Introduction, uses, aerial photographs, definitions, scale of vertical and tilted photograph (simple problems), Ground co-ordiantes (simple problems). Relief displacements (derivation), Ground control. Procedure of aerial survey, overlaps and mosaics. Stereoscopes, derivation parallax (derivation).

<u>Introduction:</u>

Photogrammetry is the process of measuring images on a photograph which further results in accurate measurements. It includes:

a) Photographing an object.
b) Measuring the image of the object on the processed photographs, and
c) Reducing the measurements to some useful form such as a topographic map.

<u>Object of photogrammetry:</u>

The main object of photographic survey is to prepare a map of the topographical features of the ground.

The aerial photographic surveys are used for various purposes such as classification of soils, the construction of planimetric and topographic maps, interpretation of geology, the preparation of composite pictures of ground and acquisition of military intelligence, in accessible regions, forbidden properties unhealthy material regions, reconnaissance and preliminary survey of railways, roads, transmission lines, survey of buildings, town and harbours, etc. terrestrial surveying is suitable only for small scale mapping of hilly or mountainous country.

<u>Types of Photographic surveying:</u>

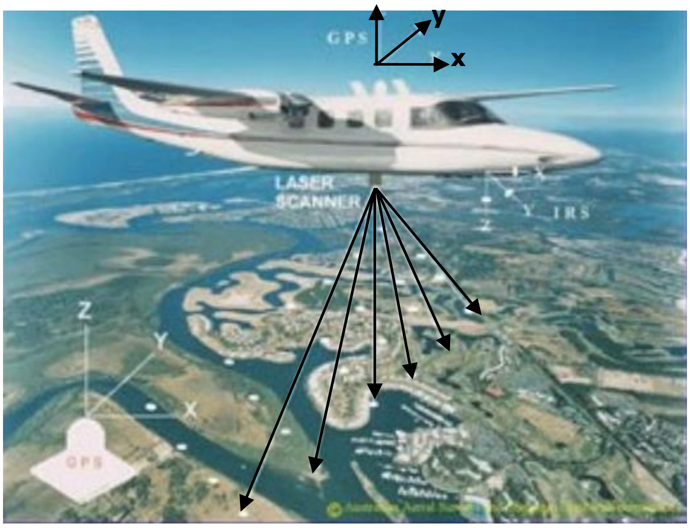
The Photographic surveys may be mainly of two types, i.e.,

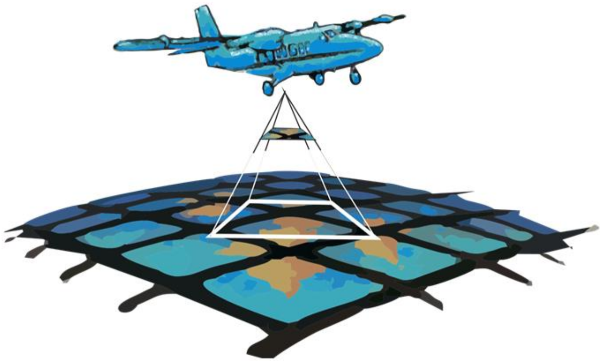
a) Aerial photographic surveying
b) Terrestrial photographic surveying.

<u>Aerial Photogrammetry:</u>

Aerial photogrammetry is the science of deducing the physical dimensions of objects on or above the surface of the Earth from camera stations in the air (aeroplane for the purpose of photography) with the axis of camera vertical or nearly vertical..

These are the best mapping procedure developed for large objects and are useful for military intelligence.





Aerial photogrammetry is often used for the following:

1. Highway reconnaissance
2. Environmental
3. Preliminary design
4. Geographic Information System (GIS) The information produced from aerial photographs of the existing terrain allows both designers and environmental personnel to explore alternate routes without having to collect additional field information.

The photographs can be used to layout possible alignments for a more detailed study. Photogrammetry has evolved into a limited substitution for topographic ground surveying. It can relieve survey crews of the most tedious time-consuming tasks required to produce topographic maps and DTMs. However, ground surveys will always remain an indispensable part of aerial surveys as a basis for accuracy refinement, quality control and a source of supplemental information unavailable to aerial data acquisition.

Photogrammetric Advantages / Disadvantages Surveys collected by aerial photogrammetry methods have both advantages and disadvantages when compared with ground survey methods as follows:

Advantages:

1) Photos provide a permanent record of the existing terrain conditions at the time the photograph was taken.
2) Photos can be used to convey information to the general public, and other federal, state, or local agencies.
3) Covers large area.
4) Less time consuming and very fast.
5) Photogrammetry can be used in locations that are difficult or impossible to access from the ground.
6) Cheap and effective for large area and in a long run.
7) Easy to interpret and understand.

Disadvantages:

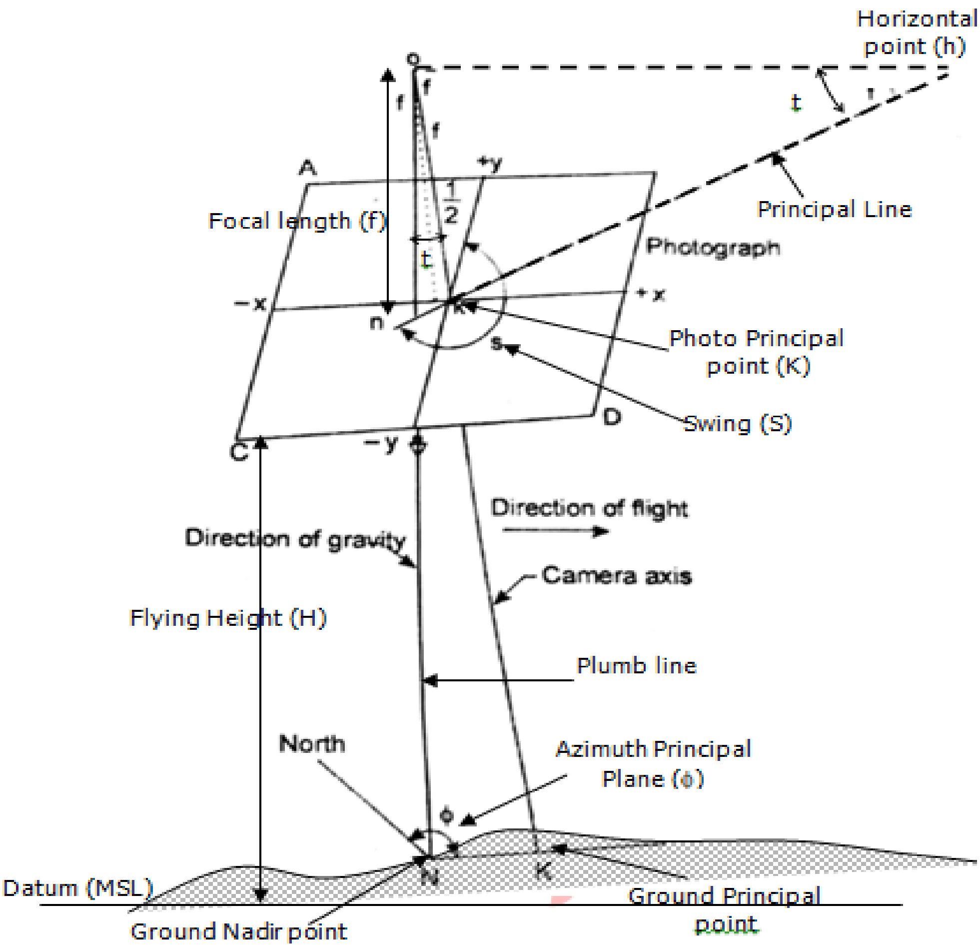
1) Seasonal conditions, including weather, vegetation, and shadows can affect both the taking of photographs and the resulting measurement quality. If the ground is not visible in the photograph it cannot be mapped.
2) Overall accuracy is relative to camera quality and flying height. Elevations derived from photogrammetry are less accurate than ground surveys (when compared to conventional or GPS ground survey methods using appropriate elevation procedures).
3) Identification of planimetric features can be difficult or impossible (e.g. type of curb and gutter, size of culverts, type of fences, and information on signs).
4) Underground utilities cannot be located, measured, or identified.
5) Right of Way and property boundary monuments cannot be located, measured, or identified.
6) Complex system, highly trained human resource needed.
7) Lengthy administrative procedure for getting permission to fly.
8) Weather dependent.

