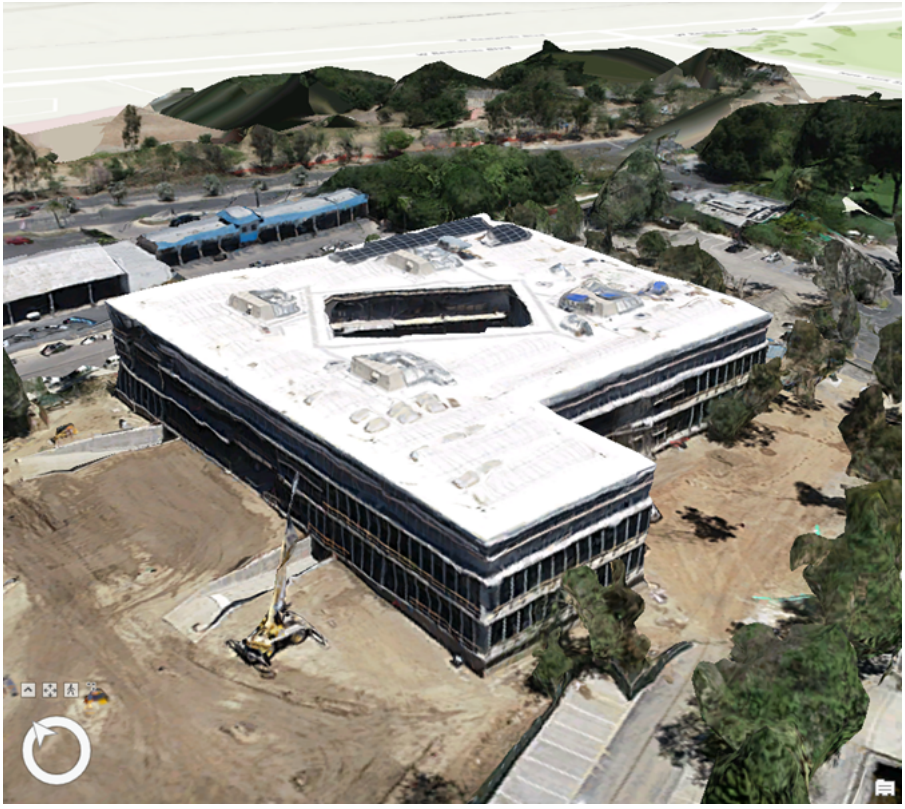
Note: In the preceding graphic, the hardware used has 16 CPU Threads available and an NVIDIA GPU enabled, so the CPU+GPU is the option shown. Set your Hardware options to maximize your processing speed based on your available resources.

Point Cloud Density

The Density Matching (Point Cloud Density) defines the level of density of the final point cloud used to derive and build the geometric features of the meshes. As the density of the point cloud increases from Low to Ultra, the processing speed increases as well. Additionally, the size of the mesh products increases, too. For the Rapid Template, the Project Resolution is set to 4x by default. This option multiplies the default ground sampling distance (GSD) by a factor of 4, in this case, and helps reduce the file size on disk of the final product. GSD is the distance between the center points of adjacent pixels, and it is related to pixel size and spatial resolution. Increasing the multiplier will not only increase the product GSD and image resolution, but it will also create a larger file and increase the processing time.

Tip: Use lower point cloud density–such as Low or Medium–and coarser GSD settings for initial product creation to maximize processing speed and time. Use higher settings for could density–such as High or Ultra–and 1x only for final products or products for presentation.

The following graphics provide three examples of not only the point cloud density settings but also examples of different project resolution settings.



This graphic represents a 3D mesh product generated using a Medium point cloud density and a project resolution of 4x GSD. The resulting file size 41.3 MB.

This graphic represents a 3D mesh product generated using a High point cloud density and a project resolution of 4x GSD. The resulting file size 144.4 MB.

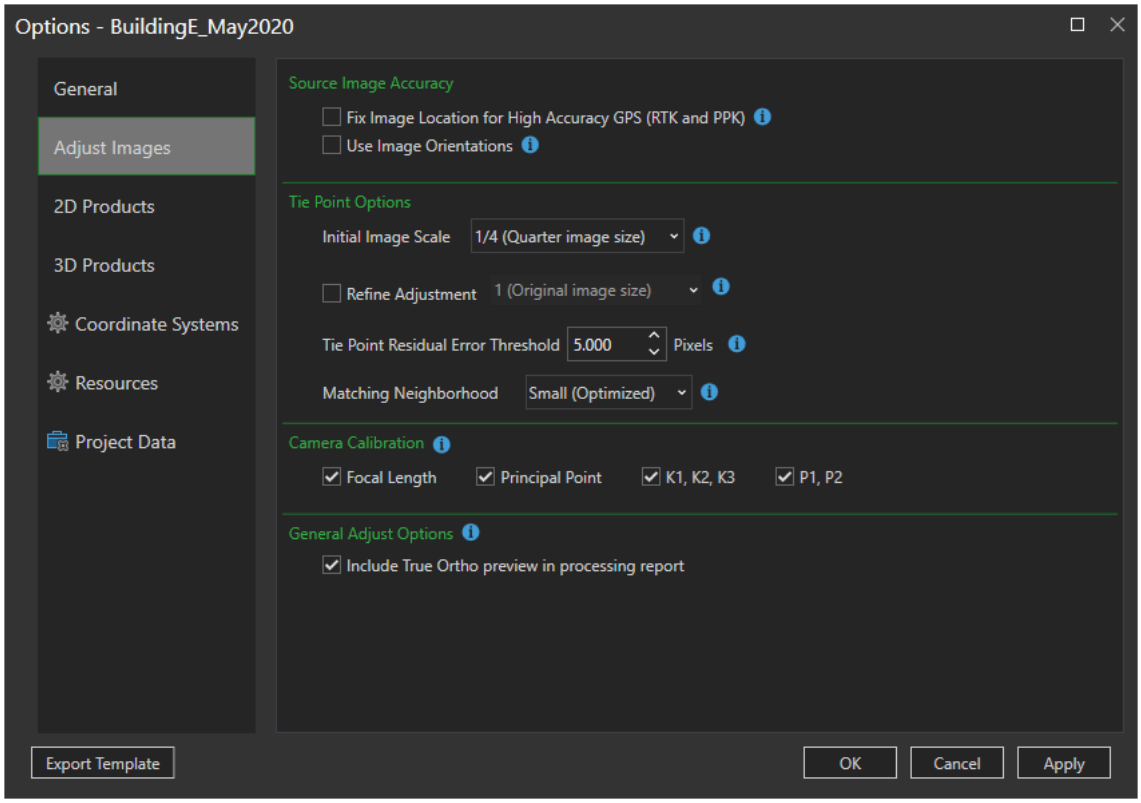
This graphic represents a 3D mesh product generated using a Ultra point cloud density and a project resolution of 1x GSD. The resulting file size 713.2 MB.

For more information and specifics about all the General options, go to ArcGIS Drone2Map Help: Processing options – General.

p Click the Adjust Images tab and review the various options that are available.

The options on the Adjust Images tab allow for finer control of certain image parameters, if necessary. You can define key adjustments to be used in the block adjustment process, tie point matching, and point cloud generation options. These parameters, and their settings, are dependent on the type of drone that you use for collection, the type of internal accuracy of the drone collection, different orientation variables, and calibration types. Refer to your drone manuals and documentation to see which of these that you may need to adjust when necessary.

q Verify that the Adjust Images tab parameters look like the following graphic.



For this exercise, and for these images, there is no need to adjust any properties or options for these images on this tab. For more information on these options, go to ArcGIS Drone2Map Help: Processing options – Adjust Images.

r On your own, examine the final two options tabs: Coordinate Systems and Resources.

In most cases, your coordinate system will be set based on the input parameter of your drone imagery, but you have the option to modify these, if desired. If you want to have a different output coordinate system, for instance, if your final project files are in a different spatial reference system than the drone imagery, the Coordinate Systems tab is where you can modify those parameters.

The Resources tab provides you with the flexibility of setting how you want to allocate various image resources, project settings, files, and image locations when necessary.

s Click OK.

For more information about these remaining options available on the Coordinate Systems and Resources tabs, go to ArcGIS Drone2Map Help: Processing options.

In this step, you selected the 2D and 3D products that you want to create and set their processing parameters. To further refine your output, you will provide ground control points.

