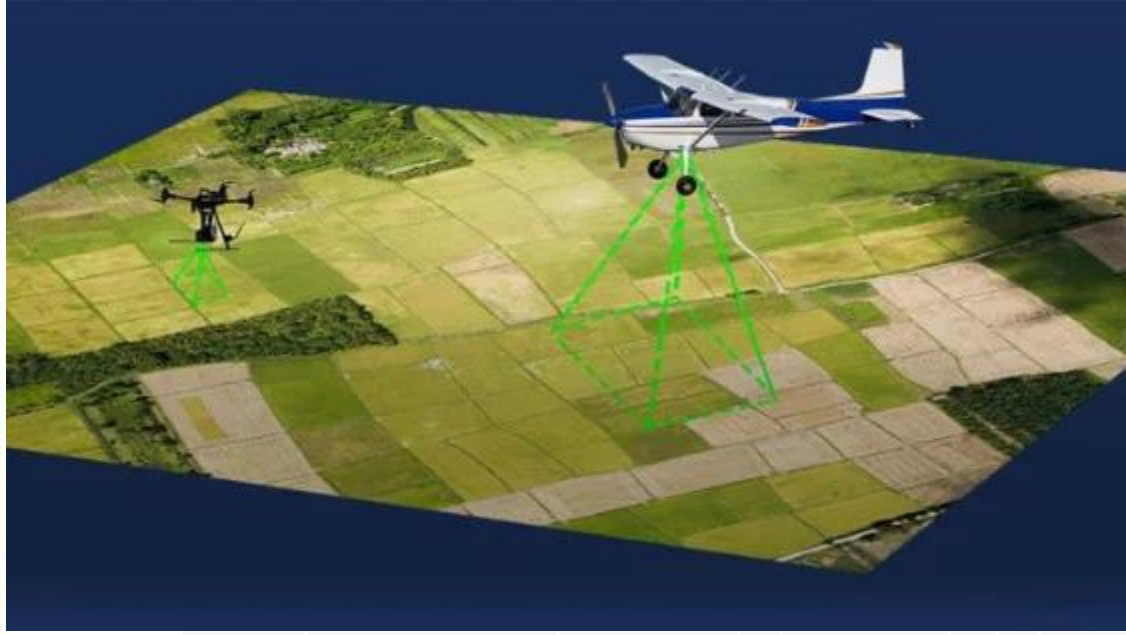
EWCE-103

SURVEYING

PHOTOGRAMMETRIC SURVEYING

Photogrammetric Surveying





Photogrammetry

Photography

Photographs

Picture

Imagery

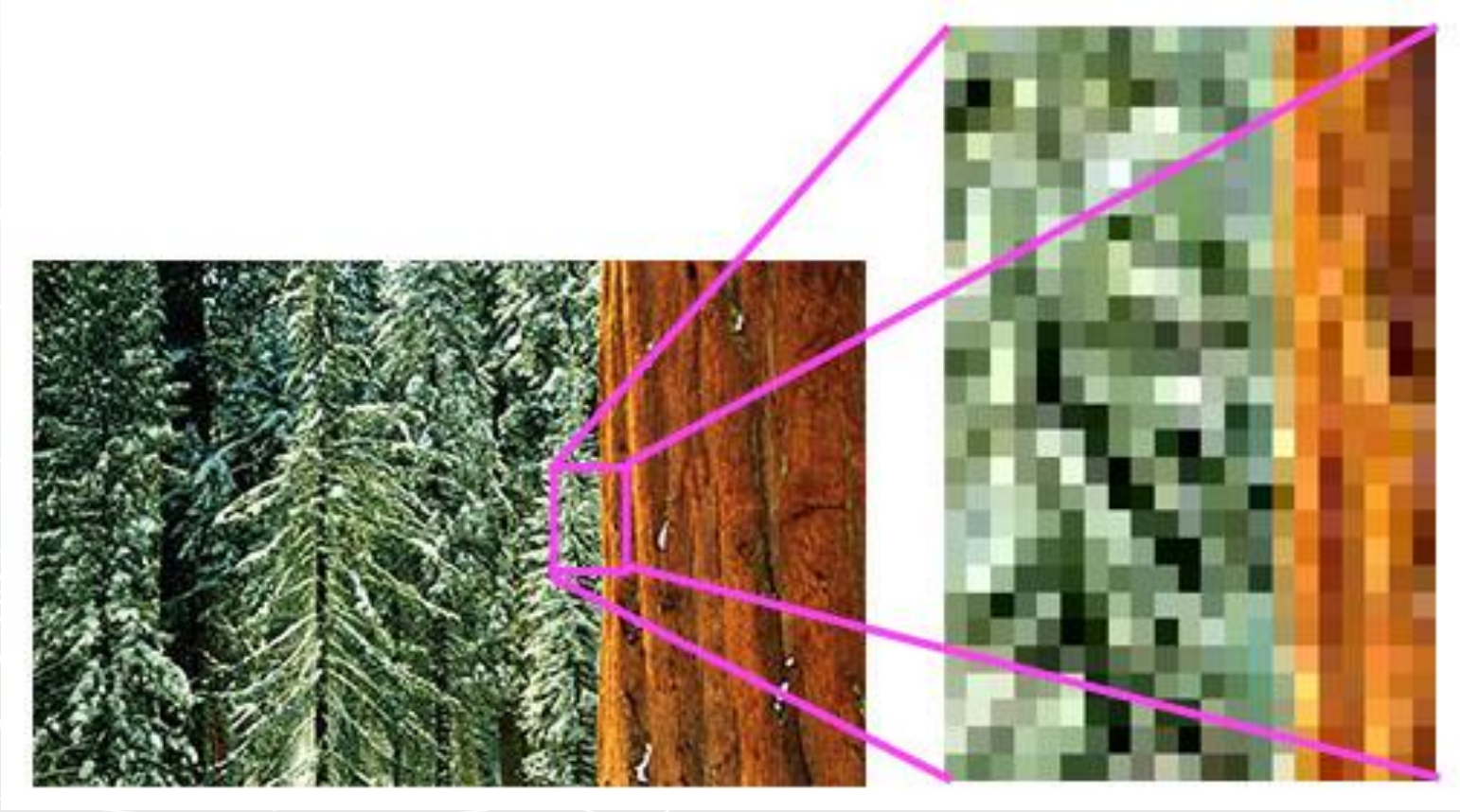
Digital Photo Imagery

What are pixels?

- Word “pixel” means a **picture element**.
- Every photograph is made up of pixels.
- **Smallest unit of information** that makes up a picture.
- Usually square, they are typically **arranged** in a **2-dimensional grid**.

In the image below:

- One portion has been magnified many times over so that you can see its **individual composition in pixels**.
- As you can see, the pixels approximate the actual image.
- **More pixels** you have, the **more closely the image resembles the original**.



Resolution:

- **Number of pixels in an image.**
- Conventional way to express resolution as the **width by the height**, for example a monitor **resolution of 1280 × 1024**.
- Means there are **1280 pixels from one side to the other**, and **1024 from top to bottom**.

Resolution (cont.)

- **Another conventional way** to **express resolution** is as a single number, like a **5 megapixel camera** (a megapixel is a million pixels).

- Pixels along the width multiplied by the pixels along the height of the image taken by the camera equals 5 million pixels.

- In the case of **1280×1024 monitors**, it could also be expressed as **1280 x 1024 = 1,310,720, or 1.31 megapixels.**

So, How Many Pixels Do I Need?

- **Image resolution** describes the amount of detail that an image contains.
- Term can be applied **to digital images**, **film images**, and **prints**.
- Bottom line is that **higher resolution means more image detail.**
- **Camera manufacturers** are always trying to sell you on the number of megapixels.

- For **excellent quality pr**ints, you'd ideally like a **minimum of 240 pixels per inch in each dimension.**
-
- Means for a **4"x6" print**, you need 240×4 pixels in the width, and 240 x 6 pixels in the height. That's **960px wide x 1440px high.**
- Multiplied together, that's 1,382,400 pixels, or approximately **1.4 megapixels**.
- By the same token, to make decent 8"x10" print, you'd need a **4.6 megapixel** camera.

- Probably around **4 to 5 megapixels, more** megapixels will not necessarily yield a better image.

- **Lack of** overall image sharpness due to **poor image** or **lens quality**, or **poor lighting**, will **limit the usefulness** of more megapixels.

