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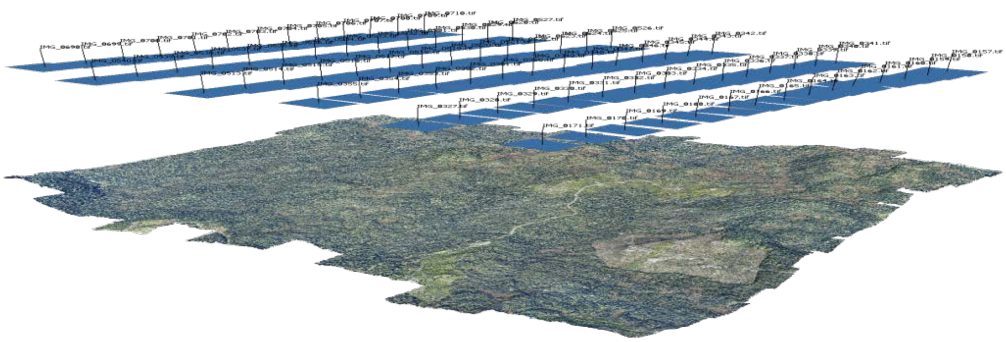
Metashape Image Processing for Digital Aerial Imagery



Introduction

Metashape is a tool for orthocorrecting imagery taken with a non-metric camera and can align and calibrate the camera with minimal input from the user. The program can also process scanned historical imagery and terrestrial imagery. In this exercise, you will learn the basics of Agisoft Metashape as you produce an orthomosaic and a 3-D point cloud. The exercise data consists of six aerial images taken with a Canon DSLR camera while flying over a portion of the Tongass National Forest in Alaska with a fixed-wing airplane.

As you work through this exercise, please refer to the Metashape Help Documentation for additional information about each of the steps. The help documentation can be found by going to the main menu in Metashape and selecting **Help** and then **Contents**.

Objective

- Become familiar with the user interface and features found within Metashape.
- Learn how to create an orthomosaic and 3-D point cloud with Metashape.

Prerequisites

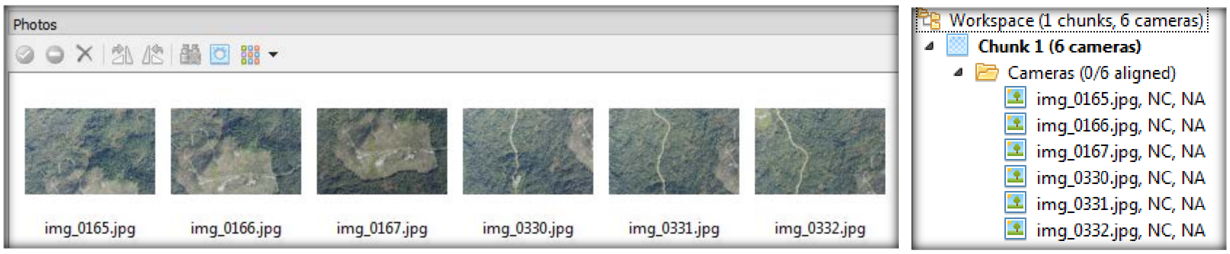
- Download and unzip exercise data: **Metashape_digital_aerial.zip**.
- Install and activate Metashape (please see Metashape Installation Guide for details).

Table of Contents

Part 1: Getting Started

A. Add the imagery

1. Launch Metashape from the **Start** menu (Start, All Programs, Agisoft, and Agisoft Metashape Professional).
2. Add the project images by going to the main menu in Metashape and selecting **Workflow** and then **Add Photos**.
   i. Navigate to the **01_imagery** folder in your exercise data and select the six images in the list (see following figure) and then click **Open**. The photos should now be added to both the Photos pane and the Workspace pane (see following note).