- Step 5: Add ground control points

Ground control points (GCPs) are marked points on the ground used in aerial photography to identify known coordinate locations. These points are used to
improve the spatial registration and accuracy of your images by linking them to precisely measured ground locations.

When applied, GCPs include two parts:

- Known (x,y) coordinates for a photo-identifiable feature in a defined coordinate system (ideally including values that represent the uncertainty of the measurements as these coordinates cannot ever be absolutely accurate)
- "Links" to multiple images that show the location of that control point in each image

The "photo-identifiable feature" refers to either a temporary object, such as a black/white marker or white cross, or a permanent feature, such as the corner of a concrete block, that you can locate in your drone images.

Next, you will add GCPs to your project to improve the quality of the 2D and 3D products derived from your drone imagery. Upon being imported as
part of your project, these points appear on your map—based on the known (x,y) coordinates—and will provide more accurate results by controlling the spatial registration for your images.

While there are several methods to add control points to a project (see *More Information* below), you will import six GCPs from the construction site which were previously linked to this set of example images within a Drone2Map project, then exported as a zip file. In this case, the exported GCPs also include the image links, but in a normal project you will have to complete the process of linking control points to the images. The steps below will show you an example for one GCP, with the remaining five already completed.

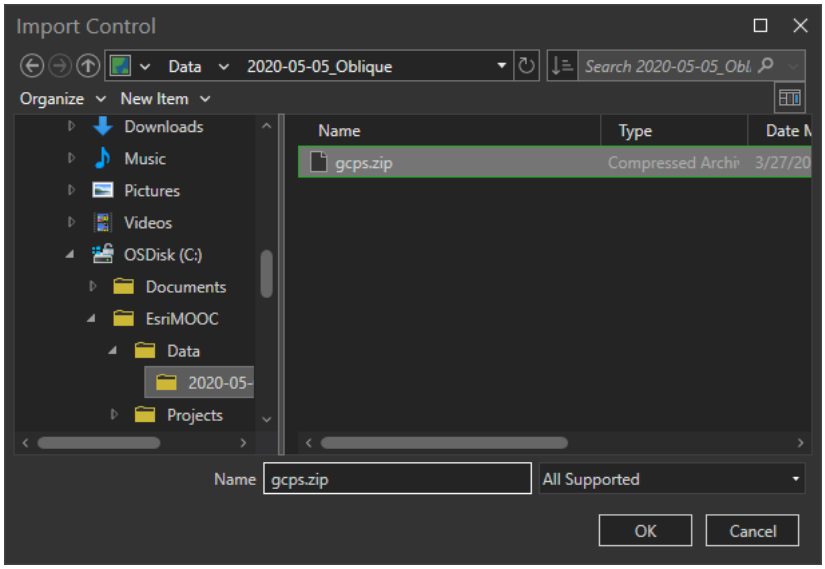
More information

a From the Home tab, in the Layers group, click Basemap and select the Imagery basemap.

The Imagery basemap is appropriate for viewing control points, as it will allow you to visualize the control points against features present in the imagery.

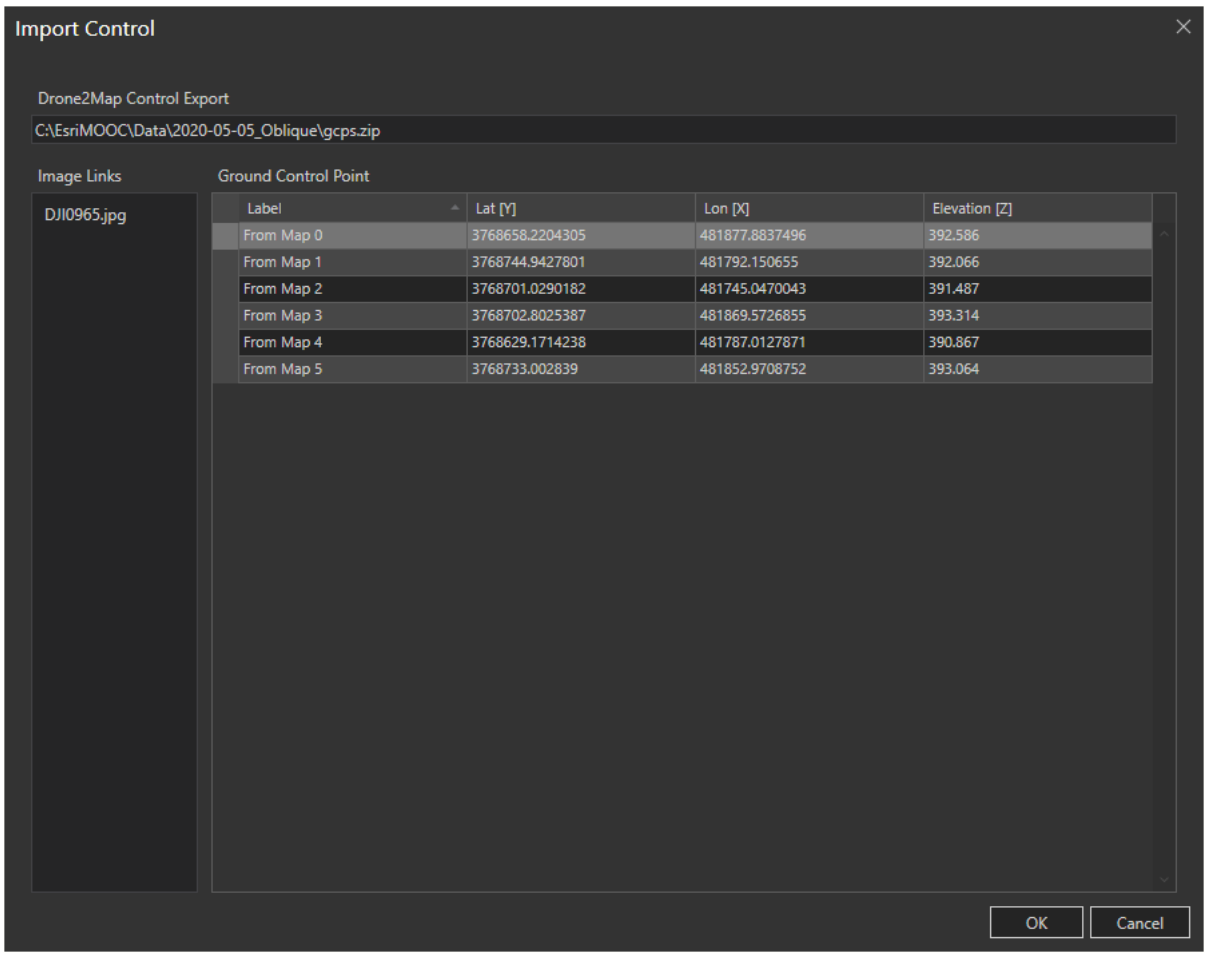
b From the Home tab, in the Control group, click the Control down arrow and choose Import Control.

c In the Import Control dialog box, browse to **..\EsriMOOC\Data\2020-05-05_Oblique** and select gcps.zip.



*Step 5c***: Add ground control points.*

d Click OK.



