GST 105: Introduction to Remote Sensing Lab Series

Lab 4: Image Rectification

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Organization: American River College
Author: Nathan Jennings

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Introduction

Although many photogrammetric processes require specialized photogrammetric software, this lab reviews how to perform image rectification, which can be done using ArcMap. Image rectification is one of the fundamental methods used in photogrammetry. In a real-world setting, it is likely that more advanced training and education would be required in addition to an investment in specialized photogrammetric software. Many ortho-imaging and analysis firms make the necessary investments to perform photogrammetric processes. Students are encouraged to investigate the software available and firms that conduct photogrammetry.

Objective: Perform an Image Rectification

Students will walk through the processes of conducting an image rectification using 2009 6" ortho rectified aerial photography to "rectify" a 2005 1m Color IR USGS image.

Lab Settings

Required Virtual Machines and Applications

Windows Machine User Account	Train
Windows Machine User Password	Train1ng$

All of the imagery can be found in the ***Lab 4\Data*** folder.

- **SAC_13.sid** – MrSID compressed image format image. ~50Mb reference image. Ortho image from the City of Sacramento, (2009). Pixel size 6 inches. Coordinate Systems - CA State Plane Zone 2, NAD 83, Units-feet.

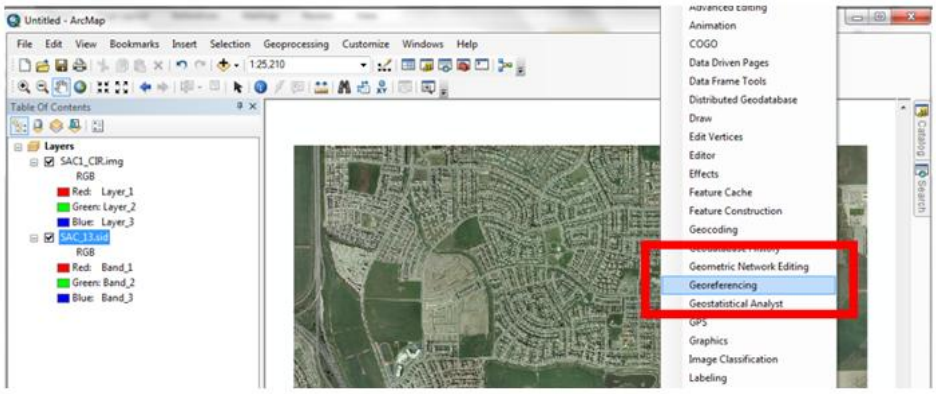
- **SAC1_CIR.img** – ERDAS Imagine format. Undefined/Unknown coordinate system. Image to be rectified.

To rectify **SAC1_CIR.img,** use the **SAC_13.sid** as the reference image.

1 Load Images and the Georeferencing Toolbar

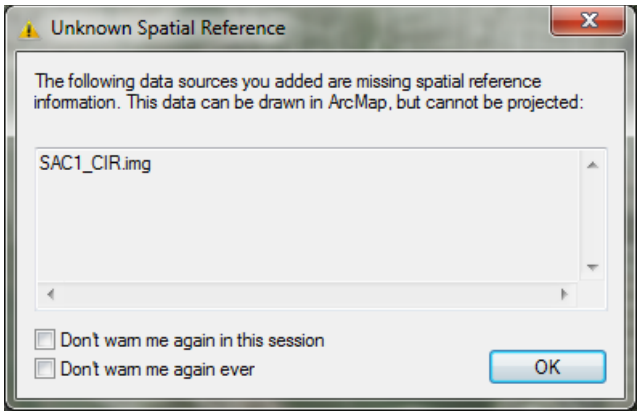
1. Log into the computer, using the information provided in the Lab Settings section.
2. Load the **SAC_13.sid** image into ArcMap. This image will be used as the reference image. Zoom to the extent of the **SAC_13.sid** image.
3. Load the **Georeferencing toolbar** by right-clicking in the toolbar area and choosing Georeferencing.

The Georeferencing toolbar is used for image rectification.



The Georeferencing toolbar is shown below.

