

Processing Aerial Survey Data

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About this tutorial

In this tutorial, you will import a text (.csv) file containing ground control point (GCP) names and coordinates and a JobXML (.jxl) file containing aerial survey data. (Referenced photo images are automatically imported along with the JobXML (.jxl) file.) Then you will adjust the aerial photo stations to ensure the highest precision and create three deliverables: an orthomosaic, a point cloud, and a raster-based digital surface model (DSM).

Note: If you need additional help at any time you are using the software, press **F1** to display the online help.

Overview of aerial survey data

Aerial survey data is collected using an *unmanned aircraft system (UAS)*, such as a Trimble UX5 aerial mapping and surveying system.

An aerial survey *flight mission* consists of an interconnected series of *aerial photo station* images, along with autonomous GNSS station positions recorded with each image, intended to be processed as a single unit. A single flight mission can include one or more *flight blocks*, each intended to cover a single polygonal area.

The following figure shows the area that could be covered by either two separate flight missions or two separate flight blocks contained in a single flight mission.



Each time an aerial photo image is taken, an aerial photo station is created, much like a terrestrial photo station. The following figure shows the aerial photo stations created for the flight mission.



Before you can use imported aerial survey data to create an orthomosaic, raster-based digital surface model (DSM), or point cloud, you must adjust the aerial photo stations using the **Adjust Photo Stations** command. The command allows you to make two types of adjustments, which must be performed in the sequence shown here:

- **Relative adjustment** - In this adjustment, SO automatically identifies *tie points* (a point in a photo image that represents the same location in an adjacent image) in aerial images and matches them to correctly orient the aerial photo stations to each other and reference them to the ground based on autonomous GNSS positions recorded when the photo images are taken. This is the minimal adjustment required prior to creating aerial survey deliverables from UAS data.
- **Absolute adjustment** - In this adjustment, SO adjusts the photo station points more precisely to the ground using three or more ground control points (GCPs) for autonomous UAS data. A camera calibration is included in the absolute adjustment process to provide the highest precision.

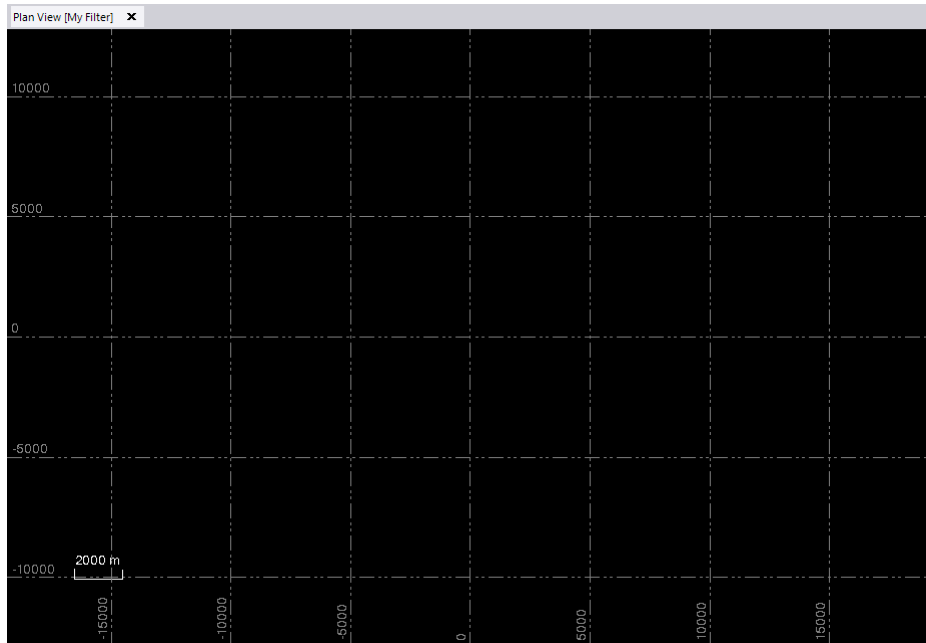
Step 1. Open the project

For this tutorial, you will use the project file *Processing Aerial Survey Data.vce*.

Note: The downloaded *ProcessingAerialSurveyData* folder contains this PDF file, a *Data* folder, and the *Processing Aerial Survey Data.vce* project file. You will import data from the *Data* folder later in this tutorial.

1. In SO, select **File > Open**.
2. In the **Open File** dialog, browse to `..\ProcessingAerialSurveyData\Processing Aerial Survey Data.vce` and click **Open**.

The project opens in the **Survey Office** window.

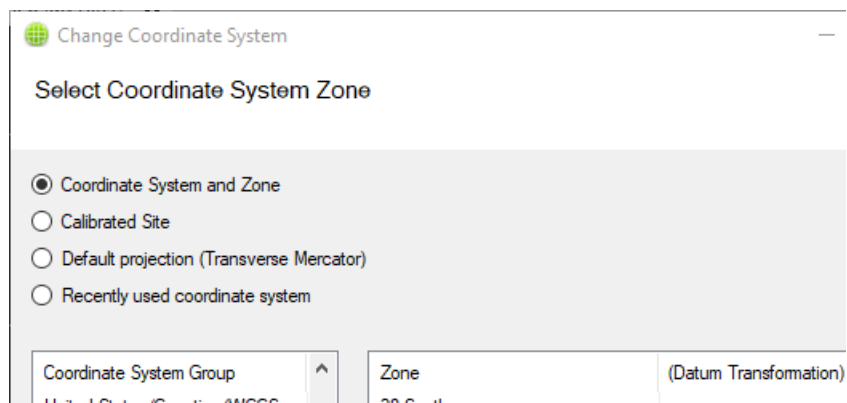


The project file is read-only. You can perform the tutorial steps without saving the project file. However, if you are interrupted while performing the tutorial, you can save it with a new name by selecting **File > Save Project As**. Then, you can re-open the project to continue the tutorial at a later time.

Step 2. Select the coordinate system

Before you import aerial survey data into your project, you must select the correct coordinate system for the survey.

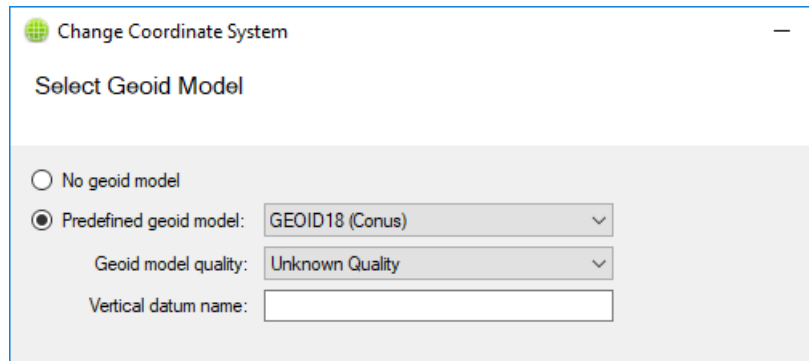
1. In the **SO** ribbon, select **Photogrammetry > Setup > Change Coordinate System** to display the **Change Coordinate System** dialog.
2. If it is not already selected, select the **Coordinate System and Zone** option.