*Step 5d***: Add ground control points.*

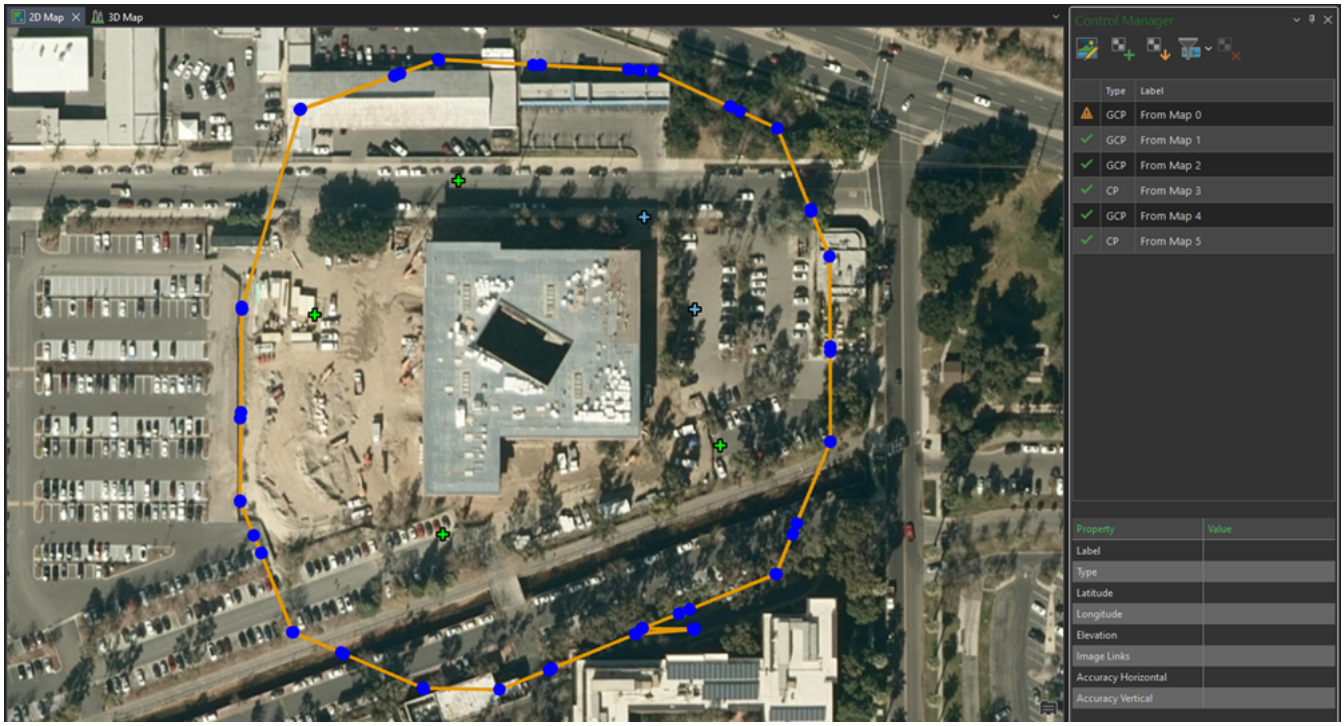
The Import Control dialog box shows the six GCPs that will be imported. If you select one of the control points, the dialog box will display the names of the image files, which are linked to the selected GCP. You will notice that the GCP labeled From Map 0 only has one image link, DJI0965.jpg.

e Select the GCP labeled From Map 3.

This GCP has eight image links. A GCP must be linked to a minimum of two images to be used during processing. However, Drone2Map recommends linking GCPs to three to eight images for best processing results.

> ? Does the GCP labeled From Map 0 have enough image links?
>
> - Answer
> No; for best results, it will need at least two more image links.

f Click OK.



*Step 5f***: Add ground control points.*

The six control points appear in the map as green and blue plus symbols—green symbols are ground control points (GCPs), and blue symbols are check points (CPs). The CPs will be used by Drone2Map to provide a measure of project accuracy in the Processing Report provided after processing.

The Control Manager pane also appears, showing information about the imported control points, including a type of GCP or CP. You will notice that five of the six control points have green check marks in the first column. These control points have the minimum number of image links and can be used for processing. However, the first control point, a GCP labeled From Map 0, has a yellow warning icon in the first column indicating a problem. Without additional image links, the From Map 0 control point will be ignored during processing.

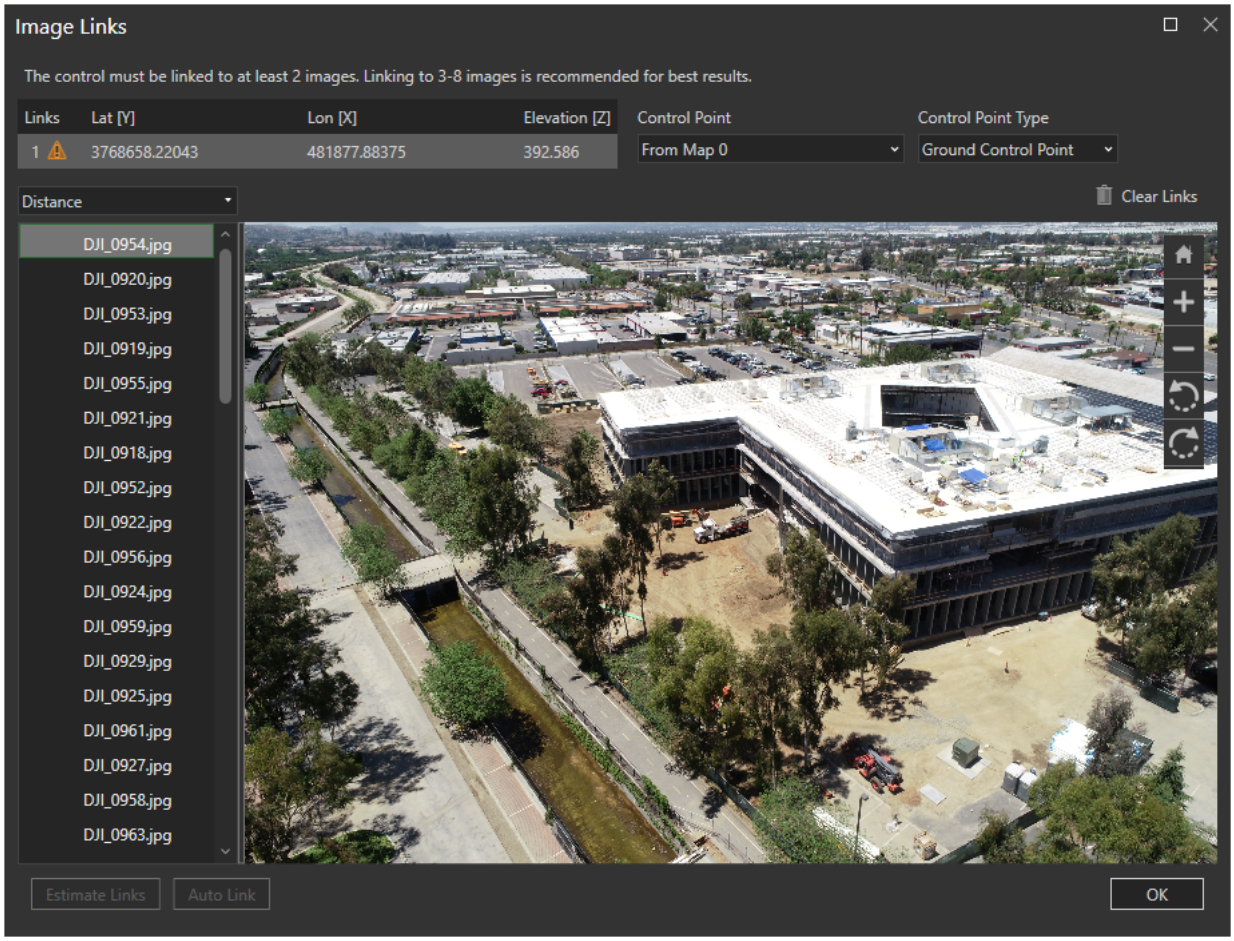
In this step, you added GCPs to use during processing of your 68 drone images. However, you identified one GCP is missing image links. Next, you will create additional image links.

- Step 6: Add image links to a ground control point

In the previous step, you identified a GCP that requires additional image links. In this step, you will add image links to the GCP. Upon completion of this step, your GCPs will be ready to use during processing of your 68 drone images; these GCPs will improve the accuracy of your drone data. As a result, the spatial accuracy of your final products will improve, as well as the overall quality of your image products.

a If necessary, in the Control Manager pane, select the first control point, a GCP labeled From Map 0.

b Near the top of the Control Manager pane, click the Show Image Links Editor button to open the Image Links window.

