NAME: ______________________________

ESRM430
Instructor: Dr. L. Monika Moskal
Lab 3 – in the UW Map Library Suzzalo

Lab 3 – Part 1

Lab Objectives:

- Aerial photo measurements

Tools:

- Metric ruler, pen or black marker
- Aerial photo (attached to the lab)
- Google Earth software

What you will hand in:

- This handout with answers written directly on it (no digital submission for the lab)
- Annotated aerial photograph (write your name on the back)

Answer the following directly on this handout.

1. On what date was the panchromatic (black and white) historic aerial photograph of the UW campus taken? Assure that you write the whole date out (example: May 11, 1992). Which direction is north on the historic aerial photograph of UW?

   Answer: ____________________ ____________________

2. Aerial photographs are not maps because of the constant change in horizontal scale. Therefore, we cannot measure long horizontal distances on aerial photographs to high accuracy unless the photo is perfectly vertical and the terrain is perfectly flat.

   a) Would you be more accurate measuring the width or length of the Rainier Vista on the historic aerial photograph of UW?

   Answer: ____________________

3. Radial distortion is also a common artifact of aerial photographs, creating lean the farther away an object is from the center of a photograph; this can be well observed on taller buildings or objects near the edges of the photograph. In the upper-left quad of the UW historic aerial photograph **circle an object that shows a significant amount of 'lean'** due to radial distortion.

4. Google Earth is excellent visualization software and a very simplified version of geospatial analysis package. However, due to its emphasis on quick and seamless visualization it is not a photogrammetric platform.

   a) Measure a known distance, such as the dimensions of a sports field, using the Google Earth software; what are some of the challenges in making an accurate measurement with the software?

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Photographic Scale Calculations

Metric Units - use metric units for all of your lab calculations: 1 km = 1000 m = 100000 cm = 1000000 mm

The scale of an aerial photograph is used to ascertain linear and areal measurement. The definition of scale is quite simply stated as: a ratio, or proportion, between the air photo distance (and area) and its actual distance (and area), or

$$\text{scale} = \frac{\text{photo distance}}{\text{actual distance}}$$

Scale may be represented in several ways. One may state that an inch on a photo represents one mile in reality, or that two centimeters on an aerial photograph represents five kilometers in reality. This form of representation is referred to as a **verbal statement**. Another form of scale representation is **graphic**. This form is most common on road maps where a specific line segment, when applied to the map, represents a certain actual distance. Finally, a **numerical** representation is a common form. The most frequently used numerical representation is the **representative fraction** (RF). The numerator is always "1" which is the photo distance. The denominator, say 63,360, is the actual distance. Since RF is a ratio, the same units of measurement may be added to the numerator and denominator. For instance, 1/63,360 could refer to 1 inch on the photograph represents 63,360 inches in reality.

1. Verbal Statement - 1 centimeter to 1 kilometer
2. Graphic - l====l====l====l kilometers (also known as bar scale)
   0 25 50 75
3. Ratio Fraction (RF) - 1/24,000 or 1:24000

Frequently, a conversion from one scale representation to another form is required. This can be accomplished quite easily if one keeps the definition of scale in mind. For example, if a photo has a scale of 1/2 inch to five miles (verbal statement), this is the same as 1 inch to ten miles. Since there are 63,360 inches in one mile, one can convert to an RF by multiplying 63,360 times ten. Hence, the RF of the photo is 1/633,600 - a ratio of photo distance to real distance.

Example: The length of a 100 meter dash running track on an aerial photograph is measured to be 1 cm. What is the representative fraction of the aerial photograph?

$$\text{RF} = \frac{\text{photographic distance}}{\text{ground distance}}$$

$$\frac{1}{x} = \frac{1\text{ cm}}{100\text{ m}} = \frac{1\text{ cm}}{10000\text{ cm}}$$

1x = 10000 RF = 1:10000

Calculating a scale of an aerial photograph using a topographic map

First you will need to find out the true ground distance from a topographic map, once that is done you can plug in your ground distance results and your measurement taken in Google Earth of the air photo result to the above equation. This method can also be used to calculate the scale of a hard copy of an air photo if the question asks you to calculate the scale of the hard copy; you will simply use a hard edge ruler to make the measurement. The scale of the hard copy will not be the same as the scale of your digital image, the scale of the digital image can change if you resize the image.