4. To load the image to rectify, add the **SAC1_CIR.img** file to ArcMap. The following warning may appear.

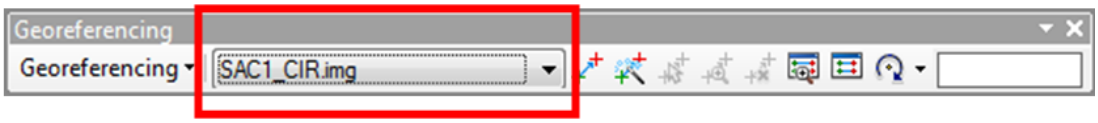


Click **OK**.

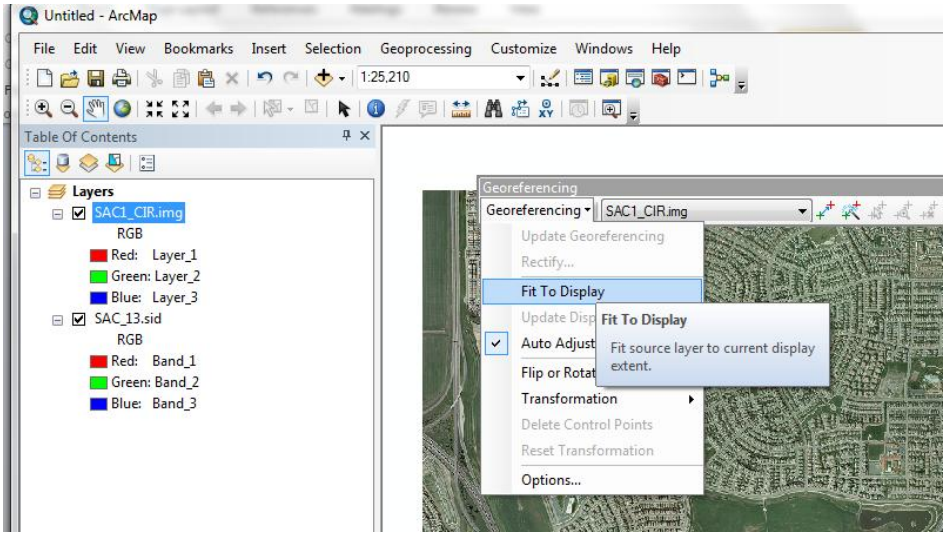
Exercise A: *What is the coordinate system for the SAC1_CIR.img?*

2 Rectify the Image

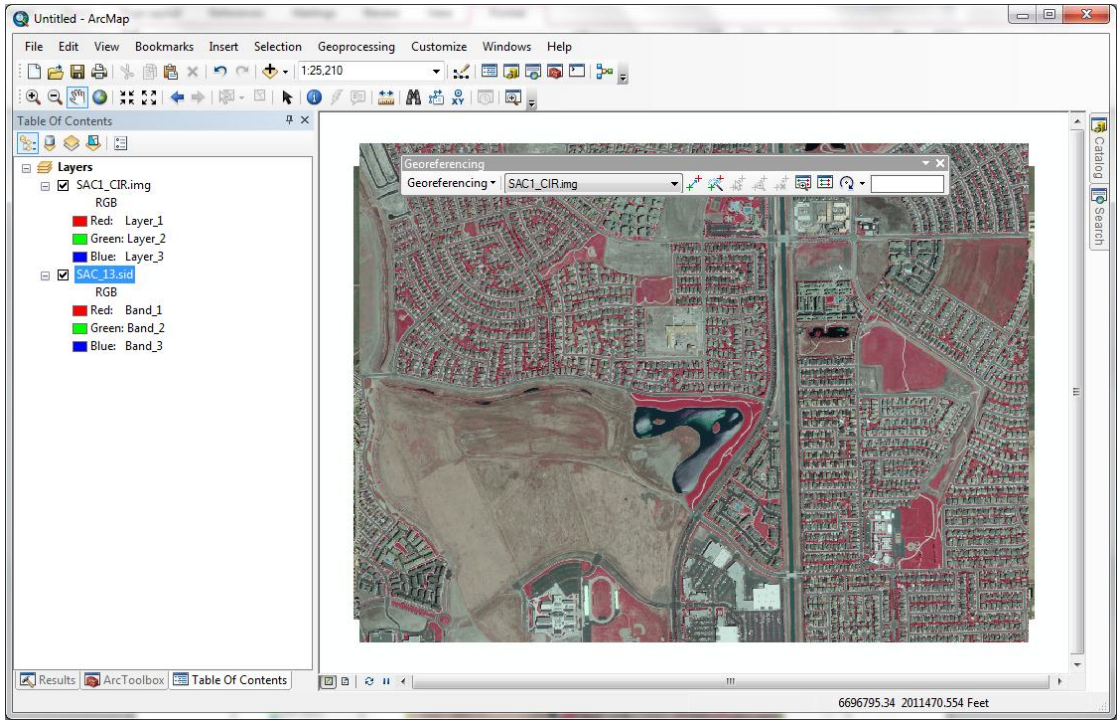
1. In the Georeferencing toolbar, choose the **SAC1_CIR.img**. You may have to choose this image from the dropdown list.