Comparison between the topographic map and an aerial Photograph:

SL No	Item	Aerial photograph	Topographic map
1	Cultivated land	Short grass or crops light in tone. Tall crops darks different crops by tone variation. Ploughed field have regular tone.	Not shown
2	Canals	Uniform width	Named locked shown
3	Water	Clear water dark, muddy water light.	Symbols, words coloured.
4	Streams and rivers	Irregular out line ground relief indicates fall.	Direction of flow by arrow
5	Orchards	Regular pattern	Symbols
6	Wood land	Trees can be counted if photographed in winter. Height of tress may be judged	Symbols, density and heights are not indicated.
7	Uncultivated land	Varying tone according to nature and relief	Colors or symbols
8	Foot paths	Show clearly on grass	Symbols
9	Roads	Light tone, culvert and bridges visible.	Symbols show class route
10	Railways	Long straight rails can be counted	Symbols
11	Boundaries	Hedges and fences visible legal boundaries not shown	Places dimension scaled. Elevations not possible symbols or words
12	Building	Size and relative height can be estimated. Functions are not	Single line only administrative

		indicated but can be judged from surroundings.	buildings may be shown by symbols.

Definition of Basic terms:



1) **Vertical photograph:** An aerial photograph made with camera axis or optical axis coinciding with direction of gravity.
2) **Tilted photograph:** An aerial photograph made with camera having its optical axis tilted usually less than 30 from the vertical, is known as tilted photograph.
3) **Oblique photograph:** An aerial photograph taken with the camera axis directly intentionally between the horizontal and vertical.
4) **Perspective centre:** The real or imaginary point of the origin of bundles of perspective rays. In an aerial camera, there are two perspective points – one perspective centre which relates to point on the photograph and the other which relates to the objects photographed.
5) **Principal distance:** The distance between the principal point of the photograph and the point through which all rays of light are assumed to pass. In a properly adjusted camera, the principal distance is about equal

to the focal length of the lens. But the principal distance of camera and focal length of lens are different.

6) **Principal axis:** The line joining the principal point of the photograph and the point through which all rays of light are assumed to pass.

7) **Homologous Points:** In perspective projections, rays originating from the one plane pass through a point before projecting on another plane. The pairs representing ground points and their photo points, are called homologous points.

8) **Plate parallel:** A line in the negative plane and perpendicular to the principal line is horizontal.

9) **Isometric parallel (Axis of tilt):** The plate parallel which passes through the isocentre. It is sometimes called axis of tilt.

10) **Perspective projection:** A perspective projection is the one produced by straight lines radiating from a common (or selected) point and passing through point on the sphere to the plane of projection. A Photograph is a perspective projection.

11) **Exposure station:** Exposure station is a point in space, in the air, occupied by the camera lens at the instant of exposure. Precisely, it is the space position of the front nodal point at the instant of exposure

12) **Flying height:** Flying height is the elevation of the exposure station above sea level or any other selected datum.

13) **Flight line:** It is a line drawn on a map to represent the track of the aircraft.

14) **Focal length:** The distance from the front nodal point of the lens to the plane of the photograph or the distance of the image plane from the rare nodal point is known as the focal length.

15) **Principal point (PP):** Principal point is a point where a perpendicular drop from the front nodal point of the camera lens strikes the photograph it is also known as photo principal point.

16) **Nadir point or plumb point (N):** The point where a plumb line drop from the front nodal point strikes the photograph is called nadir point.

17) **Principal plane (ONK):** The plane passing through O, N, and K is called principal plane.

18) **Principal line:** The principal line is the line (NK) of intersection of the principal plane with the plane of photograph. It is thus the line on a photograph obtained by joining the principle point and the photo nadir point.

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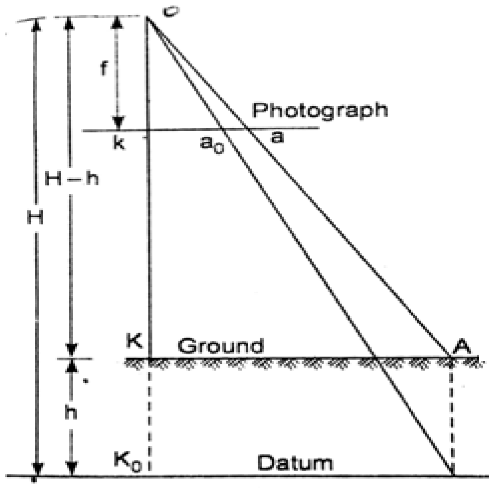
Derive the relation for the scale of a vertical photograph

Solution:

Scale of a vertical photograph for flat terrain:

Since a photograph is the perspective projection, the images of ground points are displaced where there are variations in the ground elevation. The images of two points 'A' and 'A_0', vertically above each other, are displaced on a vertical photograph and are represented by 'a' and 'a_0' respectively. Due to this displacement, there is no uniform scale between the points on such a photograph, except when the ground points have same elevation.



(a)

$$S = \text{scale} = \frac{\text{Map distance}}{\text{Ground distance}} = \frac{ka}{KA}$$

From similar triangles, Oka and OKA

$$\frac{ka}{Ok} = \frac{KA}{OK} \qquad \Rightarrow \frac{ka}{KA} = \frac{Ok}{OK} = \frac{f}{H-h}$$

$$\therefore\ S = \frac{f}{H-h}$$

Where, H= Height of exposure station (or the air plane) above the mean sea level.

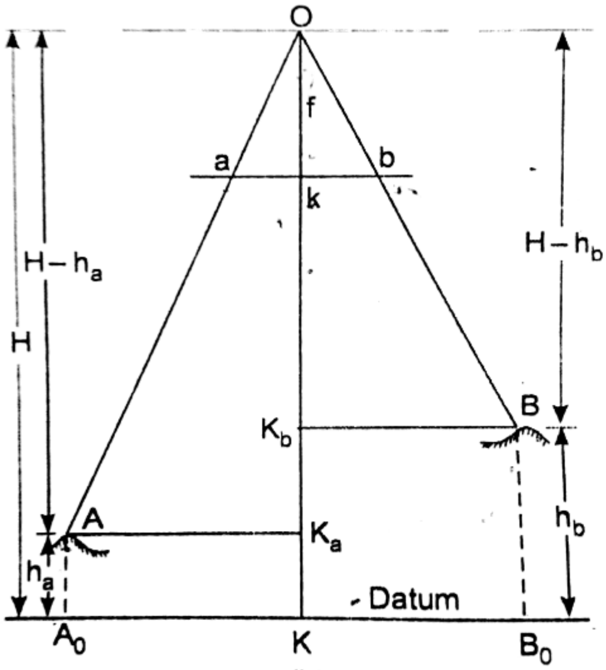
f = focal length of the camera

h = Height of the ground above mean sea level.