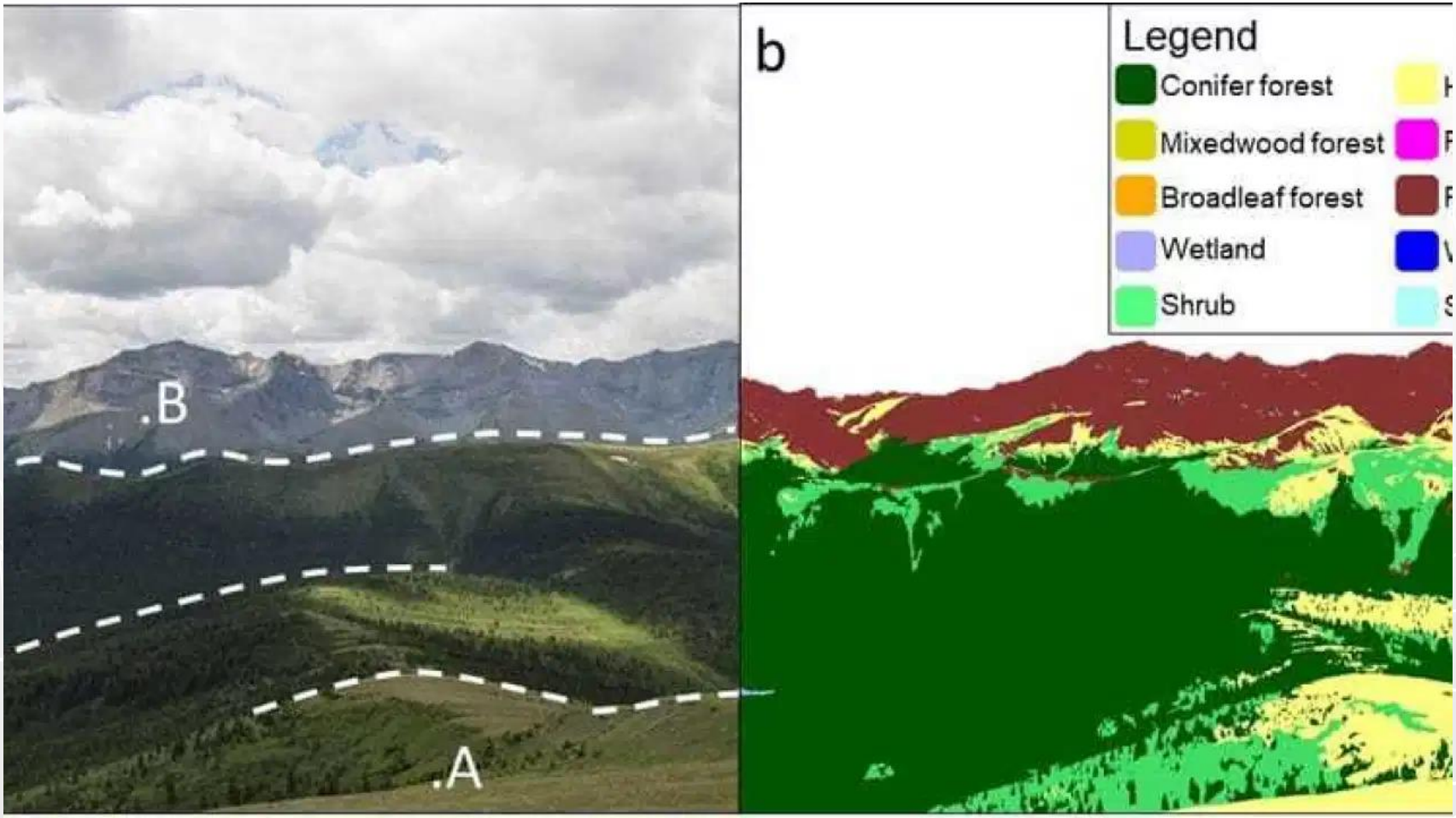
Photogrammetric Surveying

Definition: Branch of surveying in which **maps are prepared from the photographs** taken form the ground stations and from the air vehicle.

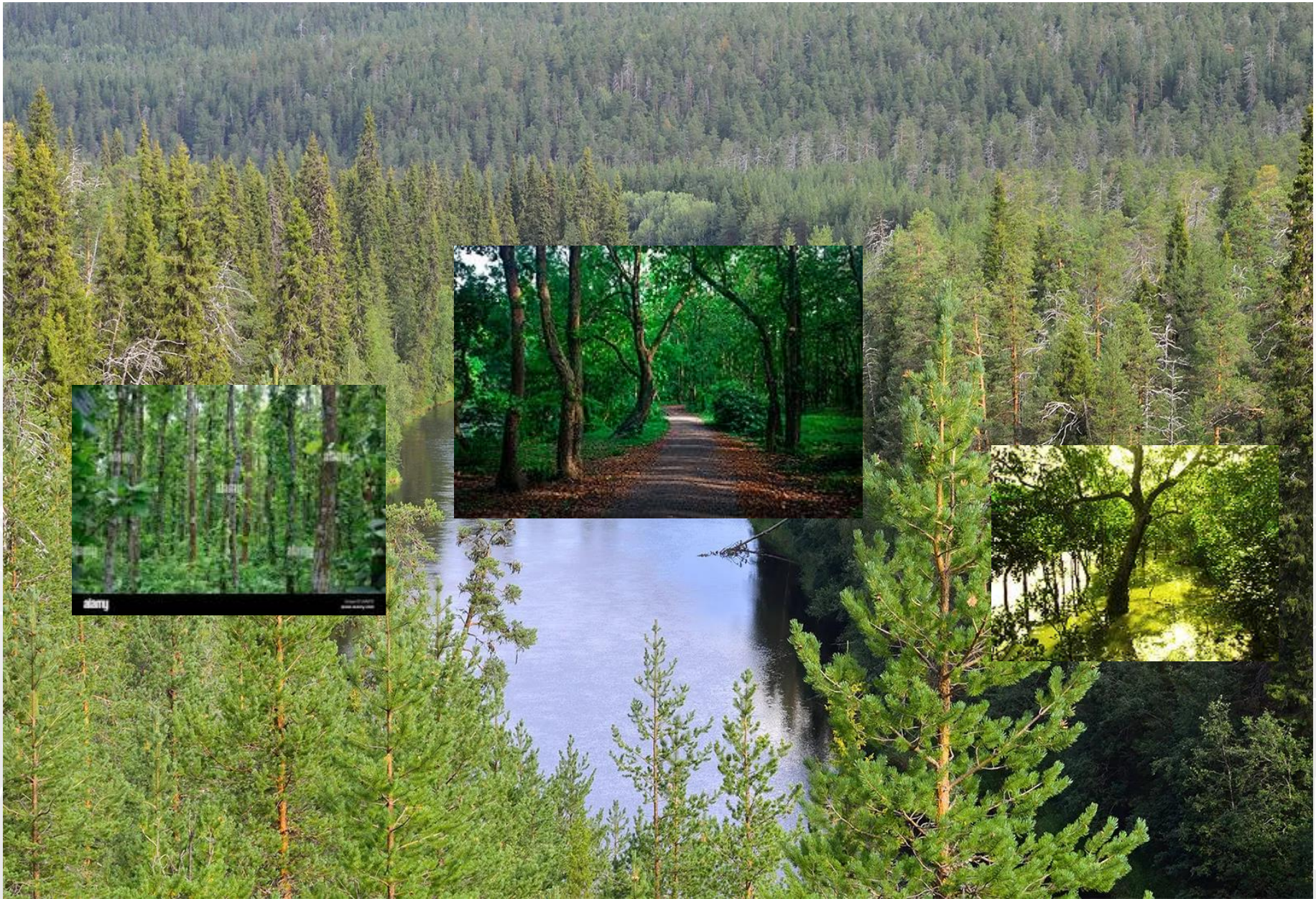
What is Photogrammetry?

Defined as **the science of making reliable measurements** using photographs or digital photo imagery **to locate features** on or above the surface of the earth.

Photograph to map



Conifer Forest











Photogrammetric Surveying

Applications of Photogrammetry:

- **Tracking of the relative positioning alternations** in all earth environments (tectonic motions etc).

- **Guide and match the results of computational models** of natural system.

- **Helping to invalidate or confirm new theories or methods** for predicting or/controlling the consequences of **EQ**, **tsunamis**, **any other weather conditions.**

Question: Describe the applications of photogrammetry in surveying.

Photogrammetric Surveying

Advantages & Disadvantages:

Advantages:

- Cover large areas.
- Fast
- Can reach inaccessible and restricted areas.
- Cost effective for large areas.
- Easy to interpret and understand.

Photogrammetric Surveying

Disadvantages:

- **Complex system**, **highly trained human resources** are needed.

- **Costly** at the time of initiation.

- **Heavy and sophisticated equipment** are needed.