3. Do the following:
 - a. In the **Coordinate System Group** list, select *United States/State Plane 1983*.

- b. In the **Zone** list, select *Wyoming East 4901*.
- c. Click **Next**.

The **Select Geoid Model** dialog displays.



The **Predefined Geoid model** option is selected by default. (If it is not selected, select it now.)

The **Coordinate System Manager** is a standalone utility that gives you access to your coordinate system database (*Current.csd*). In the **Coordinate System Manager**, geoid models can be predefined. These predefined models are listed in the **Predefined Geoid model** list.

The default model selection is *GEOID 18 (Conus)*. The default quality setting is *Unknown Quality*. There is no need to change the default settings. In addition, there is no need to specify a vertical datum name.

Note: For this project, you will be importing ground control points (GCPs) with grid coordinates of *Control Quality*, so there is no need to change the default *Unknown Quality* for the geoid model. However, if the control points were derived from GNSS data and you were using a *Survey Quality* geoid, you would need to set the geoid model to *Survey Quality* to avoid degrading the quality of the elevation of the points. If you did not have a *Survey Quality* geoid, you would not be able to use GNSS-derived control points.

4. Click the **Finish** button.

You are now ready to import aerial survey data into your project.

Step 3. Import data


For this project, you will import two data files:

- A text (.csv) file containing the ground control points (GCPs) for the project.
- A JobXML (.jxl) file containing aerial survey data from a single flight mission: *X100 site*

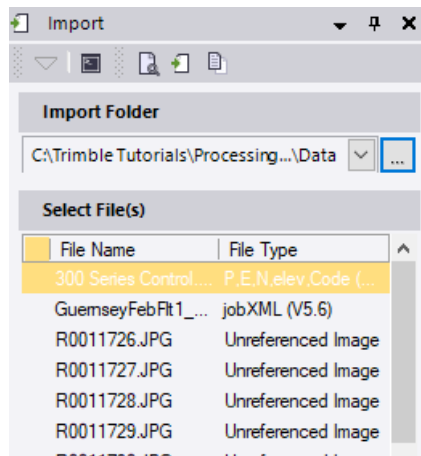
To import data, follow these steps:

1. Select **Home > Data Exchange > Import**.

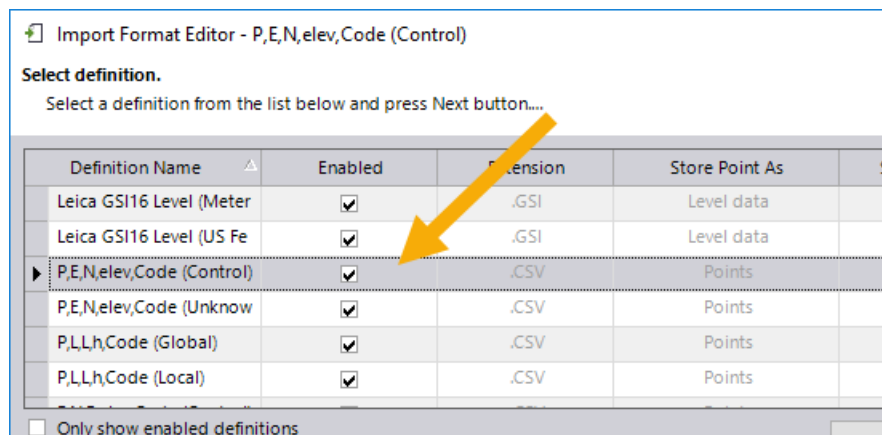
The **Import** pane opens in the right side of the **Survey Office** window.

2. In the **Import** pane, click the **Browse** button .
3. In the **Browse for Folder** dialog, browse to `..\ProcessingAerialSurveyData\Data` and click **OK**.

The content of the *Data* folder displays in the **Select File(s)** list in the **Import** pane

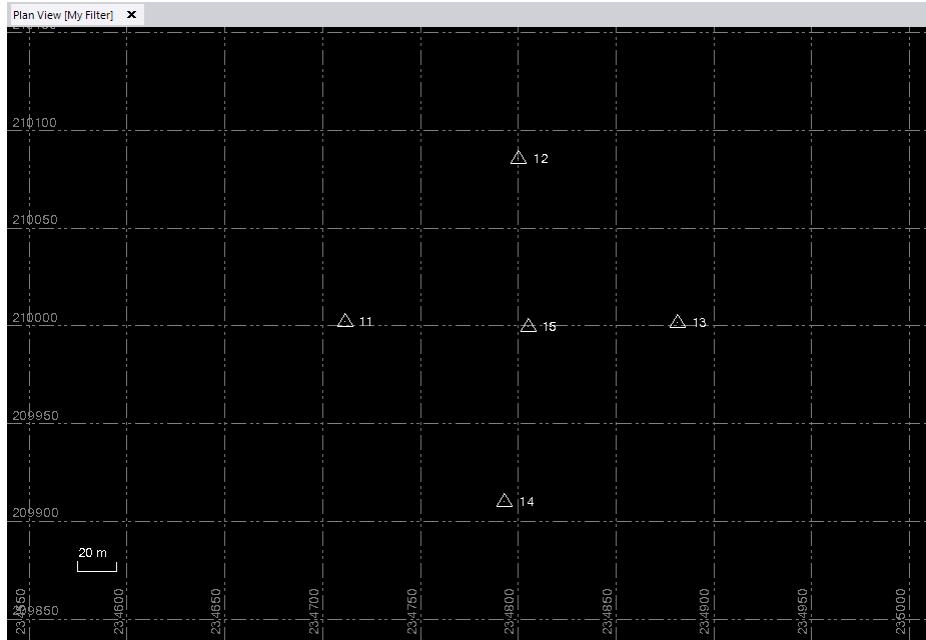


4. In the **Select File(s)** list, select *300 Series Control.csv* and click the **Import** button.
5. In the **Import Format Editor** dialog, verify the selected definition is *P,E,N,elev,Code (Control)*. Then, click the **Import** button.



The newly imported ground control points are displayed in the **Plan View**.