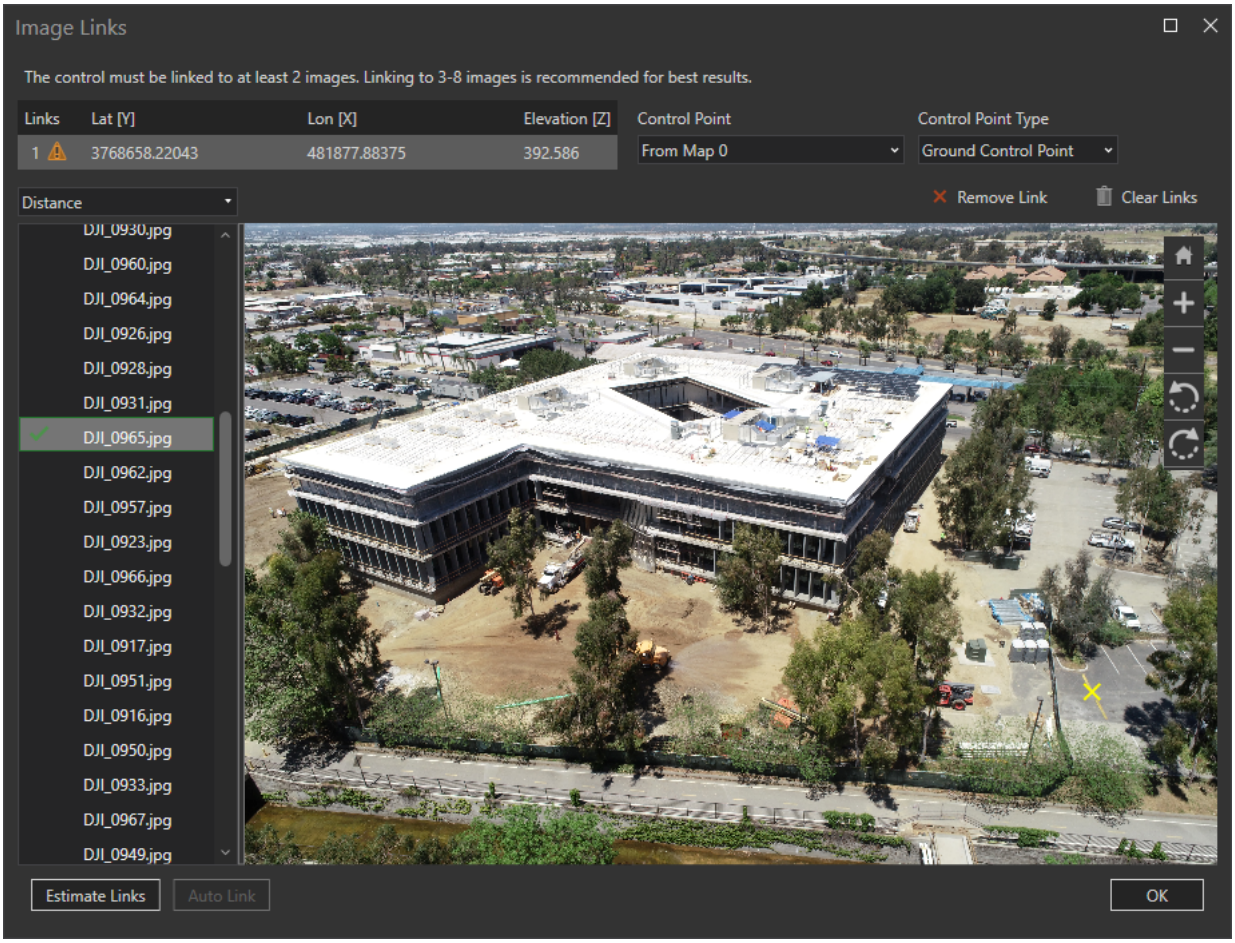


*Step 6b***: Add image links to a ground control point.*

Near the top left of the Image Links window, the coordinates and number of image links are shown for the selected control point. On the left side of the window is a list of the 68 drone images in the project, sorted by default by the distance from where the image was captured to the control point location.

c In the list of images, scroll down and locate the DJI_0965.jpg image.

d Click DJI_0965.jpg to select it.



*Step 6d***: Add image links to a ground control point.*

e In the bottom-right corner of the image, notice the yellow X, as indicated in the following graphic.

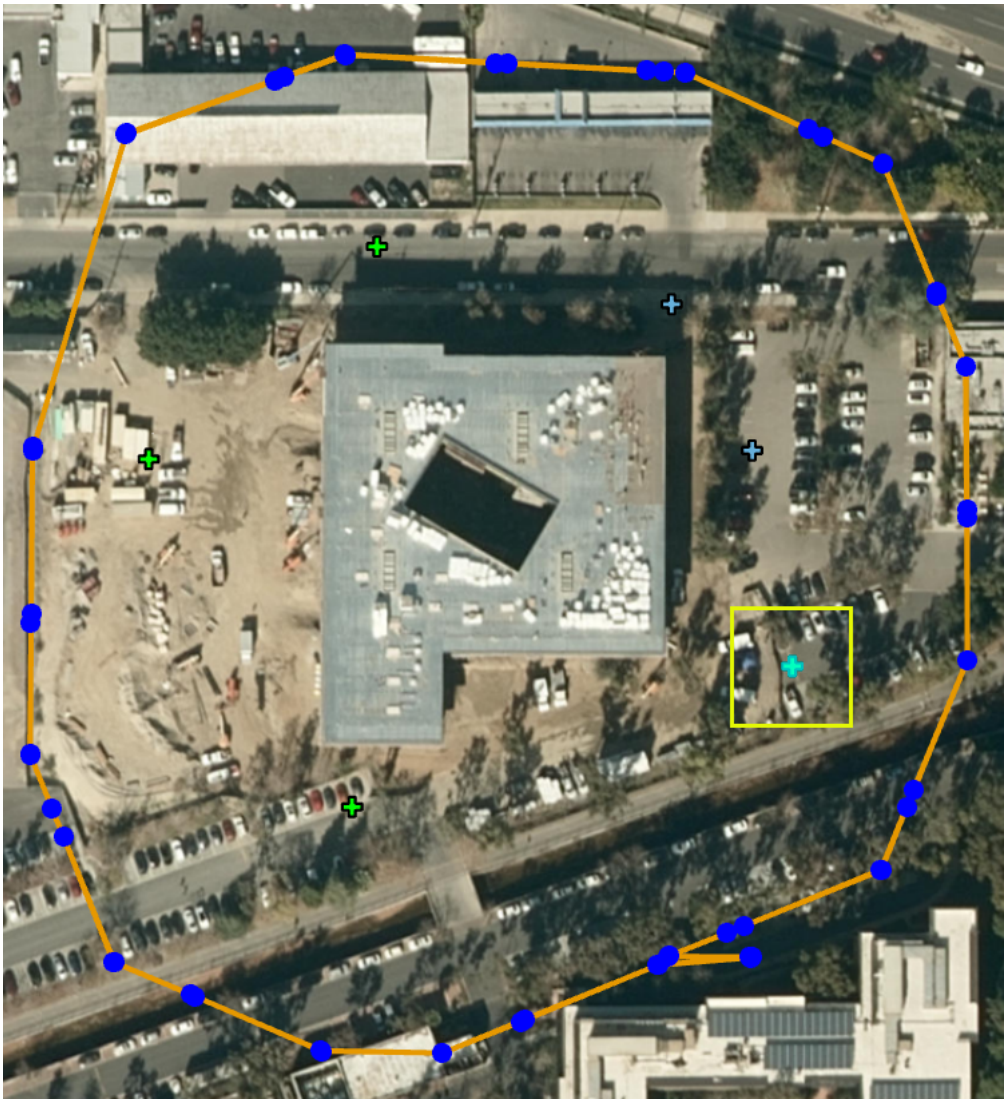
f Using the scroll wheel on your mouse, zoom in on the yellow X, as indicated in the following graphic.

You can also use the Zoom In button and Zoom Out button in the image to adjust your zoom level. If necessary, you can click the Reset button to return the image to the default view. To reposition the image while zoomed in, click and drag the image as needed.

The location of the GCP is at the southern end of a speed bump. You will locate the GCP in the Imagery basemap to help orient yourself and provide the context for setting additional image links for the From Map 0 GCP.

g Close the Image Links window.

h In the map, zoom in on the From Map 0 GCP, as indicated in the following graphic.



The map updates as you zoom in, with older, but more detailed imagery that predates construction of Building E.

You will notice that the location of the GCP at the southern end of one of the speed bumps corresponds to the image link that you saw in the Image Links window. Next, you will return to the Image Links Editor to link this same location to two other images.

i In the Control Manager pane, select the From Map 0 GCP, if necessary.

j Open the Image Links window.

- Hint

  Near the top of the Control Manager pane, click the Show Image Links Editor button .

k From the list of images, scroll down and select the DJI_0931.jpg image.

The image named DJI_0931.jpg is a great first candidate because there is an unobstructed view of the ground at the GCP, and the location of the GCP will not be too close to the edge of the image.

l In the bottom-right section of the image, zoom in until the two yellow speed bumps are clearly positioned in the center of your view, as shown in the following graphic.

m Place your cursor at the bottom edge of the upper (northernmost) speed bump, and then click to place the image link.

*Step 6m***: Add image links to a ground control point.*

The From Map 0 GCP now has the minimum number of image links for processing; however, you should add at least one more image link for best results.

n On your own, find three more images that contain the target GCP location.