Scale of a vertical photograph for varing terrain:

Let, A and B be two ground points having elevations h_a and h_b respectively above mean sea level. They are represented by 'a' and 'b' respectively on the map, k is the principal point of the vertical photograph taken at height 'H' above mean sea level.

The scale of the photograph at the elevation h_a ,



(b)

$$S = \text{scale} = \frac{\text{Map distance}}{\text{Ground distance}} = \frac{ka}{K_aA}$$

From similar triangles, Oka and OK_aA

$$\frac{ka}{K_aA} = \frac{Ok}{OK_a} \quad \Rightarrow \frac{ka}{K_aA} = \frac{f}{H-h_a}$$

$$\therefore\ S_{ha} = \frac{f}{H-h_a}$$

Similarly, The scale of the photograph at the elevation h_b,


$$S_{hb} = \frac{f}{H - h_b}$$

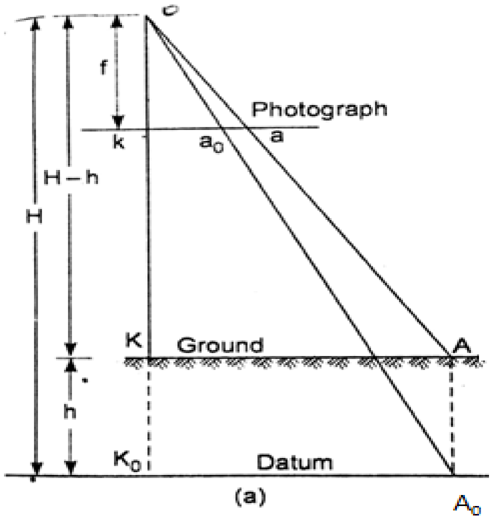
The scale of the photograph can also be designated by the representative fraction (R_h) as

$$R_{ha} = \frac{1}{\left(\frac{H - h_a}{f}\right)} \quad \text{and} \quad R_{hb} = \frac{1}{\left(\frac{H - h_b}{f}\right)}$$

Datum scale (S_d):

The datum scale of a photograph is that scale which would be effective over the entire photograph if all the ground points were projected vertically downward on the mean sea level before photographed.

$$\text{Datum scale} = S_d = \frac{ka}{K_0A_0} = \frac{Ok}{OK_0} = \frac{f}{H}$$



(a)

Average scale (S_d):

The average scale of a vertical photograph is that scale which would be effective over the entire photograph if all the ground points were projected vertically downward or upward on a plane representing the average elevation of the terrain before being photographed.

$$\text{Average scale} = S_{av} = \frac{f}{H - h_{av}}$$

June / July 2017 – 15 CV 46 – 06 marks: ®

Dec 2018 / Jan 2019 – 15 CV 46 – 10 marks: ®

A vertical photograph was taken at altitude of 1200 meters above mean sea level. Determine the scale of the photograph for a terrain lying at elevations of 80 meters and 300 meters if the foal length of the camera is 15 cm.

Solution: Given : H = 1200 m, f = 15 cm, case (i): h = 80 m, case (ii): h = 300 m

The scale at any height 'H' is given by

$$S_h = \frac{f}{H - h}$$

Case (i): $$S_{80} = \frac{15\text{cm}}{(1200 - 80)\text{m}} = \frac{1\text{cm}}{(1200 - 80)\text{m}} = \frac{1\text{cm}}{\frac{(1200 - 80)}{15}\text{m}} = \frac{1\text{cm}}{74.67\text{m}}$$

S_{80} is 1cm = 74.67 m

As a representative fraction, the scale is


$$R_{80} = \frac{15cm}{(1200 - 80)m \times 100cm} = \frac{1cm}{\frac{(1200 - 80)}{15} m \times 100cm} = \frac{1}{7467}$$

$$R_{80} = 1 : 7467$$

<u>Case (ii):</u> $S_{300} = \frac{15cm}{(1200 - 300)m} = \frac{1cm}{(1200 - 300)m} = \frac{1cm}{\frac{(1200 - 300)}{15} m} = \frac{1cm}{60m}$

S_{300} is 1cm = 60 m

As a representative fraction, the scale is

$$R_{300} = \frac{15cm}{(1200 - 300)m \times 100cm} = \frac{1cm}{\frac{(1200 - 300)}{15} m \times 100cm} = \frac{1}{6000}$$

$$R_{300} = 1 : 6000$$

Problem: ®

A camera having focal length of 20 cm is used to take a vertical photograph to a terrain having an average elevation of 1600 m. what is the height above MSL at which an air craft must fly in order to get the photograph at a scale of 1:10000.

<u>Solution:</u> **Given:** f = 20 cm, h = 1600 m, scale =1:10,000, H = ? m.

The scale at any height 'H' is given by

$$R_h = \frac{f}{H - h}$$

$$\frac{1}{10,000} = \frac{20cm}{(H - 1600)m \times 100cm}$$

$$(H - 1600) = \frac{20 \times 10000}{100} = 2000$$

$$H = 2000 + 1600 = 3600m \text{ above MSL}$$

Problem: ®

A line AB 3000 m long lying at an elevation of 600 m measures 9 cm on a vertical photograph for which focal length is 30 cm. determine the scale of the photograph in an area the average elevation of which is about 800m.

<u>Solution:</u> **Given:** f = 30 cm, h = 600 m, map distance =9 cm, Ground distance = 3000 m, S_{800} = ?

$$\text{Scale} = \frac{\text{Map distance}}{\text{Ground distance}} = \frac{f}{H - h}$$

$$\frac{9cm}{3000m} = \frac{30cm}{(H - 600)m}$$

$$(H - 600) = \frac{30 \times 3000}{9} = 10000m$$

$$H = 10000 + 600 = 10600m \text{ above MSL}$$

$$\therefore S_{800} = \frac{30\text{cm}}{(10600 - 800)\text{m}} = \frac{1\text{cm}}{\frac{(10600 - 800)}{30}\text{m}} = \frac{1\text{cm}}{326.67\text{m}}$$

S_{800} is 1cm = 326.67 m

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A line AB 2.0 km long, lying at an elevation of 500 m measures 8.65 cm on a vertical photograph for which focal length is 20 cm. Determine the scale of the photograph in an area the average elevation of which is about 800m.

<u>Solution:</u> Given: f = 20 cm, h = 500 m, map distance =8.65 cm, Ground distance = 2 km = 2000 m, S_{800} = ?

$$\text{Scale} = \frac{\text{Map distance}}{\text{Ground distance}} = \frac{f}{H - h}$$

$$\frac{8.65\text{cm}}{2000\text{m}} = \frac{20\text{cm}}{(H - 500)\text{m}}$$

$$(H - 500) = \frac{20 \times 2000}{8.65} = 4{,}624.28\text{m}$$

$$H = 4{,}624.28 + 500 = 5124.28 \text{ m above MSL}$$

$$\therefore S_{800} = \frac{20\text{cm}}{(5{,}124.28 - 800)\text{m}} = \frac{1\text{cm}}{\frac{(5{,}124.28 - 800)}{20}\text{m}} = \frac{1\text{cm}}{216.21\text{m}}$$

S_{800} is 1cm = 216.21 m

Problem: ®

A section line AB appears to be 10.16 cm on a photograph for which the focal length is 16 cm. the corresponding line measures 2.54 cm on a map which is to a scale 1/50,000. The terrain has an average elevation of 200 m above mean sea level. Calculate the flying altitude of the aircraft, above mean sea level, when the photograph was taken.