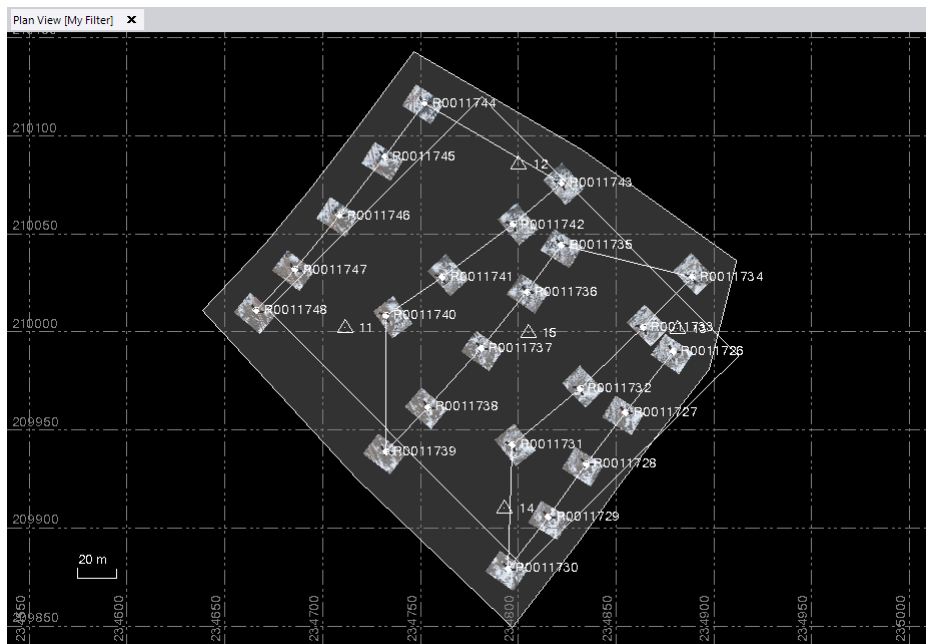
You will use these ground control points to adjust the aerial photo stations later in this tutorial.



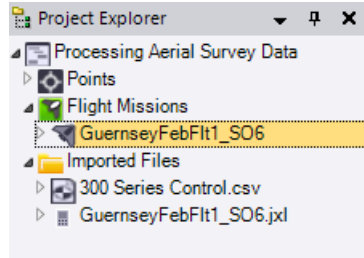
You are now ready to import a JobXML (.jxl) file containing the aerial survey data.

6. Select **Home > Data Exchange > Import** and import the *GuernseyFebFlt1_SO6.jxl* file.

The newly imported aerial survey data is displayed in the **Plan View**. In addition, the photo image files displayed in the **Select File(s)** list are copied to the project folder.

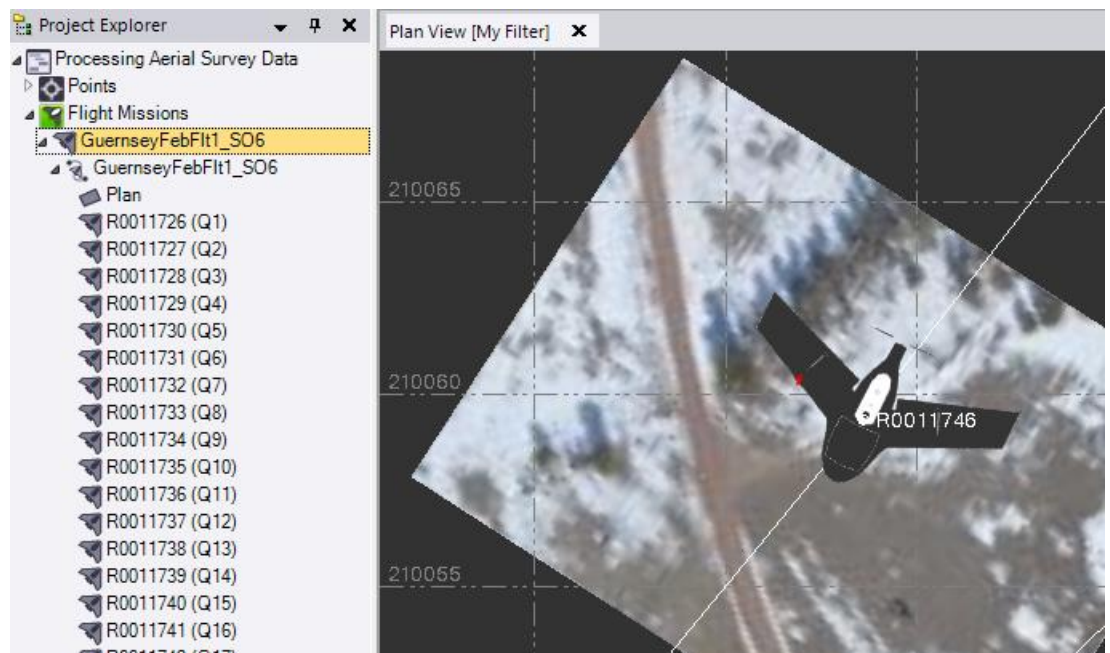


The imported *GuernseyFebFlt1_SO6.jxl* file contains the *GuernseyFebFlt1_SO6* flight mission, as shown in **Home > Data > Project Explorer**.



In the **Plan View**, the icons representing the aerial photo stations point in the direction the aircraft was traveling when the image was recorded. Its black interior color indicates the station has not yet been adjusted. A connecting line runs through each of the aerial photo stations contained in the flight block. A polygonal border line identifies the perimeter of the flight mission.

Underneath each photo station icon is a thumbnail of the captured image, which can be more easily viewed when you zoom in on the **Plan View**.



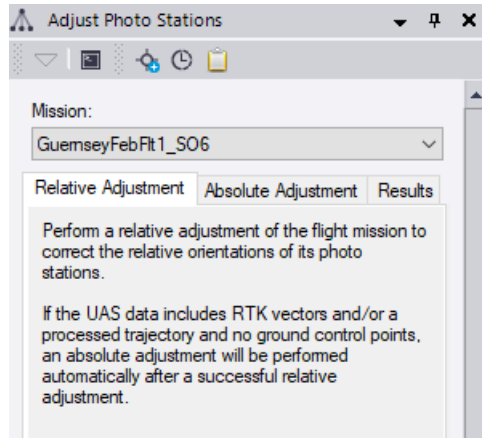
Step 4. Perform a relative photo station adjustment

In this adjustment, SO automatically identifies *tie points* (a point in a photo image that represents the same location in an adjacent image) in aerial images and matches them to correctly orient the aerial photo stations to each other and reference them to the ground based on autonomous GNSS positions recorded when the photo images are taken. This is the minimal adjustment required prior to creating aerial survey deliverables from UAS data.

To perform a relative adjustment of the aerial survey photo stations, follow these steps:

1. In the **SO** ribbon, select **Photogrammetry > Adjust > Adjust Photo Stations**.

The **Adjust Photo Stations** command pane displays. Since *GuernseyFebFit1_SO6* is the only flight mission in the project, it is selected by default in the **Mission** drop-down list.



2. On the **Relative Adjustment** tab, click the **Adjust** button.

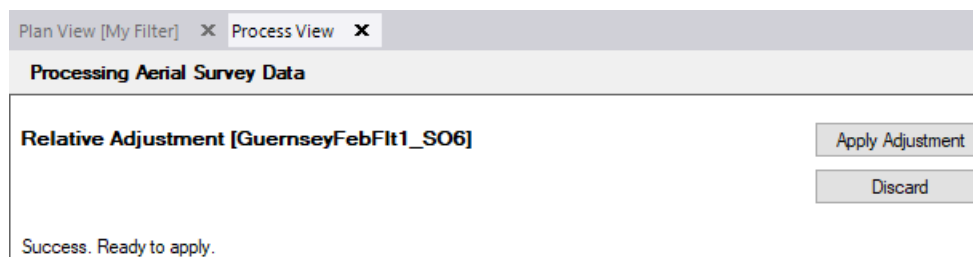
The aerial photo stations within the selected flight mission are adjusted using tie points and their autonomous GNSS positions. The **Process View** tab displays to show the progress of the process.

