Surveying-II
CE-205 (T)

Lecture 8
Photographic Surveying

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Photographic Surveying

- It is also known as photogrammetry, is a method of surveying in which plan or maps are prepared from photograph taken at suitable camera station.

  Or

- Photogrammetry is a sign of making measurement from photograph.

  Or

- Photogrammetry may be defined as the science , art or technology of obtaining reliable information from photograph.

it may be divided into two classes

A) Terrestrial (or Ground) photogrammetry

B) Aerial (or Air) photogrammetry

Photographic Surveying

A) Terrestrial (or Ground) photogrammetry

- In this class the maps are prepared from terrestrial or ground photographs ,Or
- Terrestrial Photogrammetry employs photographs taken from the point of earth surface for measurement purposes.
- It is considered as further development of plane table surveying.

B) Aerial (or Air) photogrammetry

- In this the maps are produced from air photographs (photographs are taken from air).

Photographic Surveying

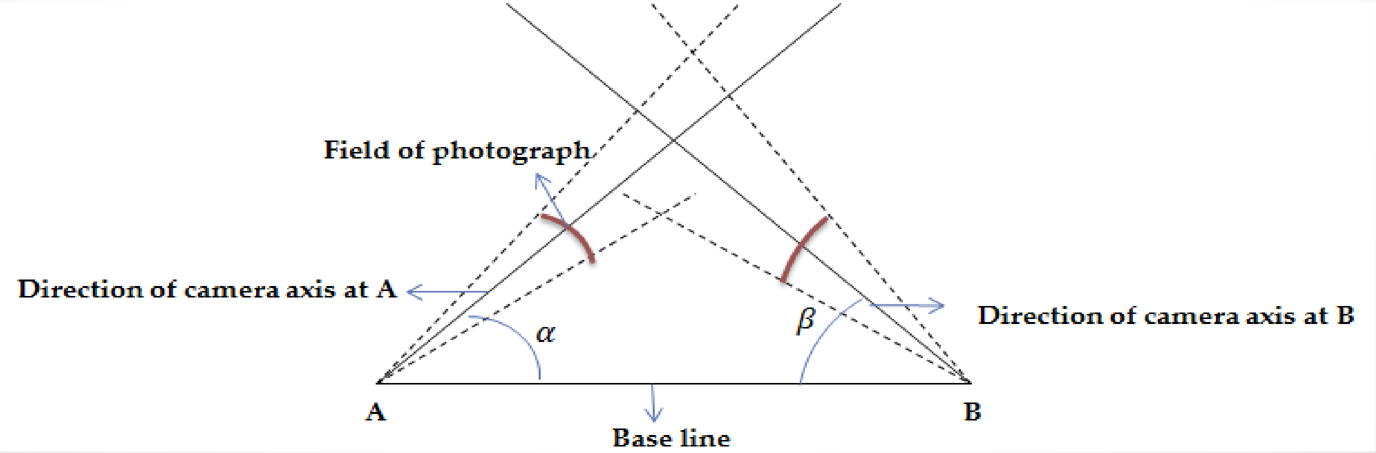
Uses of photogrammetry

- Used & preparing the topographic maps.
- Used in land surveying to compute the coordinates of section corners, boundary corners etc.
- Used to make the shore line in hydrographic surveying.
- It is used to determine the precise ground coordinates of point in control surveying.
- It is used to develop the maps & cross sections for routes & cross sections for engineering surveying.
- Photogrammetry is successful in many non- engg fields i.e. Geology, Archeology, Forestry, Agricultural, Conservation, Planning, Military intelligence, Traffic management & Accident investigation.
- It is also used particularly for inaccessible region forbidden properties & unhealthy material region

Photographic Surveying

Photo Theodolite

- It is a form of ground camera. It is combination of camera & theodolite.
- It is used for taking the photographs & measuring the angles which the vertical plane of collimation makes the base line.
- The optical axis of camera is arranged parallel to the line of collimation of theodolite telescope.
- The theodolite also used for
  - a) The determination of orientation of camera axis
  - b) The angular measurement needed to fix camera station during the control survey



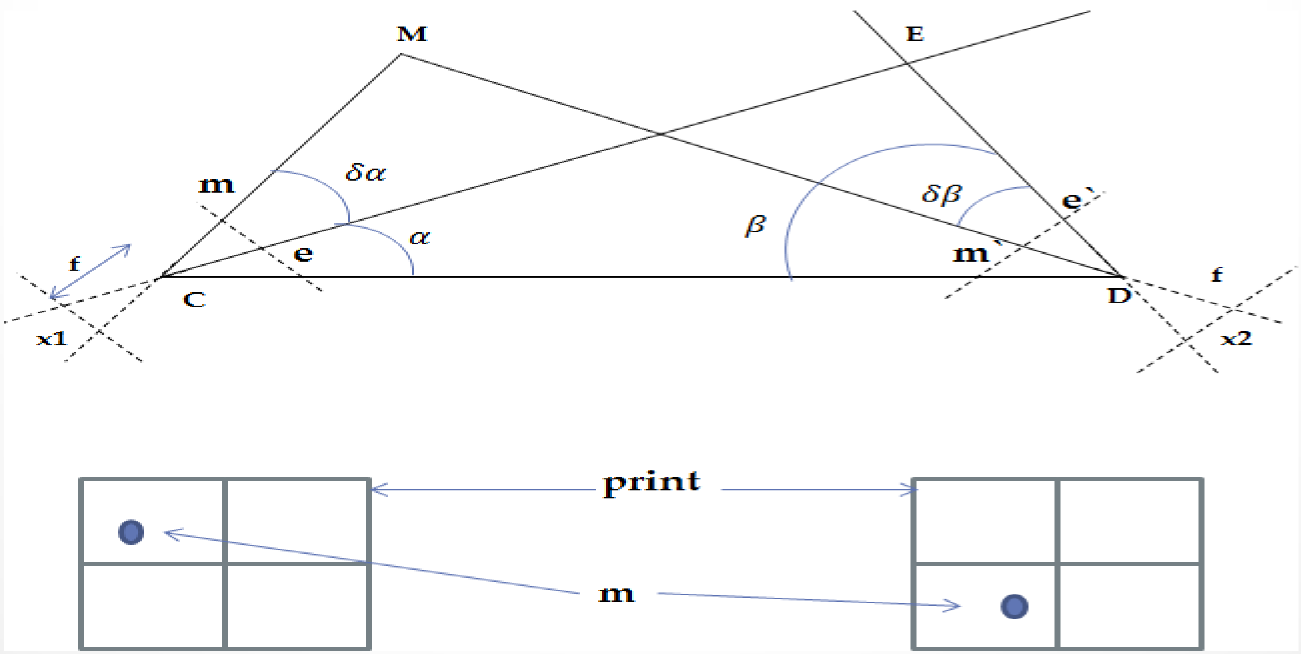
Photographic Surveying

Photo Theodolite

Photographic Surveying

Principle of methods of terrestrial photogrammetry

- The principle is exactly similar to that of plane table survey & it may be stated as "The position of an object with reference to the base line is given by intersection of the rays drawn to it from each end of the base line"
- In plane table most of the work is executed in the field while in this method it is done in office.



Principle of methods of terrestrial photogrammetry

Let C & D are camera stations

CD = Base line of the length b ,

CE & DE position of vertical plane of collimation (i.e. the vertical plane containing the optical center)

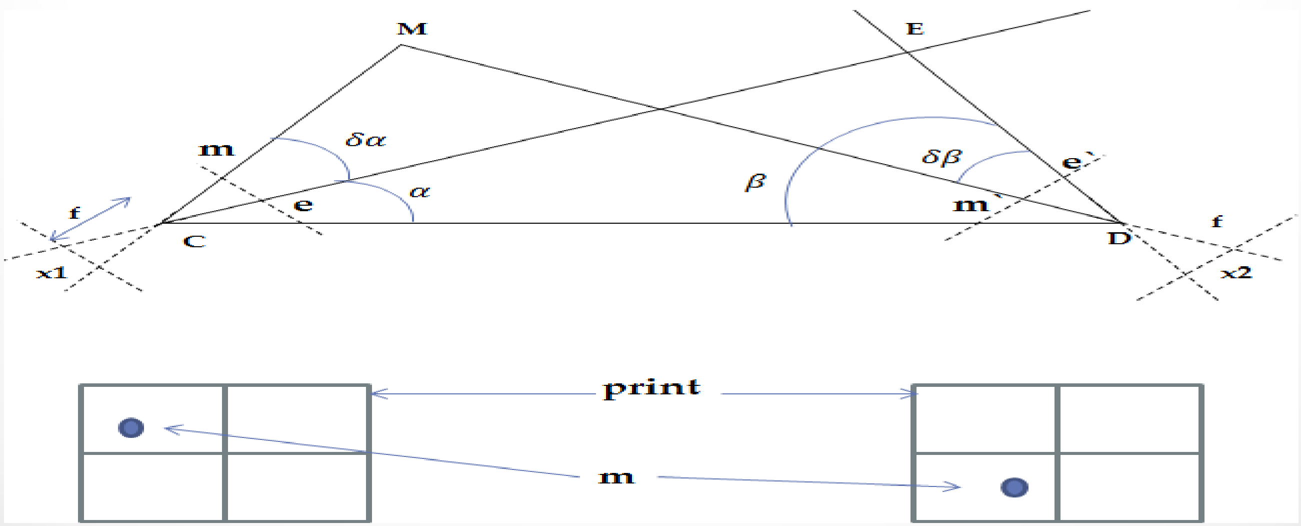
α & β angle which vertical plane of collimation make the base line CD.