Ground distance = measured distance * the denominator of the RF (the number after the :)

For example you measure a length of a street (between two main intersections) on the topographic map to be 10 cm, now you wish to find out the true length of that street.

x=10 cm * 24000
x = 240000 cm or 2.4 km

Thus the street that you have measured is 2.4 km on the ground; this is your ground distance.

Find the same street on your air photo, measure it on the aerial photograph and record the length, this is your photographic distance. For example if the aerial photograph based street length was 8 cm, you now know that those 8 centimeters represents 2.4 km on the ground. Thus, you have the two pieces of the equation for the RF fraction.

$$RF = \frac{\text{photographic distance}}{\text{ground distance}}$$

$$\frac{1}{x} = \frac{8\text{ cm}}{2.4\text{ km}} = \frac{8\text{ cm}}{240000\text{ cm}}$$

$8x = 240000$

$x = 240000/8$

RF = 1:30000

Making a scale bar

Now that you know the scale of the aerial photograph you can make a scale bar. In this example we will use a 10 km scale bar. I recommend that you use a 2 to 4 km scale bar for your labs. First convert that 10 km to cm units (since you will be drawing the line in cm) 10 km = 1,000,000 cm. You want to know what the photographic distance will be. You can use the RF equation (you know the RF):

$$RF = \frac{\text{photographic distance}}{\text{ground distance}}$$

$$\frac{1}{30000} = \frac{x}{1000000\text{ cm}}$$

$30000\,x = 1000000$ cm

$x = 1000000$ cm/30000

$x = 33.3$ cm

Draw a line 33.3 cm long on your map, this line represents 10 km, thus you can label the beginning of the line 0 km and the end 10 km.

Calculating scale from flight and camera parameters

Scale may also be calculated by the knowledge of the camera focal length and altitude of the plane above ground datum:

$$RF = \frac{\text{Camera focal length (m)}}{\text{Altitude above ground datum (m)}}$$

where ground datum would represent the "average" ground elevation above mean sea level of which the photograph is taken.

Example: An aerial camera has a focal length of 35 mm, the altitude of the plane is 800 m above sea level, the average ground elevation above sea level is 100 ft., find the RF.

$$RF = \frac{\text{Camera focal length}}{\text{altitude above ground datum}} = \frac{35\text{ mm}}{800\text{ m} - 100\text{ m}}$$

$$\frac{1}{x} = \frac{35\text{ mm (3.5 cm)}}{700\text{ m (70 000 cm)}}$$

$3.5x = 70\,000$

$x = 20000$ RF = 1/20000

NOTE: most standard focal length for aerial metric cameras is 152mm

Lab Objectives:

- Flightline characteristics
- Stereo imagery viewing
- Simple area calculations
- Image interpretation

Tools:

- Metric ruler, pen or black marker
- 8 aerial photographs of Pack Forest (4,300 acres of third-party certified, working forestland) owned by the University of Washington's College of Forest Resources. The forest also housed the Center for Sustainable Forestry. Photo date: May 19th 1996
- Copy of a map for the area
- Google Earth software
- Mirror stereoscopes provided in the lab

What you will hand in:

- This handout with answers written directly on it
- Annotated photograph 257 (write your name on the back)

To locate the principal and conjugate points on aerial photographs you need to be working with a stereoscopic photograph pair (stereo-pair). First find the fiducial marks on the photograph, some examples are show in Figure 1, the marks are often located in corners or the middle of the photo margins as seen in Figure 2. Using a ruler, draw lines connecting the opposite fiducial marks, the lines can be drawn only in the center of each photograph, just long enough to locate the intersection. This intersection is the principal point (PP) of the photograph. Since most stereo photograph pairs overlap by more than 50%, the location of the principal point of each photo shows up on the companion photo. You can find this location about 3cm away from the photo's edge in the direction of the overlap; this location is called a conjugate principal point (CPP). In other words, if the PP falls on a particular tree, intersection or other easily identifiable photo image look for the same point (same tree, same intersection) on the companion photo; this is the CPP. In some cases the CPP needs to be located stereoscopically.

