GEE 3622

School of Engineering
Geomatics Department
Lecturer: Z Zulu.
Email: zebron.zulu@unza.zm

PROJECT PLANNING

- BASIC PHASES

1. FLIGHT PLANNING
2. GROUND CONTROL
3. COST CONSINDERATIONS

FLIGHT PLANNING

- Reasons for Procurement of new photography
- Available photography could be outdated for applications such as land use mapping
- Available photography could have been taken in the wrong season

- Photography for topographic mapping must be flown in spring to minimise vegetative cover (such photography will be inappropriate for applications involving vegetation analysis)
- Existing photos could be at an inappropriate scale for applications at hand or they could have been taken with unsuitable film type

- Analysts who require colour infrared coverage of an area will find that only black and white panchromatic photography is available

- Highly specialised applications may require unusual film-filter combinations or exposure settings, making it highly unlikey that existing photography will be suitable.

Geometrics aspects of flight planning

- *Parameters for the task are:*
- focal length of the camera
- film format size
- photo scale desired
- size of the area to be photographed
- average elevation of the area to be photographed
- *overlap (endlap)* & sidelap desired
- Flying Height & ground speed of the aircraft
- Tilt and crab tolerances

Specifications

- Projects often contain specific specs
- Technical specs may include
  - General – discusses who will perform the work: general and sub-contracts
    - Experience/qualifications
    - Area to be covered
  - Scale – may designate negative scale
    - Criteria for variance (i.e. 5%) due to tilt/flight altitude

Specifications

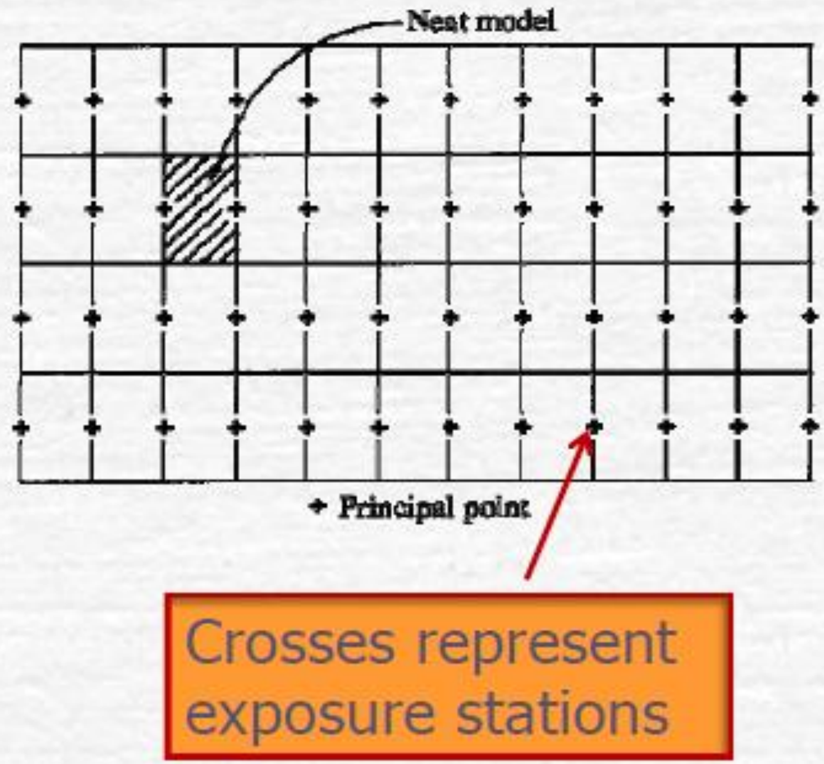
- Cont.
  - End lap/side lap – specify amount and acceptable variations
  - Tilt – usually specify maximum amount acceptable, average tilt for entire project, and tilt differences between adjacent photos.
  - Crab – specify amount (i.e. 3°) above which flight/photos can be rejected