M= point to be located which is shown as **m** on both print

x_1 & y_1 = distance of m from vertical & horizontal hair measured on photographs at C.

x_2 & y_2 = distance of m from vertical & horizontal hair measured on photographs at D.

f = local length of the camera lens.

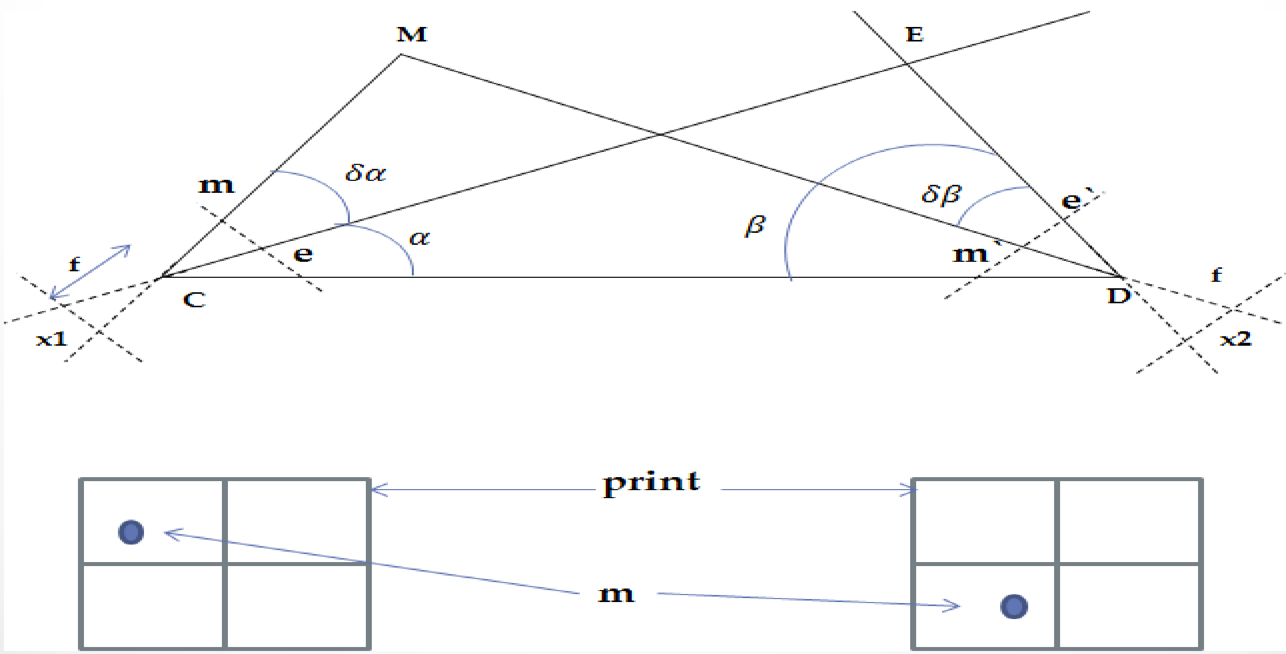


Photographic Surveying

- The point **M** may be plotted graphically as well as analytically.

A) Graphical method

- First plot the base line to the given scale. Draw **CE** making an angle of ***α*** with base line **CD** with the help of protector.
- Similarly draw **DE** making angle of ***β*** with **DC** (base line).
- On **CE** mark the line **Ce** at a distance equal to ***f*** (focal length of the curve) in front of **C** .
- Similarly set off a distance **De'** equal to ***f*** along **DE** in front of **D**.

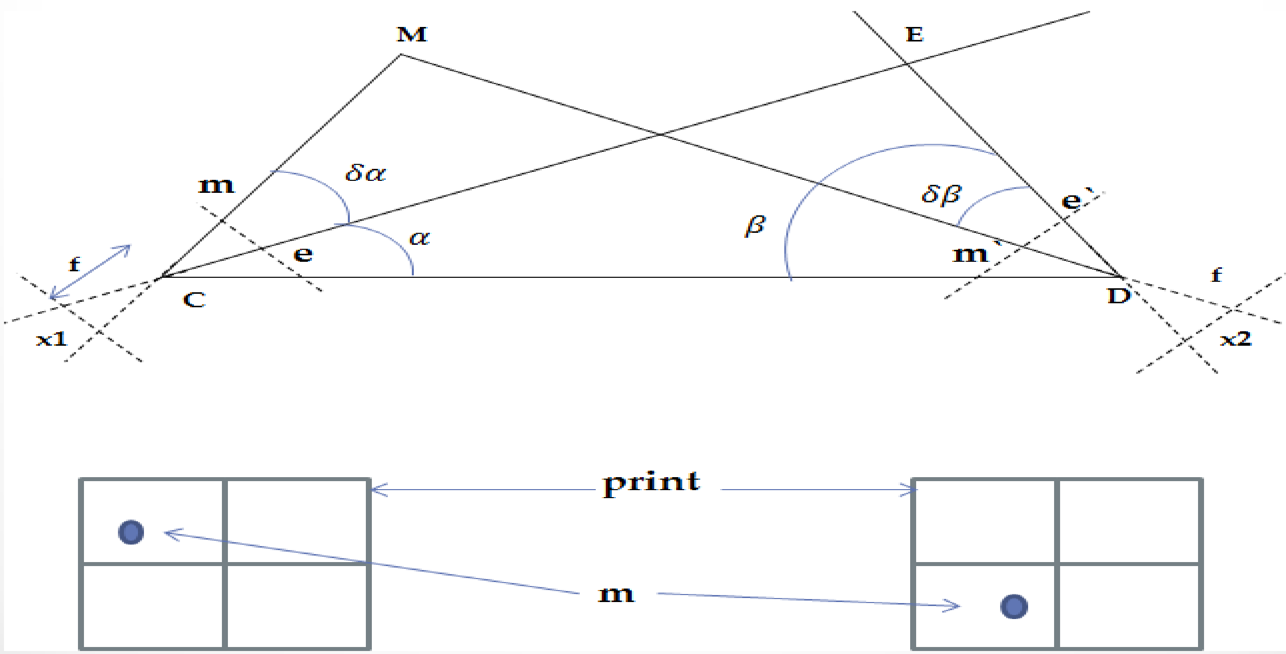


Photographic Surveying

- The point M may be plotted graphically as well as analytically.

A) Graphical method

- Through the point **e** & **e'**, draw a line at right angle to **CE** & **DE** respectively. Measured **em** equal to $\mathbf{x_1}$ & **e'm'** equal to $\mathbf{x_2}$ along the perpendicular line on the same side as on the photograph.
- Join **Cm** & **Dm'** & produce them so as to meet at **M** which give the required position of **M** on the plans.



A) Graphical method

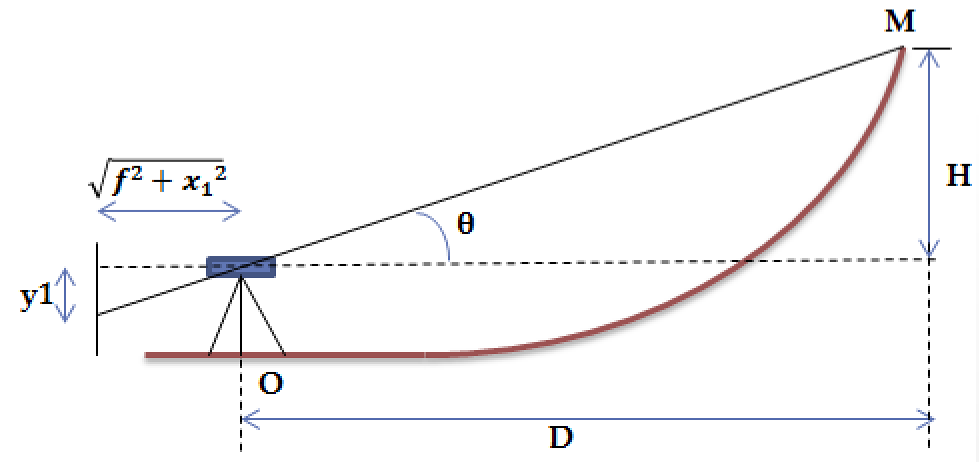
To Determine The Level of point M

- Measured y_1 which gives the height of **m** above the horizontal hair.
- Rise of the ray from **m** to the center of the object glass is equal to the y_1 in a horizontal distance $\sqrt{f^2 + x_1^2}$
- Measure the distance **CM** to the scale on the plan
- The height **H** of **M** above the horizontal plane of collimation at **C** is given by

$$H = CM \; x \; \frac{y_1}{\sqrt{f^2 + x_1^2}}$$

- Knowing the reduce level of the horizontal plane of collimation, the reduced level of **M** may be obtained by the relation.

