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Metashape Image Processing for Ground-based Imagery

Introduction

Today's handheld cameras are extremely portable and easy to use. Images captured by these devices, if taken correctly, can be processed in Metashape to create a 3D model of the site or feature. These 3D models can be very useful for documenting site conditions and sharing 3D content with others. In this exercise, we will create a 3D model of a portion of a dry streambed using images taken with a DSLR camera. If you plan to take your own images, please refer to the *Appendix: Tips for taking Photographs* found at the end of this document.

Objectives

- Learn how to process ground-based images to create a 3D model.

Required Data

- Metashape_ground_based_data.zip – contains 9 images taken with a handheld camera.

Prerequisites

- Install and activate Metashape (please see Metashape Installation Guide for details).

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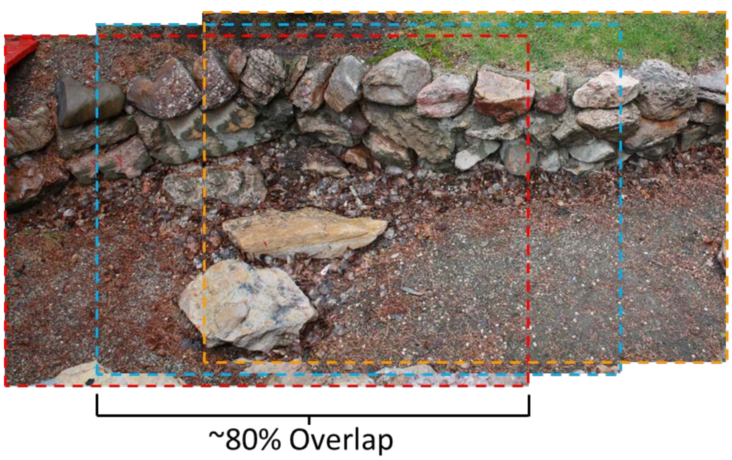
Part 1: Set up Metashape project file

In this section, we will set up the Metashape project file by adding the images to the project file and reviewing the camera information. Since we don't have ground control points, we won't be able to define a geographic coordinate system. However, we will later add some markers and scale bar to adjust the model to the correct scale.

A. Load images

1. Launch Agisoft Metashape from the start menu by clicking **Start**, **All Programs**, **Agisoft**, and then selecting **Agisoft Metashape Professional**.
2. Add the exercise images by going to the main menu in Metashape and selecting **Workflow** and then **Add Photos** (see following note).

NOTE*: If you are taking your own images, be sure to capture plenty of overlap. You'll notice that the images used in this exercise overlap one another by 70-80% (see following figure). The amount of overlap needed depends on the complexity of the feature that you are modeling. For example, if you are modeling a flat surface, 60% overlap is likely adequate. However, if the feature has a lot of faces, such as with vegetation, you'll want to increase the overlap to something like 80-90%. Always err on the side of capturing more images than you need because it is a lot easier to weed a few out before processing rather than to revisit the site.*



3. Navigate to the **01_imagery** folder in your exercise data (Metashape_04_data) and select the 9 images in the list and then click Open. The photos should now be added to both the Photos pane and the Workspace pane (alternatively, you can drag and drop the JPEG or TIFF images into the Photos or Workspace panes).

B. Review camera information and coordinate system

Before we start processing the images, it's always a good idea to review the camera information and coordinate system.

1. In the main menu, click on **Tools** and then select **Camera Calibration**. Note the following information:
    i. On the left side of the calibration window, you should see a camera icon with information about the camera next to it. This indicates that there are 9 images in this group. All of the information (camera type, pixel size, etc.) seen to the right of it is for the selected group (see following note).

> ***NOTE****: Try to avoid changing the lens' focal length (zooming in and out) during the image collection. Metashape creates a separate group for each focal length. Some projects may require varying focal lengths, but try to minimize this as much as possible since it can add unneeded complexity to the project.*

    ii. Camera type should be set to **Frame** (only change this setting if you know that you are using a fisheye or other unique lens)**.**
    iii. Pixel size should be 0.00521437 mm (this is automatically pulled in from the images metadata).
    iv. Under the **Initial** tab, the only field that should have a value is **f**, which represents the focal length measured in pixels. The other values should all be 0 since we have not yet calibrated the camera. After we align the images, the Adjusted tab will become available.
2. Click **OK** to close the camera calibration window.
3. Activate the Reference pane by clicking on the **Reference** tab in the lower left corner.
4. In the Reference pane, select the **Reference Settings** button (see following figure and note).

