Georectification.

Background: These days, we rarely have to georeferenced imagery – especially relatively coarse imagery like Landsat. We simply download them already georeferenced. However, the task of georeferencing airphotos, especially historic airphotos, is still very common.

In airphoto, I understand that you’ve done this – a quick and dirty example. In this class, we’re going to take that lab and put it on steroids. Not only will there be more involved, but I will expect a high accuracy – and for you to understand that accuracy. We’ll be using both ERDAS and ArcGIS Pro for this lab. And we’ll work in pairs because everyone has different familiarity levels with Arc (and rectification in general). Pair up with someone who complements your skills!

Grab the files in the lab6 subdirectory and put them on your flash drive. They are photos of Ellensburg (and just to the west) from 1954. Your ultimate task is to georeferenced and merge these two images into one seamless raster layer.

Bring them up in ERDAS. Note, they are not georeferenced… so who knows where they end up. You’ll probably want to work with them in separate windows. But, open them up and take a good look to familiarize yourself with the area. You might also open google earth and take a peek.

The first thing you’ll notice is the black area around the outside of each photo. If we’re trying to merge things, we need to get rid of that (imagine Google Earth if all their data had this….). Fortunately, you know how to do this. Remember lab 3 where you clipped out the circles using an aoi? Well, refamiliarize yourself with this process and clip out two rectangular areas which include all of the airphoto and none of the rim space. Set your export/save format to tiff (I know Arc can handle .tif files). Don’t worry about the text that is on the airphotos..

Now, you should have two .tif files that are the two airphotos sans rims.

Quit out of Erdas.

Read this! <https://pro.arcgis.com/en/pro-app/latest/help/data/imagery/overview-of-georeferencing.htm>

1. Georeference the airphoto:
2. Open ArcGIS Pro and zoom into the Ellensburg area.
3. Select a new map. Under the Map and “Navigate” section, change the basemap to “Imagery with labels”. We will use this basemap to georeferenced our photo to.
4. Notice how this basemap will automatically be projected in WGS 1984 Web Mercator. This will produce distortions in our selected area of the globe, so we need to modify this to a more accurate coordinate system/projection.
5. Right-click on “Map” in the Contents tab (left side of screen) and select “Properties” at the bottom of the drop down list. Next, select “Coordinate Systems”. In this order, select: “Projected Coordinate System”>>”UTM”>>”North America”>>”NAD 1983 (2011) UTM Zone 10N”
6. Next, select “Basemap” and change the basemap to “Imagery with Labels”. This is necessary for our georeferencing so that you can identify landmarks better on the foundation map.
7. Click “Add data” and then the “data” button to add another layer to your map. Navigate to one of your airphotos and add it to your project. Click through the warning labels ArcGIS Pro may give you, allow it to run statistics if it asks.
8. You should get a warning in the top right corner that says “Unknown coordinate system”. This is correct—ArcGIS isn’t sure where to place this map. We are going to show it where it needs to go!
9. Right click on the airphoto and select “zoom to layer”. This will bring you to our photo, which is situated out in the middle of the ocean. This area is utilized by ArcGIS when it receives unreferenced data. We will now move it to the proper location.
10. Zoom out and navigate to Ellensburg. You should be able to see the streets relatively well.
11. Highlight the airphoto over in the contents pane. Under the “Imagery” tab, select “Georeference”
12. Click “Fit to Display” to move your photo to Ellensburg. It won’t line up perfectly on top of the city, but it should be close.
13. Next, we will begin adjusting the photo to fit where it should go. Study the base map and the airphoto image by toggling between the two layers. Do you notice any common landmarks that stand out? Buildings and road intersections work well for this in urbanized area but be careful as they may have moved over time. Do not choose a point unless you are fairly certain it has not changed its position over time. Make sure to note these locations either mentally or by adding a point to your map where they exist. These will soon help us.
14. By using the “move”, “scale”, and “rotate” tools under the Prepare tab, move the photo until it lines up relatively close to your landmark of choice. It does NOT have to be perfect by any means, but the closer you are able to line it up now, the easier it will be later!
	1. Hint 1: It may be helpful to turn down the transparency of the image so that you can see the layer underneath without having to toggle. You can do so on the Appearance tab
	2. Hint 2: to look at your progress, select the “Explore” button on the Map tab to pause the georeferencing process.
	3. Throughout this process, hit the save button under georeferenced. You don’t want to have to redo things if Arc glitches!
	4. Redo this process for the second airphoto.
		1. You’ll notice that we now have both photos in just about the right place. You’ll also notice about 30% overlap. This overlap is absolutely key if you want to build a new image that combines both without any odd glitches.
15. You’ll see below that things don’t line up perfectly, but we are going to fix that!
16. Next, we are going to add control points. These points are spots of commonality between the two photos that the GIS will use to sequence the two layers together. *Make sure that “Auto Apply” on the Adjust tab is selected.* Your map will get distorted if this is selected because ArcGIS will try to apply the control points as you go. We will have it do this at the end so it is easier for you to find common landmarks.
17. On the Georeference tab, select “Add Control Points”. Your cursor should say “from point (source)”. This means it is looking for a point from the .tiff file. Make sure that this layer is selected when you see this dialogue.
18. Navigate to one of those points of commonality that you identified earlier.
19. Making sure that you have the .tiff layer selected and are zoomed in as close as possible, click on a part of the common point. Then, select the base map layer and toggle off the .tiff layer. Click on the same part of the common point. when the cursor says “To Point (target)”. This will create a crosshair point on your map, known as a control point. This point will sync up the two layers so that they are within one reference system. Basically, when putting in a control point, click the point on the airphoto first, then the point on the base layer.
20. Repeat this process with at least twenty more points. Try to choose points from all four quadrants of the map, dispersed from the outside edge to nearer the center. Find as many as you can in the area of overlap between the two photos. You will want to re-use these! This will make your referencing as accurate as possible. If things get odd, goto the control point table and delete your inputs.
	1. Hint: try to avoid long stretches of roadways for control points. It is challenging to identify where the point is that you place on the road, and road widths often change. Since you want this to be as accurate as possible, try to choose building corners, intersections, and other distinct point landmarks.
	2. Once you get over 14 points, change your transformation from first to third order. Third order is the correct choice, as you need to deal with radial distortion.
21. To see how well you did, there are really two ways. The first is visible. When you zoom out, the red and green circles should be in the same place. If they aren’t, you did something goofy. Or the world changed. Or….. The other method is quantitative: select the “Control Point Table under Review. In the column marked “Residual” your points should be as close to 0 as possible. You also can see how good things are in X and Y. Further, the points with the highest residuals are the ones that are the worst. You can always select and delete control points!
	1. So.. what do the residuals mean? And what are forward vs inverse RMS errors? Well, forward is the distance things are “off” in map units. Since you’re now working in UTM (remember setting that earlier?), this is in meters. The inverse is in pixels. Since inverse and forward RMS errors are almost identical, we’re working with about 1m imagery.
	2. For this lab, I want you to get under a 1.5, total forward RMS error. With a bit of work, you could get it under a 1.
	3. When you get things done, hit save and then export the control points (just in case). ***Also, grab a screenshot which includes your map (which shows all the control points) – and the table of control points with all the rms details. You will end up with two of these, one for each photo.***
	4. Then you can close georeferenced.
	5. Turn on the second airphoto and note all the control points in the overlap area. You will need to use these for the second georeferenced. I’d suggest a few screenshots or something to reference.
	6. Once you’ve done this, close the georeferencing.