R.L of the M = R.L of horizontal plane of the collimation + H



Photographic Surveying

B) Analytical method

Assignment

Field Work

The field work of terrestrial photogrammetry consist of:

1) Reconnaissance
2) Triangulation
3) Camera work

Assignment

Photographic Surveying

Aerial Photogrammetry Or Air Surveying

- Aerial photogrammetry involve the use of photograph taken in a systematic manner from the air .
- They are then controlled by land survey & measure by photographic techniques.
- Since the 1st world user the terrestrial photographic surveying has been replaced by the aerial photographic surveying due to the development of the aero-plane.

Advantages

- The survey work can be carried out with great speed.
- It can be used with great success for other purposes i.e. classification of land or soil, geological or archeological investigations etc.
- Aerial survey is highly technical & specialized work & must be carried out stilled specially trained & experience persons.
- It is mainly made by government organization e.g. Survey Of Pakistan Department

Photographic Surveying

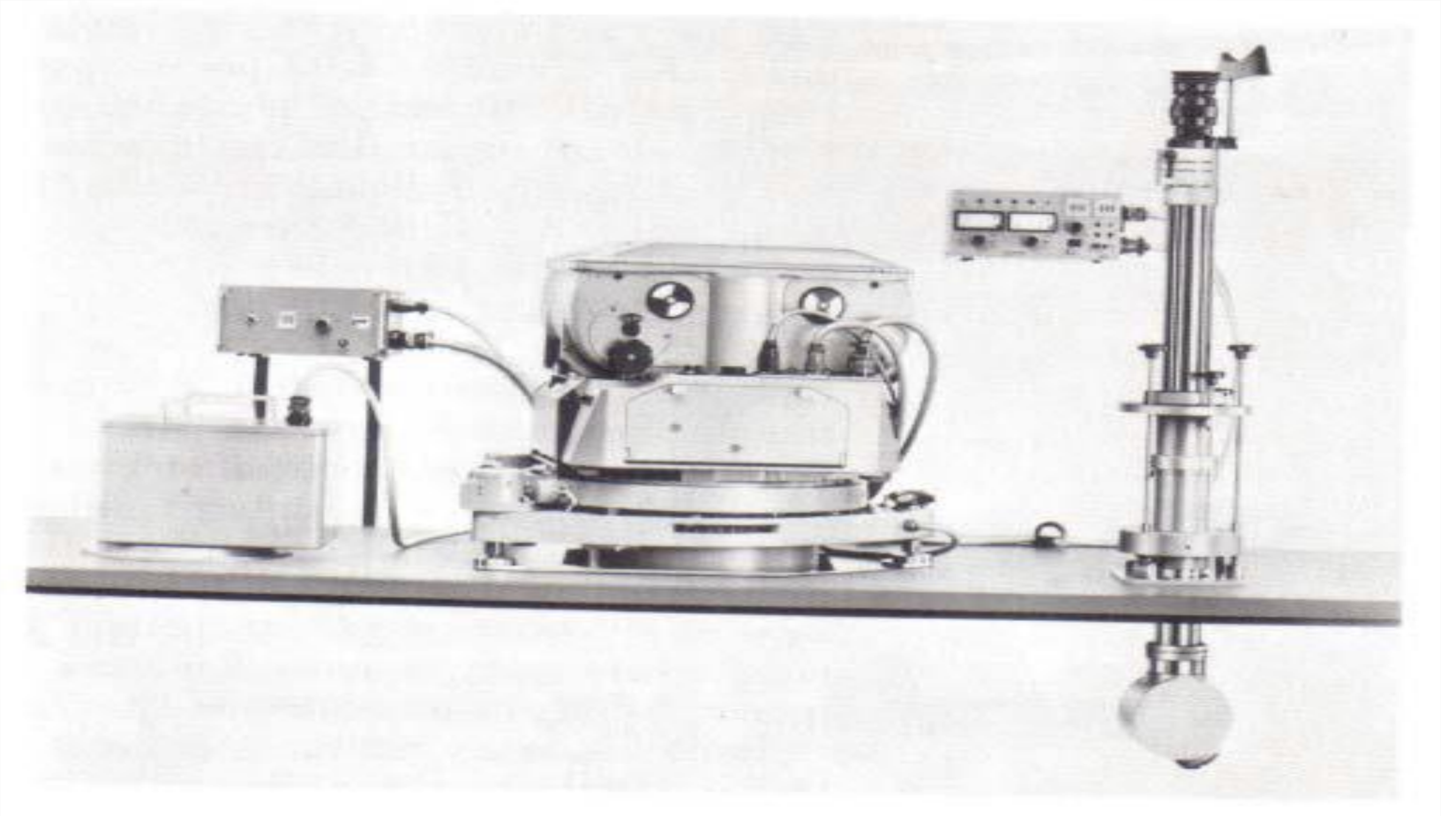
Aerial survey consists of 4 parts

- Flying
- Photography
- Ground control
- Compilation or mapping

Equipment required are:

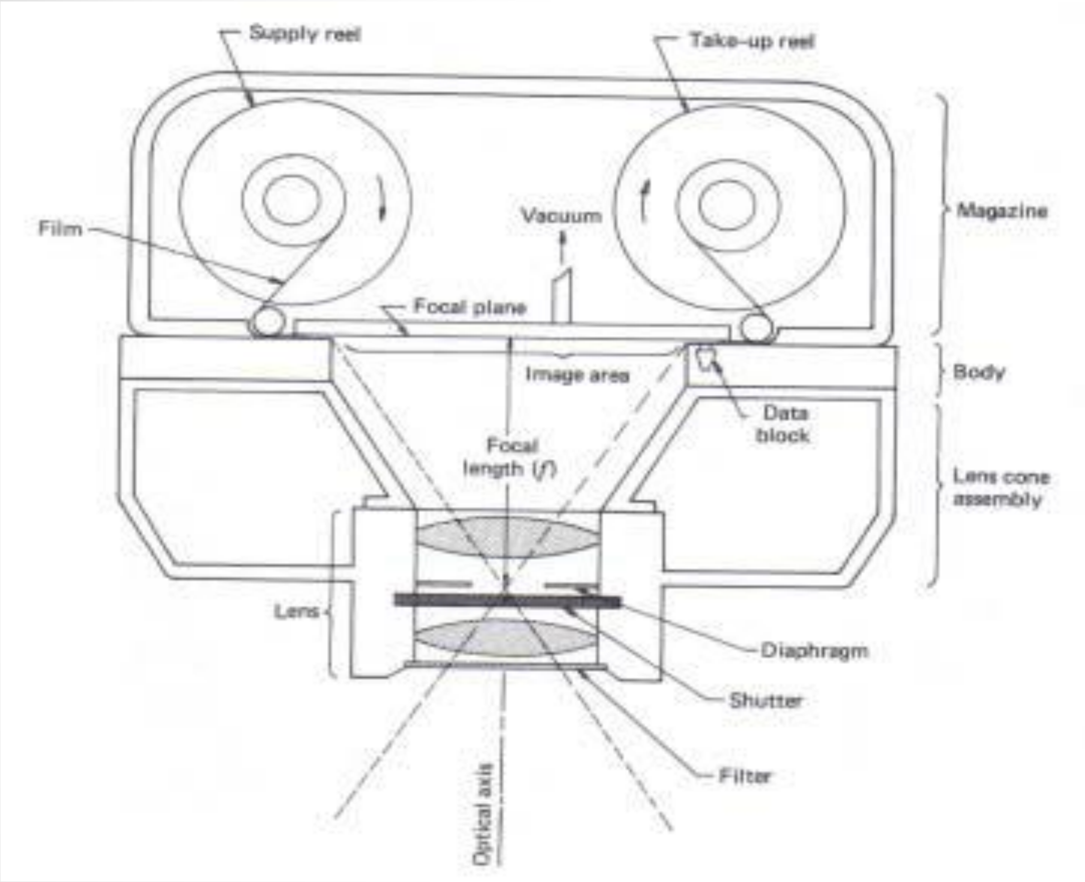
- An aero-plane
- An aerial camera
- Accessories required for interpolation & plotting

Aerial Survey Camera



An aerial mapping camera with
automatic levelling and exposure control.

Aerial Survey Camera



The principal components of a single lens mapping camera.

Aerial Survey Camera

Principle components of an aerial survey camera are

Lens: It is the most important part of the camera.