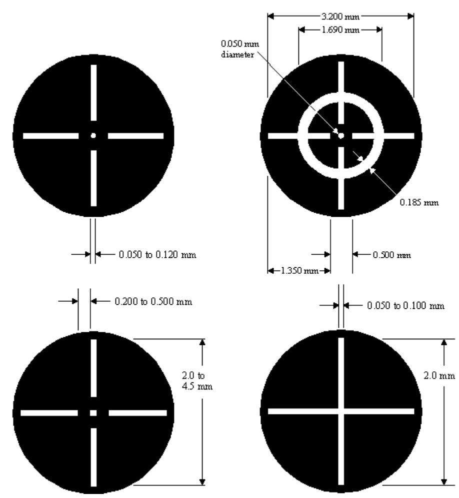
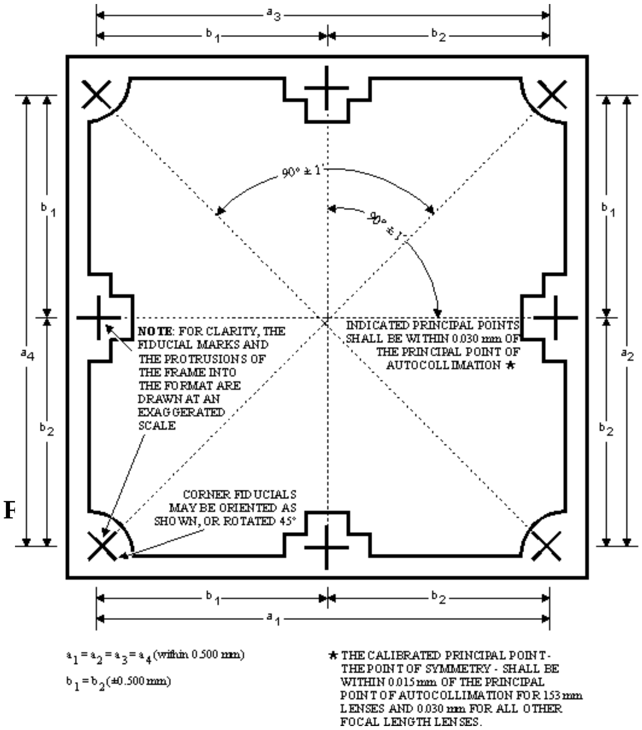


Figure 1. Examples of Acceptable Forms of Fiducial Marks

When you draw a line that connects the PP and the CPP, the line is called the base line; the distance of this line is called the basal length. If the base line is extended to cross the entire width of the photo, it is called the flight line, the path the plane flew when taking the photos. Notice that the base or flight lines do not necessarily correspond to the horizontal line connecting the photo fiducial marks. The difference between these can be used to evaluate the exterior orientation of the photograph. The PP, CPP, base line and flight line are the basis for correct photo orientation and thus most of the stereoscopic photo measurements.

In order to view the photos in stereo using a mirror stereoscope, the photos need to be carefully oriented. This involves getting the photos properly aligned and separated by a distance which is suitable for your eyes. To view a stereo-pair with a mirror stereoscope, place the two photos in front of you so that their base or flight lines form one imaginary, continuous horizontal line. Make sure the overlap areas of repetitive details of each photo are adjacent such as in Figure 3. Looking through the stereoscope, experimentally adjust one of the photos until its base line falls exactly over the fixed photo's base line. There should appear to be only one merged baseline, even though the two photos are actually separated. Incorrect photo orientation, as shown in Figure 3, will result in objects that have height appearing as depressions in the image. As you visually merge theses base lines, you will at the same time begin to see photo details in the overlap area have apparent height or stereo effect. Take a few minutes to observe stereoscopically objects in your photos such as trees, terrain, or buildings that have apparent height.

By making a base and flight line on all of the photographs in the acquisition, it is possible to reproduce the flight path for the whole flight mission as shown in Figure 4. Standard missions that are aimed at collecting stereo overlap are flown so that the endlap of photographs is about 60% and the sidelap of photographs is about 25%. This will vary depending on terrain, in extreme terrain (mountainous areas) both overlaps will be increased to assure continuous stereo coverage. Missions that are flown to acquire imagery without stereo overlap are often flown with both overlaps as low as 10% depending on the terrain characteristics. Such data acquisitions save time and cost but lack the ability for stereoscopic analysis. Orthophotography with low overlap missions are possible if a high quality, well georeferenced terrain model for the area is available from a prior mission or different data source (such as LiDAR).