Notes:

- Unless you have changed the default **Process Monitoring** settings in the **Options** dialog, the progress also displays in the **Survey Office** button on the Windows taskbar by way of a colored bar moving across the button's background. When the process is complete, a check mark is displayed on the button and a notification is displayed in a pop-up **Desktop Alert**.

- You cannot perform other aerial survey tasks until processing is complete.

When the tie point adjustment process is complete, the **Apply Adjustment** and **Discard** buttons are displayed on the **Process View** tab.




Note: The adjustment process can take a long period of time to complete if you are working with a large amount of data. If your computer goes to "sleep" during processing, the process will stop and will not re-continue until the computer is "awakened." To prevent this from happening, you can extend the period before which your computer goes sleep by selecting **Power & sleep** in your Windows **Settings**.

3. On the **Process View** tab, click the **Apply Adjustment** button to save the adjustment results in the project.
4. In the **Flight Mission Adjustment Report** message dialog that displays, click **Yes** to display the report.

The report includes the following information (as applicable), much of it in easy-to-understand graphical views.

- General project information (project name, process type and date/time, resulting file, number of cameras and images used, number of strips, flying and terrain height, average photo scale, and coordinate system)
- Flight overview information (camera locations, strip definitions, and tie points)
- Tie point distribution (distribution and number of images containing each point)
- Camera calibration (camera data, distortion values, and image residuals)
- Block adjustment results (parameters, accuracy, and mean standard deviation of translations/rotations/ground control points)
- Exterior orientation (camera locations and standard deviations)
- GNSS statistics (residuals and tie point locations)
- Ground control points (if applicable; errors, residuals, and standard deviations)

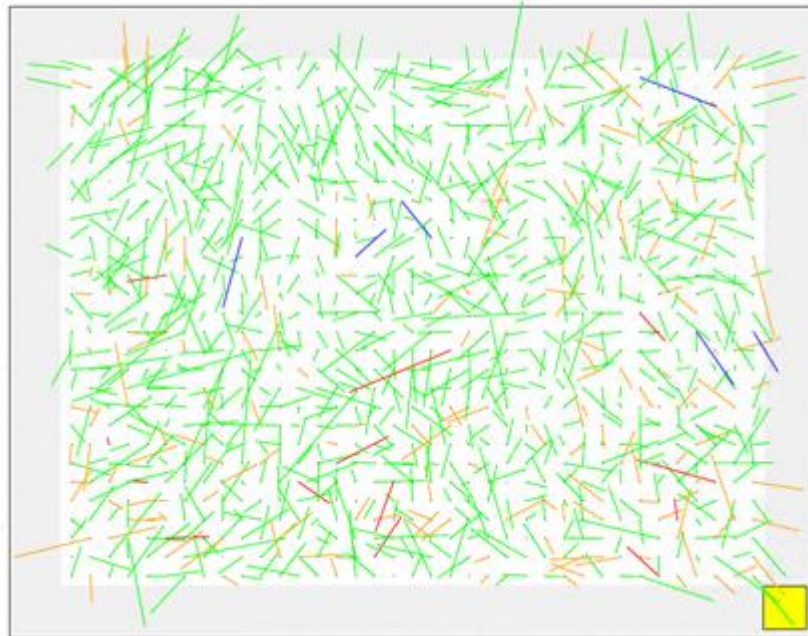

UAS

Processing Report

General project information

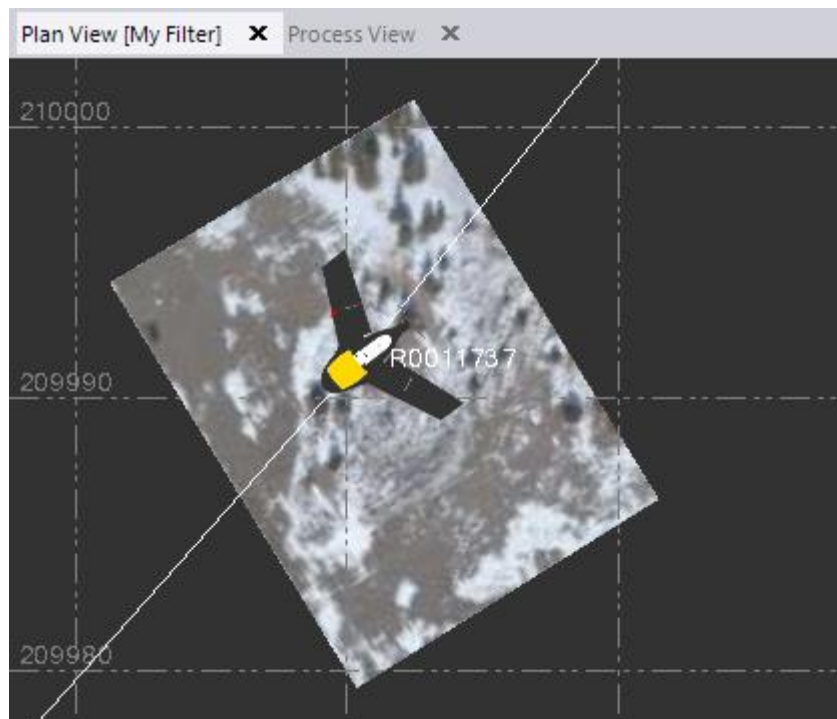
Project name	
Process	Geo-referencing
Computer node	ERYAN-US-LE
Operating system	Microsoft Enterprise Edition (build 9200), 64-
Machine	Intel(R) Core(TM) i7-5600U C 2.60GHz 4 core
User name	eryan

Image residuals (Camera: 1194)



By viewing the adjustment results, you can often make a determination about the precision of the adjusted aerial survey data. After viewing the report, you can close it.

In SO, the adjustment is applied and the project is automatically re-computed. The aerial photo station icons displayed in the **Project Explorer** and **Plan View** change from black to indicate they have been adjusted with tie points.



You can see that eight of the points include red flags in the **Plan View**. If you select **Home > View > Flags Pane**, you can see the points exceed the computational settings for horizontal point tolerances specified in the **Project Settings** dialog.

Flags Pane	
Flagged Objects	Message
R0011731	This point is out of tolerance. H = 18.081 m exceeds the computational tolerance.
R0011732	This point is out of tolerance. H = 18.520 m exceeds the computational tolerance.
R0011733	This point is out of tolerance. H = 21.263 m exceeds the computational tolerance.
R0011734	This point is out of tolerance. H = 16.059 m exceeds the computational tolerance.

For additional information, select any of the flagged points in the **Project Explorer** or **Plan View**, right click, and select **Point Derivations Report**.