> ***NOTE****: 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****.*

5. In the Reference Settings window, the coordinate system should be set to **Local Coordinates (m)** (see following note).

> ***NOTE:*** *Some cameras may be GPS enabled, which means that geographic coordinates are saved in the image's metadata when the image is taken. If GPS information is available, Metashape will automatically pull in this information to use as reference and also change the coordinate system to match the reference data. However, you'll likely not want to rely too heavily on this GPS information since it is only accurate to within a few meters. If you know the GPS accuracy, go ahead and enter the value into the Camera accuracy field. In this exercise, our images don't have GPS information, but you may encounter this when working with your own imagery.*

6. Use the default values for the other fields and click **OK**.
7. Save your project file by selecting **File** and then **Save**.
    i. Navigate to the 03_outputs folder in your exercise data and give your project file a name and then hit **Save**.

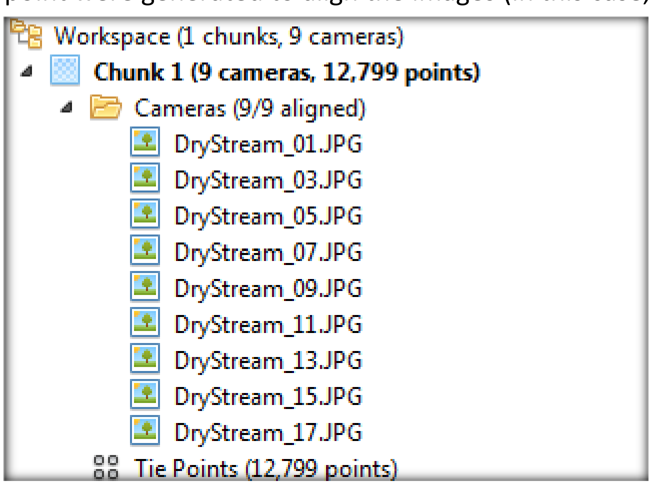
Part 2: Process Images in Metashape

A. Align the images

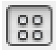
1. In the main menu, click on **Workflow** and then select **Align Photos**.
2. In the Align Photos window, click on **Advanced** to expand the options and then specify the following settings:
   i. Accuracy: Medium (see following note)

> ***NOTE:*** *The medium setting runs about 4 times faster than high and 16 times faster than highest. For actual project work, it may be worthwhile to run it on high accuracy. But for the sake of time, we'll just use medium. Be sure to look at the Metashape help documentation, found under* ***Help*** *in the main menu, for added details as you go through this exercise.*

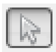
   ii. **Generic preselection: enabled** *(this allows Metashape to align the images using lower accuracy setting first and then refine the model; this can usually reduce alignment time)*
   iii. **Key point limit: 40,000** *(this is the number of points that Metashape will attempt to create for each image)*
   iv. **Tie point limit: 4,000** *(among all of the key points creates, Metashape will attempt to match this many tie point for each image)*
   v. **Adaptive camera model fitting: enabled** *(this allows Metashape to determine which camera calibration parameters to use during the image alignment step)*
3. Click **OK** to run alignment. This may take a couple of minutes to process (speed will vary depending upon your workstation).
4. Once alignment is complete, go to the **Workspace** pane and verify that all images have correctly aligned. You will need to expand **Chunk 1** and then **Cameras** to find this information (see following figure). It should show that 9/9 images aligned. If an image didn't align, an **NA** will be present next to the image name. At the bottom, you should also see how many tie point were generated to align the images (in this case, 12,799 points).



5. After alignment is complete, the sparse point cloud should appear in the main viewer. If not, click on the **Model** tab just above the main viewer and ensure that the sparse point cloud button is selected (see following figure).