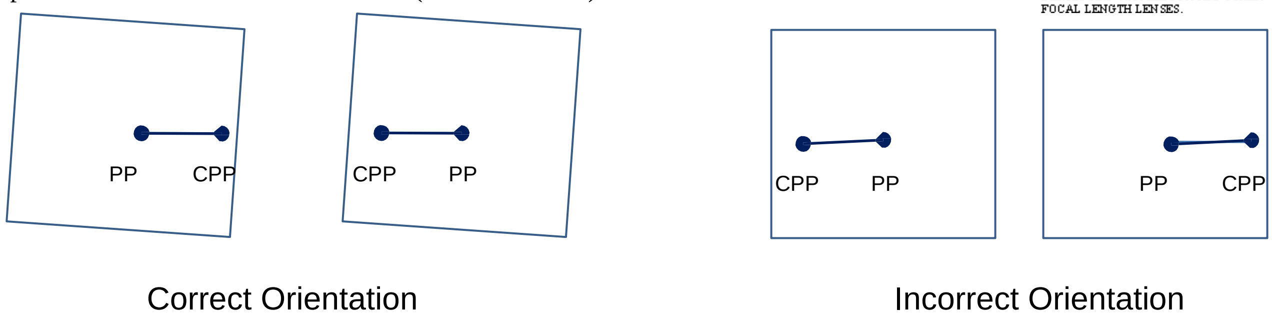


Figure 3. Correct and incorrect placement of a stereo-pair for stereo viewing with a mirror stereoscope.

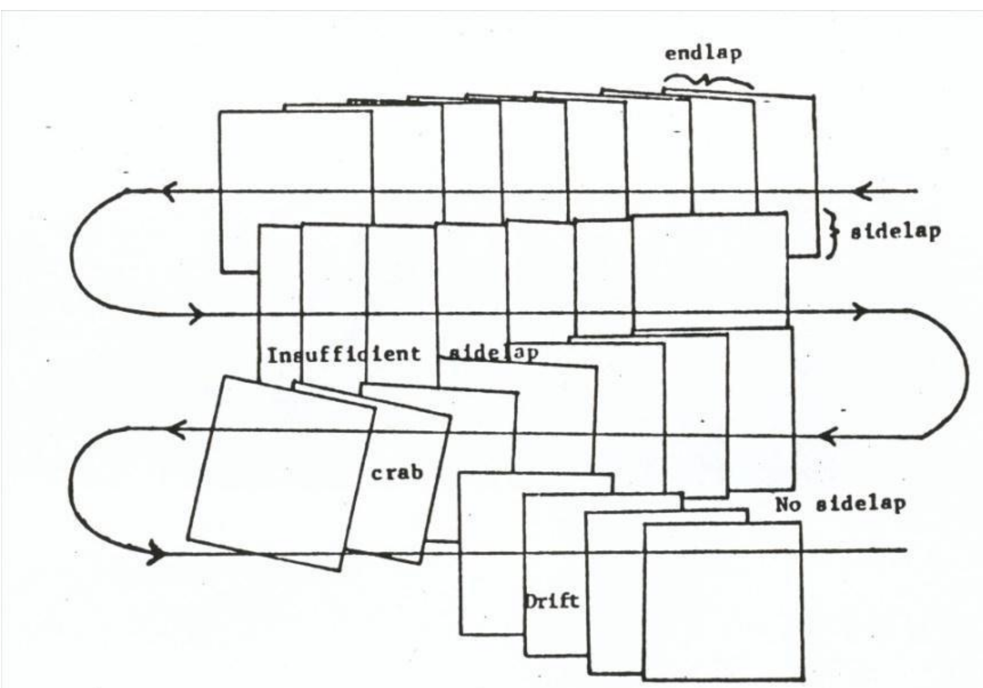


Figure 4. Overlap, drift and crab in aerial photographs.

1. Draw and mark the principal point (PP) and the conjugate principal point(s) (CPP) on photograph 257; connect the points to determine the flight line.