Shutter: It controls the time of exposure. The shutter of modern aerial camera capable of speed ranging from 1/50 to 1/2000 sec

the range is commonly between 1/100 to 1/ 1000 sec

Diaphragm: To regulate the size of lens opening or it controls the physical opening of the lens & therefore the amount of the light passing through the lens.

Filter : To reduce the effect of haze & distribute the light uniformly over the formats & also protects the lens from flying particles in the atmosphere

Camera cone: To support the lens. – shutter diaphragm assembly w.r.t the focal plane.

Focal plane: Surface on which the film lies when exposed.

Feducial marks:(not shown in the fig) They are 4 or 8 in number to define the photographic principal point.

Camera body: To house the dry mechanism that trips the shutter, flatten, the film & advances it between exposure.

Magazine: it holds the supply of exposed & unexposed film.

Photographic Surveying

Aerial Survey Camera

- An aerial camera shutter can be operated manually by an operator or by an **intervalomater** which automatically traps the shutter at the specified time.
- A level bubble attached to the camera helps to keep the optical axis of the camera lens nearly vertical in spite of any slight tilt of aircraft.
- The value of the focal length is determine accurately through the calibration for each camera.

Aerial cameras may be

- Single lens camera
- Multiple lens camera

Photographic Surveying

Air photographs

There are 2 ways of taking aerial photographs

A) Vertical

B) Oblique

Vertical are taken with the axis of the camera pointing vertically downwards.

- These photographs are produced most accurately maps as the variation in the scale over the area is small & no areas remain hidden.
- However the details in the photographs cant be easily identified as the view offered is unfamiliar to the eyes.

Oblique are produced by giving the camera axis a tilt upto 30° to the forward direction.

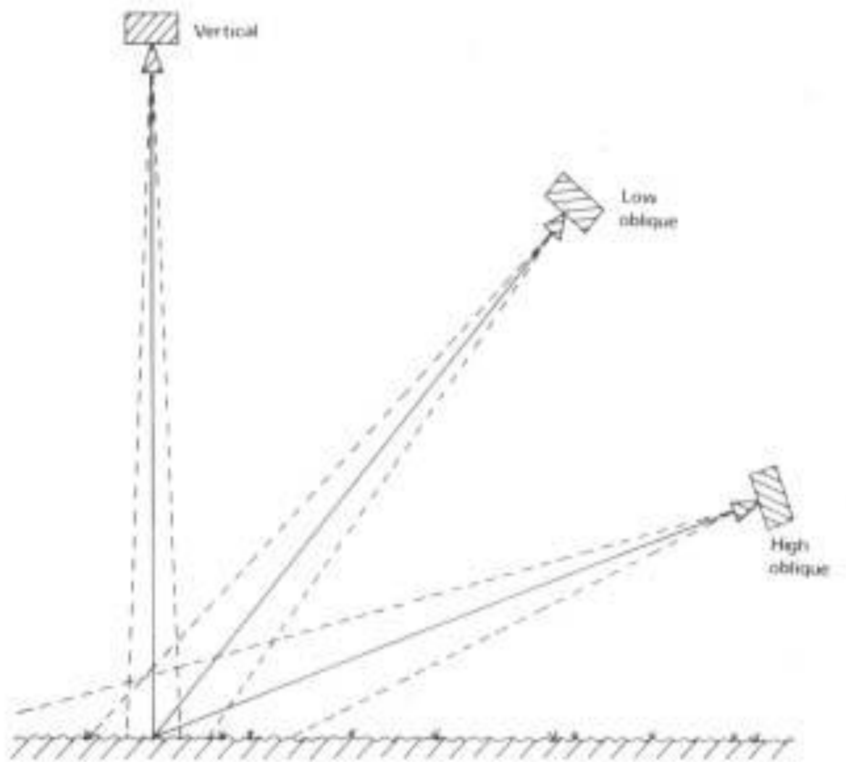
Oblique are further classified as:

High Oblique: when the imagine of the horizon is included on the picture

Low oblique: when the horizon is not seen & the camera is tilted in excess of 3°

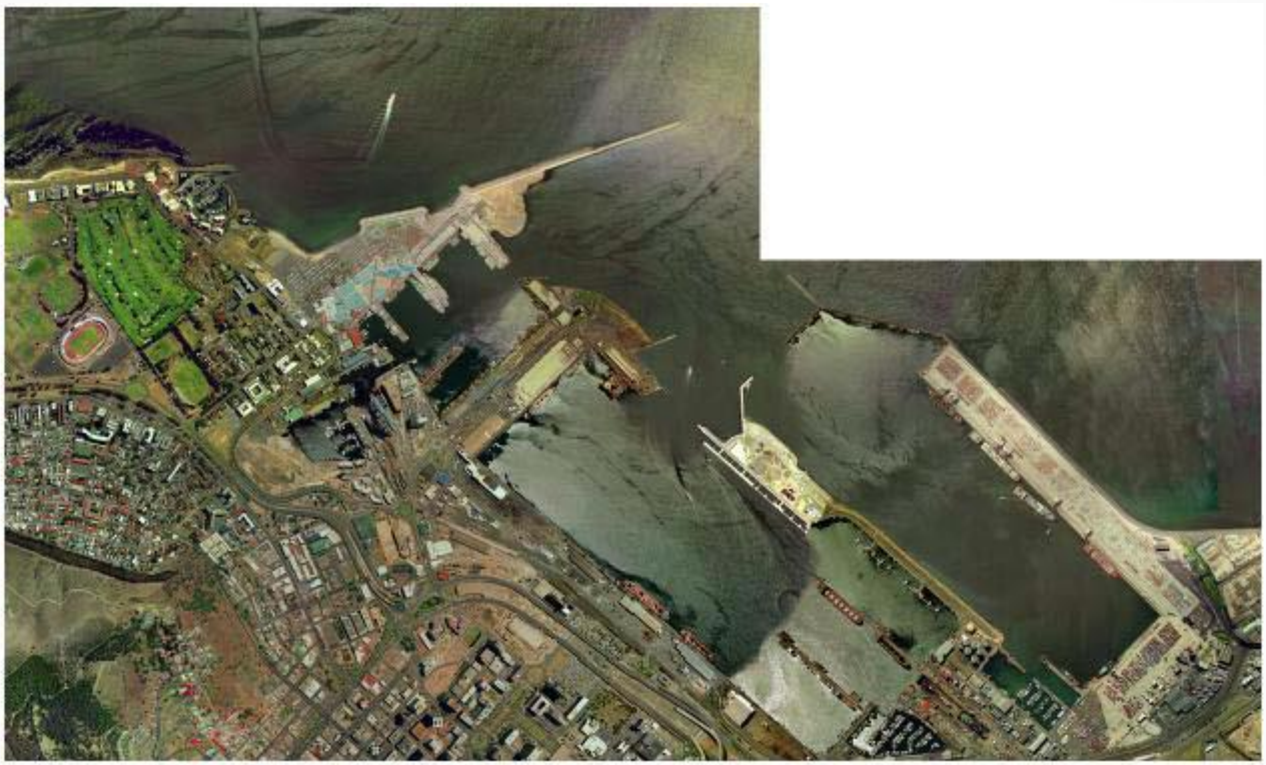
Photographic Surveying

Air photographs



Photographic Surveying

Air photographs



Photographic Surveying

Air photographs

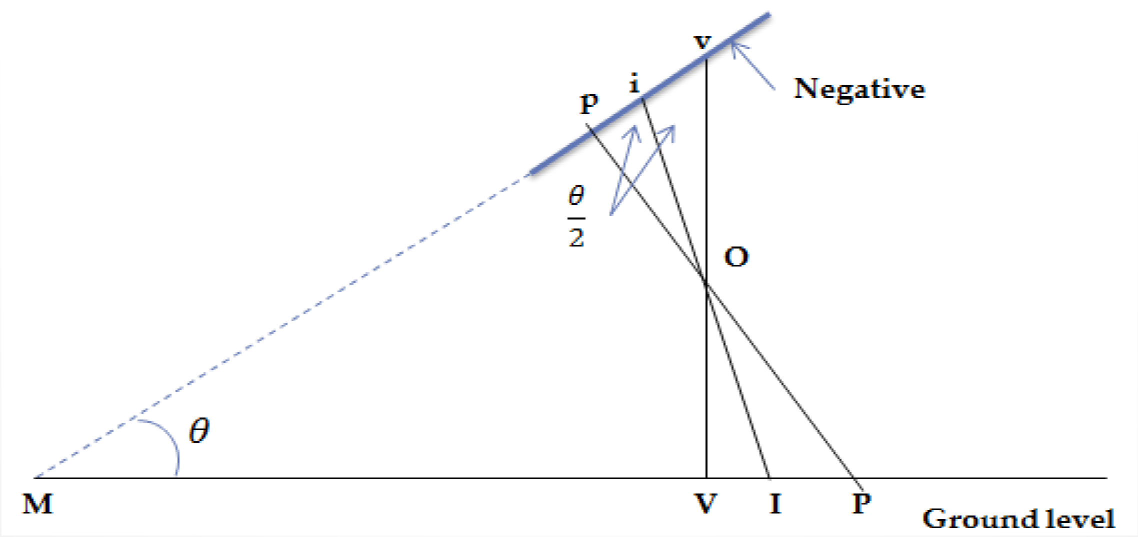
Oblique

- They provide information of the enemy territory without crossing the border .
- Features can easily recognized as these provide the views familiar to the eye sights.
- However some details remain hidden behind the tall structures i.e. building, hills etc.
- The scale variation large & therefore preparation of maps becomes more laborious & expensive.
- Vertical photographs are principal mode of photogrammetric work .
- Oblique are seldom used for mapping or measurement application. But are advantageous in interpretive work & for reconnaissance.