2. From the **Georeferencing dropdown**, choose **Fit to Display**.



ArcMap should look like the following:

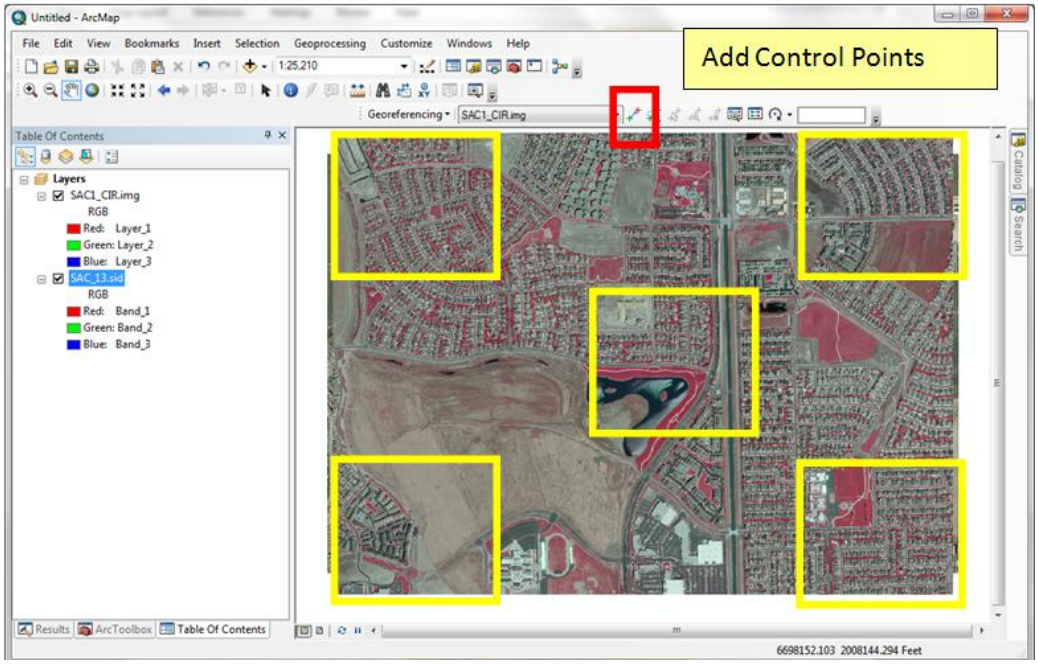


Exercise B: *What happens to the unrectified image after the analyst chooses "Fit to Display"?*

The CIR image may extend beyond the reference image. This is ok.

2.1 Locate Common Features/Add Control Point - Example

In this section, we will demonstrate the process for adding control points (also known as ground control points), by identifying a number of mutually identifiable features in both the reference and "non-rectified" image using the **Add Control Points** tool shown below. Typically, the analyst should find mutually identifiable points in the four corners of the image and the center of the image for best results.