- Hint

  The following three images are ideal candidates for image linking, which have a clear and unobstructed view of the target GCP location:

  - DJI_0915.jpg
  - DJI_0916.jpg
  - DJI_0932.jpg

  This list is not an exhaustive list of possible candidates for image linking. You may find other suitable candidates for image linking besides the three listed above. While the Image Links Editor recommends linking GCPs to between three and eight total images, you will have a total of five images linked to the GCP in this exercise.

o Click OK to close the Image Links Editor.

p In the Contents pane, right-click Flight Lines and choose Zoom To Layer.

All your GCPs now meet the requirements for minimum number of image links, and they can now be used during processing. Next, you will process the drone imagery to produce imagery products.

- Step 7: Produce imagery products

Note: Processing drone images in ArcGIS Drone2Map can take a long amount of time, depending on multiple factors. The results shown in this exercise were generated on a system using an AMD EPYC 7v12 64-Core Processor, 2.44 GHz (4 Cores), no NVIDIA GPU, and with 14 GB of RAM. Based on the options set in the *Select processing options* step, creating all the 2D and 3D products took approximately 57 minutes. A zipped ArcGIS Pro project file of finished 2D and 3D products can be downloaded from this location (https://links.esri.com/Products) and extracted to the **..\EsriMOOC\Data** folder. This zipped file is approximately 215 MB in size. You can use ArcGIS Pro to examine these products; however, the remainder of this exercise examines and reviews these output products directly in ArcGIS Drone2Map, so some of the steps may vary.

Next, you will create the 2D and 3D products that you specified in the processing options. These products are what you will use to share with interested parties on the progress of the Building E construction.

a From the Home tab, in the Processing group, click Start to create the imagery products.

As the different products are created, they will automatically be added to your map.

Note: The progress for the project will be indicated at the bottom of the Manage pane on the right. Depending on your computer system, processing times may be lengthy.

When the processing is complete, the 2D map still shows the original project data, such as the images and flight lines, but now it also includes the 2D products.

b In the Contents pane, turn off the visibility of the Project Data layer.

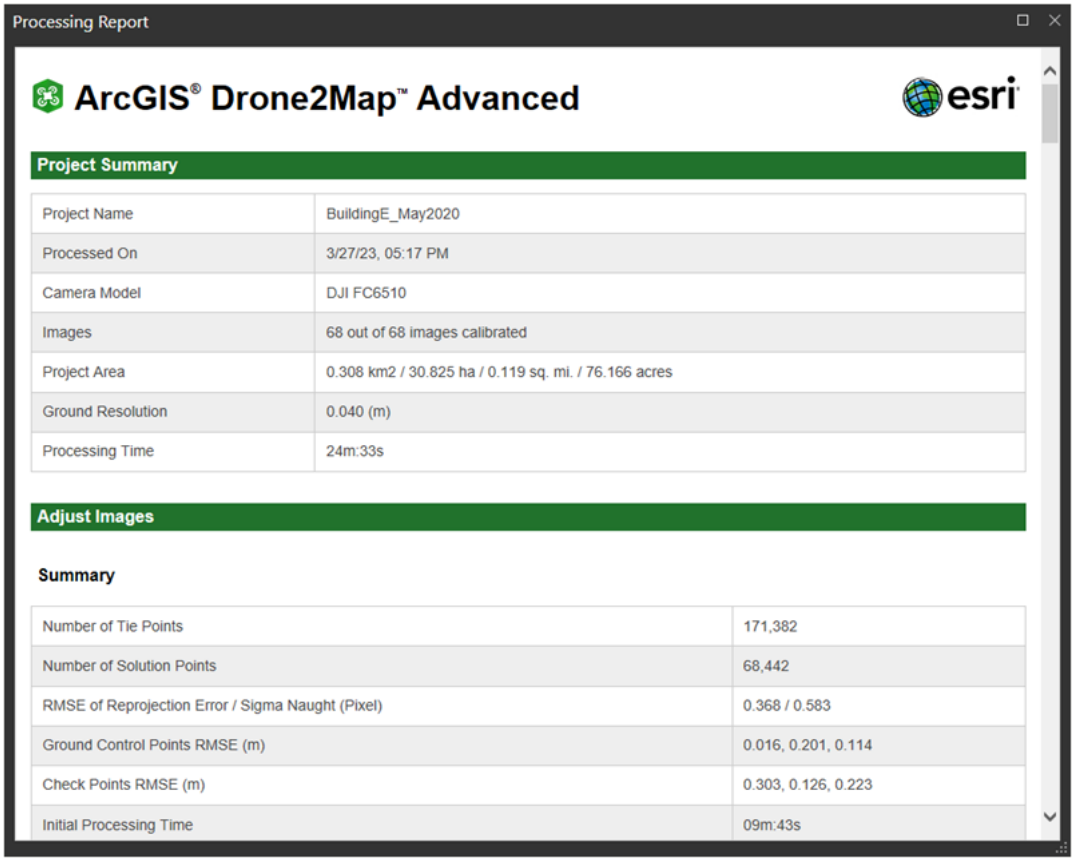
*Step 7b***: Produce imagery products.*

In the Contents pane, the 2D imagery products are displayed in two group layers: the Imagery Products group layer, which contains the True Ortho layer, and the DEM Products group layer, which contains the Digital Surface Model and Digital Terrain Model layers.

- Step 8: Review the Processing Report

Following product creation, either 2D, 3D, or both, it is a good idea to review the products themselves either visually or by evaluating the various accuracy statistics generated during their creation. This assessment will ensure that they meet any quality standards for analysis that your project team may have predefined. For this project, you will review various elements of the Processing Report to assess whether the products will meet the quality standards necessary for your project.

a From the Home tab, in the Processing group, click Report to open the Processing Report.



*Step 8a***: Review the Processing Report.*

The Processing Report includes information about the process and the resulting products.

Ground Resolution represents the ground sampling distance (GSD) of the original sensor.

? In the Project Summary section, what is the ground resolution?

- Answer
The ground resolution is 0.039-0.040m or 4 cm (1.575 in).

Knowing the ground resolution of your sensor is important when conveying information to engineers, architects, and other construction team members, including survey teams. This value determines the size of the smallest feature that you can resolve, or see, in your images. This information becomes very important to members of the construction and survey team, not only for project site status and updates but also as inputs for survey information.

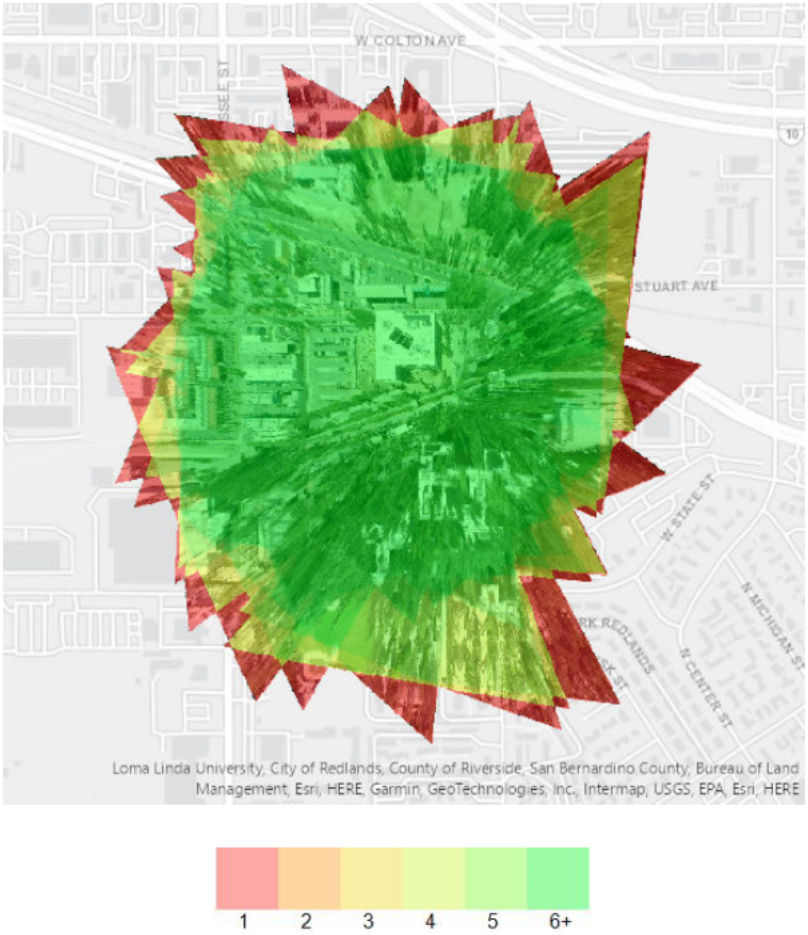
One measure of successful processing performance is whether all input images were used to create the imagery products.