- **Lengthy administrative** procedure.

- **Weather dependent**.

Principle of photogrammetric survey:

- **Simplest form** and similar to plane table survey.
- **Main points** of each photo is **used as fixed stations** and rays are drawn to get the point of intersections.
- **Suitable for topographic or engineering survey and projects demanding higher accuracy.**
- **Unsuitable** for **dense forest and flat lands** due to difficult in identifying points/objects.

Question: Write down the principle of photogrammetric survey.

Photogrammetric Surveying

Where to Use the photogrammetric survey:

- **Topographic** survey and **engineering** survey.
- Survey for **mountainous or hilly terrain** with little vegetations.
- For **geological mapping** which includes identification of rock type, landform etc.

Photogrammetric Surveying

Where to Use the Photogrammetry surveying (cont..):

- **Projects for higher accuracy**, since it provides accurate information.

- **Urban and regional planning.**

- In planning and designing of **transportation plan**, **bridges**, **pipeline**, **hydropower,** security & strategic planning, **disaster management**, city modeling etc.

Question: Write down the uses of photogrammetric Surveying.

Photogrammetric Surveying

Types of Photogrammetry:

Depending on the camera position

- **Terrestrial photogrammetry**
- **Aerial photogrammetry**

Terrestrial Photogrammetry:

- Photos taken with the **camera supported on the ground.**
- Photos taken with photo-theodolite.
- Maps are then prepared or compiled from the photograph.

Selection of Camera Station

Terrestrial Photogrammetry:

Maps are prepared from photographs taken from some fixed positions on or near the ground with camera axis horizontal









Dr. Ramesh Babu A.V, Professor, nec

•photographs are taken from elevated ground stations.
•Method is very similar that the camera is in stationary position.
•Camera used in this method is called photo-theodolite as it will require the same features as theodolite.
•It is much cheaper and can be carried out by individual surveying firms also.

Terrestrial Photogrammetry and Plane table survey- comparison.

Similarity:

• If the **directions of same objects photographed** from two extreme ends are known, positions can be **located by intersections** of two rays to same objects.

Differences:

- **More details are at once obtained** from the photographs.

- Subsequent plotting are done **in the office**.

(In plane table survey, **all works are done in the fields)**

Special Points:

- **Minimum numbers of photos** should cover the whole areas.

- **Select the best positions** of the camera stations.

Question: As a surveyor, how do you compare photogrammetric surveying with the plane table surveying?

Selection of Camera Station



Selection of Camera Stations

- **Through study of the area** from **existing maps** followed by a **ground reconnaissance**,
- **Position and number of stations** depends on **the extension and ruggedness of the area** to be surveyed.
- **Should be on higher points** of the area.
- Cameras to be **directed downwards** rather upwards.

Question: Write down the criteria for the selection of camera station in terrestrial photogrammetric survey.

Terrestrial photogrammetry is <u>used for</u>:

- **Small scale mapping** of open hilly or mountainous countries.
- **Reproduction of plan and elevation views** buildings or structures.
- **Motion pictures** photography.
- For **furnishing** **supplementary ground control** for aerial photography.

Divisions of **Terrestrial** Photogrammetry

- **Plane-table photogrammetry.**
- **Terrestrial stereo-photogrammetry.**

Plane-table photogrammetry.

- Taking photographs of the area to be mapped **from each of the two or three stations.**
- Photograph perpendiculars **may be oriented at any angle to the base**, usually from an acute angle.
- **Difficulty arises in the identifications of image points** in a pair of photographs specially in homogenous areas.

Question: Describe the different types of terrestrial photogrammetry.

Terrestrial stereo-photogrammetry

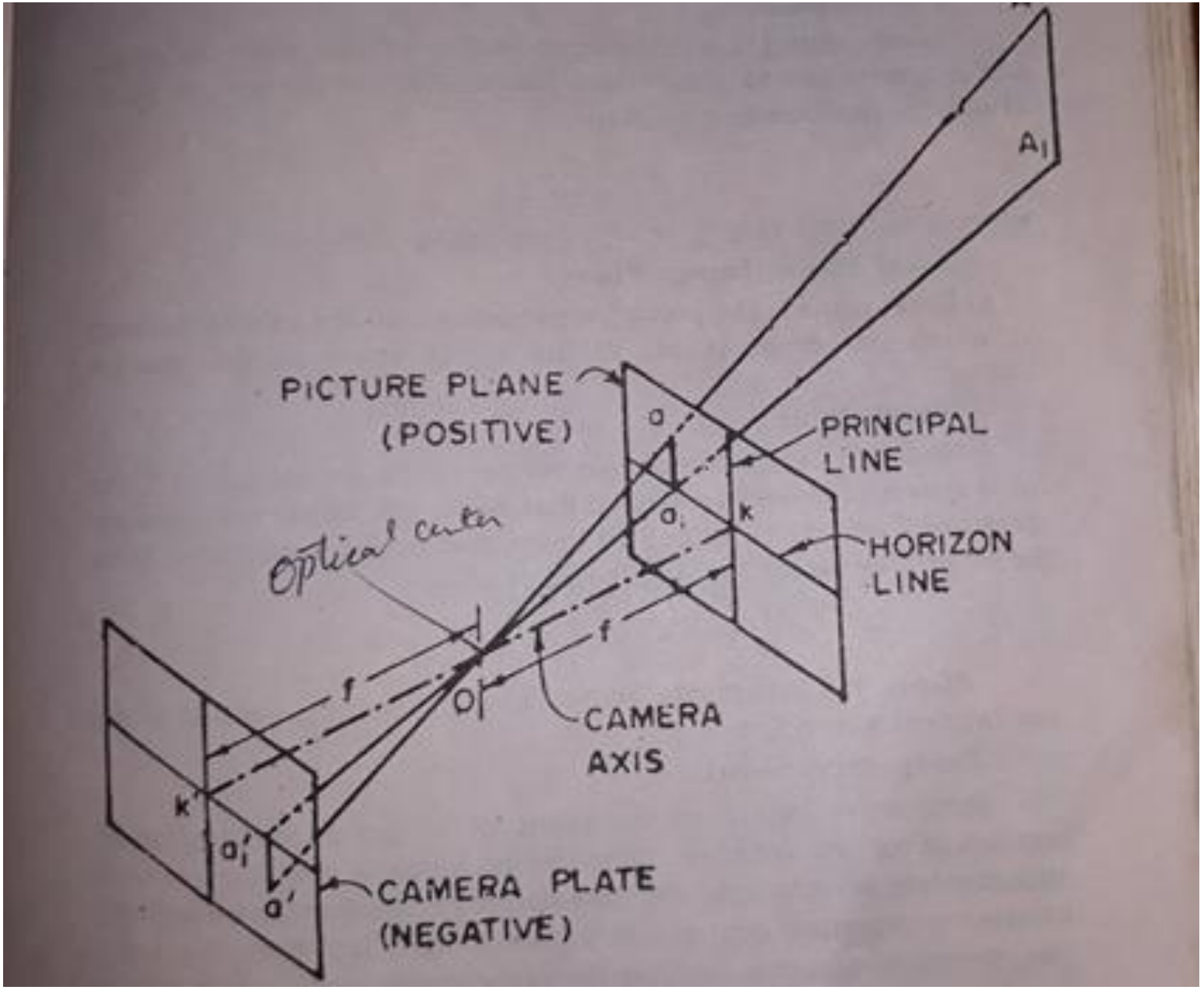
- A **special case**, called stereo-photogrammetry.

- Involves **estimating the three-dimensional coordinates** of points on an object employing measurements made in **two or more photographic images taken from different positions.**

Terrestrial stereo-photogrammetry (cont..)