Terminology :

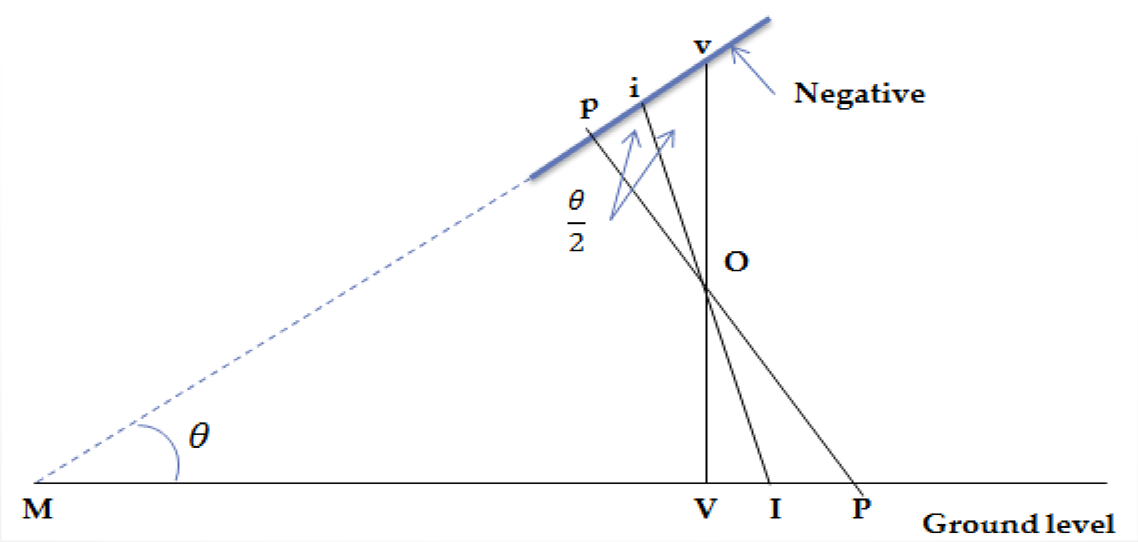
The terminology used in air photograph geometry is explained with reference to the fig

- **Perspective Centre** : Rays from point on the ground pass through **O** called as perspective centre
- **Plumb Point :** The vertical through the optical centre of the camera lens intersect the ground & picture planes at **V** & **v** respectively termed as the ground by photographs plumb point
- **Principal Point: T**he perpendicular to the picture plane through the optical centre of the lens meets the ground & picture plane at **P** & **p** respectively termed as the ground & photographs principal points. The principal point **p** in the photograph is located by the intersection of the lines joining the feducial marks



Terminology :

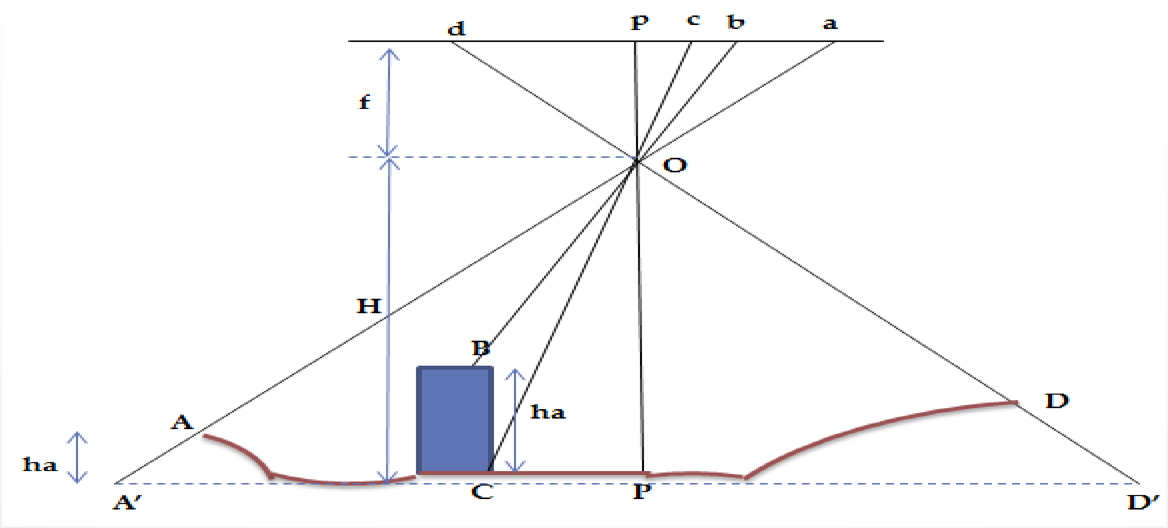
- **Isocenters:** The bisector of the angle between the lines joining the plumb point & principal point intersect the ground & picture planes at point **I** & **i** respectively called as isocentres.
- Points (**I, i, V, v**) are called homologous points.
- **Principal planes:** The principal line through **p** &**v** when produced meet the ground plane at **M**
- The vertical plane through the points intersects the ground along the ground principle line through P & V . The isocentre **I** & **i** lie also on this vertical plane or the vertical plane containing **O**, **V** , **v P**, **p** is termed principal plane its intersection with the negative plane giving principal line



Scale & distortion of a vertical photograph

Scale Of The Vertical Photographs

- The scale of the photographs is the ratio between distance measured on the photograph & the ground distance between same two points.
- In map → photographic projection → so the scale is uniform
- In case of vertical photograph → perspective view so the scale varies from point to point with variation in elevation.
- The Scale of the photograph is expressed as representative fraction .
- knowing the height of plane above the datum & the focal length of the camera, the scale of the photograph can be determine as.
- If the ground were in level as shown in fig by the dotted line through p, the scale of the photograph would be

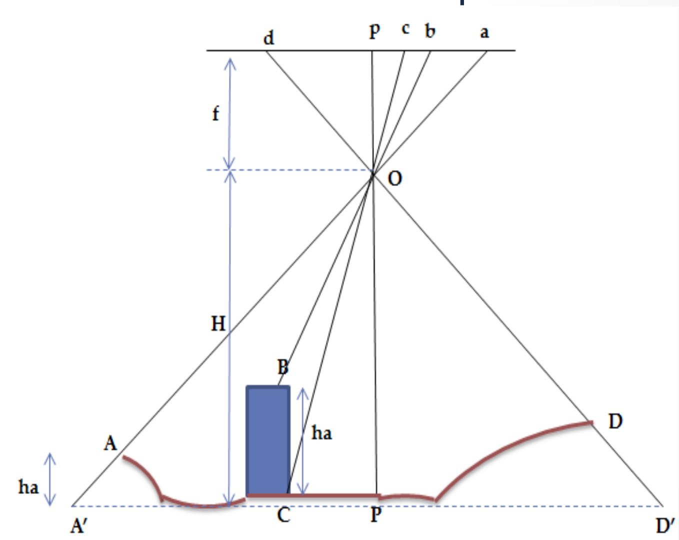


Scale & distortion of a vertical photograph

Scale Of The Vertical Photographs

- Triangles oda and OD’A’ are similar and $\frac{da}{D`A`} = \frac{f}{H}$
- by drawing Horizontal planes through A and B ad by similar consideration , the scales at points a and b would be $\frac{f}{H - h_a}$ and $\frac{f}{H - hb}$ respectively.
- The scale for the line ab assuming elevation of AB equal to

$$\frac{h_a + hb}{2} = \frac{f}{H - \frac{h_a + hb}{2}}$$



Average photoscale = $\frac{f}{H - h_{ave}}$

where $h_{ave} = \frac{h_1 + h_2 + h_3 + \ldots + hn}{n}$

- As the scale of the photographs depends on the height H, which will change the scale. It is therefore essential that the plane flies at a constant elevation
- Flying altitude of the plane is given by an instrument called altimeter.

Scale & distortion of a vertical photograph

Distortion due to relief or Height

In fig, BC side of the building appears as cb in the photo print, though B is exactly above C and in plan the two would coincide.

bc is called distortion due to height BC of building.