<u>Solution:</u> Given: f = 16 cm, photo distance = 10.16 cm, Map distance = 2.54 cm, map scale = 1 / 50,000. h = 600 m, map distance =9 cm, Ground distance = 3000 m, S_{800} = ?

The relation ship between the photo scale and map scale is given by

$$\frac{\text{Photo scale}}{\text{Map scale}} = \frac{\text{Photo distance}}{\text{Map distance}}$$

$$\text{Map scale} = \frac{1}{50{,}000}, \quad \text{Let photo scale be } \frac{1}{n}$$

$$\frac{1/n}{1/50{,}000} = \frac{10.16}{2.54}$$

$$\frac{1}{n} = \frac{10.16}{2.54} \times \frac{1}{50000} = \frac{1}{12{,}500}$$

$$\therefore S_{200} = \frac{1}{n} = \frac{f}{(H - h)m}$$

$$S_{200} = \frac{1}{12{,}500} = \frac{0.16}{(H - 200)}$$

$$(H - 200) = 0.16 \times 12{,}500 = 2000m$$

$$H = 2{,}000 + 200 = 2{,}200m \text{ above MSL}$$

Computation of length of line between points of different elevations from measurements on a vertical photograph:

Let, A and B be two ground points having elevations h_a and h_b above datum, and the co-ordinates (X_a, Y_a), (X_b, Y_b), respectively with respect to the ground co-ordinate axes which coincide in direction with the photographic co-ordinate x and y axis. The origin of the ground co-ordinates lie vertically beneath the exposure station.

Let, 'a' and 'b' be the corresponding points of the photograph, and (x_a, y_a), (x_b, y_b) be the corresponding co-ordinates.

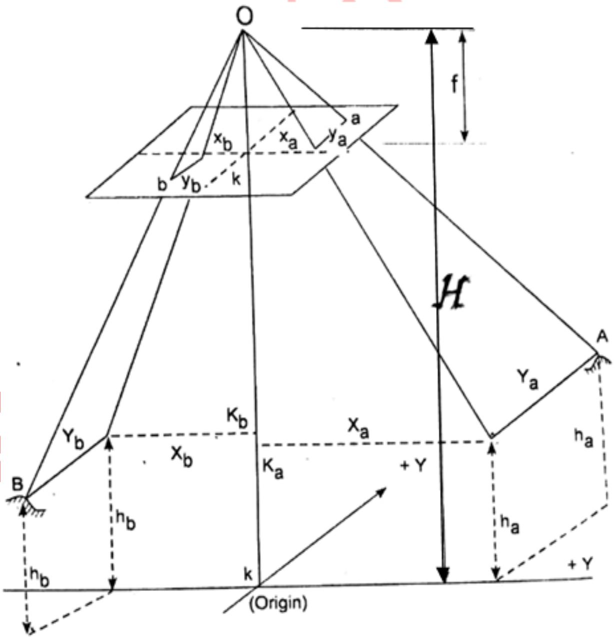


Fig. Computation of length of a line

From similar triangles, Oka and OK_aA

$$\frac{Ok}{x_a} = \frac{OK_a}{X_a} \Rightarrow \frac{Ok}{OK_a} = \frac{x_a}{X_a}$$

$$\frac{x_a}{X_a} = \frac{y_a}{Y_a}$$

$$\text{Also, } \frac{Ok}{OK_a} = \frac{f}{H - h_a}$$

$$\therefore \frac{x_a}{X_a} = \frac{y_a}{Y_a} = \frac{f}{H - h_a}$$

$$\therefore X_a = \left(\frac{H - h_a}{f}\right) \times x_a \; ; \quad Y_a = \left(\frac{H - h_a}{f}\right) \times y_a$$

$$\therefore X_b = \left(\frac{H - h_b}{f}\right) \times x_b \; ; \quad Y_b = \left(\frac{H - h_b}{f}\right) \times y_b$$

In general, the co-ordinates X and Y of any point at an elevation are

$$X = \left(\frac{H - h}{f}\right) \times x; \qquad Y = \left(\frac{H - h}{f}\right) \times y$$

The length 'L' between the two points A and B is then given by

$$L = \sqrt{(X_a - X_b)^2 + (Y_a - Y_b)^2}$$

The value of X_a, X_b, Y_a and Y_b must be substituted with their proper algebraic signs.

Problem:

Two points A and B having elevations of 400 m and 200 m respectively above datum appear on the vertical photograph having focal length of 20 cm and flying altitude of 2000 m above datum. Their corrected photographic co-ordinates are as follows.

Point	photographic x (cm)	co-ordinates y (cm)
a	+ 2.75	+ 1.39
b	-1.80	+ 3.72

Determine the length of the ground line AB.

<u>Solution:</u> The ground co-ordinates are given by

$$X_a = \left(\frac{H - h_a}{f}\right) \times x_a = \left(\frac{2000 - 400}{20}\right) \times (+2.75) = +220 \text{ m}$$

$$Y_a = \left(\frac{H - h_a}{f}\right) \times y_a = \left(\frac{2000 - 400}{20}\right) \times (+1.39) = 111.2 \text{ m}$$

$$X_b = \left(\frac{H - h_b}{f}\right) \times x_b = \left(\frac{2000 - 200}{20}\right) \times (-1.80) = -162 \text{ m}$$

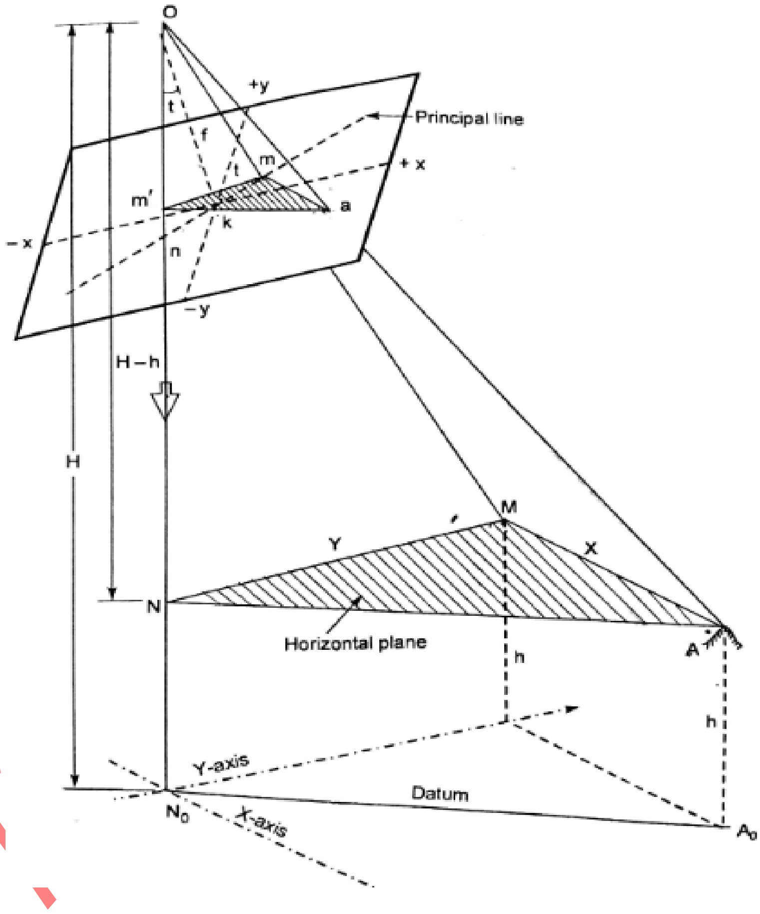
$$Y_b = \left(\frac{H - h_b}{f}\right) \times y_b = \left(\frac{2000 - 200}{20}\right) \times (+3.72) = +334.8 \text{ m}$$