6. With the **Navigation** button (see following figure) active, explore the sparse point cloud in the main viewer using your system mouse. Hold down your scroll wheel to pan around and left-click and drag to rotate the point cloud.



7. Your point cloud should appear fairly clean, but if you do see any anomalous points along the outer edges of the model or above/below the main surface, go ahead and use one of the selection tools (see following figure) to select the points and then hit the delete button on your keyboard to remove them from the point cloud.

8. Save your current project file.

B. Build a dense point cloud, mesh, and texture

In this exercise, we will set up a batch process to perform multiple steps consecutively. Each of these steps could be ran individually by going down the list of tasks found under the Workflow dropdown in the main menu, but running them as a batch process can be much more efficient than running them individually. However, keep in mind that it may be better to run the steps individually if you are working with a challenging set of images and need to experiment with various settings along the way.

1. In the main menu, click on **Workflow** and then select **Batch Process**.
2. In the Batch Process window, click on the **Add** button.
3. In the Add Job window, apply the following settings:
    i. Job type: **Build Dense Cloud**
    ii. Apply to: **All Chunks**
    iii. Quality: **Medium**
    iv. Depth filtering: **Moderate**
    v. Reuse depth maps: **No**
    vi. Click on **OK**. You should now see the build dense cloud job listed in the Batch Process window.
4. Click on the Add button again and apply the following settings:
    i. Job type: **Build Mesh**
    ii. Apply to: **All Chunks**
    iii. Surface Type: **Arbitrary** *(use arbitrary for models that include vertical faces; height field is used mainly for aerial imagery)*
    iv. Source data: **Dense cloud**
    v. Face count: **High**

vi. Custom face count: Leave at default *(it only uses the custom face count if you select Custom from the previous face count setting)*

vii. Interpolation: **Enabled** (default)

viii. Point classes: **All**

ix. Click on **OK**. The Build Mesh job should now be added to the Batch Process window.

5. Click on the Add button one more time and apply the following settings:

i. Job type: **Build Texture**

ii. Apply to: **All Chunks**

iii. Mapping mode: **Generic** *(you'll usually want to use generic for most ground-based imagery with vertical faces; whereas, Orthophoto or Adaptive Orthophoto are recommended for aerial imagery)*

iv. Texture from: **All Cameras**

v. Blending mode: **Mosaic**

vi. Texture size: **4,096** *(you can double the texture size to 8192 if you have a larger model; however, increasing it beyond that uses a lot of RAM and may not work correctly)*

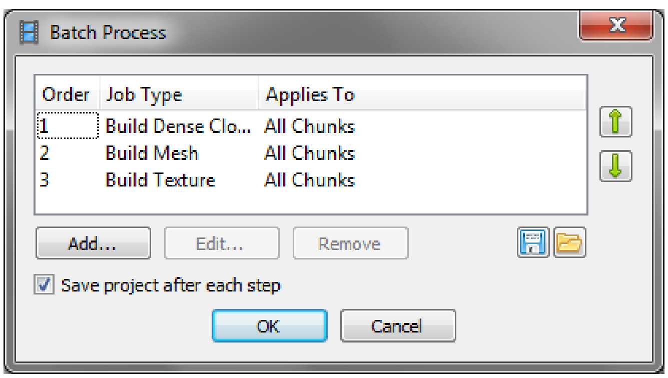
vii. Texture count: **1** *(instead of increasing the texture size, you can also increase the texture resolution by changing the texture count; this may be helpful for larger models; however, sluggish performance has been noticed in 3D PDFs that include more than one texture file)*

viii. Color correction: **No** *(this slows down the process a lot and so only use this if there are major variations of coloring in your set of images)*

ix. Hole filling: **Yes**

x. Click on **OK**. You should now see all three jobs in the Batch Process window (see following note and figure).