Point Derivations

Resultant Coordinates for point: R0011731					
Easting		Northing		Elevation	
234781.867 m		209932.357 m		1686.617 m	
Data	Used to calc.	Status	Δ East (Meter)	Δ North (Meter)	Distance (Meter)
Pre-Adjustment	NEeh	Enabled	0.000 m	0.000 m	0
Global (GuernseyFebFlt1_SO6.jxl)		Enabled	-15.047 m	-10.026 m	18
Survey Data used to calculate point: R0011731					
Precision Confidence Level: 95%					
Coordinates					
Source	Easting	Northing	Elevation		

When you perform an adjustment using ground control points, as described in the next step, these horizontal deltas should fall within the specified tolerances.

The **Results** tab displays information about the tie point adjustment. By viewing the adjustment results, you can make some determination about the precision of the adjusted aerial survey data.

Adjust Photo Stations			
Mission: GuernseyFebFlt1_SO6			
Relative Adjustment		Absolute Adjustment	
Summary			
Flight ...	Guern...	Total i...	23
Adjust...	1/7/2...	Exclud...	0
Avera...	1685...	Failed ...	0
Groun...	0.040 m	Adjust...	23
Status:	Relati...		
Station Statistics			
	<i>Easting</i>	<i>Northing</i>	<i>Elevati...</i>
Mean i...	-5.180 m	-3.690 m	-0.390 m

Note: If necessary, click and drag the command pane's left border to widen the pane, making it easier to read the labels.

Next, you will use the ground control points (GCPs) you imported into the project to more precisely adjust the aerial photo stations.

Step 5. Perform an absolute photo station adjustment

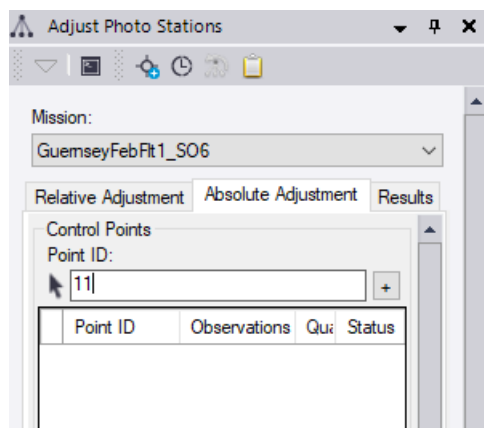
In this adjustment, SO adjusts the photo station points more precisely to the ground using three or more ground control points (GCPs) for autonomous UAS data. A camera calibration is included in the absolute adjustment process to provide the highest precision.

A ground control point (GCP) is an accurately surveyed coordinate location for a physical feature that can be identified on the ground and is used to georeference images. (For this project, easily identifiable printed targets were used to identify ground control points.) This adjustment allows you to make photogrammetry observations to the ground control points to provide more precise referencing of the aerial photo stations than was possible using only the adjustment with tie points.


To perform an absolute adjustment of the aerial survey photo stations, follow these steps:

1. In the **Adjust Photo Stations** command pane, select the **Absolute Adjustment** tab. Then click in the **Point ID** field and select ground control point **11** in the **Project Explorer** or **Plan View**.

You can also type the control point ID in the field.

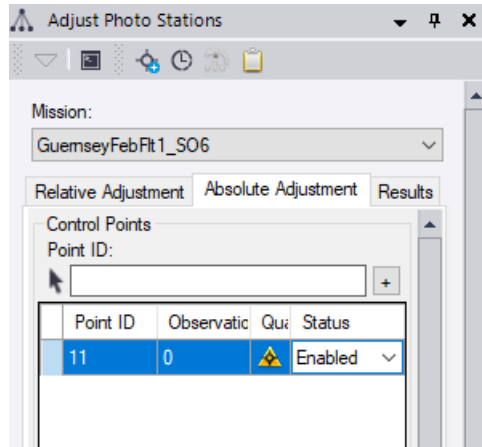


Note: Only control points with coordinate quality of *Control* or *Survey* can be used in an adjustment. The control points in this project all have *Control* quality.

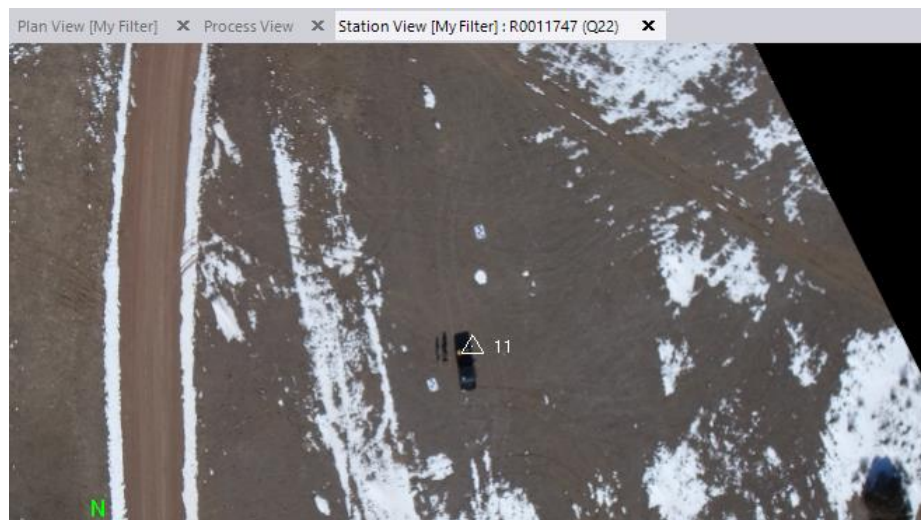
2. Click the **Add** button  located to the right of the field, or press the **Enter** key.

The following occur:

- The selected point is added to the **Control Points** list.



- The aerial photo stations with photo images most likely to include the control point are displayed in the **Photo stations** list.
- The photo image from the first station in the **Photo stations** list is displayed on a new **Station View** tab. The associated control point is used to center the photo image on the tab.



In the **Control Points** list, you can use the **Status** drop-down list to select any of the following status options for the selected ground control point:

- **Enabled** - Include all photogrammetry observations of the control point in the adjustment.
- **As check** - Make photogrammetry observations to the control point to calculate the point's position, but do not include the control point in the adjustment. This control point will be used as a check for precision.
- **Disabled** - Do not use the control point in the adjustment.

For this tutorial, you will keep the default status of **Enabled**.

3. To make a photogrammetry observation to the control point on the newly displayed **Station View** tab, click in the **Pixel Picker** field. Then, using the **Pixel Picker** view control, click as accurately as possible on the control point target located near the vehicle in the photo image (1 in the figure below).

Note: In the image for photo station *R0011747*, two ground targets can be seen. Do not select the target located farthest from the vehicle (2 in the figure below). This target is not located on a ground control point, but instead it is identifying a point of interest that can be surveyed using photogrammetry observations after the adjustment is complete.



When using the **Pixel Picker**, note the following:

- Toggle between the two **Pixel Picker** display options – dynamic view (1 below) and static view (2 below) – by pressing **Ctrl + Shift**.