$(X_a-X_b)^2 = (220+162)^2 = 15.592\text{x}10^4 \text{ m}^2$

$(Y_a-Y_b)^2 = (111.2-334.8)^2 = 5.000\text{x}10^4 \text{ m}^2$

Hence $AB = \sqrt{(X_a - X_b)^2 + (Y_a - Y_b)^2} = \sqrt{15.592 \times 10^4 + 5.00 \times 10^4} = 442.87\text{m}$


Scale of a tilted photograph:



In the case of flat ground and uniform elevation, the vertical photograph is uniform from point to point.

If the ground varies, the scale also varies. If a tilt photograph is taken over an area having no relief, the scale will not be uniform. The downward half of the photograph will have a larger scale than the upward half. The problem becomes still complicated if a tilt photograph is taken over an area with relief.

Tilted photograph which includes the image 'a' of a point 'A' at an altitude of 'h' above datum. 'k' is the principal point and 'n' the photo nadir. 'nk is the principal line. From 'a', draw 'am' perpendicular to the principal line. 'am' is, therefore, a horizontal line. From 'm' draw 'mm' perpendicular to the plumb line. mm' is, therefore, a horizontal line. Hence the triangle amm' lies in a horizontal plane.

Let N and M be the points on 'on' and 'om' extended, at heights of 'h' above datum. Thus N,M and A have the same elevation. The triangle NMA is in a horizontal plane.

From the similar triangles 'om'a' and ONA, we get

$$\frac{m'a}{NA} = \frac{Om'}{ON}$$

But, Om' = On – m'n = f sec t – mn sin t

$$ON = ON_0 - NN_0 = H - h$$

$$\frac{m'a}{NA} = \frac{\text{Map distance}}{\text{Ground distance}} = S_h$$

$$S_h = \frac{f\sec t - mn\sin t}{H - h}$$

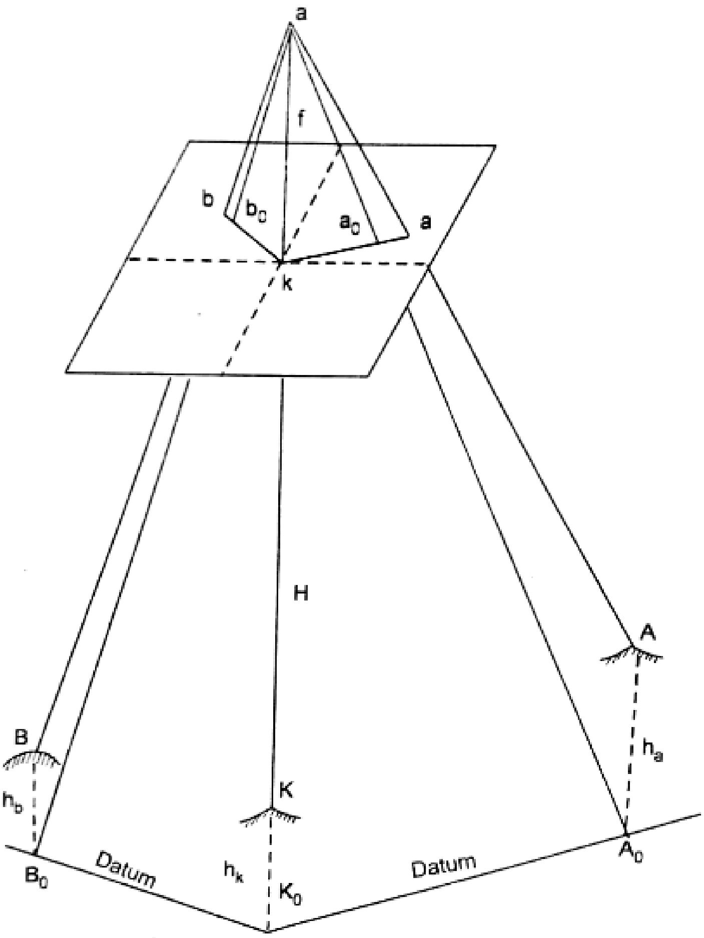
For finding the scale at a given point on a photography, the following data are essential:

(i) Focal length, (ii) tilt, (iii) Height of flight, (iv) Height of the point (v) swing, (vi) position of the point which respect to principal line.

Relief Displacement on a vertical photograph:

When the ground is horizontal and the photograph is truly vertical and sources of errors are neglected, the scale of the photograph will be uniform, such a photograph represents a true orthographic projection and hence the true map of the terrain.

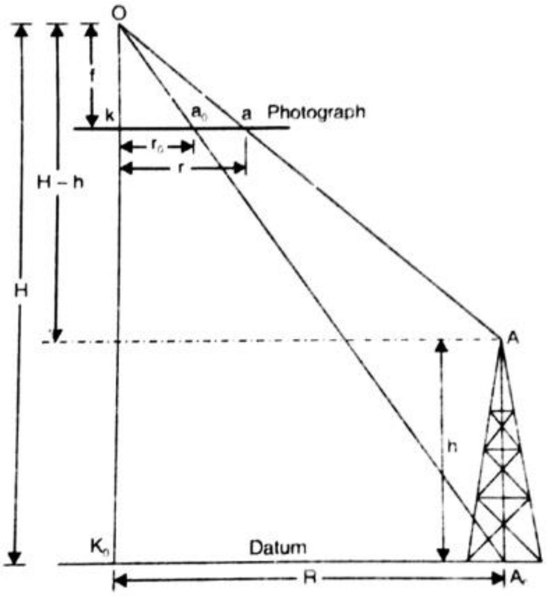
When the ground is not horizontal, the scale of the photograph varies from point to point and is not constant. Since the photograph is the perspective view, the ground relief is shown in perspective on the photograph. Every point on the photograph is therefore, displaced from their true orthographic position. This displacement is called **relief displacement**.



In the fig shown, A, B and K are three ground points having elevations ha, hb and hk above datum. A_0, B_0 and K_0 are their datum positions respectively, when projected vertically downwards on the datum plane. On the photograph, their positions are a, b and k respectively, the point k being chosen vertically below the principal point. If the datum points A_0, B_0 and K_0 are imagined to be photographed along with the ground points, their positions will be a_0, b_0 and k respectively. The points 'a' and 'b' are displaced outward from their datum photograph positions, the displacement being along the corresponding radial lines from the principal point. The radial distance aa_0 is the relief displacement of A while bb_0 is the relief displacement of B. the point k has not been displaced since it coincides with the principal point of the photograph.