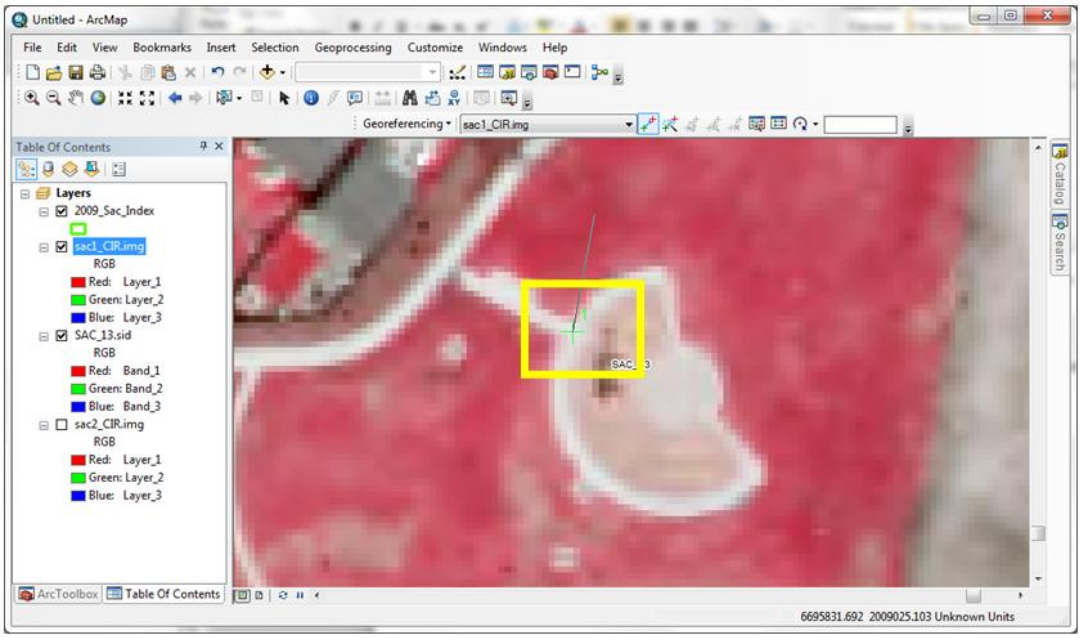
It will be necessary to zoom/pan, etc. back and forth between the reference and "non-rectified" image to find common points. When one is found, we will use the **Add Control Points tool** to add a point to the unrectified image (**SAC1_CIR.img**) and then find the same location in the reference image (**SAC_13.sid**). See some additional instructions below.

Analysts will likely need to zoom very close to the feature found in each location. Examples of common features can include street markings, street corners, bases of flag poles, bases of buildings (not the roof tops), not bridges, etc. The goal is to try to find precise locations in each image.

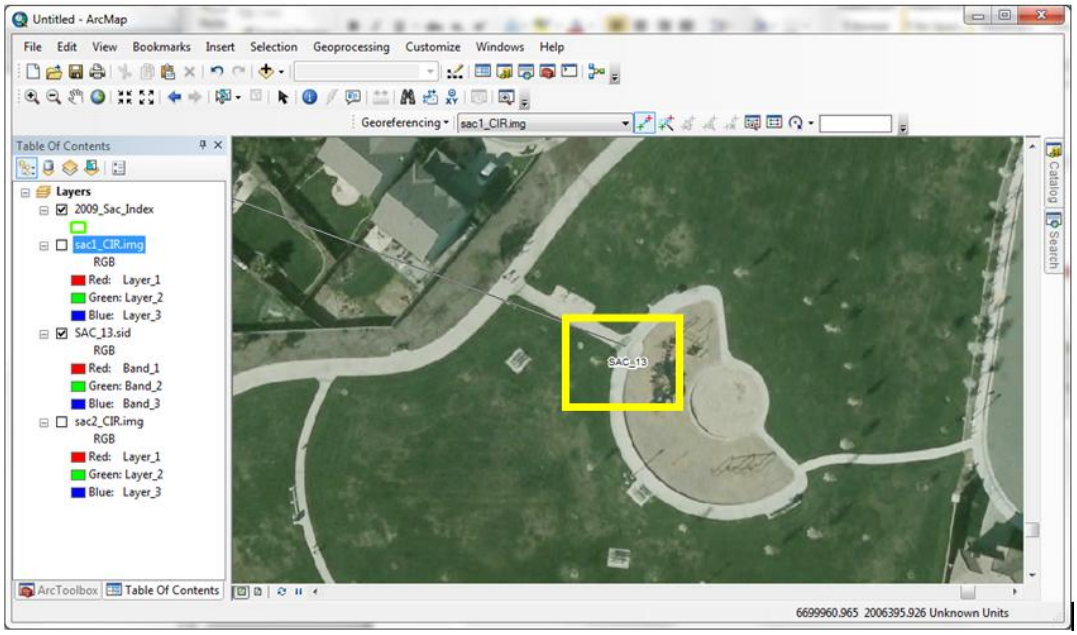
Shown below, a location is found in the “unrectified” image (a walk intersection near a playground). This same feature can be found in both the reference and unrectified images.