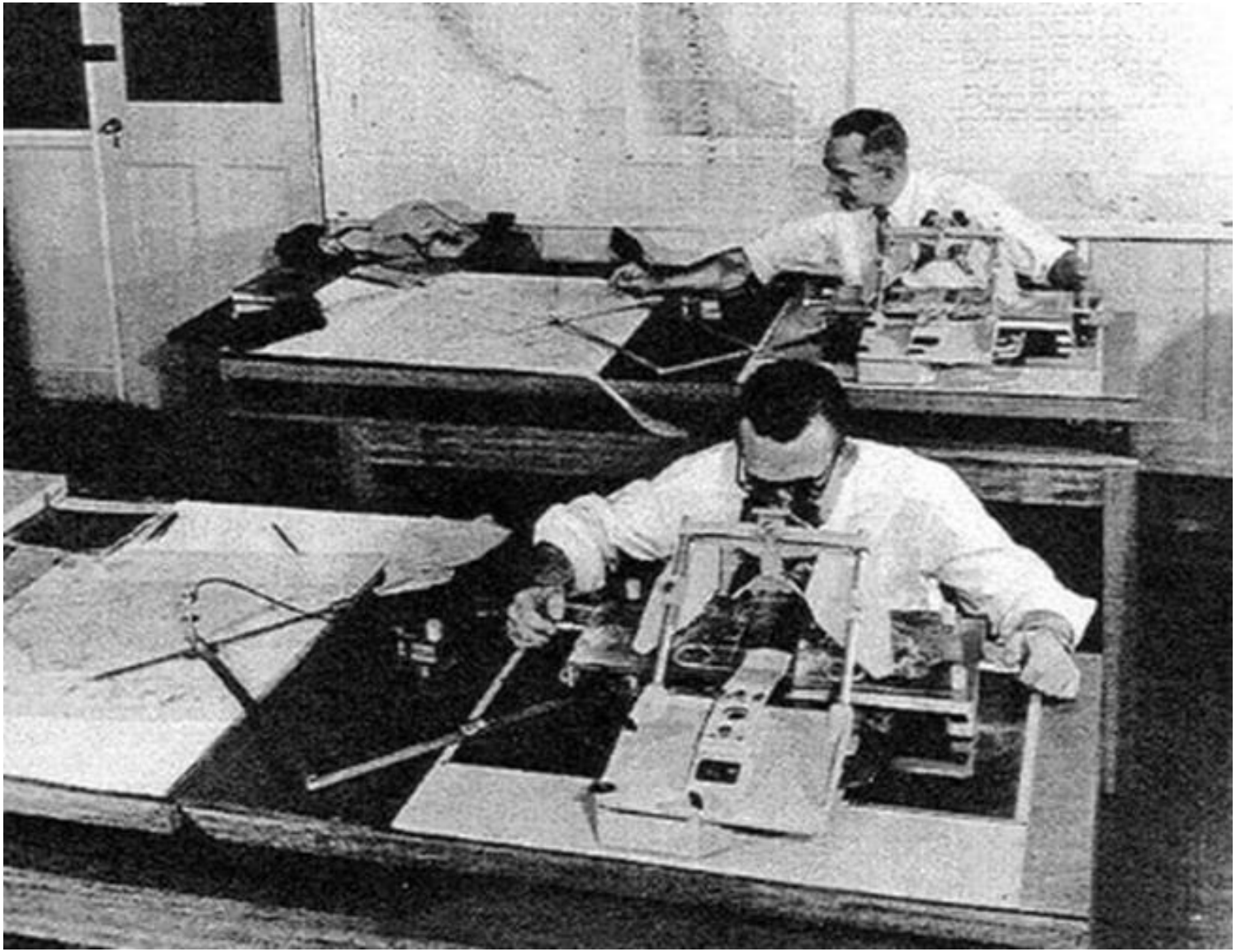
- **Common points** are identified on each image.
- A **line of sight (or ray) can be constructed** from the camera location to the point on the object.
- It is **the intersection of these rays** that **determines the three-dimensional location of the point**.

Aerial Photography - Terms used in Camera



- **Aerial photography.**
- **Types of aerial photographs.**
- **Scale of vertical photographs.**
- **Relief displacement.**

Aerial Photography



Aerial Photography

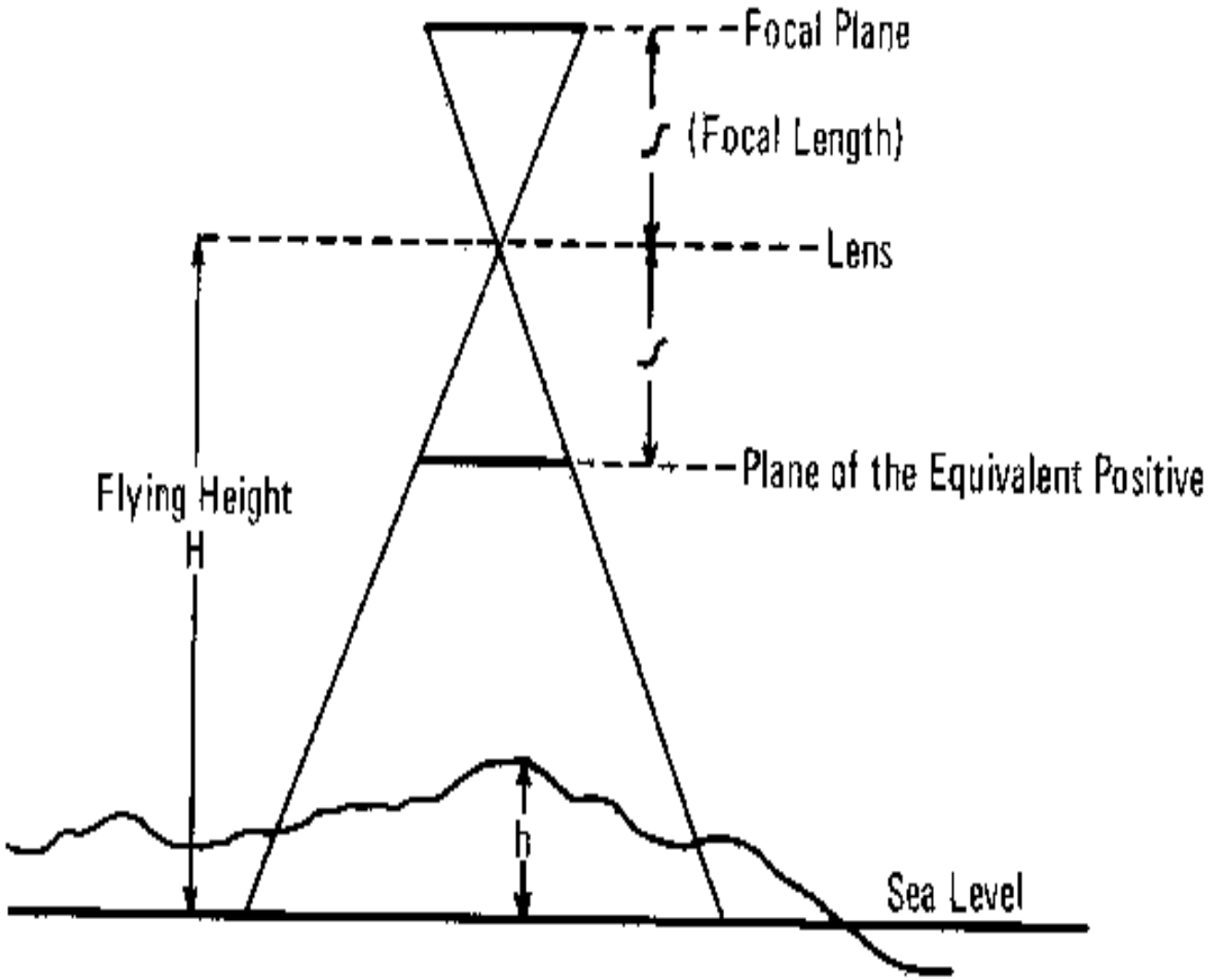
Definition:

Photographs are taken by cameras mounted in an **aerial vehicle** flying over the areas.