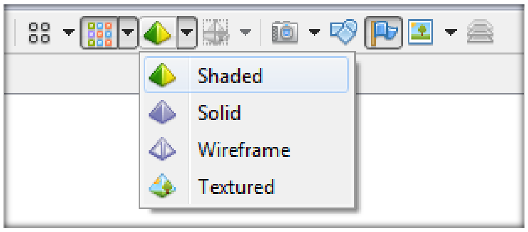
NOTE*: As you saw from the list of Job types, there are a lot of processes that can be run from the Batch Process window. This can be a helpful tool for streamlining a workflow once you become familiar with it.*



6. Make sure that the **Save project after each step** is checked and then hit **OK**. This may take a few minutes to process and so now is a good time to catch up on emails or review the Metashape user manual (www.agisoft.com/downloads/user-manuals/).

7. A status window should open, showing you the progress. Once the batch process is complete, make sure that all jobs have a green checkmark next to them indicating that they were completed correctly. If all looks good, go ahead and close the status window.

8. The textured mesh should automatically be displayed in the main viewer. Explore the 3D model using your system mouse.
9. In addition to the textured mesh, other products were created by the batch process, including the dense point cloud and mesh. You can display and review these products by clicking on the dense point cloud button or the dropdown next to the mesh button in the main toolbar (see following figure).

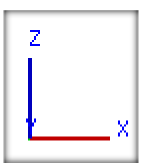


Part 3: Apply orientation and scale to model

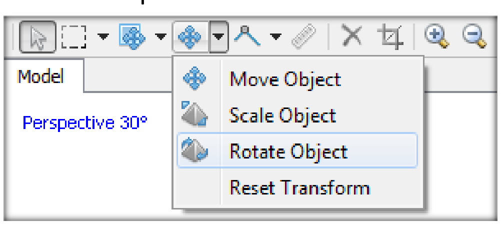
A. Orient the model

Since we are working with a local coordinate system, our model may be incorrectly rotated on the X, Y, and Z axes. This may affect some of the overhead products that we will generate from the model, such as an orthomosaic or a DSM. Georeferencing would correct this issue; however, since we won't be georeferencing our model in this exercise, we can use some of the tools in Metashape to manually adjust the rotation of the model.

1. In the main viewer, keep an eye on the viewer's axis (lower right corner of viewer) and rotate the model until the Z axis is straight up, X axis is to the right, and Y axis is parallel to your line of sight. The axes should look like the following figure. Don't worry if your actual model is completely upside down at this point; we'll fix that soon.



2. In the model toolbar, click on the **Rotate Object** button (see following figure). This will hold the axes in place as we rotate our model.



3. Return to the main viewer and rotate your model until the bottom of the streambed is level to your view (this can be done with any plane that is known to be nearly horizontal. Also, hold your mouse wheel down and drag the model up or down until the streambed is centered on your viewer. It should look similar to the following figure.

4. We can now save our models orientation by selecting a different tool in the toolbar, such as the navigation tool.

B. Scale the model

Scale bars are used to define the scale of the model, which is necessary for measuring distance and volume in the model. For simple models requiring minimal accuracy, only one scale bar is needed. However, if improved accuracy is needed, it is usually good practice to place a few scale bars around the site. Scale bars can be defined by recording the distance between two points in the scene. A simple way to do this is to place a ruler or other feature of known dimensions directly in the scene during image collection. Or, if you forgot to place a reference object, as was the case with this image collection, you can revisit the site afterwards and measure the distance between two features in the scene.

1. We first need to place two markers on features in the scene. See the following figure for the placement of the first marker located on the large rock towards the left of the model. The marker is placed on the right edge of the black dot.

2. Markers can be placed on the individual images or directly on the mesh. Placing them on the mesh is helpful because Metashape will automatically place them on all images that the point intersects. To place the marker, make sure that the textured mesh is displayed in the main viewer and use your system mouse to zoom into the location of the first marker. Right click on

the location of point 1 and select **Create Marker**. In the Photos pane, a flag will appear above each image that intersects point 1 (see following note).