The steps detailed in this section provide an example. You will be directed to perform the process in the next section.

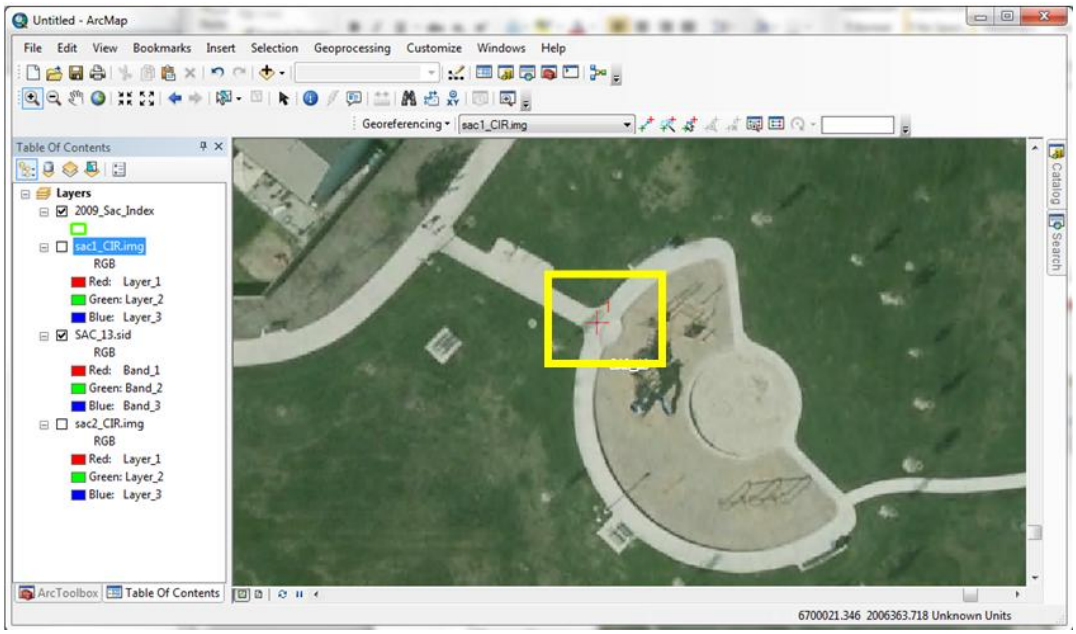
1. The analyst uses the **Add Control Point** tool and clicks in the intersection (notice how far the image is zoomed into). After the control point is added, a “green” crosshair and a connected line will be displayed.