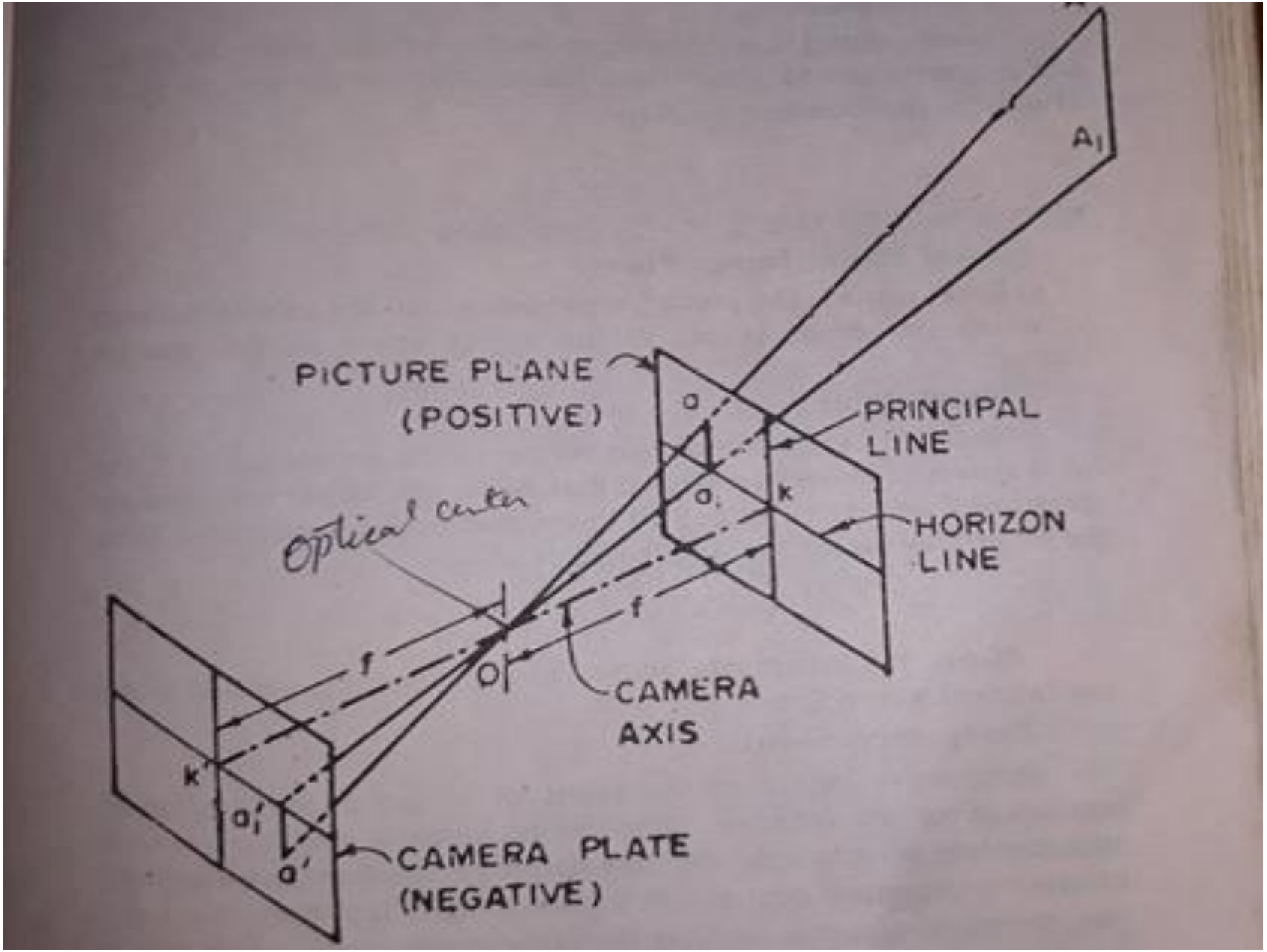




Focal length



Terms used in Camera



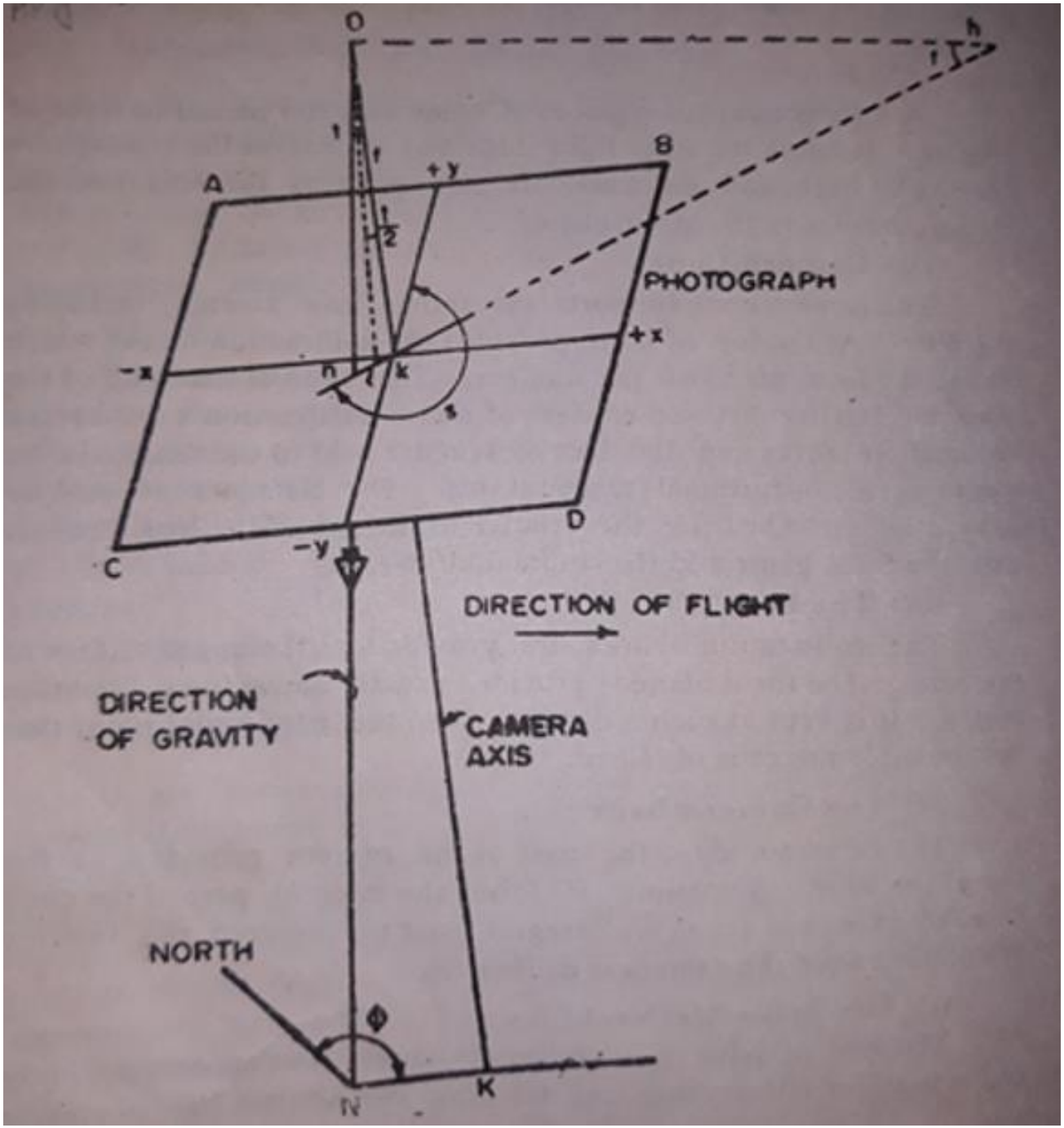
Types of Aerial Photographs

Vertical Photographs:

Aerial photographs made with camera axis or optical axis **coinciding** with the direction of gravity.

Tilted Photographs:

Aerial photographs made with camera axis or optical axis **unintentionally tilted** from the vertical by small amount , usually less than 3°.


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+y
PHOTOGRAPH
+x
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D
DIRECTION OF FLIGHT
DIRECTION
OF GRAVITY
CAMERA
AXIS
NORTH
K
N

Aerial Photographs

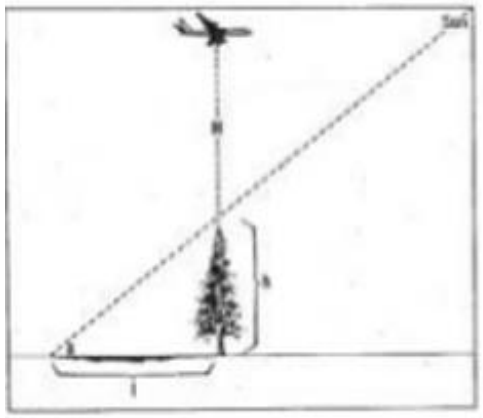
Oblique Photographs:

Aerial Photographs taken with **camera axis directed intentionally** between the vertical and the horizontal.

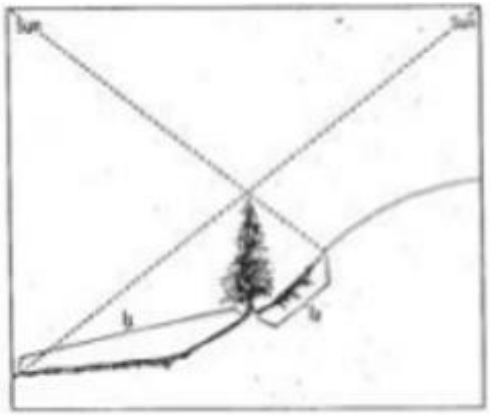
- **High Oblique Photographs**: **Apparent horizon shown** on the photographs.

