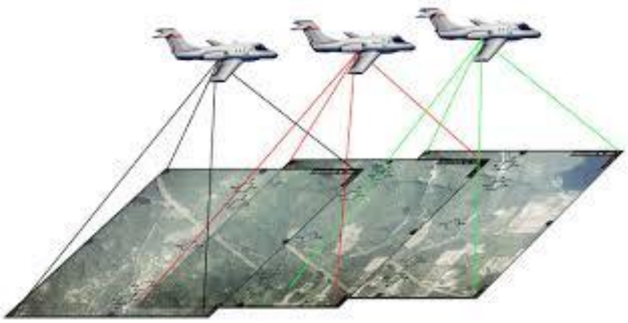

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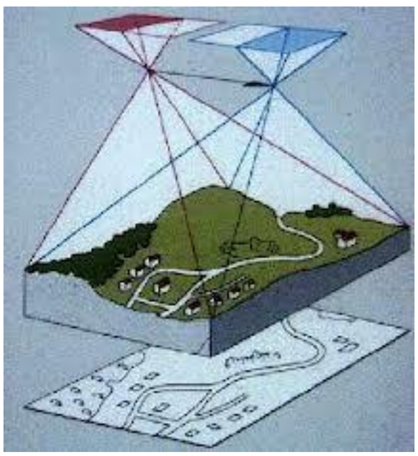

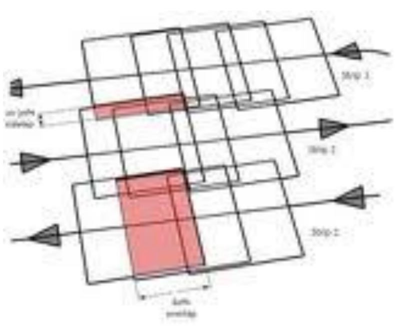

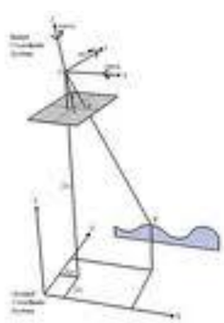

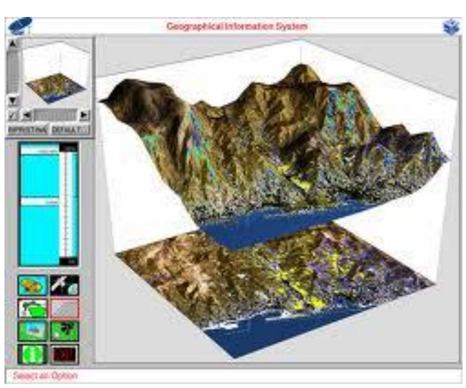

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Chapter 5 Geometric distortion on photographs

5.1 Relief Displacement on a Vertical Photograph

Relief displacement causes geometric distortion on vertical aerial photographs. Relief displacement is the shift in an object's image position caused by its elevation above a particular datum. For vertical or near vertical photography the shift occurs radially from the nadir point. This effect is demonstrated in the diagram below. Though the distances between ***A-B*** and ***C-D*** are identical on the datum plane, their corresponding representations on the photo plane are not (i.e. distances between ***a-b*** and ***c-d*** are not equivalent).