OK. Now, let’s figure out what to do about that second image. It’s basically a repeat of the above, only making sure to use EVERY control point in the overlap area. Plus more throughout the image. Work on it until you’ve got around 20 control points with a forward rms under 1.5.

Now, it’s time to stitch them together!

Goto analysis – tools and search for mosaic. Select the **mosaic to new raster** data management tool.

Enter your input rasters (the two georef airphotos), the output location (your project folder), a name and extension – make it a erdas file (hit the I button next to it), 8 bit unsigned. Number of bands = 1, last mosaic operator, first colormap mode. Redo this with a new name using a blend mosaic operator. You should now have two individually mosaic’d .tif files and two .img files that will be happy in erdas!

Alright. Now, in ArcGIS Pro, I want you to have a map open which includes (and only includes): the basemap, your .img file of the two images stitched together, the .msi image drawn in false color (lab3 imagery), and your pan sharpened image (false color as well).

Finally, the questions to turn in! Typed as usual, but no need to print out any of the text above this line…

1. Paste in your two screenshots of the airphotos and control points that you did earlier
2. What were your total forward RMS errors for each airphoto.
3. What problems/challenges did you encounter while georectifying. How did you get through them?
4. Grab a screenshot of your entire Pro window (from the last paragraph above, prior to these questions), so I can see what’s in your contents pane and your map. Paste it in here.
5. Zoom in on those areas where your two photos come together. How close did you get to a perfect match? Describe this, and, using the measure tool, tell me how far off things are in different parts of the image (roads is probably the simplest)
6. Now, compare your airphoto image with your raw ….msi imagery (using whatever band combos you want). How close are they? Again, go around the outside of the photos and take measurements?
7. Just for giggles, bring up that pan sharpened imagery and ask the same question as #6. Did the pan sharpening help your visualization, etc?