NOTE: *Metashape uses multiple panes for displaying different types of information. By default, some panes share the same screen space and can be displayed by clicking on the tabs above or below the pane. For example, the Workspace and Reference panes share the same screen space. Also, you can turn the panes on and off by going to* ***View*** *and then* ***Panes****. The panes can also be resized and rearranged.*

Metashape allows the user to select between different interface designs. This exercise was created using the Classic theme. If your toolbars appear differently than the ones shown in this exercise, you can change the theme by clicking on Tools in the main menu, Preferences, and then under the General tab, change the theme to Classic.

3. View one of the images by double clicking on it in either the Photos pane or the Workspace pane (click on the arrow next to **Chunk 1** and then **Cameras** to display the list of images).
   i. Navigate around the image by using your mouse (scroll wheel for zooming and left button for panning).
   ii. To get back to the 3D model view, click on the **Model** tab at the top of the main viewer or close the image tab by clicking on the “X” in the image tab.
4. Next, check to see if the camera information was imported correctly. This information usually comes from the metadata embedded within each of the images. In the main menu, click on **Tools** and then **Camera Calibration**.
   i. The camera type should be set to **Frame**; pixel size set to **0.006549** and a focal length of **50**.
   ii. After verifying that the information is correct, go ahead and click **OK**.

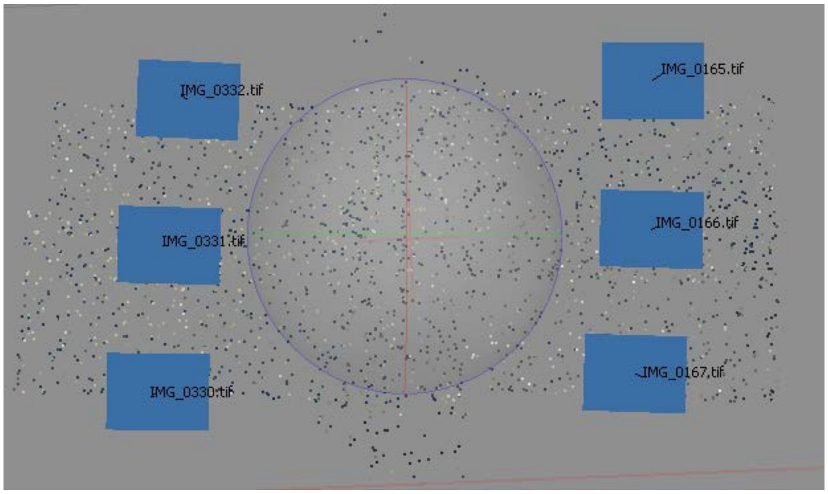
B. Align the images

In this step, the software will align the images by matching features found in overlapping regions of the images. The end result is the initial alignment of the images, as well as a sparse point cloud of the points that were matched. This process is oftentimes called Structure from Motion (SfM).

1. In the main menu, click on **Workflow** and then **Align Photos**. Use the following settings (see following note):
   i. Accuracy: **High**
   ii. Pair preselection: **Generic**
   iii. (Advanced section) Key point limit: **40,000**
   iv. (Advanced section) Tie point limit: **4,000**
2. Click **OK** to run alignment. This may take a minute or so to process (see following note).

***NOTE**: This step is very computationally intensive and for larger datasets may take several hours to complete. Time will vary depending upon computer processing power, number of images, and image size. Processing time can be slightly reduced if GPS data is available for the images. If so, import the coordinates by going to the **Reference** pane and clicking on the **Import** button. Once added, you would align the photos using **Reference** as the pair preselection method.*

3. Once the alignment has completed, you will see six blue rectangles appear in the main viewer, which represent the camera positions. A sparse point cloud with the points used to align the images should also be visible in the viewer (see following figure and note).