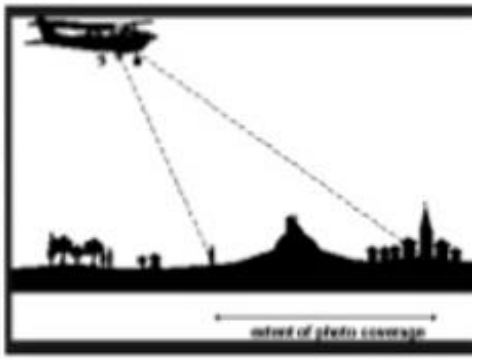
- **Low Oblique Photographs**: Apparent **horizon** are not shown.

Vertical and oblique Photograph

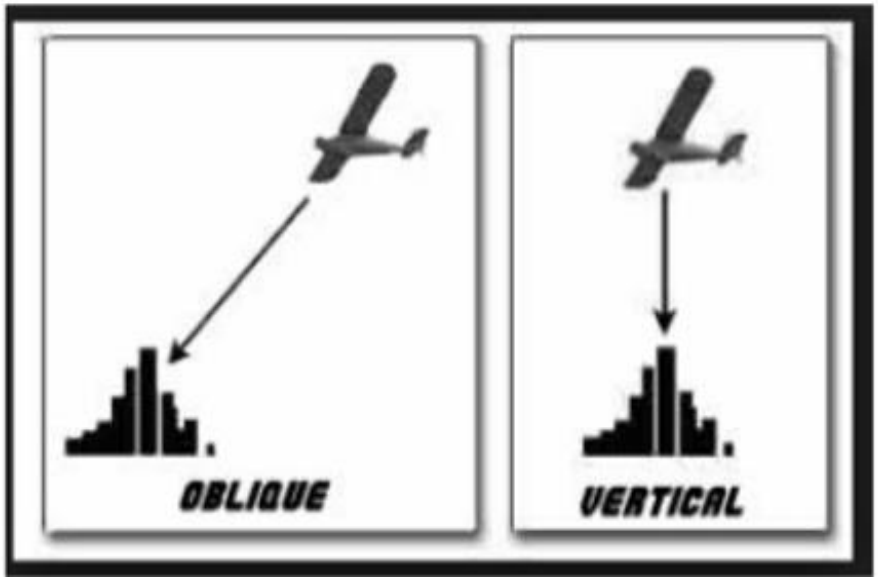


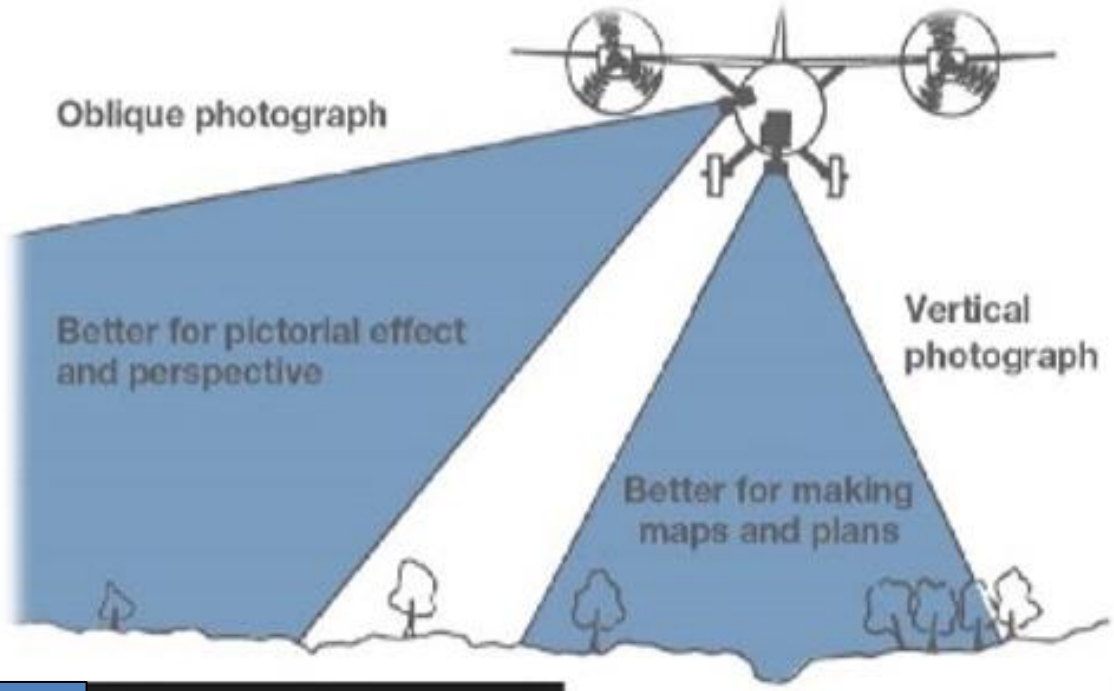
Vertical photographs





Oblique photographs





Low oblique photographs







High oblique photographs

Photogrammetric surveying

What discussed in the last class?

- Pixels and resolution
- Definition
- Application
- Advantages and disadvantages
- Principles
- Uses
- Types

Terrestrial Photogrammetry

- Comparison with plane table survey
- Selection of Camera stations
- Uses
- Divisions

Photogrammetric surveying

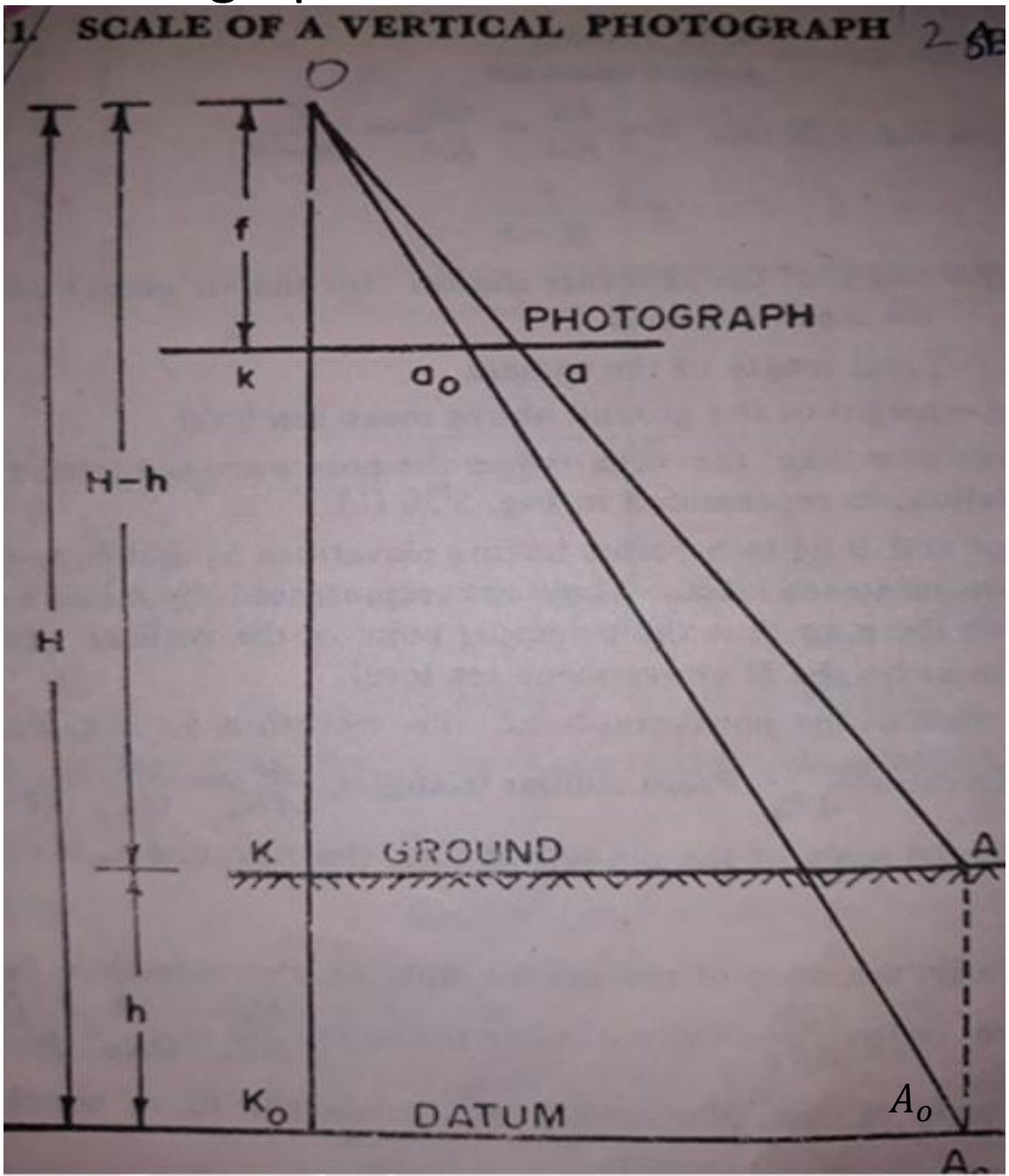
Aerial Photogrammetry

- Definition
- Types

Scale of Vertical Photographs

- Mathematical problems
- Relief displacement
- Derivation of ‘d’.
- Mathematical problems
- Condition for preparation of map from vertical photos.
- Overlap and sidelap
- Reasons for overlapping
- Number of photos required to cove an given area.