2. Mark the direction of the flightline on photograph 257.

3. Draw a 'to scale' schematic of the flight in the box below.
    - assure that the squares representing the photographs are marked with a photograph number
    - show the start and end, and the direction of the flightline of the 7 photographs in your handout
    - draw the north arrow on your diagram

4. What is the average endlap for the photographs in the flightline?

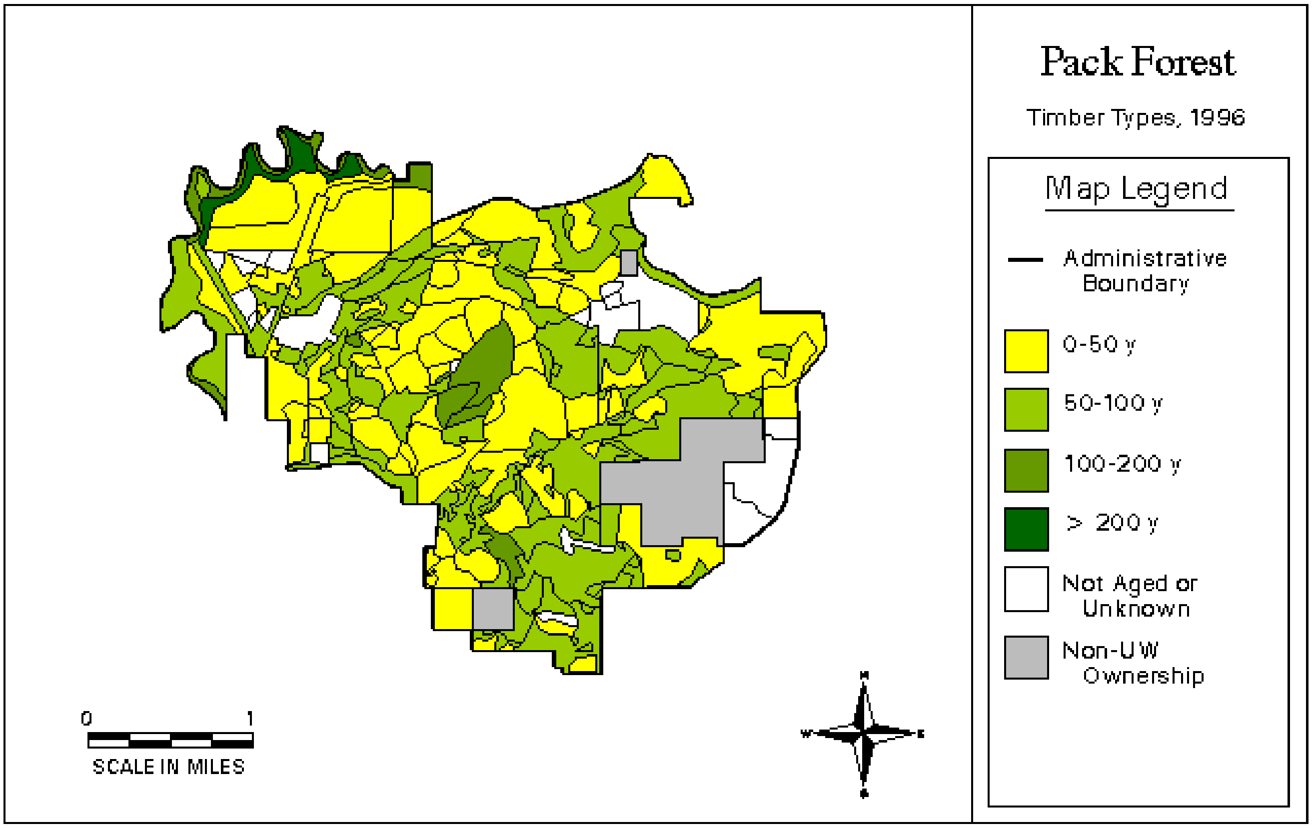
Answer: ____________________

5. What is the average sidelap for the photographs in the flightline?

Answer: ____________________

6. Using the copy of the topographic map and your stereo interpretation of photograph 257 circle the areas where you would expect the greatest potential for topographic distortion when creating an orthophotograph.

7. Using the map below, outline and label <u>an example</u> of each of the stand age classes present on photograph 257.



(Note: this map is available in color and full size on the course website)

8. What were the cues you used to help you identify the different age classes?