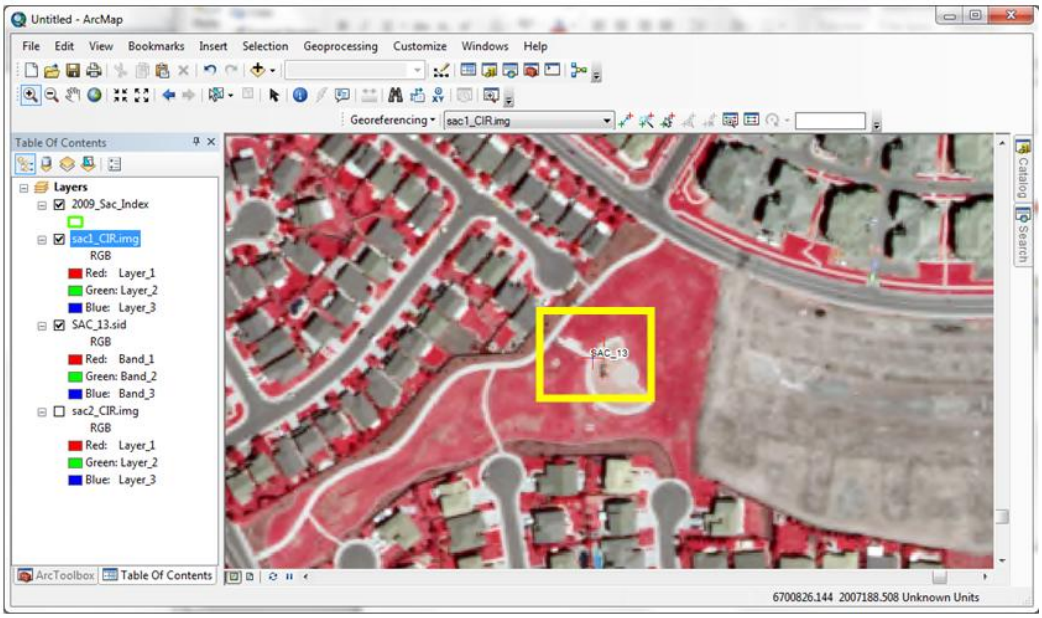
2. Next, the analyst turns off the **SAC1_CIR.img**. The **SAC_13.sid** image is turned on, if needed, and then the navigate tools are used to find the same location on the “reference” source image.
3. The analyst will then click the **Add Control Point** tool and click as close as possible to the exact same location in the “reference” image.



4. After clicking in the “reference” image, a “red” crosshair appears and is labeled a value of “1”. This is the first control point that can be found in both the “unrectified” and reference image.



When the **SAC1_CIR.img** is turned back on, notice that the **SAC1_CIR.img** shows the new control point “1” in this image.



2.2 Add Your First Set of Control Points

Now that you have seen an example of the process for adding a set of control points (as described in the previous section), you may proceed to add your first set.

The general process to add a set of control points:

1. Zoom to a corner of the "unrectified" image – **SAC1_CIR.img**.
2. Zoom to the similar area in the "reference" image – **SAC_13.sid.**
3. Find a common point that can be seen in both images
4. Using the **Add Control Point** tool, click on feature in the unrectified image
   NOTE: The tool will still be active
5. Turn off **SAC1_CIR.img**, then (navigate – zoom, pan, etc) to find the exact same location in the "reference" image. Click the same feature in the "reference" image.
6. The control point is added and its numbered label is displayed.

Exercise C: *What happens to the unrectified image after the analyst identifies the first set of Ground Control Points? (i.e. a ground control point is located in each of the two images (reference and non-rectified image).*

2.3 Add Additional Control Points Sets 2 and 3

Control points should be created in at least 4-5 locations. Ideally, a location will be identified in each corner of the image and in the middle of the image. Sometimes, the imagery does not have easily identifiable features and it may be difficult to locate a control point, so part of the image may not have a strong rectification performed on it.

1. Add the second set of ground control points. Follow the general process outlined in section 2.2.

Exercise D: *What happens to the unrectified image after the analyst identifies the second set of Ground Control Points?*

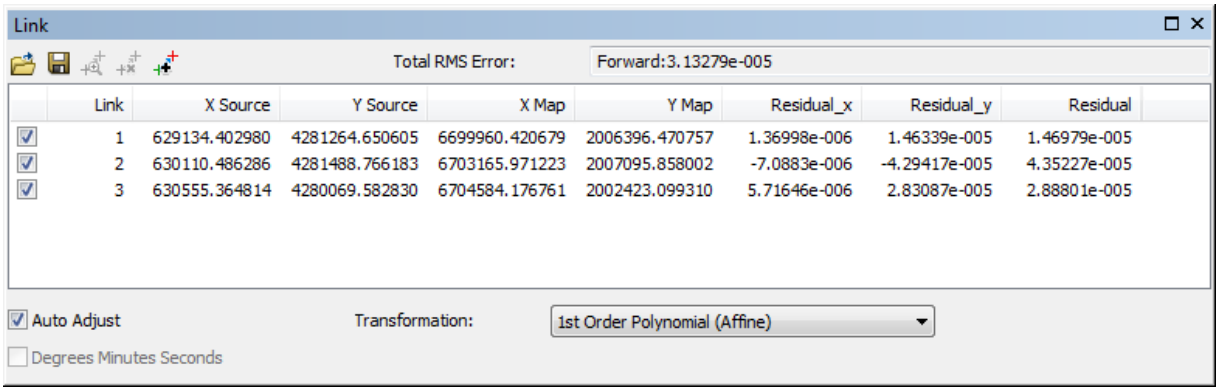
Exercise E: What causes the above shifts to occur? (HINT: Look at the Georeferencing dropdown options on the Georeferencing toolbar).