***NOTE**: In the Photos pane, a green checkmark will appear above images that are successfully aligned. If an image(s) doesn't align properly, right click on it and select **Align Selected Cameras**. If Metashape still fails to align the image(s), try realigning all of the images again using different settings (quality, key point/tie point limits). Another option is to manually add tie points (markers) between images that aren't aligning. However, Metashape will struggle to align images that have insufficient image overlap.*

4. Move around the model by using your mouse (scroll wheel for zooming, left button for rotating, and holding down scroll wheel for panning). Also, if you wish to hide items that are in the viewer (e.g., the big ball), click on **View** in the main menu and then **Show/Hide Items**.

Part 2: Define Projection and Place Markers

In this second part, we will define the projection for the project and then use control points, or markers as Metashape calls them, to geospatially position and scale the model. Ground coordinates for markers generally come from another reference image or by collecting the information in the field with a GPS unit. The latter method generally produces the most accurate results, but is also the more expensive and labor intensive of the two. The markers provided to you in this exercise were created using the reference-image method. Metashape doesn't currently have an interface for collecting marker coordinates from a reference image and so ArcMap was used instead.

A. Define the projection

1. Click on the **Reference** tab, which is located at bottom left of screen) to activate the reference pane and click on the **Settings** button (see following figure).

   i. For the coordinate system, select **North American Datum 1983 / UTM zone 8N (EPSG:26908)**. Filter using the EPSG code (**26908**) to quickly find it.

   ii. Change the **Marker accuracy** located under Measurement Accuracy to 1. Leave the default values for the other fields and click **OK** (see following note).

NOTE*: Since the markers for this exercise were created from reference imagery, we need to reduce the accuracy accordingly. This allows the software to be more flexible with the solution. If you are working with your own data, you'll want to adjust this setting based on the accuracy of your markers. Keep in mind that your outputs will only be as accurate as your reference data.*

B. Import the markers

1. Click on the **Import** button (see following figure), which is at the top of the reference pane.

   i. Navigate to the **02_reference** folder and select **markers_XYZ.csv** and then click **Open.**

      (a) The coordinate system should already be set to the correct projection system. If not, change it to NAD83 / UTM zone 8N.

      (b) Change the delimiter to **Comma** if needed.

      (c) Set the **Change import at row** field to **2** to avoid importing the column headers.

      (d) The columns should already be in the correct order (1, 2, 3, and 4).

      (e) Click **OK** to import the markers.

   ii. A message will open saying that it can't find a match for '1' entry. Select **Yes to All** (see following note). The coordinates should now be displayed under **Markers**.

NOTE*: The import dialog window is also used to import the camera center (GPS) coordinates that can be used in the initial alignment step. By default, Metashape assumes that the imported coordinates are camera centers, so it tries to match them with the image names. By selecting* ***Yes to All*** *in the previous step, you are telling Metashape that these coordinates are to be used as markers instead of camera coordinates. After doing this, you should see the eight newly added markers in the Reference pane.*

C. Place markers on photos

Now we need to specify where these markers are located on each of the photos. Metashape will help out after placing a few of them. See Appendix A to see where to place each of the markers. Try to place the markers as accurately as possible.

1. Using the first graphic in Appendix A, determine which images marker 1 falls on (answer: IMG_0332 and IMG_0331). In the **Photos** pane, double click on **IMG_0332.tif** to display it in the main viewer. Using the graphics in Appendix B as reference, navigate to marker 1.
2. Right click on the image where marker 1 is to be placed and select **Place Marker** and then **1**. Marker one should now be visible on the image with a green flag (see following figure).

3. In the Photos pane, switch to the second image that Marker 1 falls on (**IMG_0331.tif**).
4. Zoom and pan around the image to find the location of Marker 1. You'll notice that a red and white line appears on the image to show you approximately where marker 1 is located (see following figure).