June / July 2017 – 15 CV 46 – 05 marks: ®

Derive an expression for relief displacement on a vertical photograph.



Let,

r = radial distance 'a' from 'k'

r_0 = radial distance 'a_0' from 'k'

$R = K_0A_0$

From similar triangles,

$$\frac{f}{H-h} = \frac{r}{R},$$

$$r = \frac{Rf}{H-h} \qquad ----(1)$$

Also, $\frac{f}{H} = \frac{r_0}{R}$,

$$r_0 = \frac{Rf}{H} \qquad ----(2)$$

Hence the relief displacement (d) is given by

$$d = r - r_0 = \frac{Rf}{H-h} - \frac{Rf}{H}$$

$$d = \frac{RfH - RfH + Rfh}{(H-h)H}$$

$$d = \frac{Rfh}{(H-h)H} \qquad ----(3)$$

From equation (1) and (2)

$$R = \frac{r(H-h)}{f} = \frac{r_0H}{f}$$

Substituting the values of 'R' in eq (3), we get

$$d = \frac{r(H-h)}{f} \times \frac{fh}{(H-h)H} = \frac{rh}{H} \qquad --------(4)$$

$$d = \frac{r_0H}{f} \times \frac{fh}{(H-h)H} = \frac{r_0h}{(H-h)} \qquad --------(5)$$

From eq (3), (4), and (5) following conclusion could be made

1) The relief displacement increases as the distance from the principal point increases.
2) The relief displacement decreases with the increase in the flying height.
3) For point above datum, the relief displacement is positive being radially outward.
4) For point below datum (h having negative value), relief displacement is negative, being radially inward.

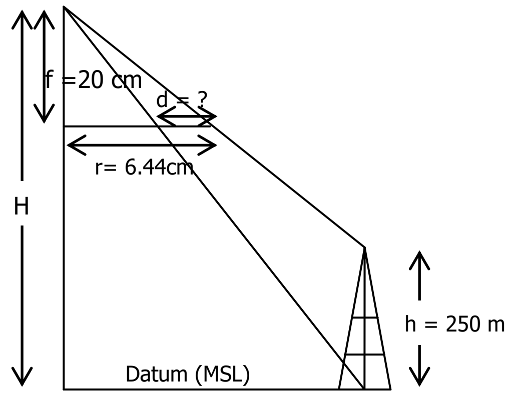
5) The relief displacement of the point vertically below the exposure station is zero.

In the above expressions, H and h must be measured above the same datum.

Dec 2017 / Jan 2018 – 06 marks: ®

The distance from the principal point to an image on a photograph is 6.44 cm and the elevation of the object above the datum (sea level) is 250 m. What is the relief displacement at the point if the datum scale is 1 in 10,000 and the focal length of the camera is 20 cm?

<u>Solution:</u> **Given:** r = 6.44 cm= 0.0644m, h = 250 m, scale =1:10000, f = 20 cm = 0.20 m, H = ? m and d = ? m



The scale at any height 'H' is given by

$$S = \frac{f}{H}$$

$$\frac{1}{10{,}000} = \frac{0.2}{(H)m}$$

$$(H) = 0.2 \times 10000 = 2000\text{m above MSL}$$

Relief displacement (d):

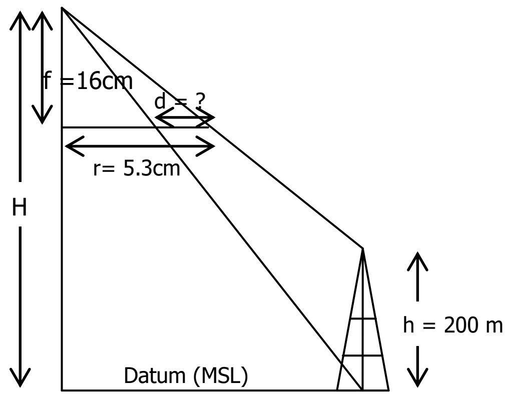
The displacement 'd' of the image of the top with respect to the image of the bottom is given by,

$$d = \frac{rh}{H} = \frac{0.0644 \times 250}{2000} = 8.05 \times 10^{-3}\ \text{m} = 0.805\ \text{cm}$$

<u>Problem:</u> ®

The distance from the principal point to an image on a photograph is 5.30 cm and the elevation of the object above the datum (sea level) is 200 m. What is the relief displacement at the point if the datum scale is 1 in 8,000 and the focal length of the camera is 16 cm?

<u>Solution:</u> **Given:** r = 5.30 cm= 0.053m, h = Elevation of the object above the datum = 200 m, scale = 1:8,000, f = 16 cm = 0.16m, H = height of the lens above the datum = ? m and d = Relief distance = ? m



The scale at any height 'H' is given by

$$S = \frac{f}{H}$$

$$\frac{1}{8{,}000} = \frac{0.16}{(H)m}$$

$$H = 0.16 \times 8{,}000 = 1280\text{m above MSL}$$


Relief displacement (d):

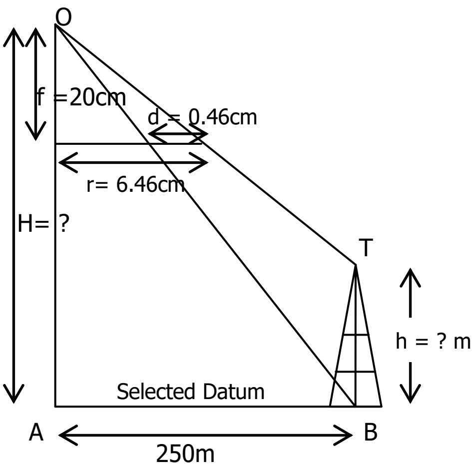
The displacement 'd' of the image of the top with respect to the image of the bottom is given by,

$$d = \frac{rh}{H} = \frac{0.053 \times 200}{1280} = 8.28 \times 10^{-3}\ m = 0.828\ cm$$

Problem: ®

The vertical photograph of a flat area having an average elevation of 250 m above mean sea level was taken with a camera having a length of 20 cm. A section line AB, 250 m long in the area, measures 8.50 cm on the photograph. A tower TB in the area also appears on the photograph. The distance between the images of top and bottom of the tower measures 0.46 cm on the photograph. The distance of the image of the top of the tower is 6.46 cm. determine height of the tower.