Flight Map

- Gives project boundaries & flight lines

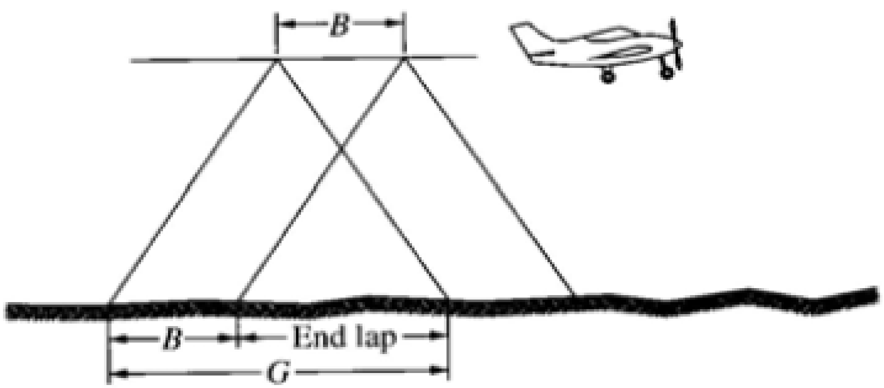
Flight Map

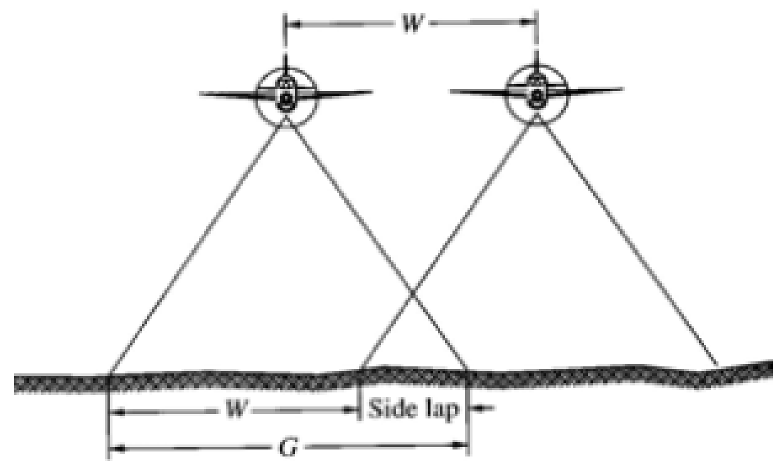
- Flight planning templates useful
  - Determine best & most economical photographic coverage for mapping
    - Especially good for small areas
  - Transparent plastic sheets at scales corresponding to scales of flight map
  - Superimposed over map and oriented in position to yield best coverage with fewest neat models



END LAP AND SIDE LAP

- End lap – overlapping successive photos
- Side lap – overlapping adjacent flight strips





END LAP AND SIDE LAP

- Percent end lap:

$$PE = \frac{G - B}{G} \times 100$$

  - Normally taken as 60%

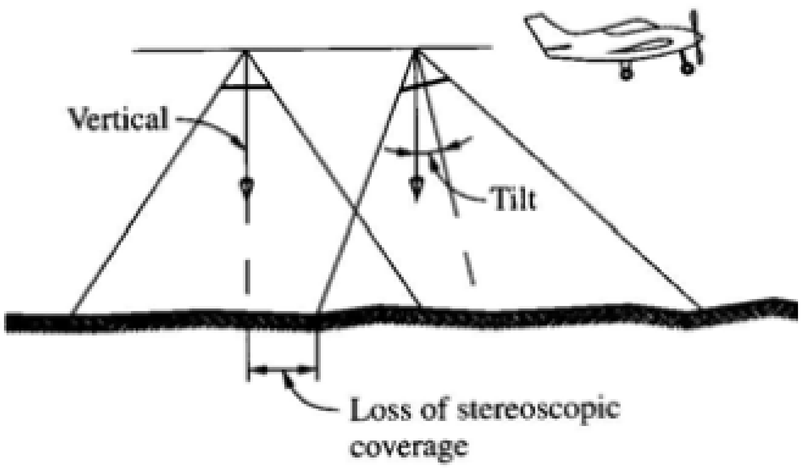
- Percent side lap:

$$PS = \frac{G - W}{G} \times 100$$

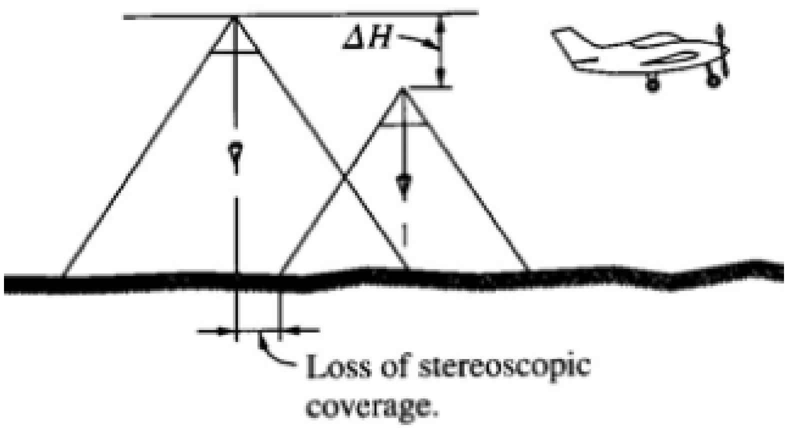
  - Normally about 30%
  - Excessive drift most common cause for gaps in coverage

LOSS OF STEREOSCOPIC COVERAGE

- Due to tilt

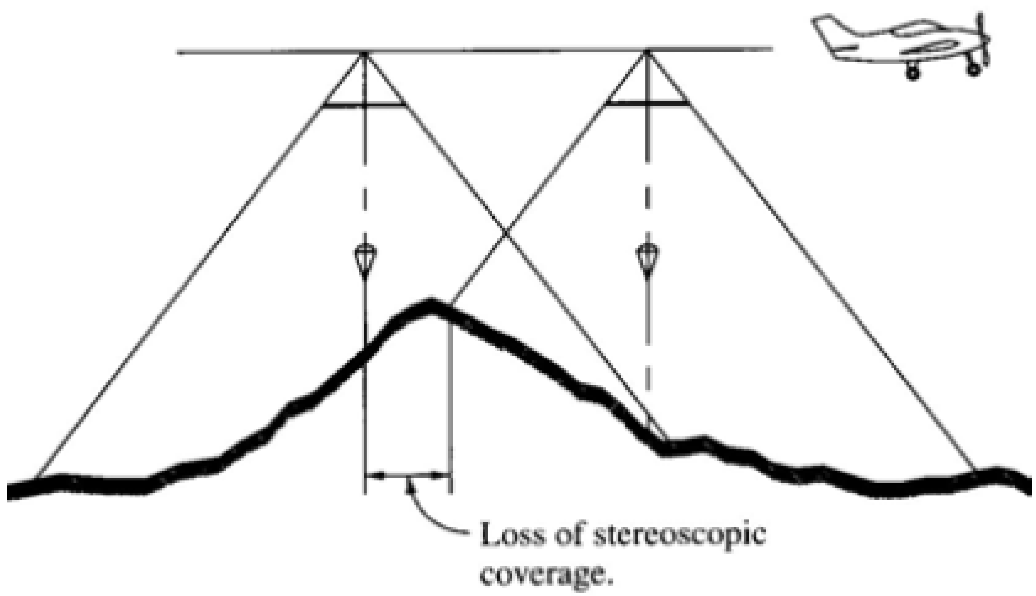


- Due to unequal flying heights



LOSS OF STEREOSCOPIC COVERAGE

- Due to terrain variations



END LAP AND SIDE LAP

- Example (18-1): Air base of a stereopair is 1400 m and flying height above average ground is 2440 m. Camera has a 152.4 mm focal length and 23-cm format. What is the percent end lap?