5. Once you find the location, right click and select **Place Marker** and **1** (see following note).

NOTE*: If you accidentally place the marker in the wrong location or need to adjust its position, you can click on it and drag it to the correct location. There are also additional options if you right click on it.*

6. Repeat steps 1 through 5, but now for the remaining seven markers (see following note).

NOTE*: After placing three markers, Metashape is able to estimate the placement of the remaining markers. To do this, click on the* ***Update*** *button (see following figure) in the reference pane.*

After a few seconds, a grey symbol will appear above each image in the Photos pane (see following figure) showing which of the images have estimated markers. You can now right click on each of the remaining markers in the Reference pane and select ***Filter Photos by Marker****. The images that intersect the selected marker will show up in the Photos pane. Double click one of these images to navigate to the estimated marker and adjust the marker's position to finalize it (it should turn to a green flag).*

7. Save your project file by clicking on **File** and then **Save**.

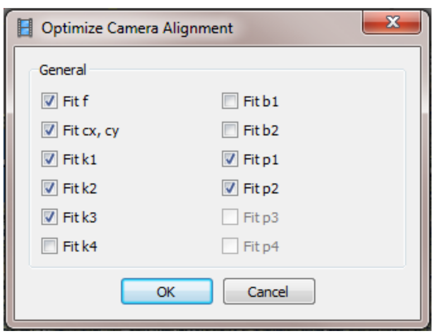
Part 3: Optimize the Camera

Now that the images have been aligned and the markers have been placed, we need to optimize the camera alignment. The goal of this step is to improve the accuracy of the interior and exterior parameters of the camera, thus correcting for lens and sensor distortions. This is done by iteratively removing tie points that have higher standard errors and then re-optimizing the cameras. The following is a simplified approach for optimizing the cameras. The BLM has developed a more complete optimization workflow, which can be found in your exercise data (**BLM_optimize_workflow.pdf**).

A. Optimize the cameras

1. In the main menu, click on **Tools** and then **Optimize Cameras** or click on the tool in the Reference pane (see following figure).

2. In the **Optimize Camera Alignment** window, place a checkmark next to all items except for k4, b1, b2, p3, and p4 (see following figure) and then click **OK**. Metashape quickly runs aerial triangulation and optimizes the camera parameters to better fit the reference data.



B. Delete points and rerun optimization

Some of the points found in the sparse point cloud may have been incorrectly matched. By using the gradual selection tool, we can select the points that are more likely to contain larger errors and remove them from the model. This can improve the accuracy of the subsequent optimization steps, which will also improve the accuracy of the end products.

1. Make sure that the model tab is selected and open up the Gradual Selection tool by clicking on **Edit** in the main menu and then **Gradual Selection**.
   i. Select **Reprojection error** and then adjust the slider to around 0.3. The points that are above the threshold will become selected and turn red in the viewer. The number of total points and selected points can be seen in the bottom-left corner of the viewer.
   ii. Click **OK** to finalize the selection.

2. Delete the selected points by clicking the **Delete** button in the main toolbar (see following figure) or by hitting the delete button on your keyboard.

3. Click on the Optimize Camera Alignment tool again and rerun it using the same parameters used previously.

Part 4: Create Products

Now that we have aligned the images and optimized the sensor, we are now ready to create a dense point cloud and orthomosaic. In this section, we will first create a dense point cloud. We will then create a mesh from the dense point cloud and use it as the surface model for the orthomosaic.

A. Create and export a dense point cloud

1. In the main menu, select **Workflow** and then **Build Dense Cloud**.
   i. Change the quality to **Medium** and depth filtering (in advanced) to **Mild**.
   ii. Click **OK**. The process may take a few minutes to complete, depending on the processing power of your computer (see following note).

NOTE*: The quality level that you select depends on the imagery that you are working with and what you are hoping to do with the point cloud. Ultra-high will attempt to match every pixel, but may result in a lot more processing time and the product may end up having holes where matches were unsuccessful. Each level that you drop down, Metashape downscales the image by a factor of 4. Usually it is a good idea to start with medium and then bump it up to a higher level if more detail is desired.*

2. View the dense point cloud by clicking on the **Dense Cloud** button (see following figures) in the model toolbar.

3. Go ahead and explore the point cloud by using your mouse to zoom, pan, and rotate the point cloud.
4. Optionally, if you want to view or further process the point cloud using another software application (e.g., Fusion, ERDAS Imagine, or ArcMap), you can export the point cloud by clicking on **File** and then selecting **Export Points**.