2. Add the third set of Ground Control Points. Follow the general process outlined in section 2.2.

2.4 Review RMS Error and Residuals and Add Control Point Sets 4 and 5

1. Click on the **View Link Table** icon.

After three ground control points are added, the Root Mean Square (RMS) Error and corresponding residuals can be reviewed to determine how well the image matching is progressing. These can be reviewed in the Link Table.



Exercise F: *What do the residuals say for each set of ground control points?*

Exercise G: *What is the Transformation type?*

Exercise H: *Is it getting easier or more difficult to locate the ground control points between the images?*

2. Add the fourth set of ground control points. Follow the general process outlined in section 2.2.
3. Click on the View Link Table.

Exercise I: *What does the Total Root Mean Square (RMS) Error indicate?*

4. Add the fifth set of ground control points. Follow the general process outlined in section 2.2.

Exercise J: *Did the RMS Error improve or get worse? Why do you think so?*

Exercise K: *Which set of ground control points had the largest residual?*

2.5 Refine the Image Matching

1. If it was the worst point, try deleting the last ground control point and choose a different location.

Describe if the RMS Error improved or became worse.

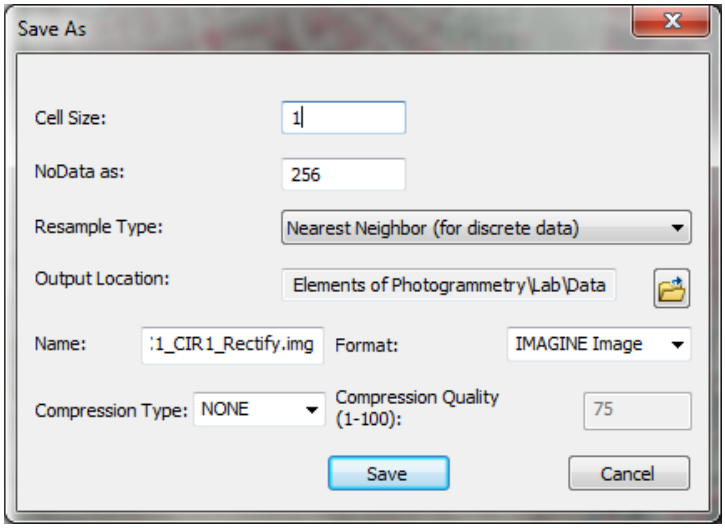
Ideally, analysts try to obtain a RMS Error < 0.5 pixel width or < some small acceptable tolerance. If the RMS Error is < 2, the "unrectified" image is probably good enough to complete the image rectification. If the RMS Error is > 2, then delete or readjust the existing ground control to make the RMS Error better.

2. Try taking more ground control point and see what effect this has on the residuals. The residual values represent the reference image units (or in some software packages, the number of pixels).

Notice that small changes and not "choosing the exact pixel" between the two images can have dramatic effect on the resulting residuals and hence the quality of the final rectified image output.

2.6 Create the Rectified Image

1. Choose **Rectify** from the **Georeferencing** menu.
2. Save the file to a new name. Some changes in the dialog box may be needed:
    a. It is recommended for this exercise that a "file-based" image format be used (such as **.TIF or .IMG**). File-based image formats need to reside in a **folder, not a geodatabase**.
    b. The resampling method is often set to Nearest Neighbor, especially if the image will be used in other image processing steps. Nearest Neighbor resampling does not change the pixels in the output from those in the input image. The other resampling methods use weighting averaging routines to create the output pixel value. Weighted averaging looks at adjacent pixels around a given input pixel and then computes an average of this "neighborhood of pixels" rather than just use the input pixel value in the output image. These methods tend to make the image "look" better and should only be used if the image data will be used as a background image. Using images created from these other resampling methods can introduce error into image processing methods and are not recommended.
    c. Make the **Output Location** a **folder** and name the file with the Imagine format extension (**.img**) and the Format indicates **IMAGINE Image**. Do not compress the image and keep the default cell size.