***NOTE:** If you don't see the newly placed marker on the model, make sure that the **Marker** button is turned on in the toolbar (see following figure). Once you place a marker on the mesh, it can't be moved with your cursor. However, as you adjust the marker position in the individual images, the marker location on the mesh will also be updated.*

3. Switch to the Reference pane (click on the Reference tab at the bottom left of Metashape). In the markers table, right click on point 1 and select **Filter Photos by Markers**. This will hide all of the images, in the Photos pane, that don't intersect point 1.
4. Double click one of the images in the Photos pane to open it up in the viewer. Zoom in until you can clearly see the black dot on the rock. Left click and drag the marker if you need to adjust it any.
5. Double click on the next image in the Photos pane and adjust the marker on that image if needed.
6. Continue to review point 1 on each image until they have all been checked and adjusted if necessary.
7. Return to the **Model** view in the main viewer to place the second marker. Use the following figure for reference. Once you find the feature, right click on the model and select **Create Marker.**

8. In the markers table, right click point 2 and select **Filter Photos by Markers**. Now all of the images that intersect point 2 should be displayed in the Photos pane.
9. Double click on the first image (DryStream_07) to open it up in the viewer. Zoom in on point 2 and drag the flag to the lower left corner of the black dot shown on the previous figure.
10. Adjust the position of point 2 on the other four images by double clicking the images in the photos pane and dragging the point to the same location on each images.
11. Create a scale bar by selecting point 1 and point 2 in the markers table, right clicking on them, and selecting **Create Scale Bar**. A new scale bar will appear in the **Scale Bars** table directly below the **Markers** table.

12. In the Scale Bars table, double click within the empty **Distance** cell for point_1_point_2 and enter in the value 2.38 meters, which is the measured distance between the two points. Your scale bar table should look similar to the following figure.

Scale Bars	Distance (m)	Accuracy (m)
point 1_point 2	2.380000	0.001000

13. Click on the **Update** button (see following figure) in the Reference pane to apply the scale.

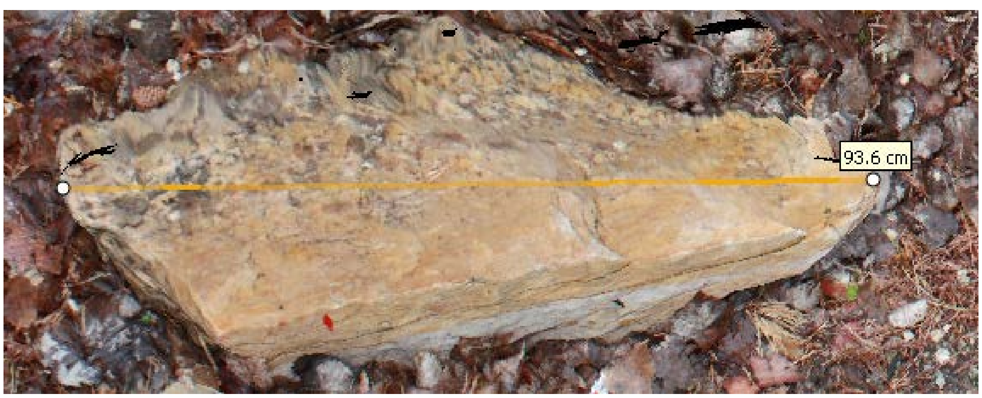
Part 4: Perform Measurements

Now that we have applied a scale to the model, we can now measure distance directly on the model or create a DSM to estimate volume.

A. Measure distance

1. With the textured mesh displayed, click on the Ruler button (see following figure).

2. Measure distances on the model by left-clicking with your mouse on the mesh and then clicking again on a different area of the mesh. Give it a try by measuring a feature such as the length of a rock (see following figure). The measurement will appear in a box next to your second point.



3. To clear your measurements, either his the ESC button or switch to a different tool.

B. Create DSM and Estimate Volume

In Part 3, we corrected the orientation of the model by adjusting the X, Y, and Z axes. Doing so allows us to create a digital elevation model (DEM). This is a necessary step in order to perform volumetric estimates.