? In the Project Summary section, how many images were calibrated in the project?

- Answer
All 68 images were calibrated.

After confirming the number of images calibrated in the project, you should confirm the coverage, including overlapping coverage, of those images.

b Scroll down to the Image Overlap section of the Processing Report.



*Step 8b***: Review the Processing Report.*

The graphic indicates the coverage relative to the number of overlapping images. Areas in green indicate more coverage. Due to the number of overlapping images in the green areas, the quality of the product is greater in those areas.

c On your own, explore the other sections of the Processing Report.

? What other information or statistics could be important for your AEC projects and why?

- Answer

Answers may vary but can include the following:

- Information related to tie points (Images with low tie point counts may indicate problematic areas, such as areas with poor image quality, insufficient image overlap, or homogeneous image textures.)
- Solution points (Solution points with a higher number of image observations generally produce more accurate results.)
- Various photogrammetric solution parameters (internal camera parameters, standard deviation of exterior orientation)
- Information on system parameters and options set for processing

d Close the Processing Report.

You reviewed the Processing Report and are now ready to review the imagery products.

- Step 9: Review the 2D imagery product

Now you will review the recently created 2D imagery product to verify its spatial resolution. Then, you will try out mensuration tools.

a In the Contents pane, in the Imagery Products group layer, right-click True Ortho and choose Zoom To Source Resolution.

*Step 9a***: Review the 2D imagery product.*

Drone imagery data is collected at low altitudes and is capable of creating high-resolution imagery.

> ? In the bottom-left corner of the map, what is the reported scale?
>
> - Answer
> The reported scale is approximately 1:600.

You can verify the spatial resolution of this imagery.

b In the Contents pane, in the Imagery Products group layer, right-click True Ortho and choose Properties.

c In the Layer Properties dialog box, click the Source tab, and then expand Raster Information.

One of the advantages of drone data is that the sensors are capable of extremely high-resolution data. With such a fine spatial resolution, you are capable of recognizing small features within the True Ortho.

> ? What is the cell size reported?
>
> - Answer
> The cell size is approximately 0.158 m.

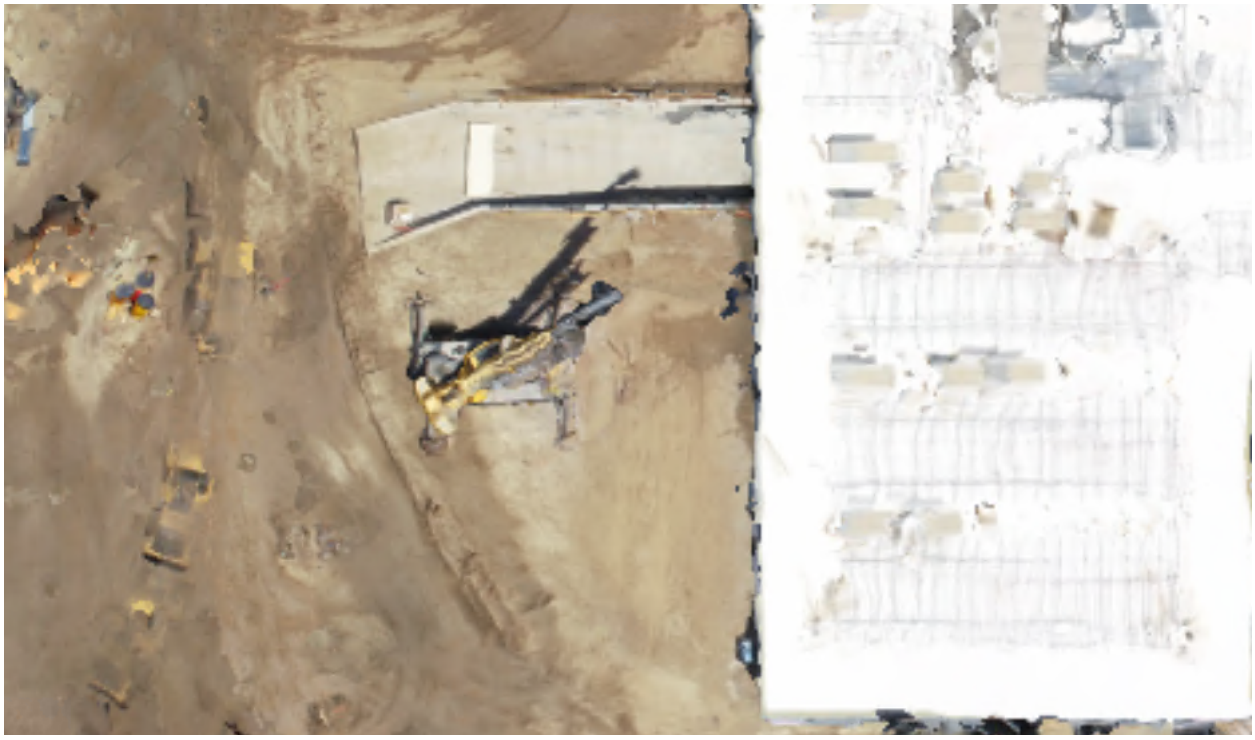
When you configured the processing options for your 2D products, the automatic resolution was set at 4x GSD, which is reflected in the cell size, or spatial resolution, of the new orthomosaic. (4 x 0.040 = .160).

While only generated at the Medium Point Density and 4x the GSD of the original imagery, at this scale, you can clearly see many features. This orthomosaic will allow the project team to visually inspect the construction site. If necessary, and warranted for your project, you can create a new orthomosaic at 1x the GSD and either High or Ultra density for the point density cloud.

d Close the Layer Properties dialog box.

You can use the Explore tool in Drone2Map the same way that you do in ArcGIS Pro. As you explore the features around Building E, remember that the imagery that you are using is not at the default resolution of 0.04 m and for initial verification and examination purposes. For any final product generated in Drone2Map, a point cloud density of High or Ultra and a GSD value of x1 will provide the most detailed and accurate representation of your project site.

e On your own, pan and zoom in your map to explore the imagery and construction site.



*Step 9e***: Review the 2D imagery product.*

The True Ortho, as the name indicates, is a truly orthographic image and can be used to accurately measure features. The process of orthorectification creates images that have been corrected to mitigate errors and distortions caused by the sensor and the terrain.

f In the Contents pane, right-click True Ortho, choose Zoom To Source Resolution, and ensure that Building E is in the center of your map view.

g From the Analysis tab, in the Measure group, click Area.

The Mensuration Results pane will open upon completing a measurement. Mensuration, or image mensuration, is defined as applying geometric rules to determine a distance, or an area of a two-dimensional or a three-dimensional surface, using the information obtained from lines and angles. It also includes measuring the height and absolute location of a feature. You performed mensuration previously in the MOOC when you determined the area of the construction site.

At this point in the construction, a few solar panel arrays have been installed, and you will use the measure tools to confirm coverage area for some of the project staff.

h Measure the area of the newly installed solar panel arrays, which are indicated in the following graphic, by clicking the outline of the array.

Note: You will need to take the area measurements of both arrays separately.

- Hint

You can zoom in to the northeast section of the roof to aid in your measurements.

i Finish the measurements by double-clicking the last point.

> ? What is the area reported for the two arrays?
>
> - Answer
> The area for the larger array is approximately 160 square meters, and the area for the smaller, incomplete array is approximately 35 square meters.

j In the Mensuration Results pane, select the measurements listed in the table, click the Delete button, and then click Yes to delete the results.

k Close the Mensuration Results pane.