Triangle vbo and EBO are similar

$$\frac{vb}{f} = \frac{EB}{H - hb}$$

Similarly Δs vco and VCO

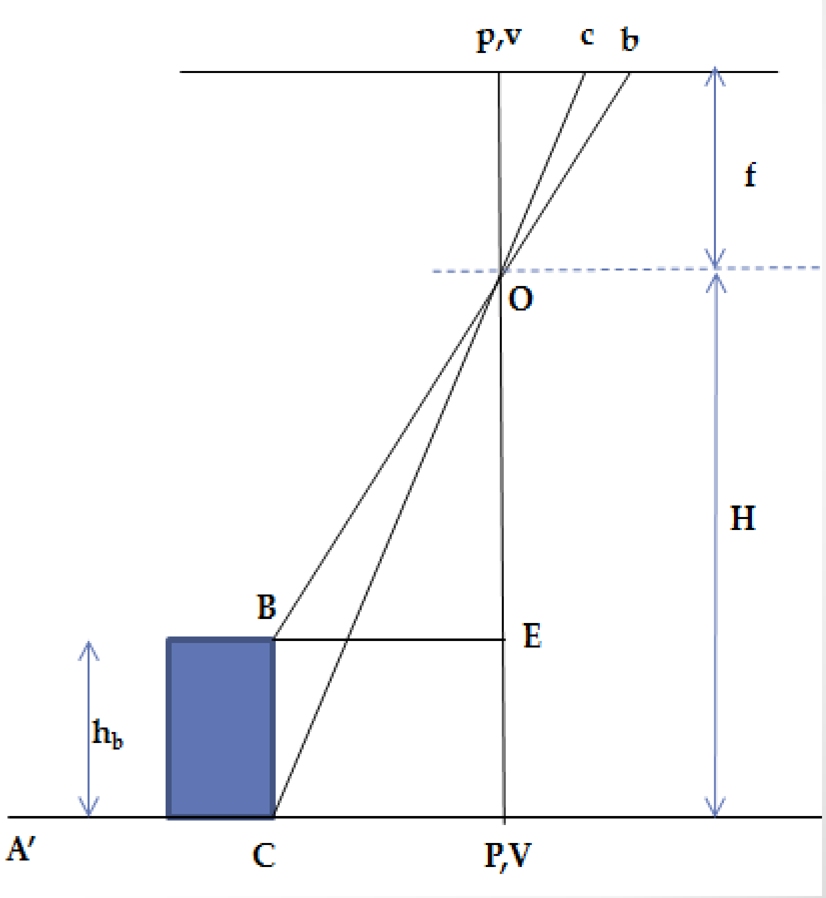
$$\frac{vc}{f} = \frac{EB}{H}$$

$$\frac{vb}{f} \Big/ \frac{vc}{f} = \frac{EB}{H - hb} \Big/ \frac{EB}{H}$$

$$\frac{vb}{vc} = \frac{H}{H - hb} = \frac{vb}{vb - bc}$$

$$\frac{vb}{bc} = \frac{H}{h_b}$$

Distortion due to height, **bc =** $\frac{h_b}{H}$ **x vb**



Photographic Surveying

Example 01:

Calculate the aero plane flying height to obtain the average scale of photograph equal to 1/7200. Ground surface elevations vary from 160 to 430 m. focal length of camera lens is 153 mm.

Solution:

f = 153 mm = 0.153 m

$$h_{av} = \frac{160 + 430}{2} = 295\ m$$

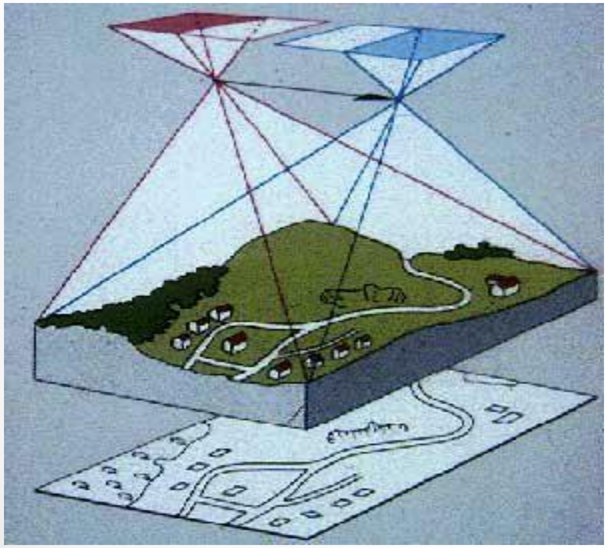
photo scale = $\frac{f}{H - have}$

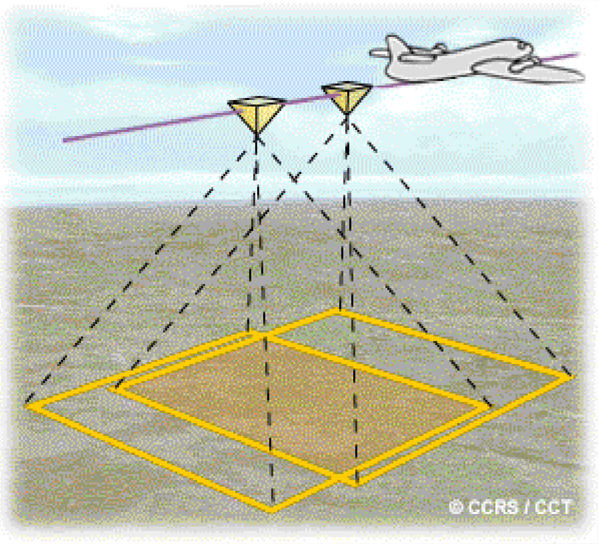
$$\frac{1}{7200} = \frac{0.153}{H - \boldsymbol{h}_{ave}} = \frac{0.153}{H - 295}$$

H = 1397 m

Stereo Scopy

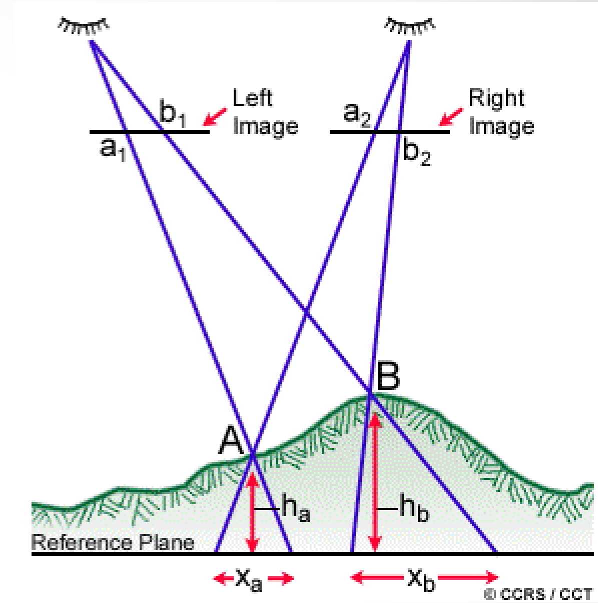
- **Monocular venison:** is seeing with one eye
- **Binocular vision:** is seeing the same object with both eyes at the same time.
- **Stereoscopic viewing:** is observing an object in three dimension , a process requiring a person to have normal binuclear (two eyed) vision.
- A person with vision with only one eye cant see stereoscopy.
- Adjacent but overlapping aerial photos are called stereo-pairs and are needed to determine parallax and stereo/3D viewing

