# Georeferencing Workshop
Spring 2015 – Spatial Analysis Lab

1.  In Windows Explore locate our collection of historic campus maps:

    Q:\Classes\Workshops\Spring2015\CampusHistoricMaps

2.  Take a moment to look at these maps. Look for changing buildings and landscapes over the years. Notice how the cartographic styles change over time. Finally decide on a map that you would like to work with in this exercise
    a.  Note: if you choose the '76/'77 map you are in for quite the challenge seeing that it is not an aerial perspective, but instead from an angle lower on the horizon – your result will be very distorted, but, if you want, you can give it a try

3.  **Copy** your chosen map
    a.  Navigate to your Desktop and **paste** the image there – do this either in Windows Explorer or simply by closing the window and pasting to the desktop
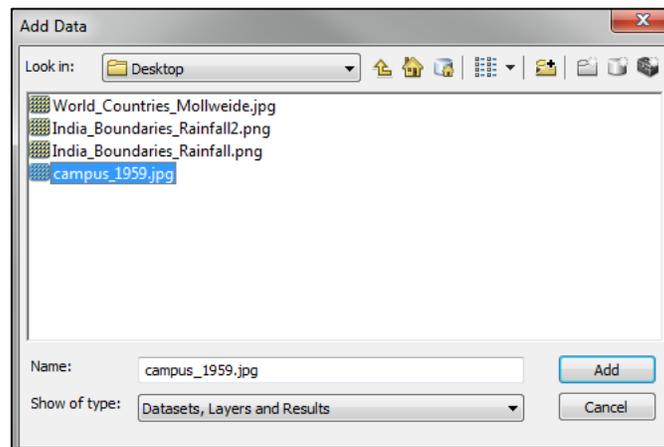
4.  Open a blank .mxd in ArcMap

5.  Go to **Add Data** and locate your image on the desktop, if you're having trouble locating the desktop, this path should get you there:

    C:\Users\gistest\Desktop

6.  Select the map and click **Add**

    

    a.  Upon adding this layer a window will appear asking about building pyramids, these will help improve the display performance of the image – go ahead and click **Yes**

    b.  A second window will appear warning you about lack of spatial reference – this is exactly what you want to see! Our goal today is to add spatial reference to the historic map, so click **Ok**

7.  The historic map image is now in the map, if you scroll your cursor around on the image you can identify its current coordinates in the bottom-right of the screen – you should be somewhere around 0, 0 in an unknown coordinate system, meaning your map is currently in the middle of nowhere, or in the corner of the ArcMap universe – again, this is what we are here to correct

> 691.496  -434.953 Unknown Units

8.  Now add in a couple of layers from our workshop folder that will assign a geographic coordinate system to the data frame and give us content to base our georeferencing on

    a.  Go to **Add Data**, select **Campus_paths.shp**, **campus_orthos.lyr**, and **Campus_buildings_2014.shp** -- click **Add**
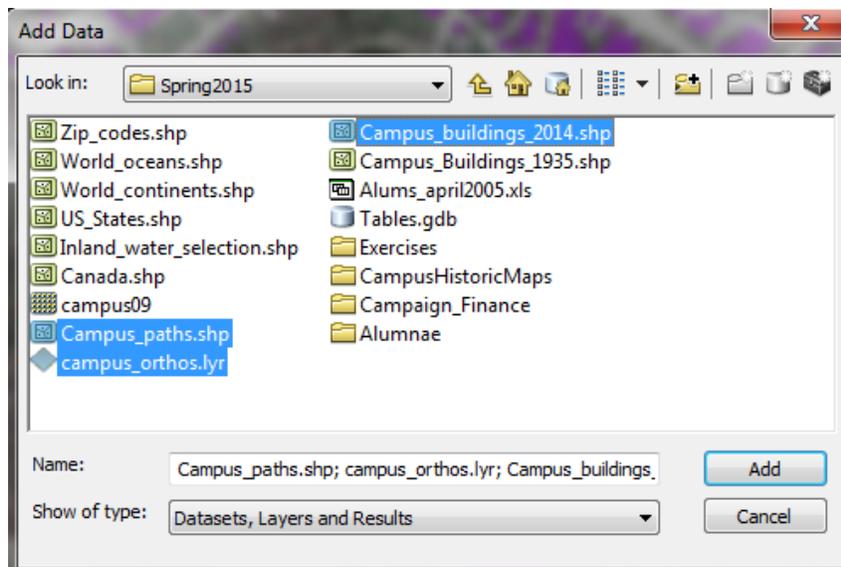


9.  Change the symbology of the buildings and paths to a color that will stand out more from the aerial photography in the background

10. Finally right-click on the **Campus_buildings** layer and choose **Zoom to Layer**

11. Go to **Customize → Toolbars → Georeferencing** – this will open the georeferencing toolbar

12. Make sure your map is the image selected in the space below



13. Next click **Georeferencing** and choose **Fit to Display**

14. You should now see the historic map displayed on campus – if you do not see this try dragging the layer above the orthos photos in the **Table of Contents**