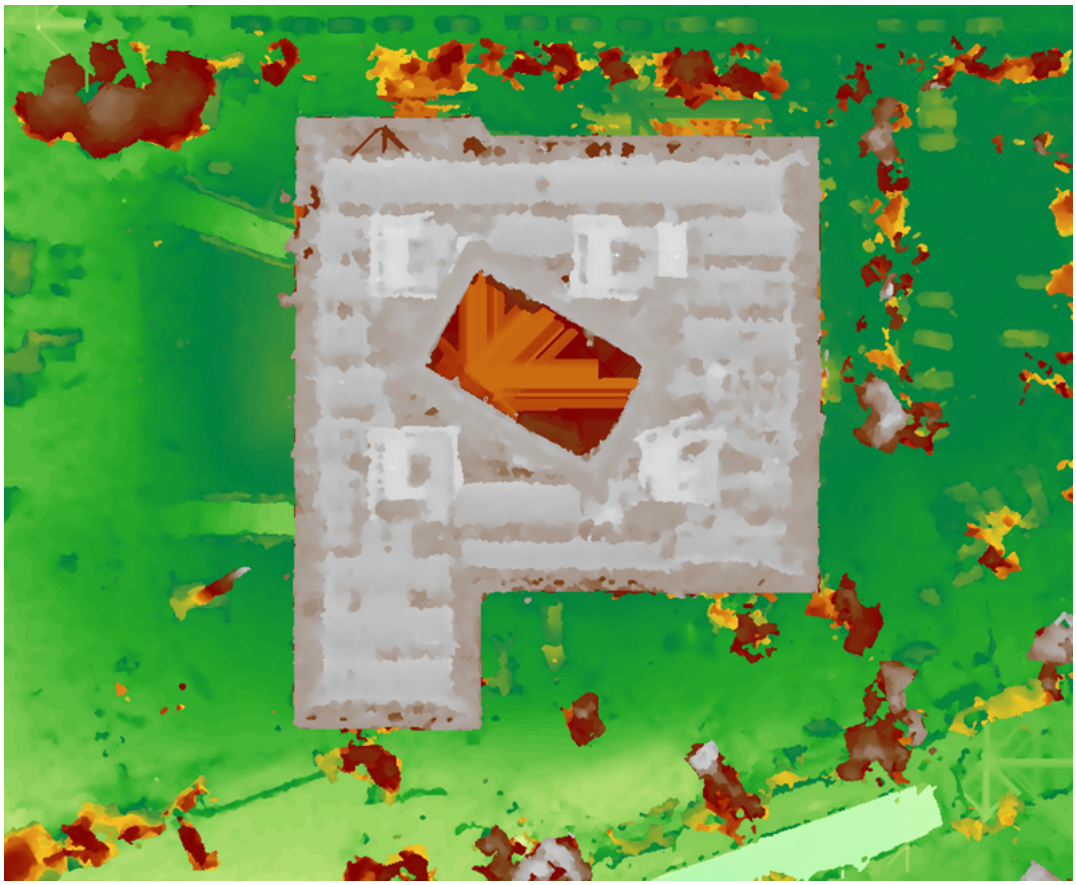
You and the project stakeholders can now use this orthomosaic image to visually assess construction progress, and you can use it to accurately measure property features.

- Step 10: Review the digital elevation model (DEM) products

In this step, you will review the DEM products created for the project. The two elevation products specified earlier in the 2D processing options and created are the digital terrain model (DTM) and the digital surface model (DSM).

a If necessary, in the Contents pane, right-click True Ortho and choose Zoom To Source Resolution, and then ensure that Building E is in the center of your map.

b In the Contents pane, in the Imagery Products group layer, turn off the visibility of the True Ortho layer.

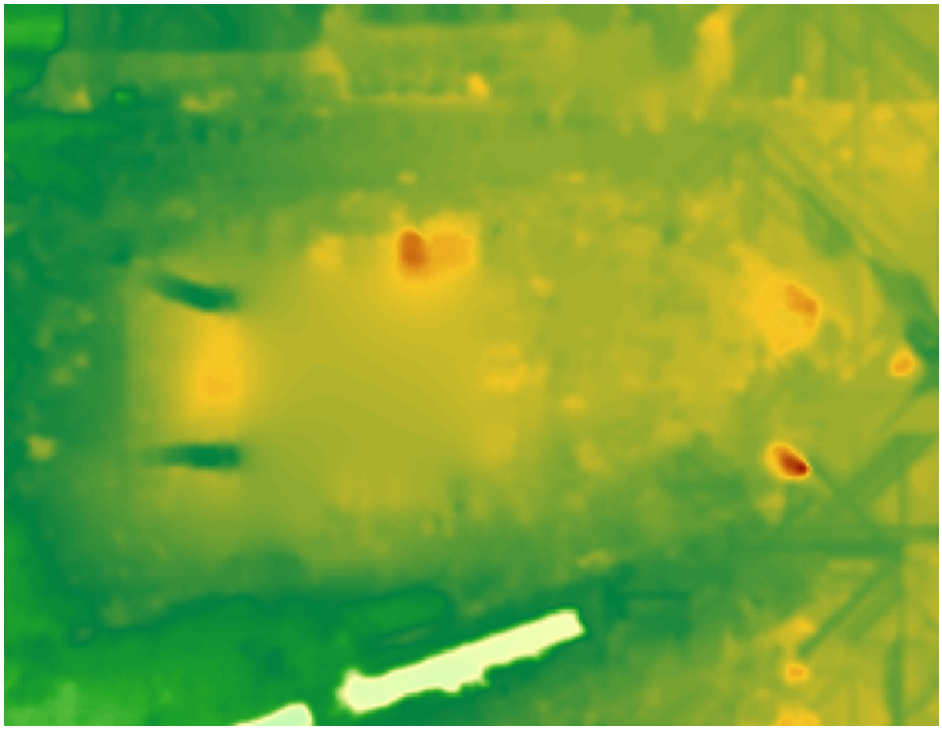


*Step 10b***: Review the digital elevation model (DEM) products.*

The digital surface model (DSM) is created from the LAS point cloud and indicates the surface elevation throughout the raster. Building E is clearly visible, and trees and other features around the construction site are also easily discernible. The values in this raster can be used for measuring the height of features.

LAS points were also used to create the Digital Terrain Model layer, which represents a bare earth surface.

c In the Contents pane, in the DEM Products group layer, turn off the visibility of the Digital Surface Model layer.



*Step 10c***: Review the digital elevation model (DEM) products.*

Note: The colors in your map may differ from the preceding graphic.

The digital terrain model (DTM) shows what the area would look like if surface features such as buildings and trees were removed; it is sometimes referred to as a base earth model or a bare earth surface.

Note: This visualization is a representation of a bare earth surface and should not be considered more than an estimation.

You reviewed the point cloud and the products derived from it (a DSM and a DTM), and you determined that they can provide additional context for communicating progress at the construction site to your stakeholders.

- Step 11: Review the 3D products

Finally, you will view the 3D Mesh layer and the drone flight lines in a local scene, which allows you to visualize the data in three dimensions and provides a unique perspective of the job site.

a At the top of the map view, click the 3D Map tab to view the data in three dimensions.

Note: It may take a moment for the data to load.

b From the Home tab, in the Layers group, click Basemap and select the Topographic basemap.