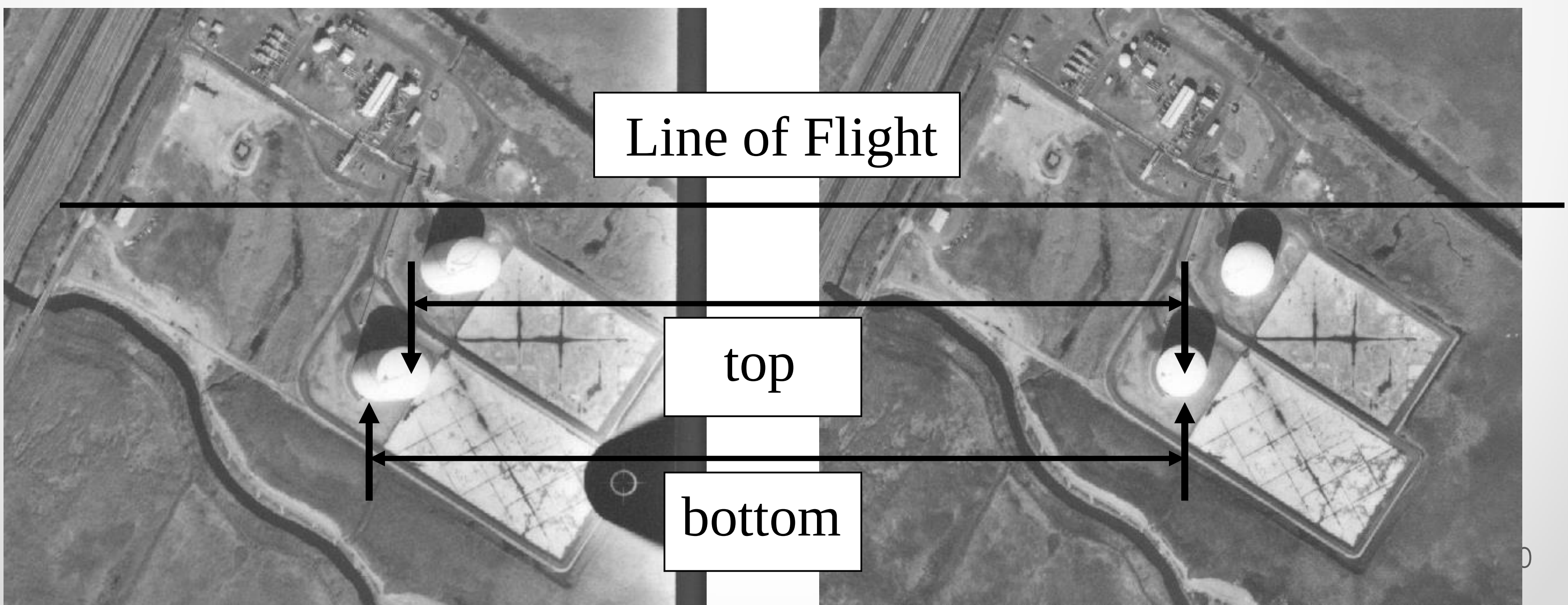




Stereoscopic Parallax

- The displacement of an object caused by a change in the point of observation is called parallax.
- Stereoscopic parallax is caused by taking photographs of the same object but from different points of observation.





Flight Planning

- In order to produce stereo pairs every part of the ground to be surveyed must be photographed at least twice.
- To achieve this aero plane files in strips and takes photographs with 60 % fore and aft overlap to secure the 50 % minimum need for stereoscopic viewing.
- Each strip overlaps the adjacent strip by at least 30 % to make sure that no part of the ground is left unrecorded.

Flying height depends upon the following factors

a) The scale of the map or plan

b) The contour interval in the map

c) The type of country flat or mountainous

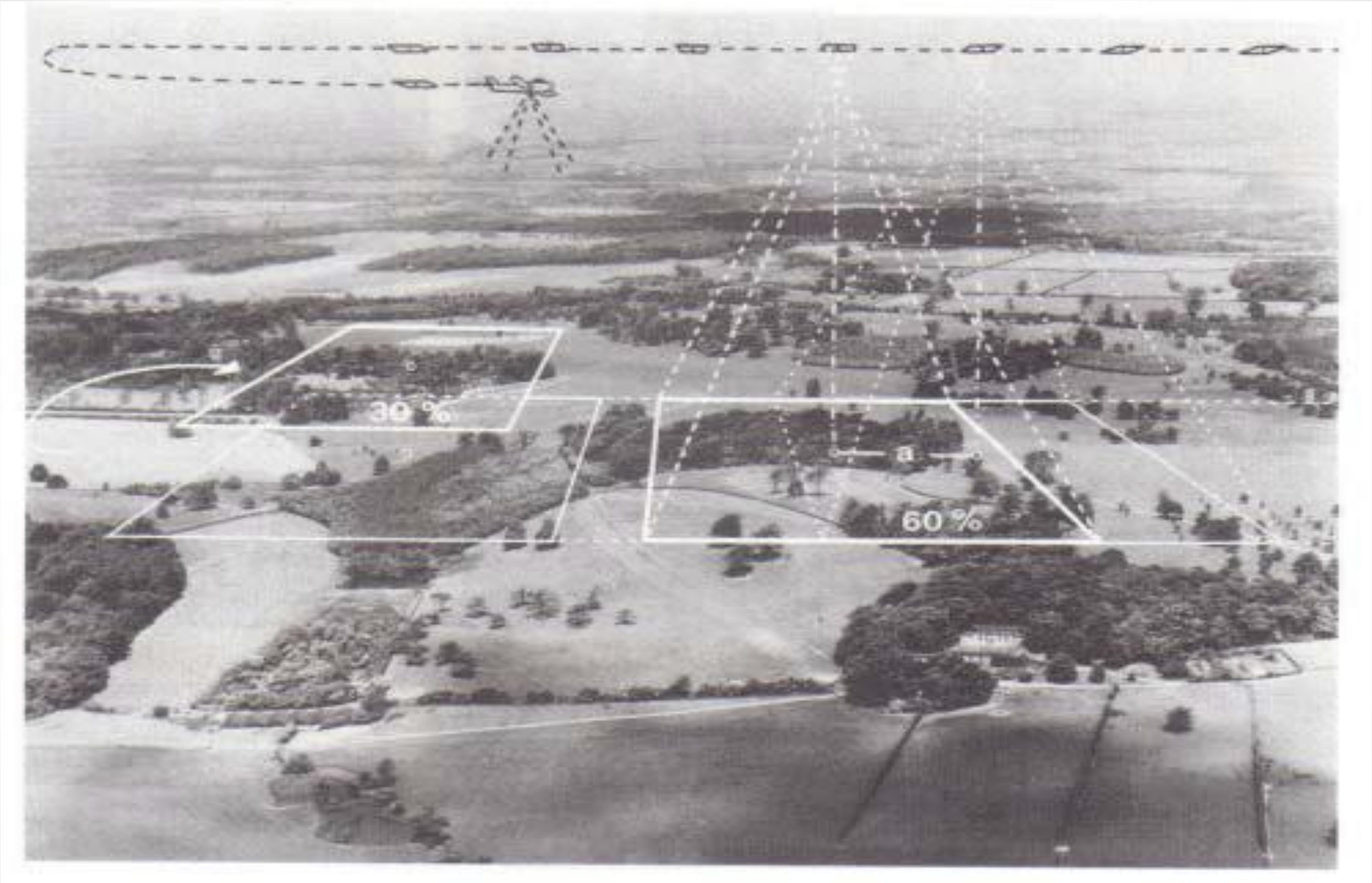
d) The characterless of the camera i.e type of plotting equipment

e) The type of aero plane available

- When sophisticated plotting machines are used, it is economical to increase the flying height 6000 m and thus increase ground coverage per photograph.
- Lower flying heights are necessary for close contouring over flat terrain.