END LAP AND SIDE LAP

- Solution:
  - Average scale: $$S_{Avg} = \frac{f}{H'} = \frac{152.4\,\text{mm}}{(2440\,\text{m})(1000\,\text{mm/m})} = \frac{1}{16{,}000}$$
  - Ground coverage: $$G = \left(\frac{23\,\text{cm}}{1/16{,}000}\right)\left(\frac{1\,\text{m}}{100\,\text{cm}}\right) = 3680\ \text{m}$$
  - Percent end lap: $$PE = \frac{3680\,\text{m} - 1400\,\text{m}}{3680\,\text{m}} \times 100 = 62\%$$

END LAP AND SIDE LAP

- Example (18-2): Assume spacing between adjacent flight lines is 2500 m in the previous example. What is the percent side lap?

- Solution:

$$PS = \frac{3680\,\text{m} - 2500\,\text{m}}{3680\,\text{m}} \times 100 = 32\%$$

GROUND CONTROL FOR PHOTOGRAMMETRY

- Photogrammetric control - point whose position is known in object space and whose image can be positively identified on photography
- Provides means for orienting or relating photographs to ground

PHOTOGRAMMETRIC CONTROL

- Must satisfy 2 requirements:
  - Must be sharp, well defined, and positively identified on all photos
  - Must lie in favorable locations
- Normally conducted after photography acquired to satisfy requirements
- Ensure control does not fall in shadowed areas on some photos

PHOTOGRAMMETRIC CONTROL

- HORIZONTAL CONTROL
  - Images must be very sharp and well defined horizontally
  - Samples: intersections of sidewalks, manhole covers, intersection of roads ...
- VERTICAL CONTROL
  - Well defined vertically
  - Samples: small flat or slightly crowned areas with some feature nearby

COMPUTATIONS & FLIGHT MAP

- Based on the above parameters, the mission planner prepares computations and a flight map that indicate to the flight crew

1. The flying height above datum from which the photos are to be taken
2. The location, direction, and number of flight lines to be made over the area to be photographed

3. The time interval between exposures
4. The number of exposures on each flight line; and
5. The total number of exposures necessary for the mission

Flight Planning - Example

- A study area is 10 km wide in the E-W direction and 16 km long in the N-S direction. A camera having a 152.4-mm-focal-length lens and a 230-mm format is to be used. The desired photo scale is 1:25, 000 and the nominal endlap and sidelap are to be 60% and 30% percent. Beginning and ending flight lines are to be positioned along the boundaries of the study area. The only map available for the area is at a scale of 1: 62,500. This map indicates that the average terrain elevation is 300 m above datum. Perform the computations necessary to develop a flight plan and draw a flight map.

a) N-S flight lines selected to minimizes the number of flight lines

b) Find the flying height above terrain (H′ =f/S) and add the mean site elevation to find flying height above mean sea level:

c) $H = f/S + h_a vg = (0.1524\ m)/(1/25{,}000) + 300\ m = 4110\ m$

d) Determine ground coverage per image from film format size and photo scale:

Coverage per photo = 0.23m/(1/25,000) = 5750 m on a side

e) Determine ground separation between photos on a line for 40 percent advance per photo (i.e., 60 percent endlap):

0.40 x 5750 m = 2300 m between photo centers

f) Assuming an aircraft speed of 160 km/hr, the time between exposures is

(2300m/photo)/160 km/hr x (3600 sec/hr)/ 1000m/km = 51.75 sec (use 51 sec)

g) Because the intervalometer can only be set in even seconds (this varies between models), the number is rounded off. By rounding down, at least 60 percent coverage is ensured. Re-calculate the distance between photo centers using the reverse of the above equation:

51 sec/photo x 160 km/hr x (1000 m/km)/ 3600 sec/hr = 2267 m

h) Compute the average number of photos per 16-km line by dividing this length by the photo advance. Add one photo to each end and round the number up to ensure coverage:

(16,000 m/line)/2267 m/photo + 1 + 1 = 9.1 photos/line (use 10)

i) If the flight lines are to have a sidelap of 30 percent of the coverage, they must be separated by 70 percent of the coverage:

0.70 x 5750 m coverage = 4025 m between flight lines

j) Find the number of flight lines required to cover the 10-km study area width by dividing this width by distance between flight lines (note: this division gives number of spaces between flight lines; add 1 to arrive at the number of lines):

(10,000 m width)/ 4025 m/flight line + 1 = 3.48 (use 4)

The adjusted spacing between lines for using four lines is

10,000 m/(4-1 spaces) = 3333 m/space

k) Find the spacing of flight lines on the map (1: 62,500 scale):

3333 m x 1/62500 = 53.3 mm

L) Find the total number of photos needed:

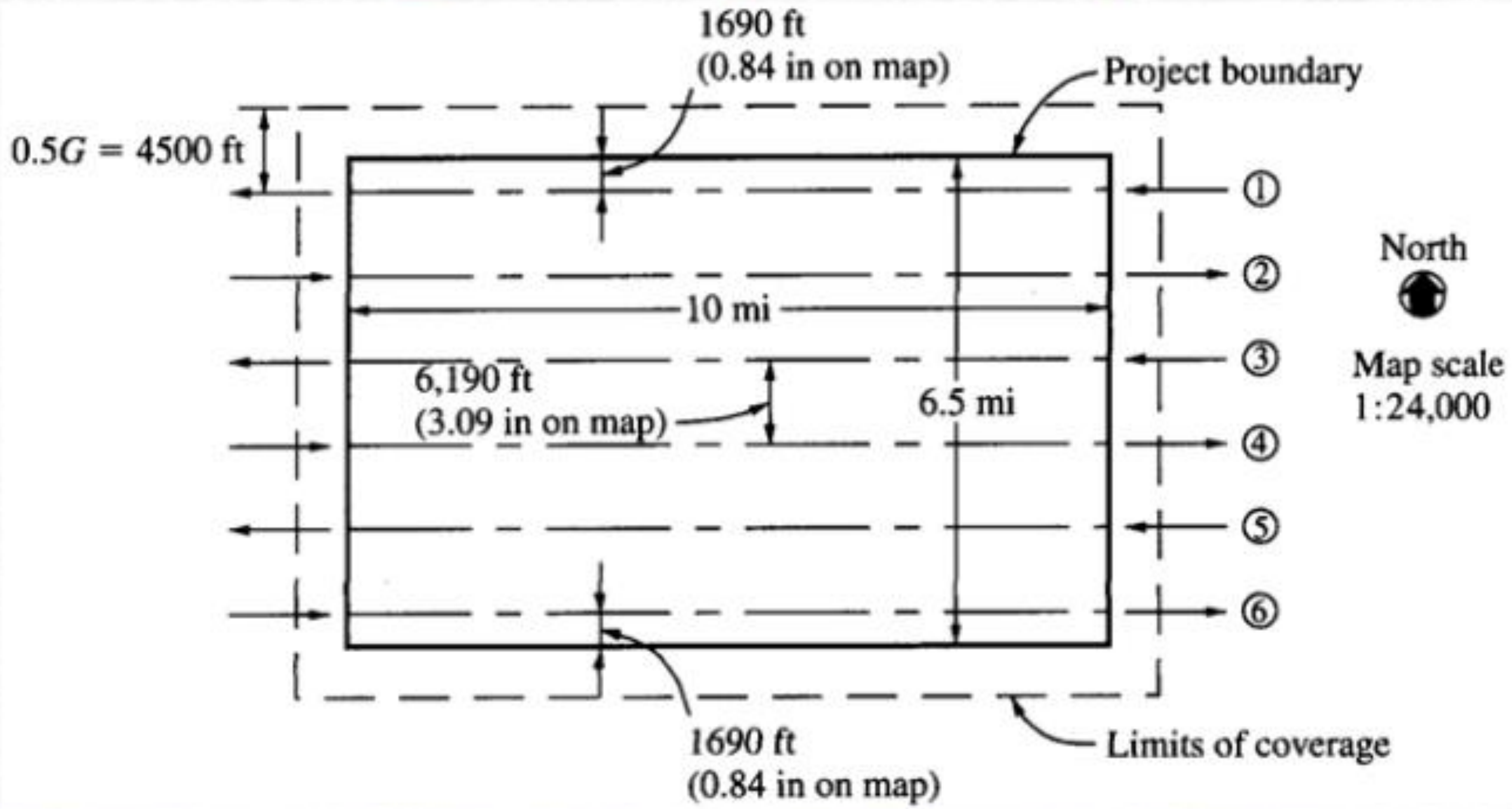
10 photos/line x 4 lines = 40 photos

- (NOTE: The first and last flight lines in this example were positioned coincident with the boundaries of the study area.
- This provision ensures complete coverage of the area under the “better safe than sorry” philosophy.
- Often, a savings in film, flight lines, and money is realized by *experienced flight crews* by moving the first and last lines in toward the middle of the study area.)

Flight Map Example

- Project are is 10 mi (16 km) long E/W and 6.5 mi (10.5 km) wide in N-S direction. Photography at scale of 1:12,000 with 60% end lap and 30% side lap required. A 6″ (152.4 mm) focal length camera with 9″ (23 cm) format will be used. Prepare flight map on a base map whose scale is 1:24,000 and compute the total number of photographs required for the project.

Flight Map Example



Flight Map Example

1. East-West flight lines selected to reduce number of flight lines