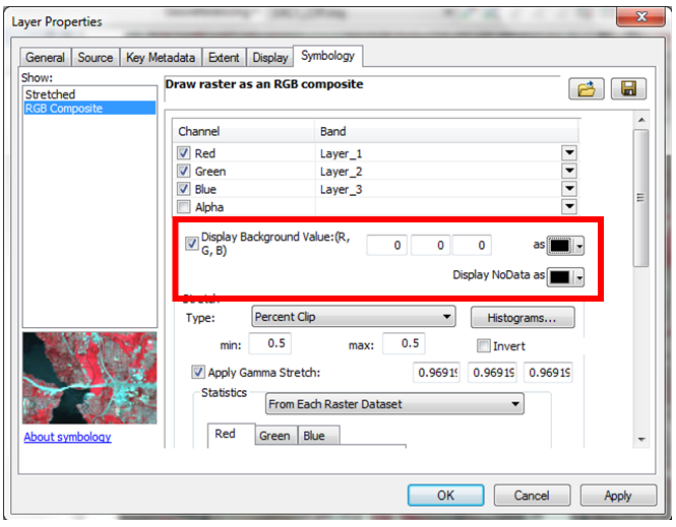


3. Add the image to the Table of Contents (you may need to close down ArcMap and reopen it to do this).

Exercise L: *What is the coordinate system on the rectified imagery?*

Exercise M: *Why does a black border show up when the rectified image is added to ArcMap?*

If no black border is present, you may need to change the Symbology for the rectified image. Go into the Symbology tab for the rectified image and check the **Display Background Value** and choose the **Black** color. Do the same for **"Display No Data as."** See the image below.



4. Load the **Effects** toolbar (shown below), select your rectified image in the **Layer** dropdown,
5. Use the **Swipe tool** to zoom in and "swipe" the new rectified image across the 2009 imagery to see if the roads, sidewalks, waterways, etc line up. If they do not line up, there may be some adjustments needed. If the RMS Error is < 2, then most places across the rectified image should look pretty good.
6. Make sure the layer in the Effects tool shows the rectified image.
7. Make sure to turn off the "non-rectified" CIR image.

Exercise N: Describe how the rectified image compares to the 2009 reference imagery.

Conclusion

You have completed a fundamental image rectification process, which is common throughout many photogrammetric processes. Although image rectification is much more involved than is shown in this lab, the same principles of identifying and collecting high quality ground control that are then used to rectify image data is important. In addition, being able to review and determine how well the image rectification process has worked, and how to take subsequent steps to improve the output is equally important.

Review Exercises

The review exercises included throughout the lab are listed in this section. You may click the name of each exercise to link to the exercise's location within the lab.

Exercise A: What is the coordinate system for the SAC1_CIR.img?

Exercise B: *What happens to the unrectified image after the analyst chooses "Fit to Display"?*

Exercise C: What happens to the unrectified image after the analyst identifies the first set of Ground Control Points? (i.e. a ground control point is located in each of the two images (reference and non-rectified image).

Exercise D: *What happens to the unrectified image after the analyst identifies the second set of Ground Control Points?*

Exercise E: What causes the above shifts to occur? (HINT: Look at the Georeferencing dropdown options on the Georeferencing toolbar).

Exercise F: What do the residuals say for each set of ground control points?

Exercise G: What is the Transformation type?

Exercise H: Is it getting easier or more difficult to locate the ground control points between the images?

Exercise I: What does the Total Root Mean Square (RMS) Error indicate?

Exercise J: Did the RMS Error improve or get worse? Why do you think so?

Exercise K: *Which set of ground control points had the largest residual?*

Exercise L: What is the coordinate system on the rectified imagery?

Exercise M: Why does a black border show up when the rectified image is added to ArcMap?

Exercise N: Describe how the rectified image compares to the 2009 reference imagery.