Solution: **Given:** r = 6.46 cm= 0.0646 m, map distance = 8.50 cm, Ground distance = 250 m, f = focal length = 20 cm = 0.2 m, d = Relief distance = 0.46 cm = 0.0046 m, H = height of the lens (camera) above the datum = ? m and h = Elevation of the object above the datum = ? m,



The scale at any height 'h' is given by

$$S = \frac{\text{Map distance}}{\text{Ground distance}} = \frac{f}{H}$$

$$\frac{0.085}{250} = \frac{0.2}{(H)m}$$

$$H = \frac{0.2 \times 250}{0.085} = 588.24m \text{ above selected datum}$$

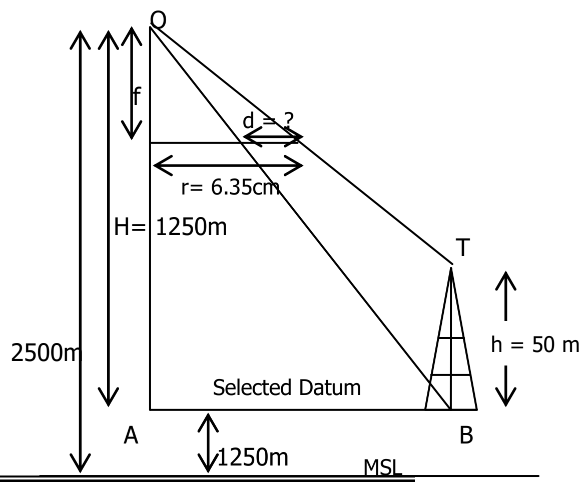
Height of the tower (h):

$$d = \frac{rh}{H}$$

$$\text{Height of the tower above base } (h) = \frac{dH}{r} = \frac{0.0046 \times 588.24}{0.0646} = 41.90m$$

Problem: ®

The tower TB 50 m high, appears in a vertical photograph taken at a high altitude of 2500 m above mean sea level. The distance of the image of the top of the tower is 6.35 cm. compute the displacement of the image of the top of the tower with respect to the image of its bottom. The elevation of the bottom of the tower is 1250 m.



Solution: **Given:** r = 6.35 cm= 0.0635 m, h = height of the tower above its base = 50 m, H = height of the lens above the bottom of tower = 2500 – 1250 = 1250 m, d = Relief distance = ? m

Relief displacement (d):

The displacement 'd' of the image of the top with respect to the image of the bottom is given by,

$$d = \frac{rh}{H} = \frac{0.0635 \times 50}{1250} = 2.54 \times 10^{-3} \text{ m} = 0.254 \text{ cm}$$

Relief displacement on a tilted photograph:

Ground control for photogrammetry:

The ground control survey consists in locating the ground positions of points which can be identified on arieal photographs. The ground control is essential for establishing the position and orientation of each photograph in space relative to the ground. The extent of the ground control required is determined by

(a) The Scale of the map, (b) The Navigational control and (c) The cartographical process by which the maps will be produced.

The ground survey for establishing the control can be divided into two parts:

(a) Basic Control (b) Photo control

The basic control consists in establishing the basic net work of triangulation stations, traverse stations, azimuth marks, bench marks etc.


The photo control consists in establishing the horizontal positions or elevations of the images of some of the identified points on the photograph, with respect to the basic control.

The photo control can be established by two methods:

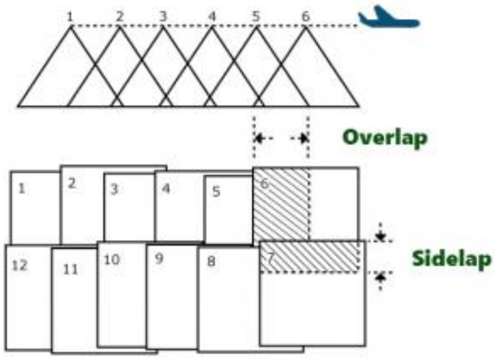
i) Post marking method and (ii) Pre marking method

In the post marking method, the photo control points are selected after the aerial photography. The distinct advantage of this method is in positive identification and favourable location of points.

In the pre marking method, the photo control points are selected on the ground first, and then included in the photograph. The marked points on the ground can be identified on the subsequent photograph. If the control transverse or triangulation station or bench marks are to be incorporated in the photo control network, they are marked with paint, flags etc, in such a way that identification on the photographs becomes easier. The selected control points should be sharp and clear in plan.

June / July 2017 – 15 CV 46 – 05 marks

Explain the procedure of aerial survey.



Dec 2017 /an 2018 – 06 marks

List the reasons for keeping overlap in photographs

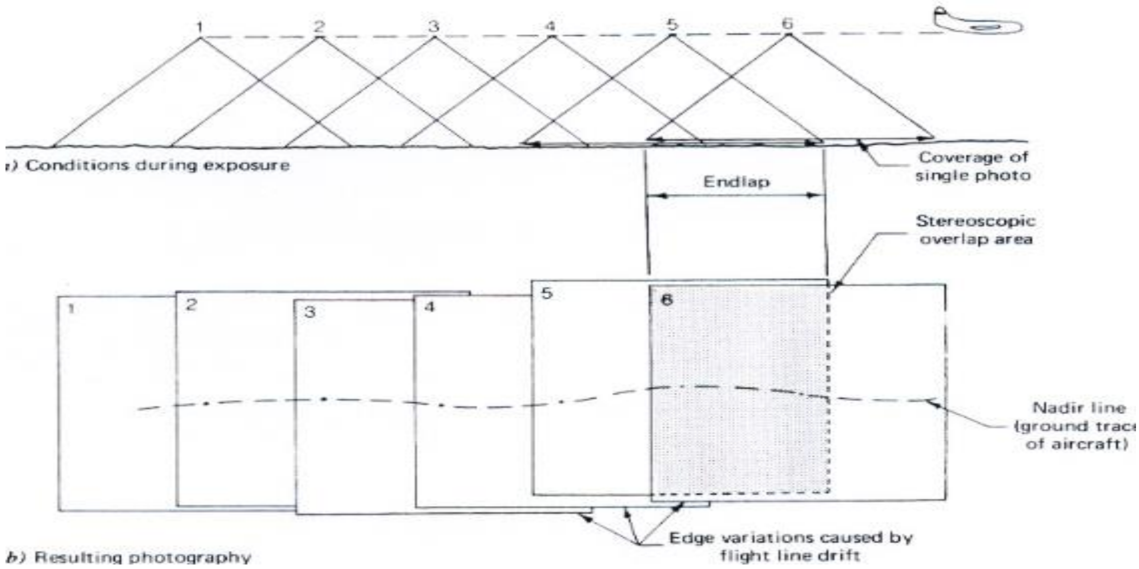
Ans: Reasons for overlaping in photographs are:

(i) When vertical photographs are to be used for the preparation of maps, photographs are taken at the proper interval along each strip to give the desired overlap.

(ii) To tie the different prints accurately.

(iii) In order to view the pairs of photographs stereoscopically.

(iv) If the flight lines are not maintained straight and parallel, the gap between adjacent strips will be left. These gaps can be avoided by having side laps.



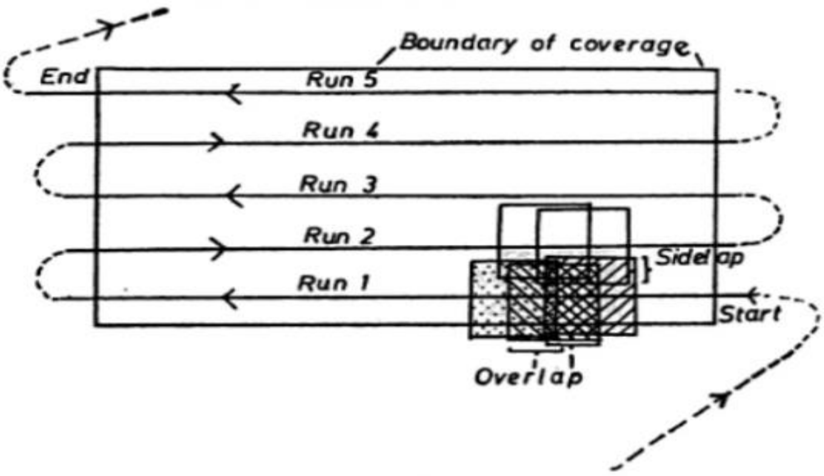


Fig. 2.1: Diagram showing the general pattern of stereoscopic ground coverage by aerial photography.