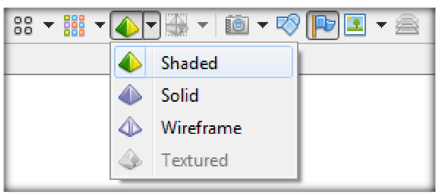
NOTE*: If you don't need a dense point cloud or orthomosaic for the entire area, you can use the region tools to specify the output boundary (see following figure). This can be very helpful for when you need to create products for specific areas within the set of images, or even for quickly testing out the Metashape parameters. The two main tools for adjusting the boundary are the Resize Region and Rotate Region tools found in the model toolbar.*

B. Build a mesh

1. In the main menu, click on **Workflow** and then select **Build Mesh**.
2. Use the following settings:
   i. Source data: **Dense cloud**
   ii. Surface type: **Height field**
   iii. Face count: **High**
   iv. Select **OK** to create the mesh.

> ***NOTE****: Either a mesh or digital elevation model (DEM) is needed to create an orthomosaic. Metashape offers multiple approaches for doing this, as listed here: (1) a DEM (TIFF format) can be imported by going to **Tools**, **Import**, and then clicking on **Import DEM**; (2) a mesh can quickly be generated from the sparse point cloud by selecting **Sparse Cloud** instead of Dense Cloud in the Build Mesh workflow; (3) a detailed mesh can be created from the dense point cloud, as explained in the previous step. Which method you select depends on the level of accuracy desired and the availability of an accurate DEM.*

3. To display the mesh, click on one of the three mesh buttons in the model toolbar (see following figure).



4. We will now smooth the mesh by clicking on **Tools** in the main menu and selecting **Mesh** and then **Smooth Mesh**.
   i. Set the # of passes to 10 and select **OK** (see following note).

> ***NOTE****: By smoothing the mesh, we are removing the individual tree crowns and making a pseudo-terrain model. This type of mesh works best for creating a traditional orthomosaic. It is possible to skip this smoothing step and go directly to creating the orthomosaic. This results in the creation of a "True Ortho" that attempts to remove building and tree lean. This approach can be useful if your imagery has a lot of overlap (>80%), but can otherwise introduce image smearing and other unwanted image artifacts.*

C. Create and export orthomosaic

1. In the main menu, click on **Workflow** and then select **Build Orthomosaic**.
2. Select the following options:
   i. Type: **Geographic** (UTM zone 8N)
   ii. Surface: **Mesh**
   iii. Blending mode: **Mosaic**
   iv. Enable color correction: **leave this unchecked** (this usually isn't needed unless there are major variations of coloring in your set of images)

   v. Pixel size: approximately **0.17** for both X and Y (the software automatically calculates the optimal pixel size)
   vi. Select **OK** to create the orthomosaic
3. To view the newly created orthomosaic, go to the Workspace pane and double click on **Orthomosaic**. If you don't see it, be sure to expand **Chunk 1** in the Workspace pane.
4. Go ahead and explore the orthomosaic by zooming in and panning around the image with your mouse scroll wheel.
5. Optionally, if you want to use the orthomosaic in another software application, you can export it by right clicking **Orthomosaic** in the Workspace pane and selecting **Export Orthomosaic** and then select **Export JPEG/TIFF/PNG…** (see following note).