The dynamic view option causes the **Pixel Picker** to display as a magnifier with a reticle, enabling you to dynamically select the precise location for a photogrammetry observation on the photo image. To change the reticle for the **Pixel Picker**, press **Ctrl + Alt**.

The static view option causes the **Pixel Picker** to display as a small selection cursor that, when clicked, opens a window with a magnified view of the photo image showing the selected area. You can then select the precise location for a photogrammetry observation on the photo image in the magnified view.

- Use your mouse wheel to zoom in or out. Press the mouse wheel and move your mouse to move the image on the **Station View** tab.
- Once the **Pixel Picker** is close to the object you want to select, you can press the arrow keys on your keyboard to move it in small increments. When you are ready to make your selection, press your left mouse button or press the **Enter** key.

After you take your observation, the photo station's **Status** changes to "Enabled" in the **Photo stations** list.

By default, the **Auto advance on select** option is selected to specify that the next station in the list be automatically selected each time you make a photogrammetry observation.

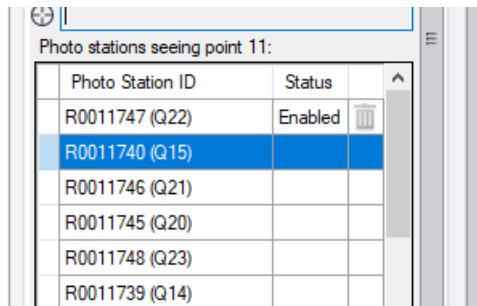


Photo stations seeing point 11:		
Photo Station ID	Status	
R0011747 (Q22)	Enabled	
R0011740 (Q15)		
R0011746 (Q21)		
R0011745 (Q20)		
R0011748 (Q23)		
R0011739 (Q14)		

4. Repeat this procedure to make two more photogrammetry observations to the selected ground control point, for a total of three observations.

The stations positioned higher in the **Station list** are most likely to provide a view of the control point. To ensure the highest precision, you would typically include as many control points as possible in the adjustment, and ensure the ones you do include are spread out as much as possible across the surveyed area. You would also want to make as many photogrammetry observations as possible to each ground control point. However, for this tutorial, you will make three observations to each of the five available control points.

An epipolar line representing each photogrammetry observation is displayed in subsequent photo images and can be used to more easily locate the ground control point target in the photo image. Notice that your second and third observations (1 in the figure below) together do not provide very good geometry because the angle between them is less than 30° . But the three observations together should be adequate. If ever in doubt, you can make additional observations.



5. After making your third observation to ground control point 11, click in the **Point ID** field, select ground control point 12, and make three observations to the point. Then, repeat this procedure for ground control points 13, 14, and 15.

Control point 12:



Control point 13:



Control point 14:



Control point 15:



6. After you have made three photogrammetry observations each to ground control points 11 through 15, click the **Adjust** button.

The selected aerial photo stations are adjusted using the ground control points. The **Process View** tab displays to show the progress of the absolute adjustment process.

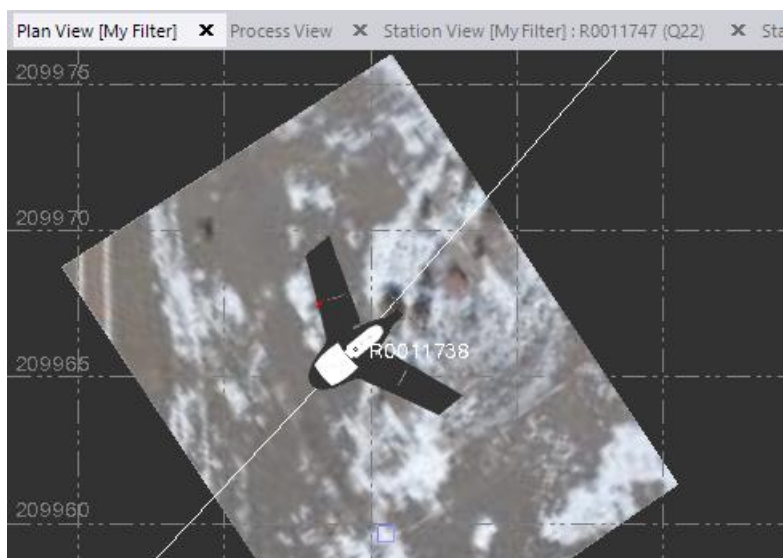
Notes:

- As with the relative adjustment, progress also displays on the **SO** taskbar button. When the process is complete, a check mark is displayed on the button and a notification is displayed in a pop-up **Desktop Alert**.
- You cannot perform other aerial survey tasks until processing is complete.

When processing is complete, the **Apply Adjustment** and **Discard** buttons are displayed on the **Process View** tab.

7. On the **Process View** tab, click **Apply Adjustment** to save the adjustment results.
8. In the **Flight Mission Adjustment Report** message dialog that displays, click **No**.

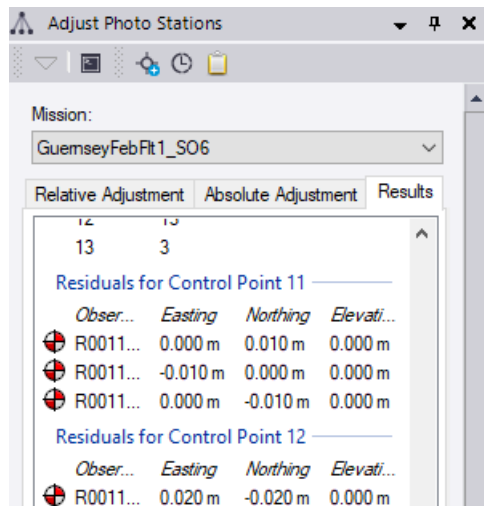
The adjustment is applied and the project is automatically re-computed. The aerial photo station icons displayed in the **Project Explorer** and **Plan View** change from yellow to white to indicate they are adjusted with ground control points.



Note that only one of the eight points that included out-of-tolerance flags still includes a flag. Photogrammetry observations are identified by red lines.

9. Select the **Results** tab to view information about the control point adjustment.

In addition to the information displayed as a result of the adjustment with tie points, the **Results** tab now also includes observation residuals. By viewing the adjustment results, you can make some determination about the precision of the adjusted aerial survey data.



Optionally, based on your results, you could choose to remove one or more ground control points from the adjustment. To do this, on the **Absolute Adjustment** tab you would select **Disabled** for the point in the **Status** drop-down list and click the **Adjust** button to re-adjust the aerial photo stations. However, for this tutorial there is no need to remove ground control points.

You are now ready to create orthomosaic, raster-based digital surface model (DSM), and point cloud deliverables from the adjusted flight mission data.

Step 6. Create aerial survey deliverables

In this step, you will use the **Create Orthomosaic** command to create an *orthomosaic* from adjusted flight data. An orthomosaic is a photo composed of multiple georeferenced orthophotos that have been corrected for topographic relief and lens distortion. It can be used to measure true flat distances because it is an orthographic (non-perspective) representation of the Earth's surface.