Scale of Vertical Photograph



Scale of vertical photographs

$$\text{Scale} = \frac{\textit{Map distance}}{\textit{Ground disance}}$$

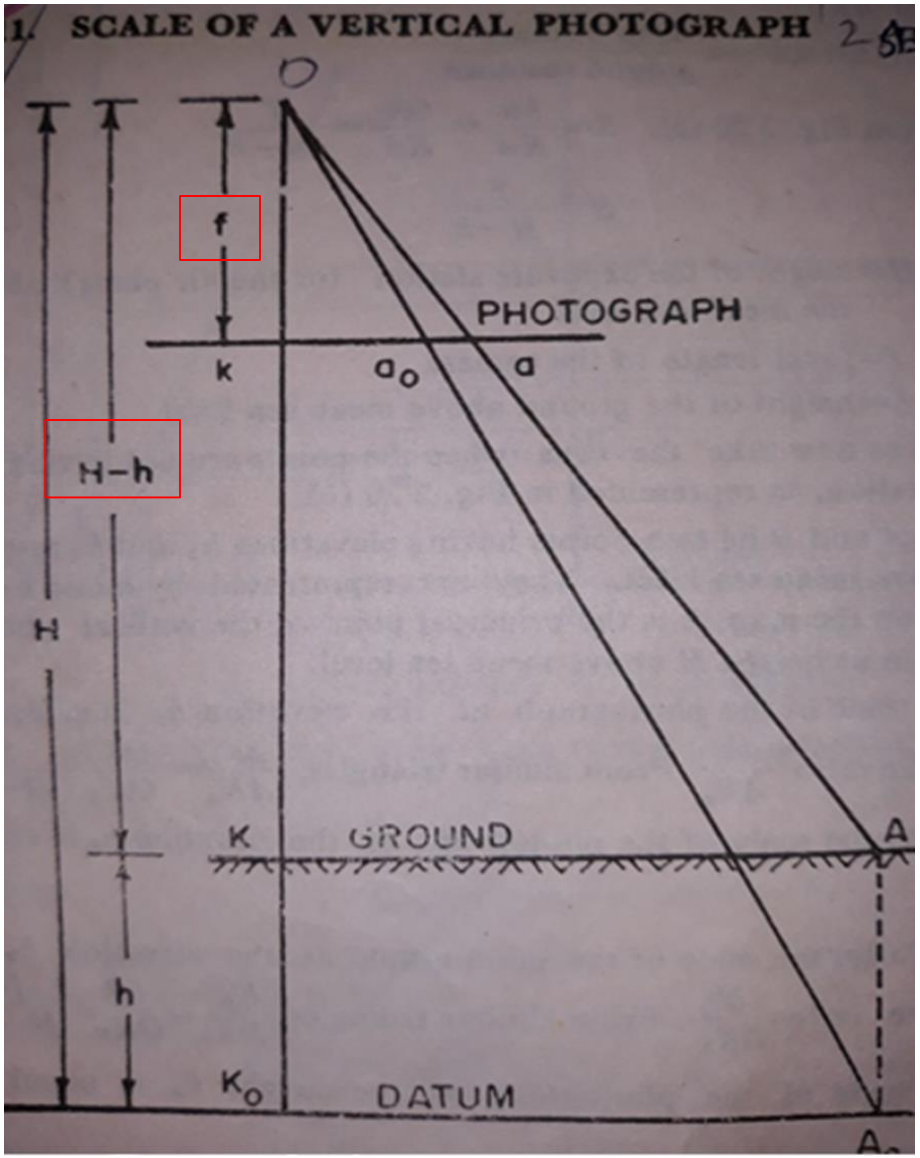
$$S = \frac{ka}{KA} = \frac{Ok}{OK} = \frac{f}{H-h}$$

where,

O=exposure point

k=principal point on the plane of the photograph.

K= Principle point on ground surface.



Problem- 1: Vertical photograph was taken at an altitude of 1200m above the mean sea level (msl). Determine the scale of the photograph for a terrain lying at elevations of 80m and 300m if the focal length of the camera is 15cm.

Solution:

Scale of any height h is given by,

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

When h=80 m, we have: $S_{80} = \frac{15\ cm}{(1200 - 80)m}$

1 cm = 74.67 m

Problem 1: Cont..

As a representative fraction, the scale is,

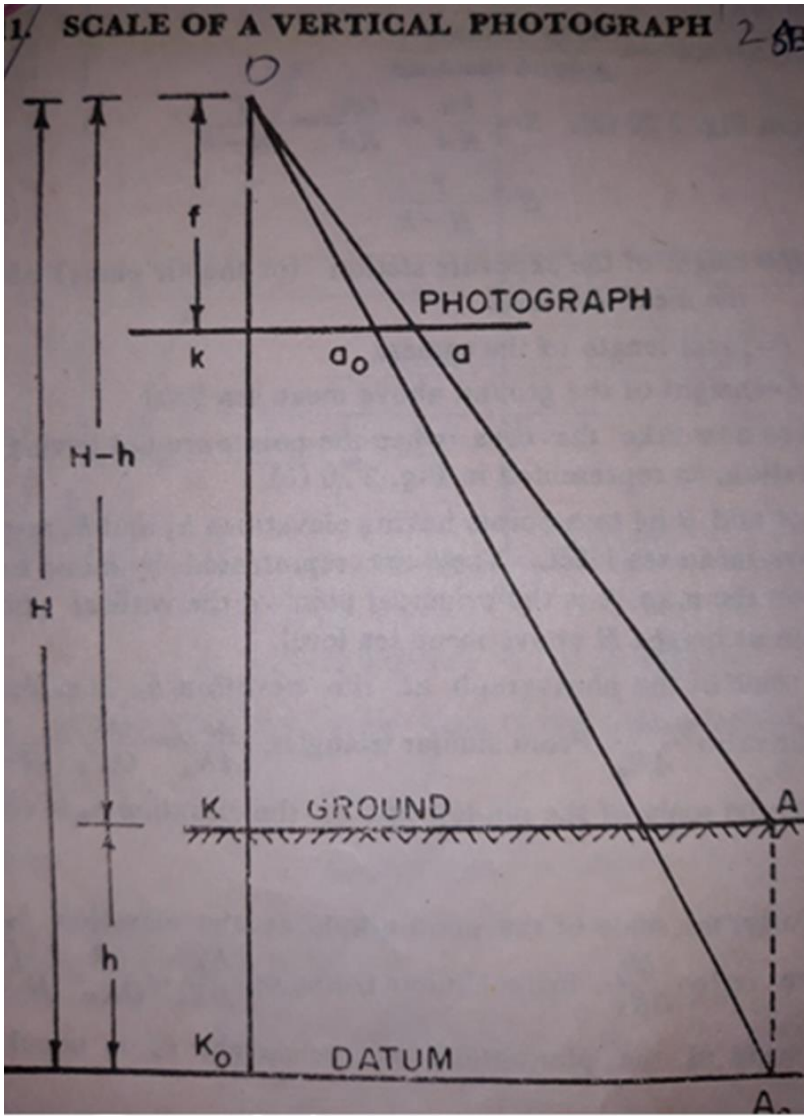
$$R_{80} = \frac{f}{H - h} = \frac{1\ 5cm}{(1200 - 80)m} = \frac{\frac{15}{100}\,m}{1120\ m} = \frac{1}{7467} \text{ or } \mathbf{1: 7467}$$

Similarly, h=300 cm, $S_{300} = \frac{15}{(1200 - 300)m} = \frac{15\ cm}{900\ m} = \frac{1\ cm}{60\ m}$

or, 1 cm= 60 m

$$R_{300} = \frac{15\ cm}{(1200 - 300)m} = \frac{\frac{15}{100}\,m}{900\ m} = \frac{1}{6000} \text{ or } \mathbf{1: 6000}$$

Problem- 2: A camera having focal length 20 cm, is used to take a vertical photograph to a terrain having an average elevation of 1500 m. What is the height above of sea level at which an air-craft must fly in order to get the scale of 1 : 8000?