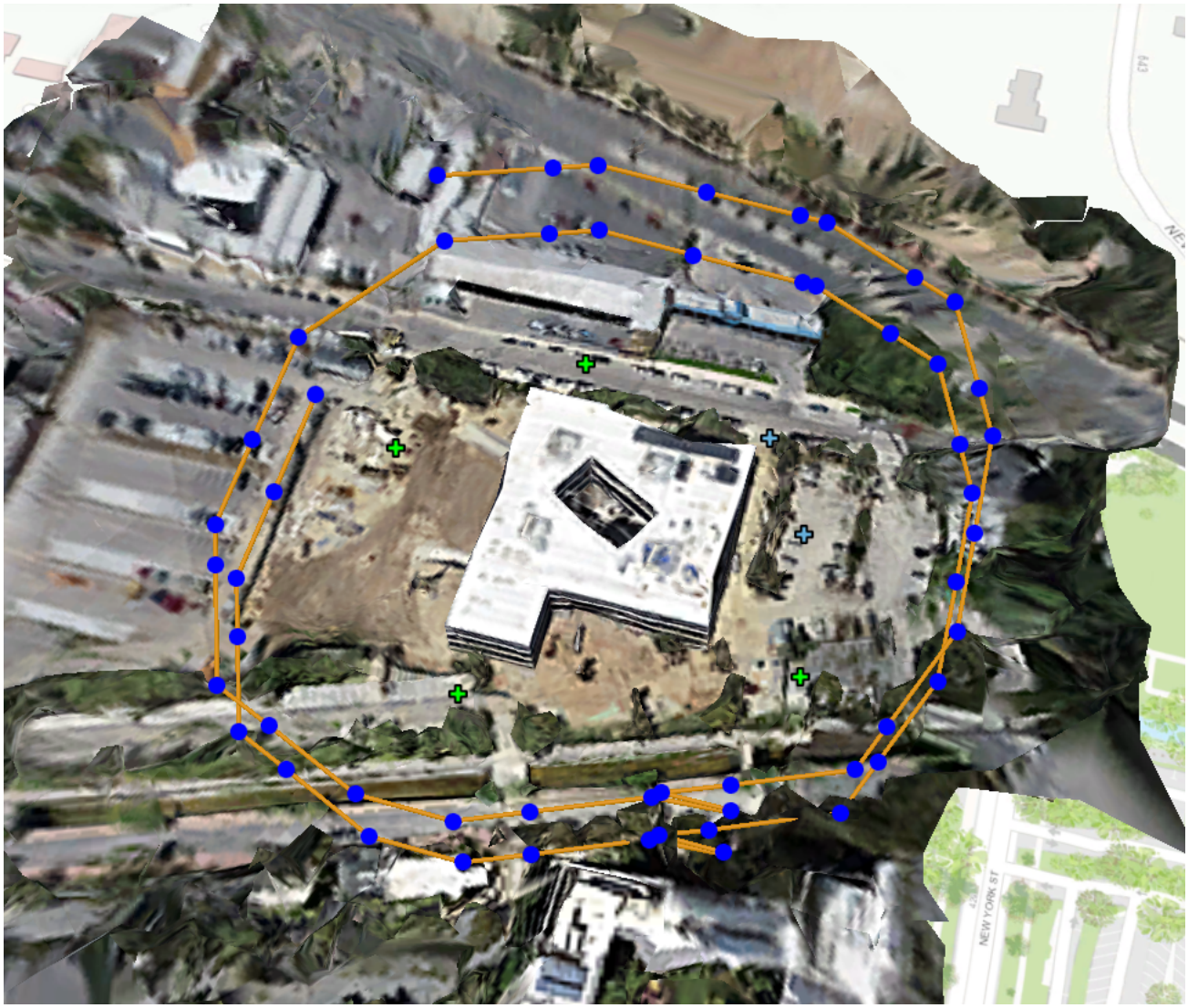
? What is the advantage when changing the basemap to topographic?

- Answer

Because the basemap appears beneath the 3D mesh, the main advantage is that it allows you to easily see the end or edge of the drone imagery collection.

c On your own, experiment with other basemaps to see whether another basemap provides for easier interpretation.

d If necessary, in the Contents pane, in the 3D Layers group layer, right-click the Flight Lines layer and choose Zoom To Layer.



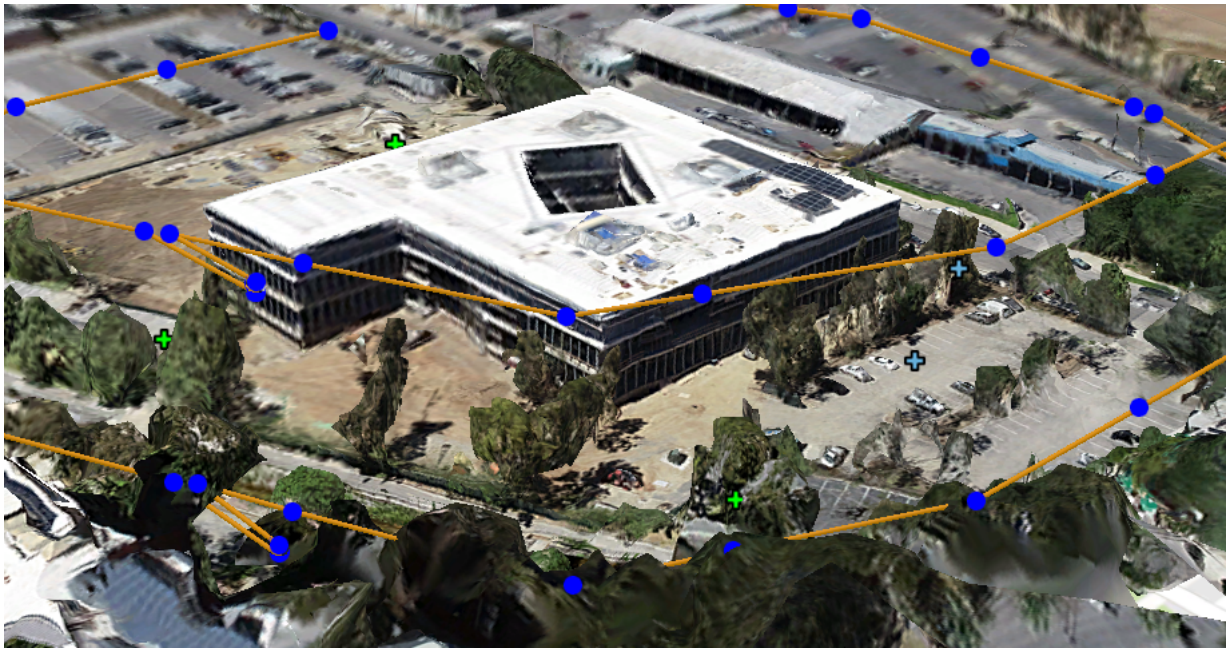
*Step 11d***: Review the 3D products.*

The flight lines are visible above the 3D mesh.

e In the map, zoom in closer and tilt the scene.

To tilt the scene, click the scroll wheel on the mouse or use the on-screen navigator located in the lower-left corner of the view. To review information about how to use 3D navigation, go to ArcGIS Pro Help: Navigation in 3D.

f Rotate the scene until the flight lines are aligned, as shown in the following graphic.



Note: The 3D mesh results look a bit distorted. There are methods in ArcGIS Drone2Map and ArcGIS Pro to improve the level of detail and quality of the 3D objects.

With the flight lines visible, you can see the position of the drone during the collection of the imagery.

? How can the observed distortion of the trees and other features outside of these flight lines be explained?

- Answer

Because the drone collected images inside the ring of the flight lines—that is, the image collection was centered on Building E—there is minimal, if any, overlapping data beyond or outside the ring of flight lines. Combined with this fact and the lack of control, only a rough mesh can be generated from the output LAS dataset and point cloud. The result is blurred or highly distorted 3D features outside the main area of drone imagery collection.

These 3D products can now be used to represent your job site, including the progress of Building E construction, with a realistic view for your stakeholders. Additionally, this view, along with others collected during the life cycle of the construction project, can be examined in its historic context to aid in lessons learned, safety checks, or to understand and track various project milestones.

g In the top-left corner, click the Save Project button  to save your project, and then exit ArcGIS Drone2Map.

In this exercise, you learned to create 2D and 3D products from drone imagery and how those images can be used to share construction progress with stakeholders. Many possibilities are available within ArcGIS to continue your analysis or visualization projects. What other AEC project applications for drone imagery products can you think of? Some examples may include inspections at a proposed dam site, evaluating a utility or power plant location, or integrity inspections of a high-rise or bridge.

In upcoming exercises in the MOOC, you will share this 3D mesh and other products to your ArcGIS Online organization.

If you would like to continue exploring your data, you can work through the optional stretch goal.

- Step 12: Stretch goal (Optional)

Stretch goals are community-supported (meaning that your fellow MOOC participants can assist you with the steps to complete the stretch goal using the Lesson Forum), and they are a great opportunity to work together to learn.

In this stretch goal, you will use the same workflow that you learned in this exercise to process a different set of drone images for the Building E project. This new set of images was captured from a nadir perspective.

1. In a web browser, go to https://links.esri.com/2020-05-05_Nadir and download the 2020-05-05_Nadir ZIP file (514 MB).

   Note: The complete URL to the data file is https://www.arcgis.com/home/item.html?id=00d9b15827f840f4b890897aa63f3840.

2. Extract the nadir images of Building E from the ZIP file.
3. Add image links to the From Map 2 GCP.
4. Create 2D and 3D products using these drone images.
5. Examine your results, and then answer the following questions:
   - What are some similarities that you notice in the output products?
   - What are some observed differences between products created by the oblique and nadir image collections?
   - What are some applications for the products created from the nadir collection as opposed to the oblique collection?

Use the Lesson Forum to post your questions, observations, and screenshot examples that best represent your answers and observations. Be sure to include the **#stretch** hashtag in the posting title.