1. In the main menu, click on **Workflow** and then **Build DEM**.
2. In the Build DEM window, use the following settings:
   i. Type: **Geographic** and **Local Coordinates (m)**
   ii. Source data: **Dense cloud** *(the dense cloud will give you the most accurate results)*
   iii. Interpolation: **Enabled** *(this will fill in any holes that exist from the dense point cloud)*

iv. Point classes: **All**

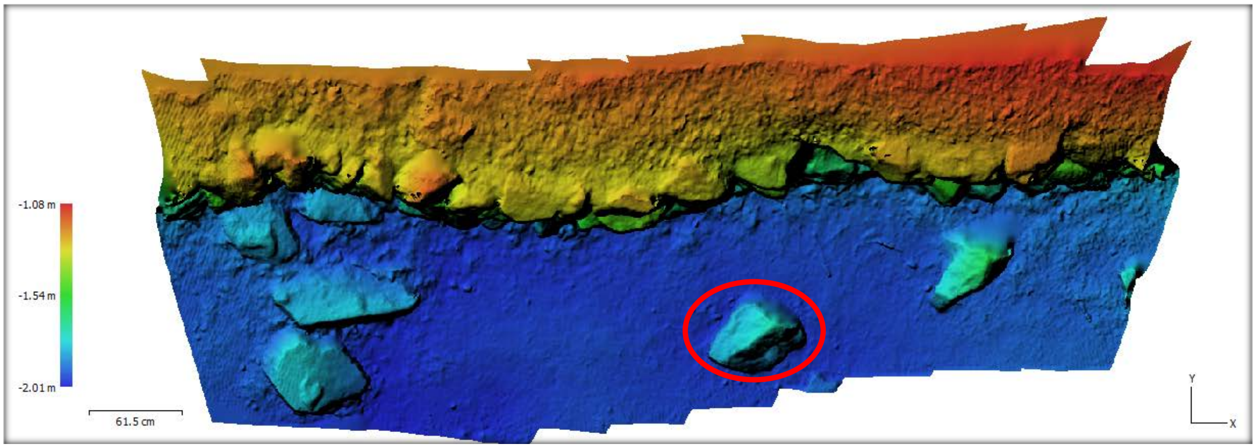
v. Setup boundaries: **unchecked** *(if you only want to create a DEM for a portion of the area, you can enable this setting and enter in coordinates)*

vi. Resolution (m): use default value (should be **around 0.0029 m**)

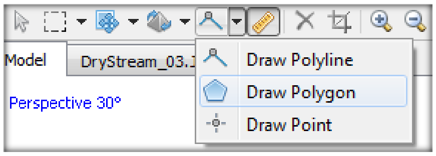
vii. Total size (pix): use default values (should be around 3000 x 1460)

viii. Click on **OK** to create the DEM. It should only take a few seconds to generate it.

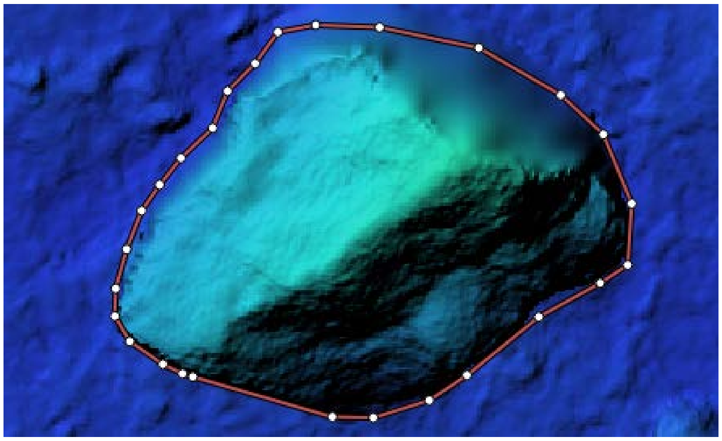
3. In the Workspace pane, double click on the newly created DEM layer (expand Chunk 1 if necessary). You should now see the DEM displayed in the main viewer (see following figure).



4. Zoom in and pan to the rock that is marked with the red circle in the previous figure.
5. Click on the **Draw Polygon** tool (see following figure) in the main toolbar.



6. Draw a polygon around the rock by left-clicking with your mouse to place vertices. To close the polygon, double click while placing the last point. Your completed polygon should look somewhat similar to the following figure (see following note).



