

Remote Sensing

Topic 4: Photo Scale and Image Resolution

Topics 2.7 & 3.3: Lillesand and Keifer
Chapter 2: Avery a Berlin

Scale

- ↳ An expression of the relationship between photo distance and actual ground distance
- ↳ Expressions of Scale and Conversions
- ↳ Large vs. Small scale

Determination of Scale

- ↳ Two Methods of determining scale:
 1. If actual ground distance or size of an object is known, or can be determined, then:

$$PSR = GD/PD$$

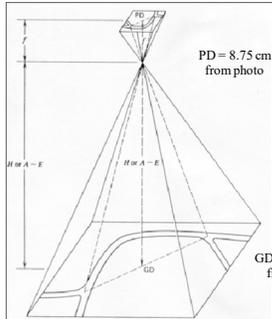
Where:

PD = photo distance (measured on photo)

GD = ground distance
(measured in field, from map, or known)

(Note: PD and GD must be in same units)

Photo and Ground Distance

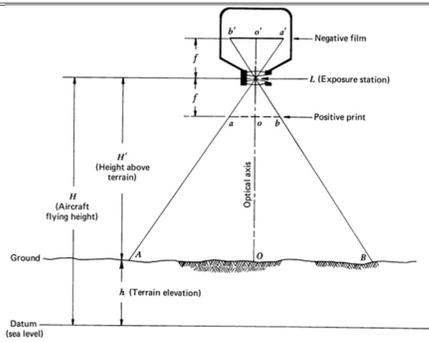


Have to be in same units

PSR = GD/PD
 PSR = 175,000 cm/8.75 cm
 PSR = 20,000
 or 1:20,000 or 1/20,000

1:50,000 NTS Topo Sheet
 Measured same = 3.50 cm
 3.5 cm x 50,000 scale x
 1 km / 100,000 cm = 1.75 km

Focal Length and Flight Height



Determination of Scale

Two Methods of determining scale

2. So, if focal length and flight height are known then:

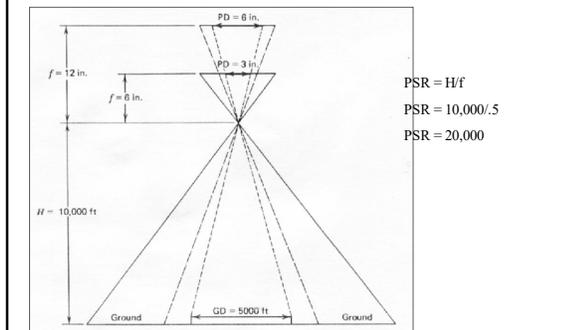
$$PSR = H/f = A-E/f$$

Where:

f = focal length of camera H = flight height A = altitude of aircraft

(Note: f and H must be in same units)

Focal Length and Flight Height

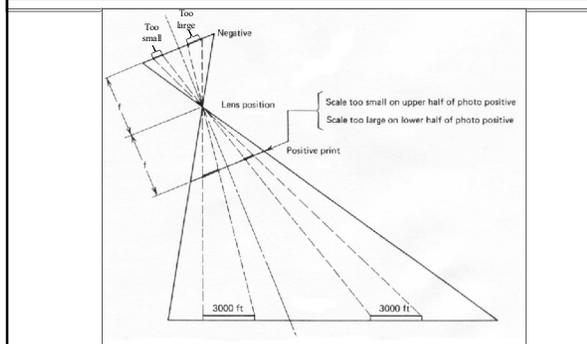


Variations in Photo Scale

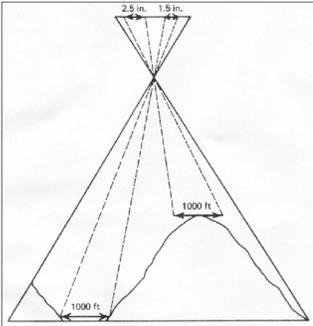
so Occur as a result of:

1. Variations in flight height (pilot error)
2. Tilt (pilot error)
3. Variations in topography
- affects the distance between ground and camera

Scale and Tilt



Scale and Topography



Two Types of Photo Scale

- ↳ Average photo scale:
 - of a photo set
 - across single photo
 - determined using average flight height

- ↳ Point scale
 - on a particular photo, at a specific point
 - varies from photo to photo within a set, and across a single photo
 - determined using ground distance / photo distance or by adjusting height using topo sheet

Spatial Resolution

- ↳ The amount of detail discernible on an image

- ↳ Aerial Photography?