2. Dimension of ground coverage/photo

$$G = \frac{\text{format}}{S} = \frac{9''}{1''/1{,}000'} = 9{,}000'\,(2800\,\text{m})$$

3. Lateral advance per strip (30% side lap)

$$W = 0.7\,G = (0.7)(9{,}000') = 6{,}300'\,(1{,}900\,\text{m})$$

Flight Map Example

4. Number of flight lines – align first & last flight line with north & south project boundaries. Dist of 1st & last flight lines inside project boundaries

$$0.5\,G - 0.3\,G = 0.2\,G = (0.2)(9{,}000') = 1{,}800'\ (550\,m)$$

number of spaces between flight lines

$$\frac{(6.5\,mi)(5{,}280\,ft/mi) - 2(1{,}800')}{6{,}300'} = 4.9 \Rightarrow 5\ (\text{round up})$$

number of flight lines = No. spaces + 1 = 6

Flight Map Example

5. Adjust percent side lap & flight line spacing

$$2\left(0.5-\frac{PS}{100}\right)G+(\text{no. spaces})\left(1-\frac{PS}{100}\right)G=\text{total width}$$

$$2\left(0.5-\frac{PS}{100}\right)9{,}000'+(5)\left(1-\frac{PS}{100}\right)9{,}000'=(6.5\,\text{mi})(5{,}280\,\text{ft/mi})$$

$$2\left(0.5-\frac{PS}{100}\right)+(5)\left(1-\frac{PS}{100}\right)G=3.813$$

$$PS=31.2\%$$

$$W_a=\left(1-\frac{31.2}{100}\right)G=6{,}190'\,(1{,}890\,\text{m})$$

Flight Map Example

6. Linear advance per photo (60% end lap)

$$B = 0.4\,G = (0.4)(9{,}000') = 3{,}600'\,(1{,}100\,\text{m})$$

7. No photos per strip (2 extra beyond project boundaries to ensure complete stereoscopic coverage)

$$\boxed{\text{No. photos / strip} = \frac{(10\,\text{mi})(5{,}280\ \text{ft/mi})}{3{,}600'} + 1 + 2 + 2 = 19.7 \Rightarrow 20}$$