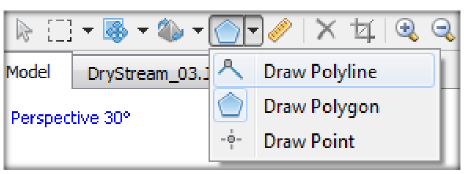
***NOTE**: Since these images were taken from only one side of the streambed, the backsides of the rocks weren't visible, which resulted in holes in our dense point cloud. When creating the DEM, Metashape interpolated these values to fill in the holes. This results in a smearing effect on the backside of the rocks. This can be avoided by taking more pictures from various angles of the scene.*

7. You can edit the vertices by dragging them with your mouse or delete them by right clicking on them and selecting **Delete Vertex**. You can also add additional vertices by right clicking on the completed polygon and selecting **Insert Vertex**.
8. Right click on the newly created polygon and select **Measure**.
   i. The **Planar** tab shows you the coordinates of each vertex, along with the perimeter distance and area of the polygon.
   ii. Click on the **Profile** tab to view the elevation changes along the perimeter of the polygon.
   iii. Click on the **Volume** tab to view the volume estimates for the polygon. Set the base plane setting to **Best fit plane** (see following note). The volume estimate of our rock should be around 0.029 cubic meters.

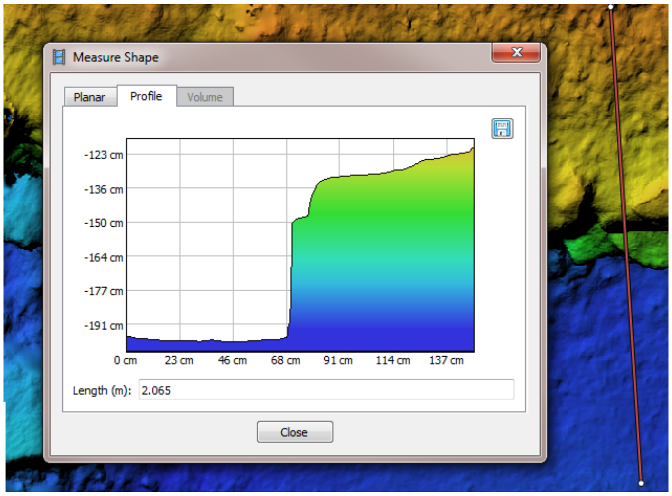
***NOTE**: The Best Fit and Mean level methods use the elevations of the vertices to calculate the base plane. These two methods produce similar results and are recommended for estimating the volume of features on an uneven surface. The Custom level method allows the user to enter in a set elevation for the base plane. This may be useful for estimating how much cut/fill material is needed for leveling an area.*

9. Close the Measure Shape window after you're done exploring the volume estimates.

   We can also view a cross section of our DEM by using the Polyline tool. Do this by selecting the **Draw Polyline** tool (see following figure) from the toolbar and drawing a line using either two points or several points along a path. Finalize the polyline by double clicking when placing the last point.



10. Right click on the polyline and select **Measure**.
    i. Click on the **Profile** tab to display the cross section of the DEM. The following cross section was created by drawing a line from the top of the streambed to the bottom.



Part 5: Export the Model

Products from each step can be exported throughout the workflow. In this step, we will export the textured model as a 3D PDF, but keep in mind that you can also export the sparse point cloud, dense point cloud, DEM, and other products by clicking the various export options found under the **File** and **Tools** sections in the main menu.

A. Export a 3D PDF of the model

1. Click on **File** in the main menu and select **Export** and then **Export Model**.
   i. Navigate to the outputs folder of the exercise data.
   ii. Give the file a name (e.g., streambed) and change the file type to **Adobe PDF (*.pdf)** and click the **Save** button.
   iii. In the Export Model – PDF window, use the following Export Parameters:
      (a) Vertex colors and normals: disabled *(these usually only add detail for low resolution models)*
      (b) Export texture: JPEG or PNG *(they both produce similar results and file sizes)*
      (c) Include comment: enabled *(go ahead and edit it to include your name: Generated by <name> with Agisoft Metashape)*
      (d) Write alpha channel: disabled *(the Alpha channel is really only necessary if you used a mask; otherwise, it doesn't add any additional information)*
   iv. Click on **OK** to export the 3D PDF (see following note).