Photographic Surveying

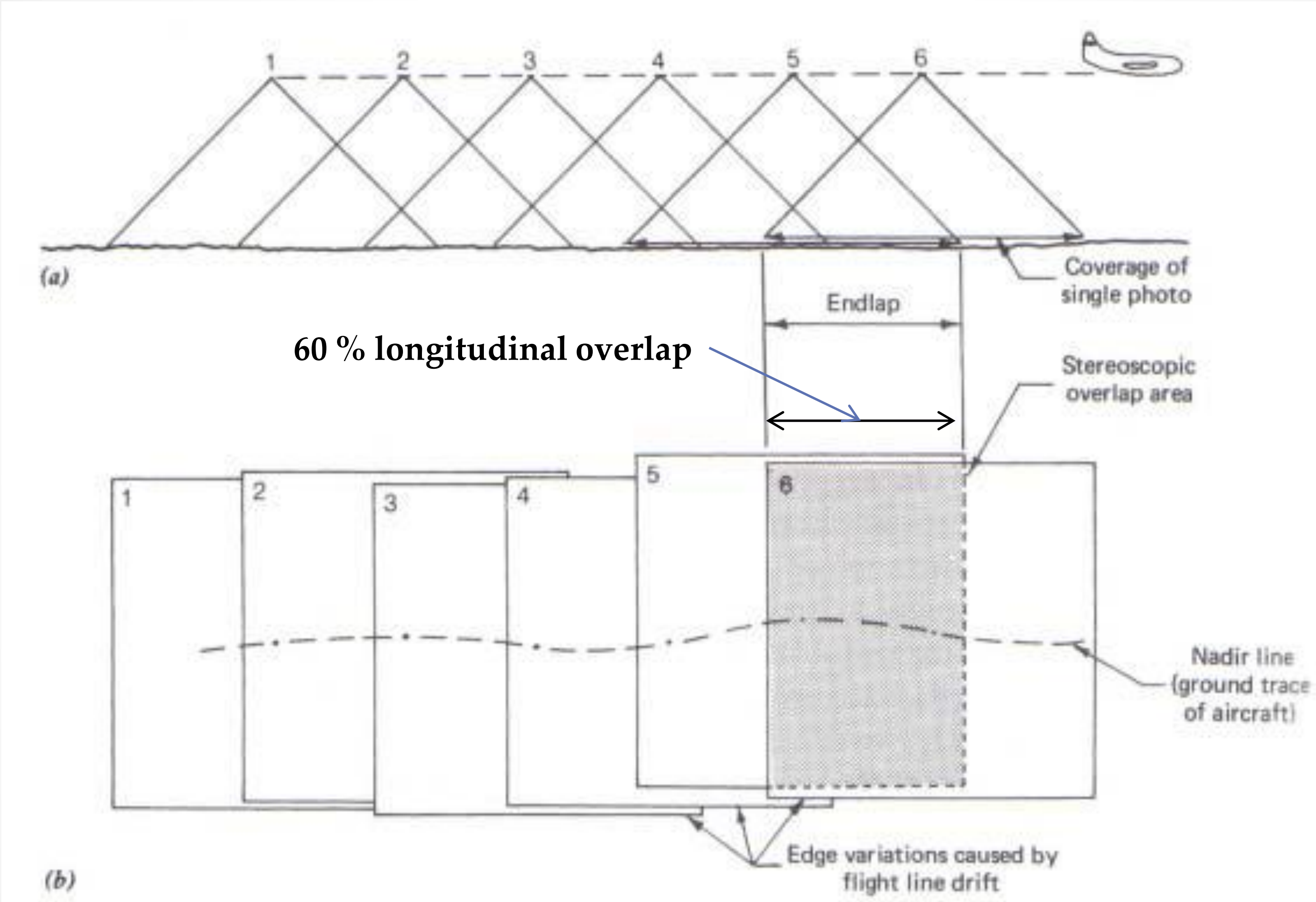
Flight Planning



Taking Vertical AP: Flying Pattern

Photographic Surveying

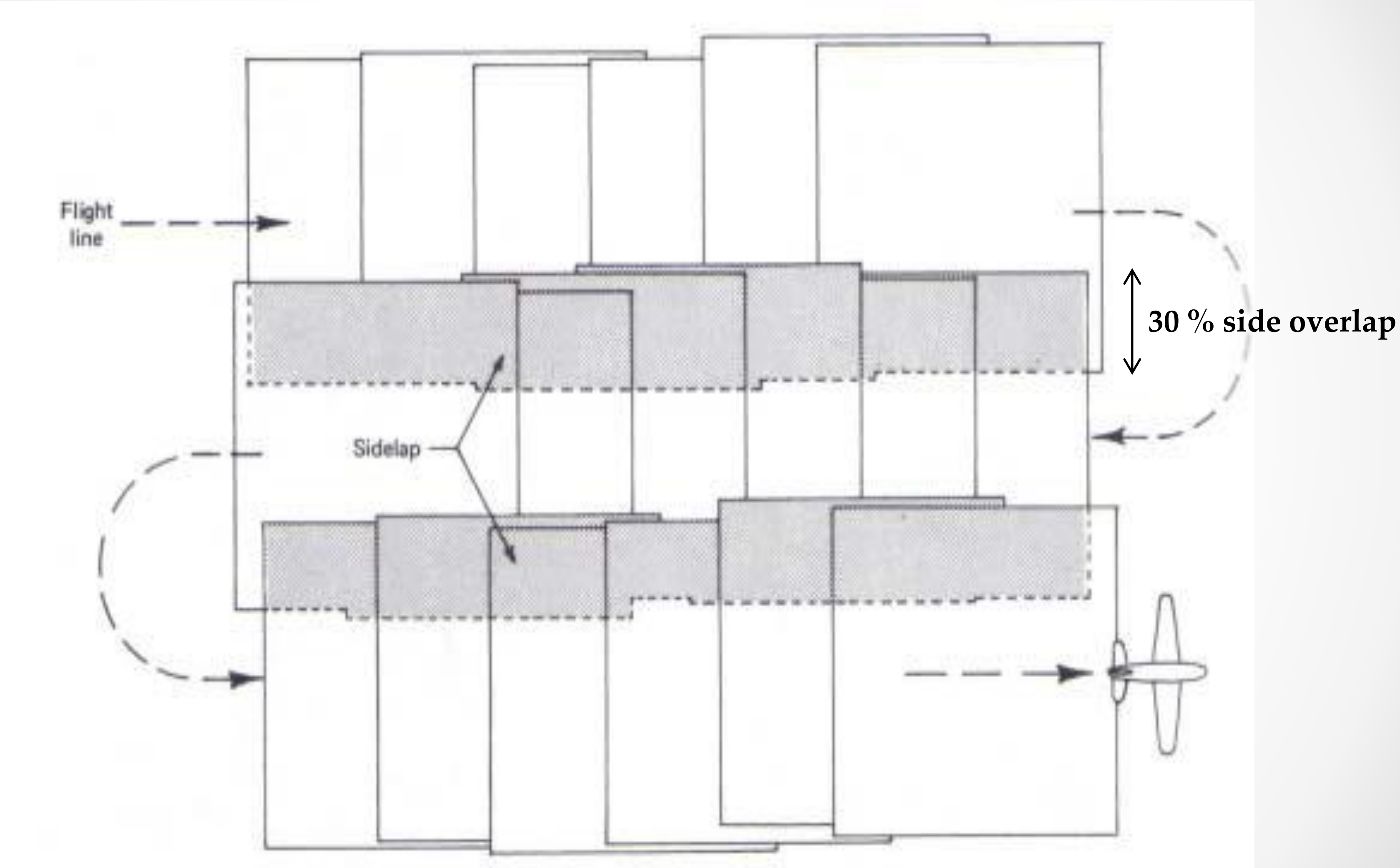
Flight Planning



Photographic Coverage
Along A Flight Strip

Photographic Surveying

Flight Planning



Flying Pattern

Photographs Required

- The total number of photographs required to cover the area to be surveyed may be determined as follows

L_p = Length of photograph in cm in direction of flight

W_p = Width of photograph in cm in direction of flight

O_l = Percentage of longitudinal overlap

O_w = Percentage of side overlap

L_g= Net ground distance corresponding to L_p in m or km

W_g= Net ground distance corresponding to W_p in m or km

S= Scale of photograph (1 cm =S m or 1 cm = S km)

N = Number of photograph required

A_p = Net area of each photograph in m^2 or km^2

A_g = Net area of tract to be photographed in m^2 or km^2

Net ground distance corresponding to L_p, $L_g = S\,L_p\,(1 - O_l)$ and

Net ground distance corresponding to W_p, $W_g = S\,W_p\,(1 - O_w)$

Net area of each photograph = $A_g = L_g \times W_g$

Number of photograph required = $\frac{A_g}{A_p}$

Photographs Required

- The total number of photographs required to cover the area to be surveyed may be determined as follows

Theoretical spacing of flight strips = net width of single photograph = W_g

Theoretical number of strips = $\frac{widht\ of\ area}{W_g}$ = K

Actual number of strips = K + 1 , one strip added to cover the sides

Theoretical number of photograph per strip = $\frac{lenght\ of\ area}{L_g}$ = M

Actual number of photograph per strip = M +1

Thus in practice there would be K+1 and M + 1 photographs in each

Actual number of photographs for complete coverage of the area= (K+1) x (M+1)

Example 2:

The scale of the photograph is 1cm = 100m. The photograph size is 23 cm x 23 cm determine the number of photograph required to cover an area of 150 km², if the longitudinal over lap is 60% and side overlap is 30%.

Solution:

L_p = 23 cm, W_p = 23 cm

O_l = 0.6 m, O_w = 0.3

S = 100

L_g = ground length covered = $S\,L_p(1 - O_l) = 100 \times 23\,(1 - 0.6)$

L_g = 920 m = 0.92 km

W_g = ground width covered = $S\,W_p(1 - O_w) = 100 \times 23\,(1 - 0.3)$

W_g = 1610 m = 1.61 km

A_g = Net ground area = $L_g \times W_g = 0.92 \times 1.61 = 1.48\ km^2$

N = Number of photograph required = $\frac{150}{1.48} = 101$

Example 3:

The scale of the photograph is 10cm = 100m. The photograph size is 23 cm x 23 cm determine the number of photograph required to cover an area of 15km x 10 km, if the longitudinal over lap is 60% and side overlap is 30%.

Solution:

Number of photograph per strip $= \frac{length\ of\ area}{Lg} + 1$

$= \frac{15\ x\ 1000}{100\ x\ 23\ (1 - 0.6)} + 1 = 16.3 + 1 = 18$

Number of strip $= \frac{width\ of\ area}{Wg} + 1$

$= \frac{10\ x\ 1000}{100\ x\ 23\ (1 - 0.3)} + 1 = 6.2 + 1 = 8$

Number of photograph required = 18 x 8 = 144

Spacing of the flight lines = $\frac{widht}{no\ of\ strips} = \frac{10}{8} = 1{,}25\ km$

Photographic Surveying

Assignment

1) Analytical method

2) Field Work

The field work of terrestrial photogrammetry

1) Reconnaissance

2) Triangulation

3) Camera work

3) Example 11, 12 , page 605