When an orthomosaic file is created, the following files are automatically created as well:

- *Raster-based digital surface model (DSM)* - A representation of the topography of the earth in digital format (that is, by coordinates and numerical descriptions of altitude). DSMs are often used in geographic information systems. The DSM you will create is represented as a raster (a grid of cells, also known as a height map when representing elevation).

- *Point cloud* - A set of vertices in a three-dimensional coordinate system that are usually defined by X, Y, and Z coordinates, and are intended to be representative of the external surface of an object.

You can select to save or not save these adjunct files. You can also create either one of these deliverables using the **Create Raster DSM** or **Create Point Cloud** command. However, for this tutorial you will select to save the raster DSM and point cloud created along with the orthomosaic.

Notes:

- A flight mission cannot be used to create an aerial survey deliverables unless it has been adjusted using tie points.
- Although it is not a requirement that you also perform an adjustment with ground control points prior to creating deliverables, performing the adjustment ensures that your flight mission is of the highest survey quality and that deliverables are as accurate as possible.

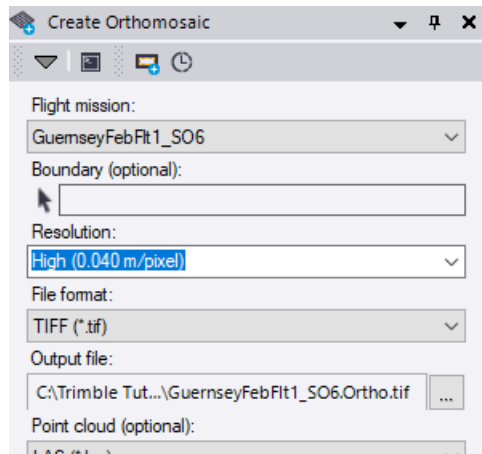
To create aerial survey deliverables, follow these steps:

1. In the **SO** ribbon, select **Home > View > View Filter Manager**. Then uncheck **Referenced Image (Plan View)** in the **Photogrammetry** list.

This hides the thumbnail image located beneath each photo station, making it easier to view the orthomosaic image you will create in this procedure.

2. In the ribbon, select **Photogrammetry > Deliverables > Create Orthomosaic**.

The **Create Orthomosaic** command pane displays.



If you had created a closed-line boundary around a specific area for which you wanted to create an orthomosaic, you could select it using the **Boundary (optional)** field. But, for this tutorial, you will leave this field blank to create an orthomosaic for the entire area covered by the flight mission.

Note: To quickly create a boundary, you can click the **Create Boundary** button located in the **Create Orthomosaic** command pane toolbar.

3. In the **Resolution** drop-down list, ensure **High** resolution (ground distance per photo pixel) is selected for the orthomosaic.

Optionally, you could type in a ground distance value.

Do not change the default **TIFF (*.tiff)** format selected in the **File format** drop-down list.

The **Output file** field defaults to use the name of the flight mission for the orthomosaic file name and the file path to the project folder. There is no need to change this information.

Warning! To avoid unexpected results, do not create an orthomosaic file that has the same name as an orthomosaic file that has already been imported into your project. In addition, do not import an orthomosaic file into your project that has the same name as an orthomosaic file that has already been imported.

Do not make any changes in the **Point cloud (optional)** or **Raster DSM (optional)** drop-down lists. These files will also be saved into the project folder using the same name as the flight mission.

Note: Because the point cloud file and raster DSM file are automatically created during the creation of the orthomosaic file regardless of your selection in the **Point cloud (optional)** and **Raster DSM (optional)** drop-down lists, no extra processing time is required if you decide to save them.

4. Click the **Create** button.

The **Process View** tab displays to show the progress of the file creation process.

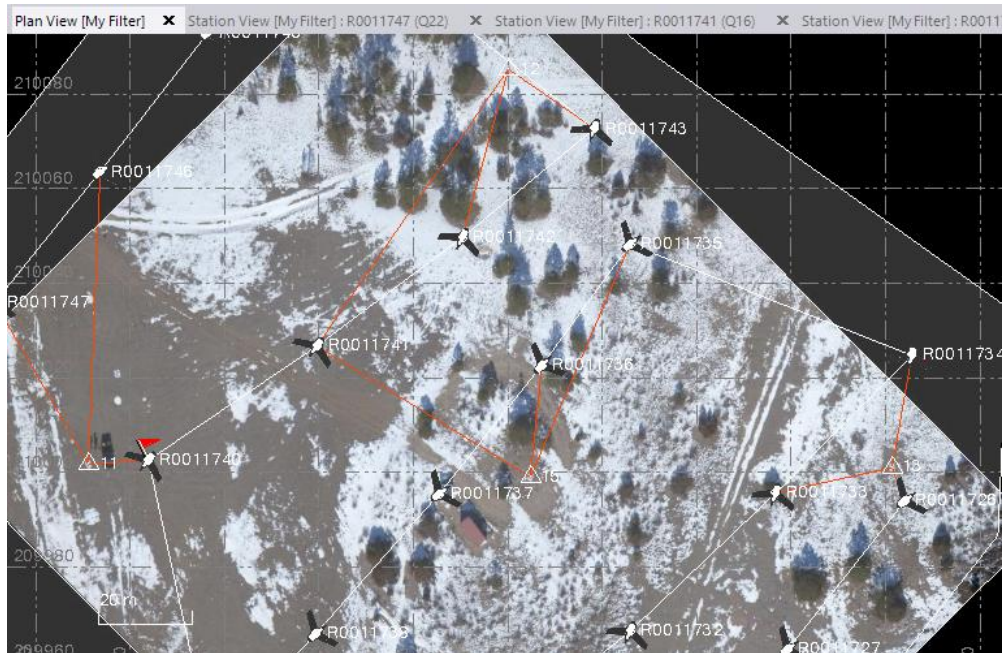
When processing is complete, an **Import** button and **Done** button display on the **Process View** tab.

5. Click the **Import** button to save the newly created orthomosaic file in your project folder and import it into your project.

If you click the **Done** button, the newly created orthomosaic file is saved to your project folder without importing it into your project.

The newly created point cloud file and raster DSM file are also saved to your project folder.

6. In the **Import Errors** message dialog, click **No**.
7. To view the newly created orthomosaic in SO, select the **Plan View** tab.