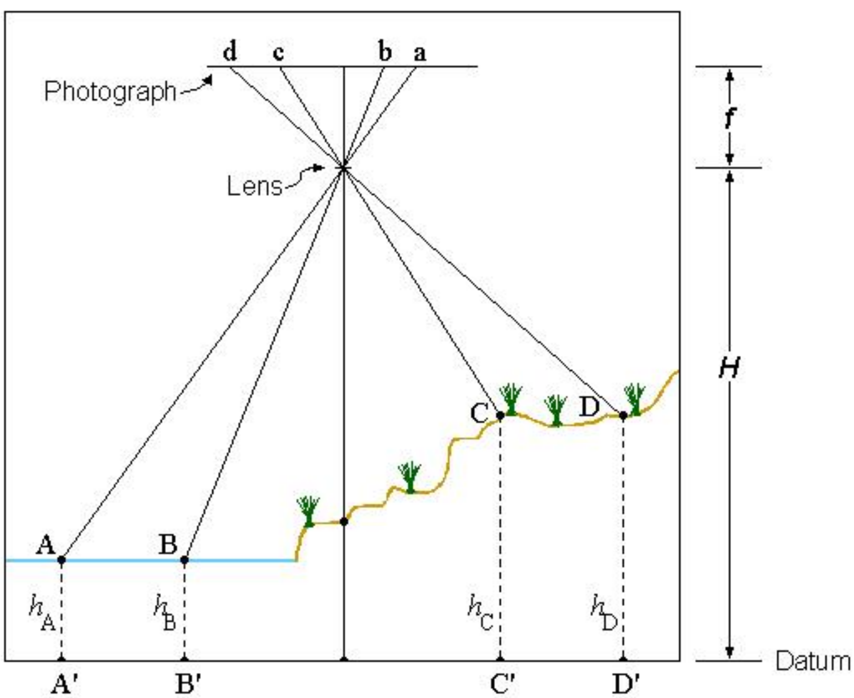

Figure (5.1): Relief displacement

In the perspective projection, two points, such as ***A*** and ***B*** in the figure, with the same (X, Y) ground coordinates but with different elevations will appear on the photo at different positions. However, their photo positions fall along the same radial line from the principle point. Photo displacement ***ab*** is the relief displacement.

- Radial photo distances of points a and b are:

$$r_a = oa \quad and \quad r_b = ob$$

- Difference in elevation between A and B is: let, h_A is Elevation of point A and h_B = Elevation of point B.

$$\Delta h_{AB} = h_B - h_A$$

- Flying height above point A is:

$$H_A = H - h_A$$

- From the similarity of triangles *Loa* and *LOA*:

$$\frac{r_a}{R} = \frac{f}{H_A}$$

$$Rf = r_a \, . H_A \; \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

- From the similarity of triangles *Lob* and *LO′B*:

$$\frac{r_b}{R} = \frac{f}{H_A - \Delta h_{AB}}$$

$$Rf = r_b . (H_A - \Delta h_{AB}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

- From Equations (1) and (2), the relief displacement d is given by:

$$\mathrm{d} = \mathrm{r_b} - \mathrm{r_a}$$

$$r_a \, . H_A = r_b . (H_A - \Delta h_{AB})$$

$$r_b \, . H_A - r_a \, . H_A = r_b . \Delta h_{AB}$$

$$(r_b - r_a) \, . H_A = r_b . \Delta h_{AB}$$

$$d = \frac{r_b . \Delta h_{AB}}{H_A}$$

- Therefore, if elevation of point ***A*** is known, elevation of B is given by:

$$\Delta h_{AB} = h_B - h_A$$

$$h_B = h_A + \Delta h_{AB}$$

$$h_B = h_A + \frac{d H_A}{r_b}$$

$$h_B = h_A + \left(\frac{d}{r_b}\right)(H - h_A) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots^{*}$$

- Height of building or target Δh_{AB} is derived from this equation as:

$$\Delta h_{AB} = \left(\frac{d}{r_b}\right)(H - h_A) = \frac{d H_A}{r_b} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots^{**}$$

$$\Delta h_{AB} = \left(\frac{d}{r_b}\right)\left(\frac{f}{S_A}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots^{***}$$

<u>Remember:</u>

$S_A = \frac{f}{(H - h_A)}$ ……… means, $(H - h_A) = \left(\frac{f}{S_A}\right)$

Example (1)

The radial distance to the image of a bottom of a building is 75.23 mm, and the radial distance to the image of its top is 77.50 mm. Elevation of the bottom of the building is 130 m above MSL. Determine the height of the building, if H = 1500m.

Solution:

Given: *Req:*

r_a = 75.23 mm d= ?

r_b = 77.50 mm $\Delta h_{AB} = ?$

H = 1500 m

h_A = 130 m

$$\Delta h_{AB} = \left(\frac{d}{r_b}\right)(H - h_A)$$

$$d = r_b - r_a$$

d = 77.50 – 75.23 = 2.27 mm

$\Delta h_{AB} = \left(\frac{2.27}{77.5}\right)(1500 - 130)$ = 40.13m

Example (2)

On a vertical photograph r_b= 62.6 mm, d = 5.5 mm. Scale at bottom of tower A is 1: 3600. Focal length = 152.3 mm. Compute elevation of the tower.

Solution:

$$\Delta h_{AB} = \left(\frac{d}{r_b}\right)\left(\frac{f}{S_A}\right) = \left(\frac{5.5}{62.6}\right)\left(\frac{0.1523 \ x \ 3600}{1}\right) = 48.17 \text{ m}$$