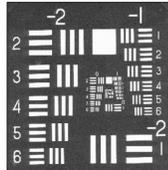
- ↳ Digital Imagery?

Spatial Resolution of a Photo

- ↳ Determined by the resolving power of the film/camera
- ↳ Resolving power is affected by:
 - 1.
 - 2.
 - 3.
 - 4.
 - 5.

Determining Photo Resolution

- ↳ Resolving power chart
- ↳ Distance between smallest lines pairs
- ↳ Expressed as inverse of distance and reported in units of lines/mm
- ↳ Example:
 - distance b/w lines is 0.025 mm
 - so $1/0.025 \text{ mm} = 40 \text{ lines/mm}$



Ground Resolution of a Photo

- ↳ So what is the smallest thing I can actually see?
 - **Function of scale**
 - **Useful for determining required photo scale**
- ↳ Convert photo resolution to ground resolution distance
$$\text{GRD} = \text{resolution} \times \text{scale}$$
 - Example:
 - Photo resolution is 40 lines/mm or 0.025 mm
 - If photo scale is 1: 6,000
 - then $\text{GRD} = 0.025 \text{ mm} \times 6,000 = 150 \text{ mm}$ or 15 cm
 - at 1:30,000 GRD is 750 mm or 75 cm
 - at 1:60,000 is 1500 mm or 1.5 m

Ground Resolution of Digital Imagery

For a digital image, ground resolution is determined by multiplying image resolution (the size of an individual pixel) by the scale of the image

$$GRD = \left(\frac{H}{f} \right) \times \left(\frac{S_x}{n_x P_x} \right)$$

gives image scale (at sensor)

gives size of one pixel in the camera

where:

- H = flight height
- f = focal length (from exif file)
- S_x = size of CCD or CMOS in dimension x
- $n_x P_x$ = number of pixels in x dimension

Examples

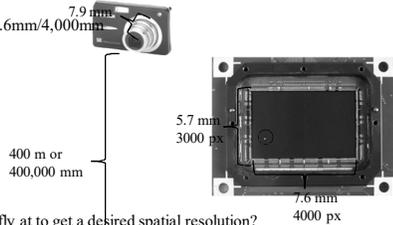
What spatial resolution would I get if I did a flight at 400 m?

$$SR_x = \frac{H}{f} \times \frac{S_x}{n_x P_x}$$

$$= 400,000\text{mm} / 7.9\text{mm} \times 7.6\text{mm} / 4,000\text{px}$$

$$= 50.633\text{mm} \times .0019\text{mm}$$

$$= 96.2\text{mm} \text{ or } 9.62\text{cm}$$



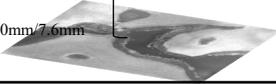
What height do I have to fly at to get a desired spatial resolution?

$$H = SR_x \times f \times \frac{n_x P_x}{S_x}$$

$$= 20\text{mm} \times 7.9\text{mm} \times 4000\text{px} / 7.6\text{mm}$$

$$= 20\text{mm} \times 4157.9\text{mm}$$

$$= 83158\text{mm} \text{ or } 83\text{m}$$



Examples

What ground resolution distance would I get if I scanned a photo at a particular dpi?

$$GRD = \text{Scale} \times (1/\text{dpi}) \times (2.54 \text{ cm/in})$$

$$= 6000 \times (1/1000\text{dpi}) \times 2.54\text{cm/in}$$

$$= 6000 \times 0.00254 \text{ cm}$$

$$= 15.24\text{cm}$$



What dpi would I use to scan a photo and get a desired GRD?

$$\text{DPI} = \text{Scale} \times 2.54 / \text{GRD}$$

$$= 6000 \times 2.54 / 8\text{cm}$$

$$= 1905\text{dpi}$$