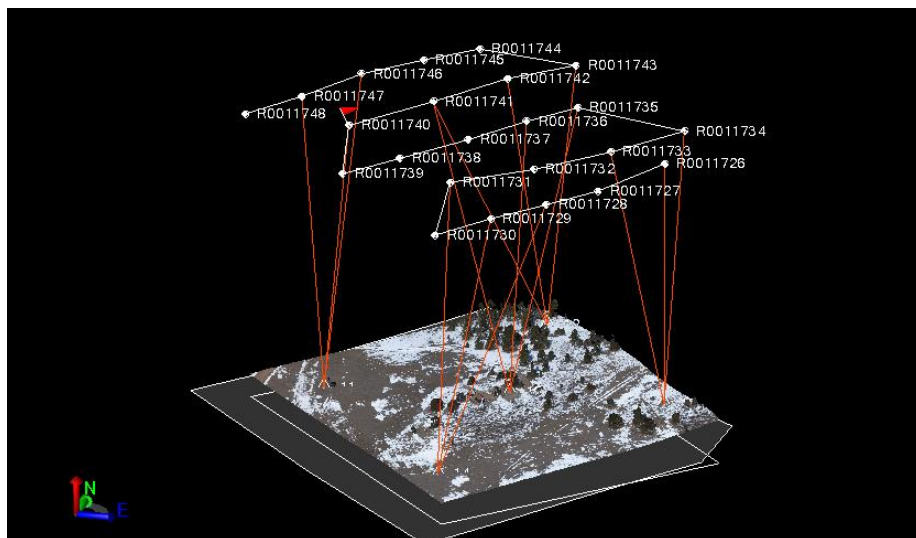


This concludes the tutorial steps for **Processing Aerial Survey Data**. However, if you would like to try some additional exercises working with the tutorial data, see the next section: "Additional exercises."

Additional exercises

Following are some additional exercises you might perform to broaden your experience with aerial survey data using Survey Office.

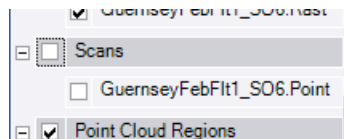
- Import the newly created point cloud file *GuernseyFebFlt1_SO6.PointCloud.las* from the project folder into Survey Office, and view it in the **3D View** (select **Home > View > 3D View**).



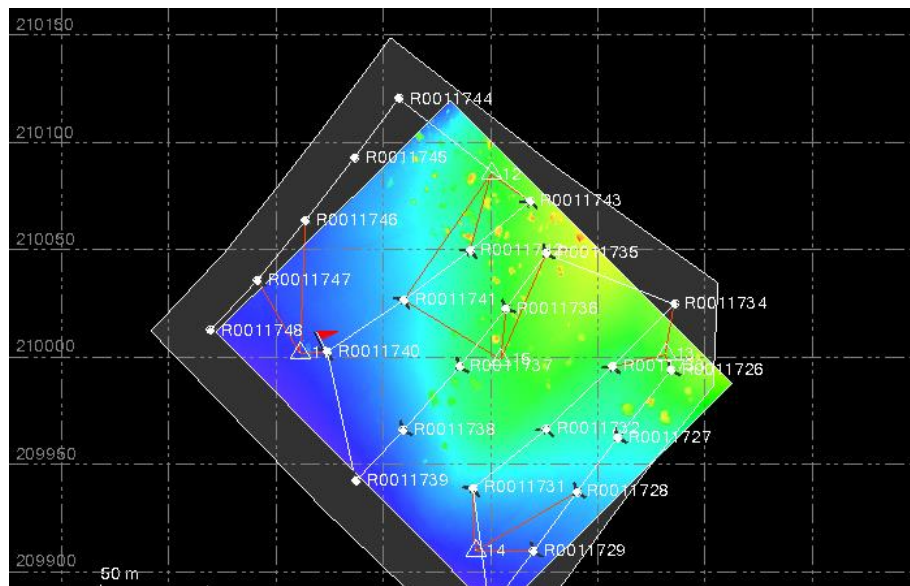
Warning! To avoid unexpected results, do not import a point cloud file into your project that has the same name as a point cloud file that has already been imported.

- Import the newly created raster-based digital surface model (DSM) *GuernseyFebFlt1_SO6.RasterDSM.tif* from the project folder into Survey Office and view it in the **Plan View**.

Hint: If an imported point cloud is displayed in the project, use the **View Filter Manager** to hide it so that you can clearly view the raster DSM in the **Plan View**. Uncheck it in the **View Filter Manager** to hide it.



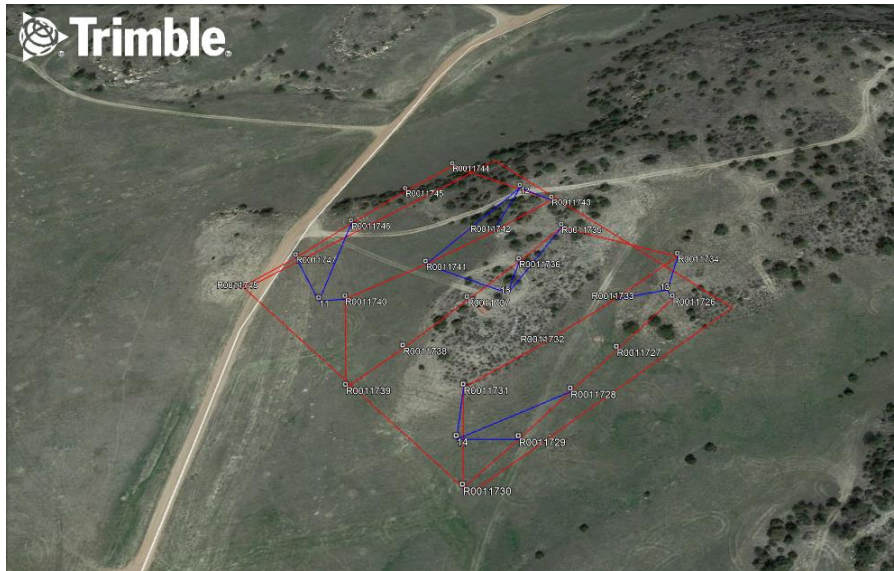
Higher elevations display in warmer colors (for example, orange and yellow); lower elevations display in cooler colors (for example, blue and green).



Warning! To avoid unexpected results, do not import a raster DSM file into your project that has the same name as a raster DSM file that has already been imported.

- Use the **Home > View > Google Earth** command to view the flight mission in Google Earth.

Hint: Use the **Select All** option in the **Selected entities** field to ensure all applicable objects in the project are selected for export to Google Earth.



- Use the **Photogrammetry > Data > Measure Photo Point** command to create a new point 20 by making photogrammetry measurements (observations) to the target located farther from the vehicle in the images for photo stations *R0011740*, *R0011745*, and *R0011747*. See the **Measuring Photogrammetry Points** tutorial or the online Help for instructions.

Hint: If an imported point cloud is displayed in the project, use the **View Filter Manager** to hide it so that you can clearly view the photo images on the **Station View** tabs to make the measurements.



After making the three photogrammetry measurements to the new point 20 and re-computing the project, right click the point in the **Project Explorer** and select to view the **Point Derivations** report. Note the observation residuals for the point and the overall strength of figure. (Your values may differ from the values shown in the figure below.)

Photogrammetry Measurements

Strength of figure: **2.480**

Observation	Azimuth	H. Distance	V. Distance	H. Dis Residu
✕ R0011747-20 (P23)	120°05'48"	30.006 m	-135.154 m	0.0
✕ R0011745-20 (P24)	194°54'00"	74.888 m	-135.842 m	0.0
✕ R0011740-20 (P25)	340°10'26"	19.400 m	-136.645 m	0.0