***NOTE**: There are a couple of options in the export window that are worth mentioning. First, if you are working with a large dataset, you can split the mosaic into tiles by checking the **Split in blocks** box and specifying a tile size. Another useful feature is the ability to specify your output region by checking the **Setup boundaries** box and entering in the bounding coordinates.*

D. Generate project report

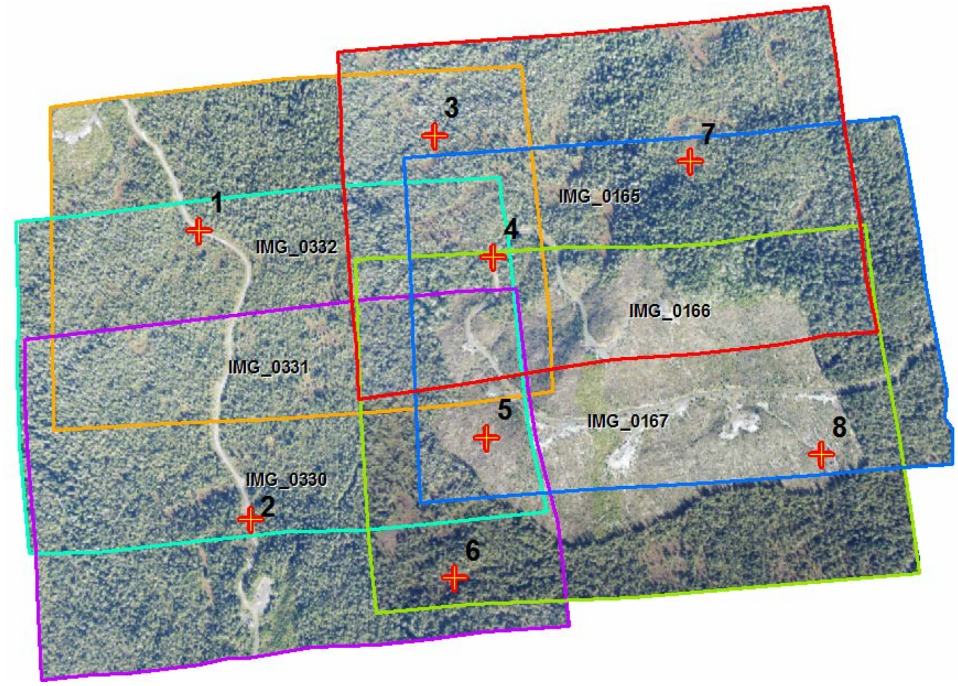
Before we finish this exercise, let's create a project report to document the project setup and outputs. Within the project report, you will find information about the camera calibration, point clouds, markers, aerial triangulation results, and the final ortho.

1. In the main menu, click on **File** and then **Generate Report**.
   i. Give the report a title and a description.
   ii. Select **Top XY** for the projection and hit **OK**. This is the view of the model that is displayed on the front cover of the report. Only **Top XY** and **Current View** are really applicable when working with orthomosaics.
   iii. Navigate to an output directory, give the file a name, and click on **Save**.
2. Locate and open your newly created PDF report.
3. Browse through the project report to become familiar with the contents.
4. Go ahead and save your Metashape project file one last time.
5. Optionally, you can explore a few other features found in Metashape such as creating and exporting a DEM (**Workflow** and then **Build DEM**), exporting individual orthophotos (right click **Orthomosaic** and select **Export Orthophotos**), exporting an orthomosaic as a Google KMZ file (right click **Orthomosaic** and select **Export Orthomosaic** and then **Export Google KMZ**), and creating a 3D PDF of the model (click on **File** and select **Export Model** and then select **Adobe PDF** as the file type).