> ***NOTE****: The status bar doesn't seems to show any progress when exporting the model. It should only take a few seconds to create the PDF, but the status bar will disappear once it is complete. Your PDF should be waiting for you in the specified folder though.*

2. Navigate to your outputs folder and double click the PDF file that you just created. It should open in Adobe Acrobat (see following note).

***NOTE**: If you see a message at the top of Adobe Acrobat saying that "3D content has been disabled," you will need to go into your Adobe Acrobat preferences and adjust a setting. Do this by clicking on **Edit** and **Preferences**. Under categories, click on **3D & Multimedia** and then place a checkmark in the first box labeled **Enable playing of 3D content**. Click on **OK** and then close Adobe Acrobat and reopen the file. Your 3D model should now be visible.*

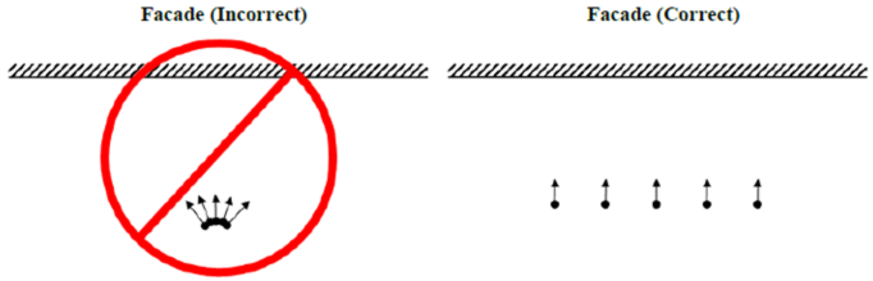
3. Use your system mouse to explore the model. Your scroll wheel allows you to zoom in and out and your left-button will rotate the model. To pan around the model, hold down CTRL and your left-button.
4. With a 3D PDF, you can easily share your 3D model with others. Go ahead and share it with someone that might be interested.

Congratulations! You have successfully completed this exercise by creating a 3D PDF of your model from ground-based imagery. In this exercise, you also learned how to streamline the workflow by running a batch process, as well as how to scale and orient a model when no geographical coordinates are available. Metashape can be a very useful tool for documenting site conditions and for obtaining measurements of a site at a later time.

Appendix: Tips for taking Photographs

Not all images, even if they are in focus and properly exposed, will produce good 3D models. Here is a list of some of the most important items to keep in mind while collecting ground-based images.

- Include sufficient overlap by making sure that the images overlap one another by at least 60%. It is better to have extra images than not enough.
- Avoid changing the lens focal length and focus distance, when possible, since these two components need to remain constant for the camera calibration to be most successful. After setting up your camera, it may be beneficial to switch the focus to manual and place tape on the lens to hold it in place.
- Change perspectives for each image by moving the camera position. Images taken from the same location (like you would take for a panorama shot) will result in poor geometry. Just remember, that you are creating structure from "Motion." The following figure comes directly out of the Metashape help documentation.



- Take pictures straight on, as perpendicular to the plane of the subject as possible.
- Fill the scene with the object to reduce the amount of background features and to maximize the resolution.
- Save images in Raw + JPEG format if your camera allows. This enables you to make adjustments to the exposure if needed.
- Use scale bars or targets if you need to define the scale, orientation, and location of the 3D model.
- Collect images when site conditions are best, such as on overcast days when shadows aren't harsh, leaf-on conditions for vegetation, or low water conditions for stream beds.
- Avoid moving objects in the scene by being aware of your surroundings. Also, be sure to take the pictures on a calm day if the scene includes vegetation or other objects that are likely to move in the wind.
- Avoid non-static shadows created by using a camera-mounted flash and by not being aware of the shadow that you or others are casting.
- Don't forget necessary gear. Here are some items that you may want to include: camera, polarizing filter (to reduce solar glare), extra batteries, SD cards, extension pole, tripod, monopod, remote trigger, measuring tape, ground targets, GPS unit, and safety gear.