Flight Map Example

8. Total number of photos:

$$(20\,\text{photos}/\text{strip})(6\,\text{strips}) = 120\,\text{photos}$$

8. Spacing of flight lines on map:

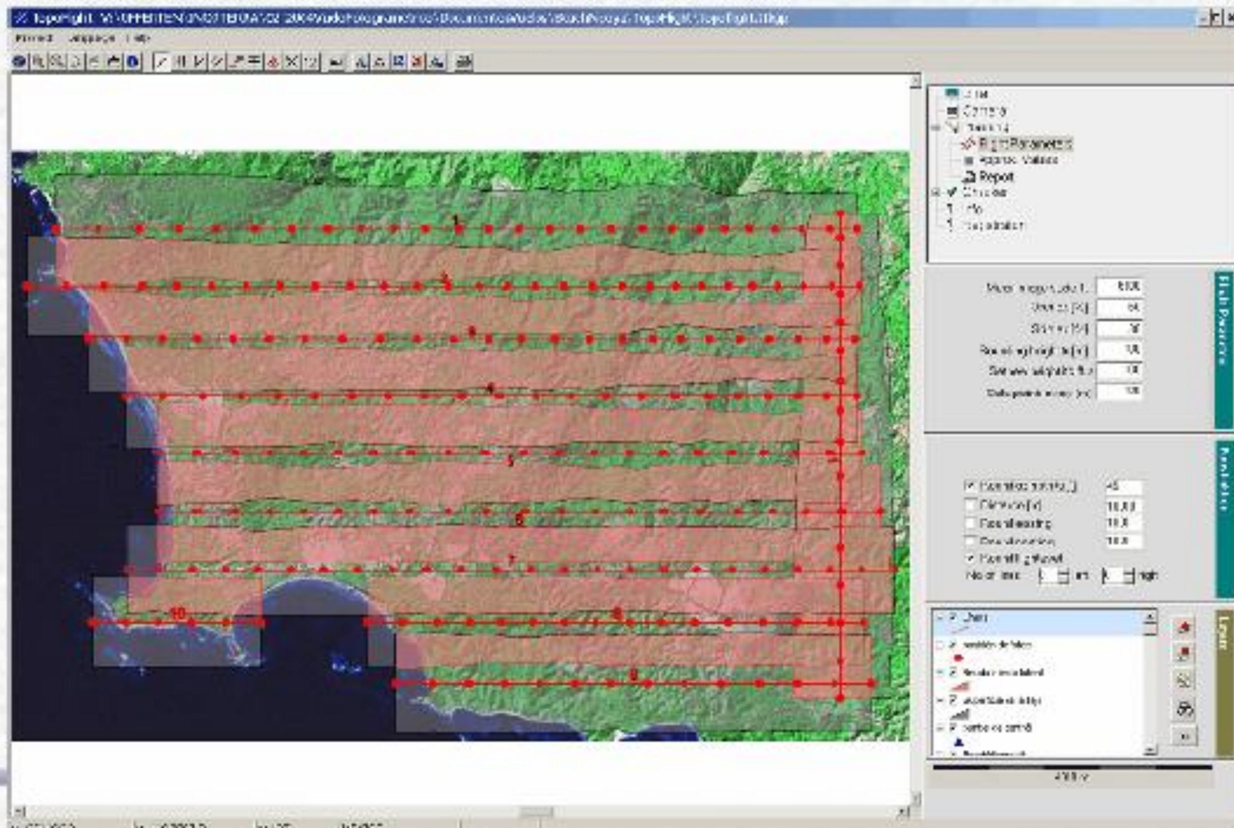
$$W_M = W_a S = (6{,}190\,\text{ft/strip})\left(\frac{1''}{2{,}000'}\right) = 3.09''\,(78.6\,\text{mm})$$

Draw flight lines at 3.09" spacing with 1st & last inside project boundaries by

$$\left[\left(\frac{0.5-31.2}{100}\right)9{,}000'\right]\left(\frac{1''}{2{,}000'}\right) = 0.84''$$

Flight Map

- Today – prepared on computer



COST CONSIDERATIONS IN FLIGHT MAPPING PROJECTS

ASSIGNMENT

- Outline five main cost considerations for flight planning projects ("Sorties").
- Hint:

  Costs of aerial photography, orthophotography and topographic line mapping

  Scanning @ $1.5/image; aerial triangulation@ $2.5/image; generation of DTM@ $120/image; digital orthophoto generation@ $30/image; mosaicking of digital orthophotos@ $20/image