June / July 2017 – 15 CV 46 – 06 marks: ®

Find the number of photographers (size 250 x 250 mm) required to cover an area of 20 km x 16 km of the longitudinal overlap is 60% and the side overlap is 30% scale the photograph is 1 cm = 150 m.

Solution:

Area 20 km x 16 km

Longitudinal overlap (P_L) = 60% = 0.6,

Side overlap (P_W) =30% = 0.3.

Scale: 1 cm = 150 m , $\therefore$s = 150 m

Photograph size = 250 mm x 250 mm = 25 cm x 25 cm

L_1 x L_2 = 20 km x 16 km

Total number of photograph required:

Total number of photograph required = N_1 x N_2

N_1 = Number of photograph per flight line.

$$N_1 = \frac{L_1}{(1 - P_L)sl} + 1 = \frac{20\text{km x } 1000\text{ m}}{(1 - 0.6) \times 150 \times 25} + 1 = 14.33 \quad \text{Say} \quad 15\text{ No's}$$

N_2 = Number of flight line required.

$$N_2 = \frac{L_2}{(1 - P_w)sw} + 1 = \frac{16\text{km x } 1000\text{ m}}{(1 - 0.3) \times 150 \times 25} + 1 = 7.09 \quad \text{Say} \quad 8\text{ No's}$$

Total number of photograph required = 15 x 8 = 120 No's

Problem:®

The scale of an aerial photography is 1cm =100m. The photograph size is 20 cm x 20 cm. Determine the number of photographs required to cover an area 10 km x 10 km, If the longitudinal lap is 60% and the side lap is 30%.

Solution:

Longitudinal overlap (P_L) = 60% = 0.6,

Side overlap (P_W) =30% = 0.3.

Scale: 1 cm = 100 m, $\therefore$s = 100 m

Photograph size= 20 cm x 20 cm

L_1 x L_2 = 10 km x 10 km

Total number of photograph required:

Total number of photograph required = N_1 x N_2

N_1 = Number of photograph in each strip is given by .

$$N_1 = \frac{L_1}{(1 - P_L)sl} + 1 = \frac{10{,}000}{(1 - 0.6) \times 100 \times 20} + 1 = 12.5 + 1 = 14$$

N_2 = Number of flight lines required.

$$N_2 = \frac{L_2}{(1 - P_w)sw} + 1 = \frac{10{,}000}{(1 - 0.3) \times 100 \times 20} + 1 = 7.6 + 1 = 9$$

Total number of photograph required = 14 x 9= 126 No's

Problem:®

The scale of an aerial photography is 1cm =100m. The photograph size is 20 cm x 20 cm. Determine the number of photographs required to cover an area 08 km x 12.5 km, If the longitudinal lap is 60% and the side lap is 30%.

Solution:

Longitudinal overlap (P_L) = 60% = 0.6,

Side overlap (P_w) =30% = 0.3.

Scale: 1 cm = 100 m, $\therefore$s = 100 m

Photograph size= 20 cm x 20 cm

L_1 x L_2 = 12.5 km x 8 km

<u>Total number of photograph required:</u>

Total number of photograph required = N_1 x N_2

N_1 = Number of photograph in each strip is given by .

$$N_1 = \frac{L_1}{(1 - P_L)sl} + 1 = \frac{12500}{(1 - 0.6) \times 100 \times 20} + 1 = 17$$

N_2 = Number of flight lines required.

$$N_2 = \frac{L_2}{(1 - P_w)sw} + 1 = \frac{8000}{(1 - 0.3) \times 100 \times 20} + 1 = 7$$

Total number of photograph required = 17 x7= 119 No's

<u>Mosaics:</u>

Two are more photograph assembled to form one single picture of an area is called as Mosaics.

Photomap consists of one single photograph. Mosaics are similar to map in many respect. They have number of advantages over maps. They show relative planimetric locations of an infinite number of objects. The objects are easily recognised by their pictorial quality whereas objects on maps which are shown with symbols are limited in number. Mosaics are easily understood and interpreted by people without having knowledge of photogrammetry or engineering.

A controlled mosaic is obtained when the photographs are carefully assembled so that the horizontal control points agree with their previously plotted position.

A mosaic which is assembled without regard to any plotted control is called uncontrolled mosaic.

A mosaic differs from a map in the following aspects:

- A mosaic is composed of series of perspective of the area whereas a map is a single orthographic projection.
- Mosaic contain local relief displacement, tilt distortion and non – uniform scale, while the map shows the correct horizontal position at an uniform scale.
- Various futures appear as realistic photographic images on the mosaic where as they are by standard symbols on the map.

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Describe how mosaic differ from a map.

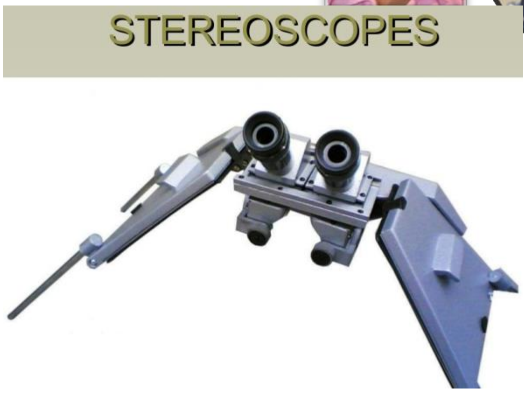
Ans:

1) A mosaic is a perspective projection where as map is a orthographic projection.
2) A mosaic contains relief displacements, tilt distortions while a map shows correct horizontal positions at a uniform scale.
3) Realistic photographic images on a mosaics where maps are portrayed by standard symbols.

Stereoscope:

It is an instrument used for viewing stereopairs. Stereoscopes are designed for two purposes:

1) To assist in presenting to the eyes the images of pair of of photographs so that the relationship between convergence and accommodation is the same as would be in natural vision.
2) To magnify the perception of depth.



Stereoscopy:

Stereoscopy is the important part of photogrammetric surveying which deals with the depth perception by virtue of which relative distance of objects is determined.

Stereoscopic vision:

The term stereoscopic vision refers to the human ability to view with both eyes in similar, but slightly different rays. This allows humans to judge distance, which develops their ability to have true depth perception. The human's ability to view the world through stereoscopic sight has given him/her a significant advantage over entities and animals in the wild that do not possess this capability.

Stereograms take advantage of human stereoscopic vision. Stereograms are pictures that appear to be 3 dimensional (3D) when the human eye views them. The technique relies on each eye perceiving images in a slightly different manner due to the physical separation between them. When the human eye observes to images that are slightly different, the brain perceives them as a single 3D image, thereby creating a stereogram.

The advantage of stereoscopic vision

Most people take their ability to view their surroundings with stereoscopic vision for granted. When a person loses the sight in one eye, it is almost impossible for him/ her to grasp depth perception at the same level as when they had sight in both eyes. Stereoscopic vision also helps humans to handle and manipulate small objects with their hands. Animals that have this type of vision can use it to navigate through dense jungle, thus helping to ensure their survival against predators.

The same ability helped humans survive in the wild as they could assess threats quickly and accurately. In the modern world, stereoscopic vision enables aviators, surgeons, and car drivers to perform their functions at a high degree of accuracy that would be quite challenging otherwise.