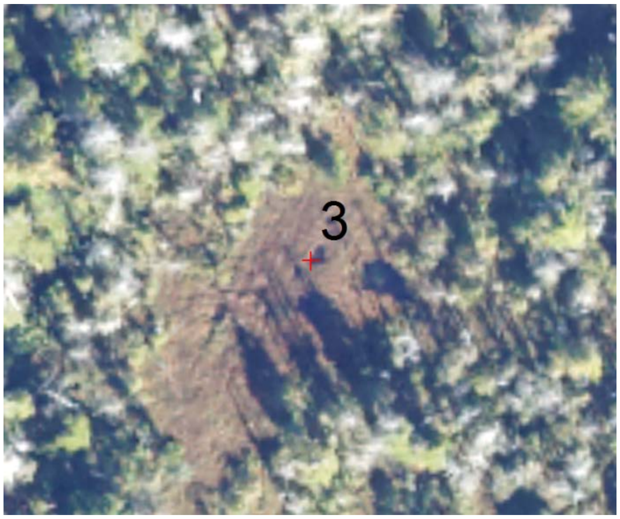
Conclusion: In this exercise, we learned how to use Metashape to orthocorrect aerial imagery and create products such as an orthomosaic and dense point cloud. Metashape is a great tool for working with imagery captured with a non-metric sensor since it is able to calibrate the camera and align the images with minimal input from the user. Metashape can also be used for processing scanned historical photographs and terrestrial imagery. Additional resources, including a few tutorials and a very helpful user forum, can be found at www.agisoft.com.

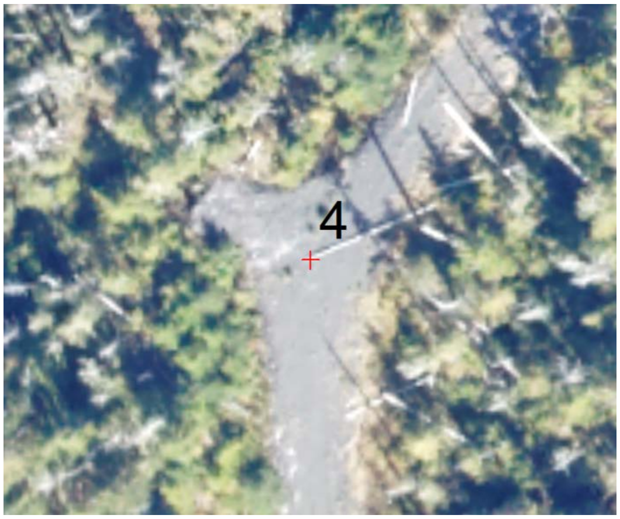
Appendix A: Marker Locations

Markers (i.e., control points) are crucial for geospatially positioning and scaling the imagery. Marker coordinates are generally obtained with a GPS unit in the field or by using a reference image (as was done for this exercise). Each marker needs to be located and added to each image it intercepts. For example, marker 1 needs to be added to images IMG_0332 and IMG_0331 since it intercepts both of these images. The graphic below shows the marker locations and the image footprints.



Refer to the following zoomed-in images to know where to place the markers. Since the scale and placement depends upon these markers, it is important to place them as accurately as possible.


3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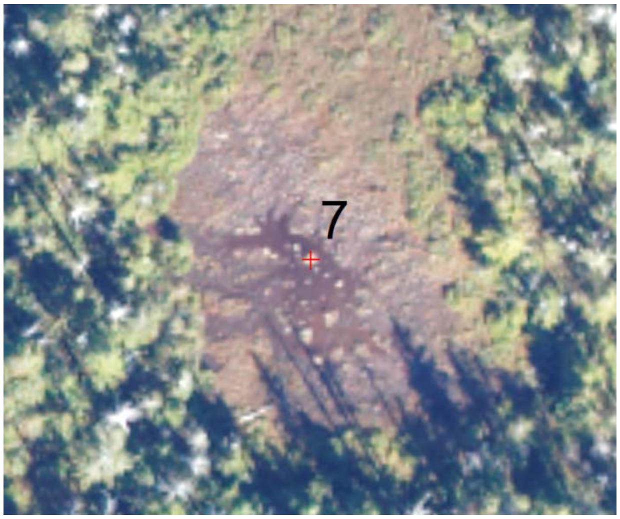
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