15. The map is closer to accurate location-wise, but we still have a lot of work to do

16. On the right-side of the **Georeferencing Toolbar** locate this button to select the **Rotate**, **Shift**, and **Scale** tools
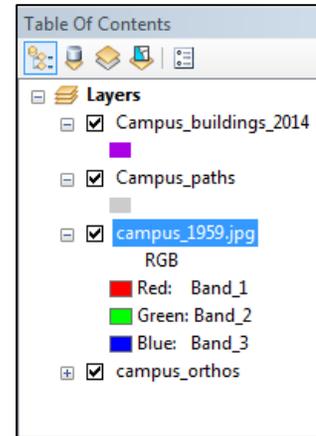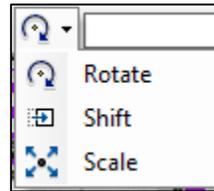
    a. Use one at a time to reposition the historic map to be more accurate to where it belongs in relation to the campus buildings, paths, and orthos
    b. You may need to turn layers on and off throughout this process – do so with the check-boxes in the **Table of Contents**

17. This process is good to start, but is inexact, once you've gotten to a point where you don't think you can make it any more accurate, or you're too frustrated to continue trying, move on to the next step:

18. Add Control Points: this is the primary way to assign geographic reference to your image – take a moment to look both at your historic map and at the buildings, paths, and orthos to identify three or four landmarks that you can use as "control points" to match the unknown (historic map) to the real (other layers)

    a. Some good control points might include corners of buildings that existed then and now or certain path intersections that have gone unchanged
    b. It's also a good idea to choose controls points that are located closer to the corners of the image rather than to the center of the image – this will minimize image distortion

19. Next, select the **Add Control Points** tool and find that location and click once on the historic map

20. Finish with a click on the corresponding "real world" location. The historic map will jump or adjust to your click

21. The process of adding control points always proceeds from **Unknown to Known Coordinates.  You should distribute your control points throughout the map.**  Try to have all 4 corners represented as well as some well distributed interior locations
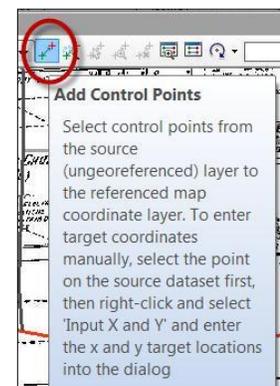
22. Note: You can zoom in/out, pan, and turn layers on/off while adding control points.  But, the Shift, Rotate and Scale tools are no longer available once you add a control point.  You can press the ESC key to remove a link while in the process of creating it

23. Continue to add control points (at least 3-4 more)

24. Open the **View Link Table** button in the Georeferencing toolbar to view the transformation data and the residual and RMS (Root Mean Square) data for each link.  Notice the numbers under the Residual column.  If one of these numbers is significantly larger than the others, you may have sneezed or blinked when adding control points



25. You may select (highlight a row with large Residual) and delete.  For example, I might select Link #3 and delete.  The Total RMS Error should improve.  A lower Total RMS Error, the better map alignment/registration

| Link | | X Source | Y Source | X Map | Y Map | Residual_x | Residual_y | Residual |
|---|---|---|---|---|---|---|---|---|
| ✓ | 1 | 780.197997 | -181.396920 | 105607.344988 | 897236.825076 | -0.790441 | -0.685456 | 1.04625 |
| ✓ | 2 | 245.096298 | -541.200406 | 105951.824750 | 896749.854719 | -2.79763 | 0.501647 | 2.84225 |
| ✓ | 3 | 819.660915 | -1010.503109 | 106355.428435 | 897299.485924 | -7.78903 | -0.711045 | 7.82142 |
| ✓ | 4 | 496.709345 | -919.183247 | 106297.786069 | 896995.637804 | 6.88441 | -0.319389 | 6.89182 |
| ✓ | 5 | 949.809222 | -712.327176 | 106091.240077 | 897413.571513 | 4.4927 | 1.21424 | 4.65389 |

Total RMS Error:   Forward:5.28211

✓ Auto Adjust     Transformation:  1st Order Polynomial (Affine)

☐ Degrees Minutes Seconds     Forward Residual Unit : Unknown

26.  A reasonable RMS error for this exercise is 6 or less.  Once you are satisfied with your RMS Error, close the Link Table

27. Choose to **Update Georeferencing** from the Georeferencing menu on the toolbar.   This saves the transformation parameters with the image.  If you are really curious, we'll show you how to look under the hood and explore the file that is written out to the system
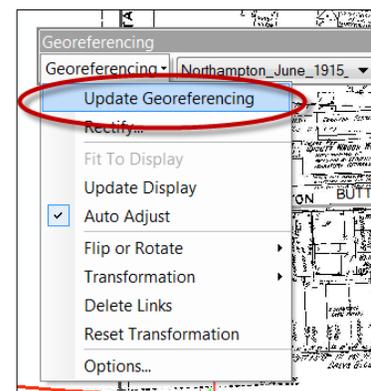


28. The historic map is now georeferenced – if you add it to any other map it should already know its geographic coordinates and appear on campus where it belongs