Solution:

Scale which expressed as **RF is given by**,

$$RF = \frac{f}{H-h} = \frac{\frac{f}{100}m}{(H-h)\,m} = \frac{1}{8000}$$

When h=1500 m,

we have: $\frac{\frac{20}{100}m}{(H-1500)\,m} = \frac{1}{8000}$

or **H-1500= 1600**

Or, Height above sea level,

H= 1600+1500=3100m.

Problem-3: A line AB 2000m long, lying at an elevation of 500m measures 8.65cm on a vertical photographs for which the focal length of the camera is 20cm. Determine the scale of the photographs in an area where the average elevation of the area is about 800 m.

Solution:

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

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

or, (H-500)= $\frac{20\ x\ 2000}{8.65}$= 4624 m or **H= 4624 +500=5124m**

$$S_{800} = \frac{20\ cm}{(5124 - 800)} = \frac{1\ cm}{216{,}2}$$ or, 1 cm=216.2m.

Problem-4: 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 scale of 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.

Solution:

Relation between the photo scale and map scale is given by,

$$\frac{Map\ distance}{Ground\ distance} = \frac{Photo\ distance}{Map\ distance} \text{ or, } \frac{Photo\ Scale}{Map\ Scale} = \frac{Photo\ distance}{Map\ distance}$$

Here, map scale= $\frac{1}{50{,}000}$, Let, the photo scale be= $\frac{1}{n}$

Problem -4

Solution:

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

Or, $\frac{1}{n} = \frac{10.16}{2.54} \times \frac{1}{50{,}000} = \frac{1}{12{,}500}$

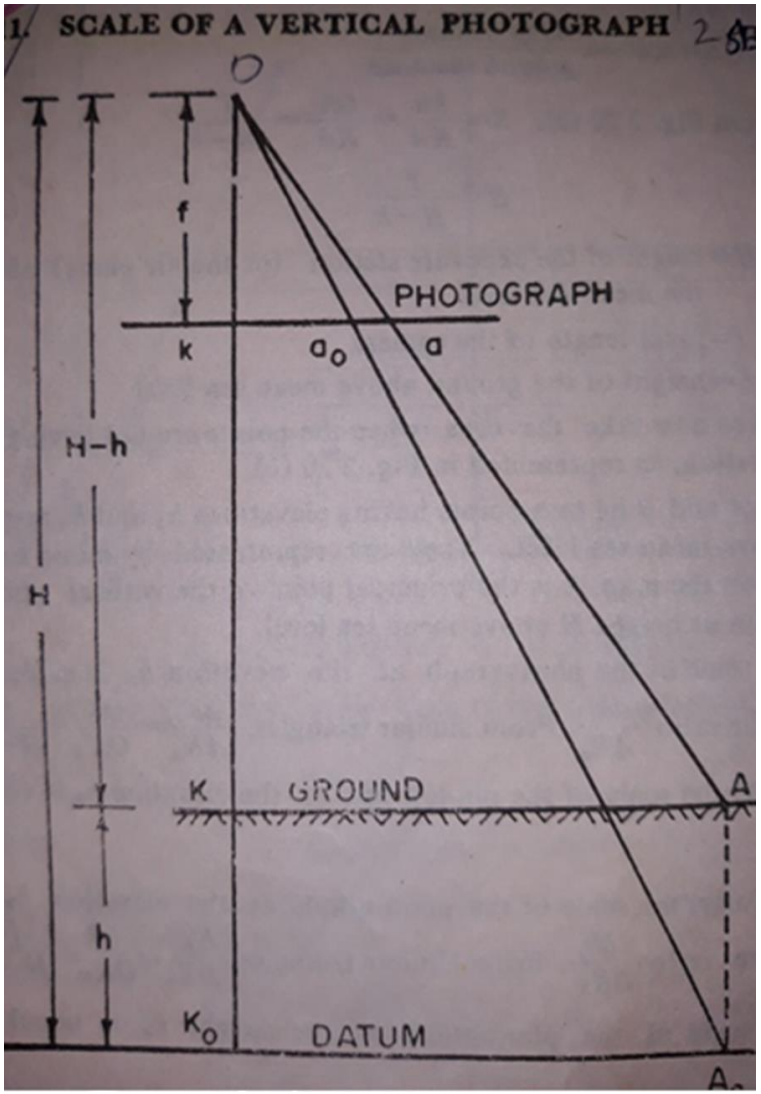
Or, n=12,500

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

or, $\frac{1}{12{,}500} = \frac{16/100}{(H-200)}$

Or, H-200= $\frac{16}{100}$ x 12,500=2000

or, H= 2000+200=2200m



Relief Displacement

What do understand by the relief displacement?

- If the photograph is **truly vertical and ground is horizontal**, and **if other sources of errors are neglected**, the **scale of photograph will be uniform.**
- Such photograph represents a **true orthographic projection** and hence the true map of the **terrain**.
- On ground, such conditions are never fulfilled.

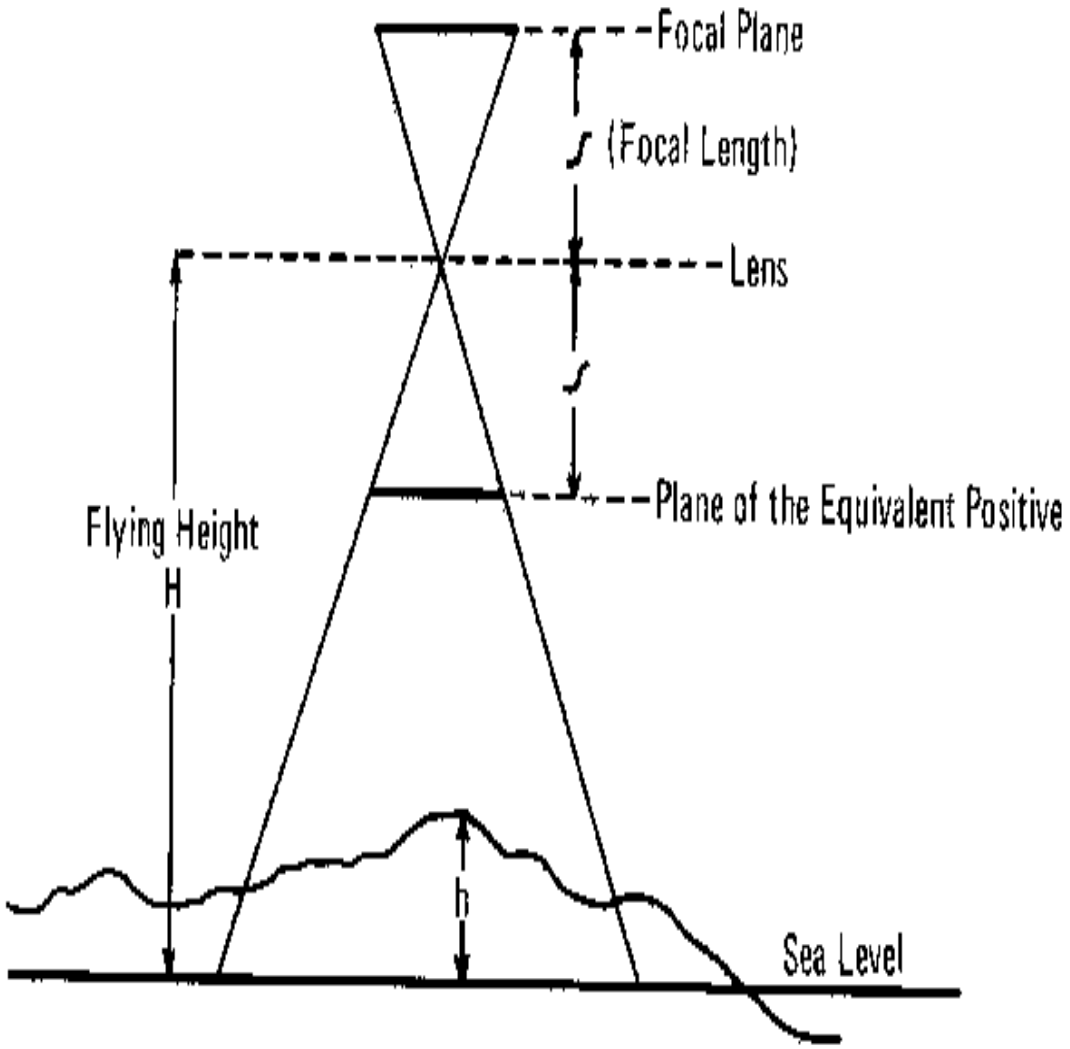
Relief Displacement

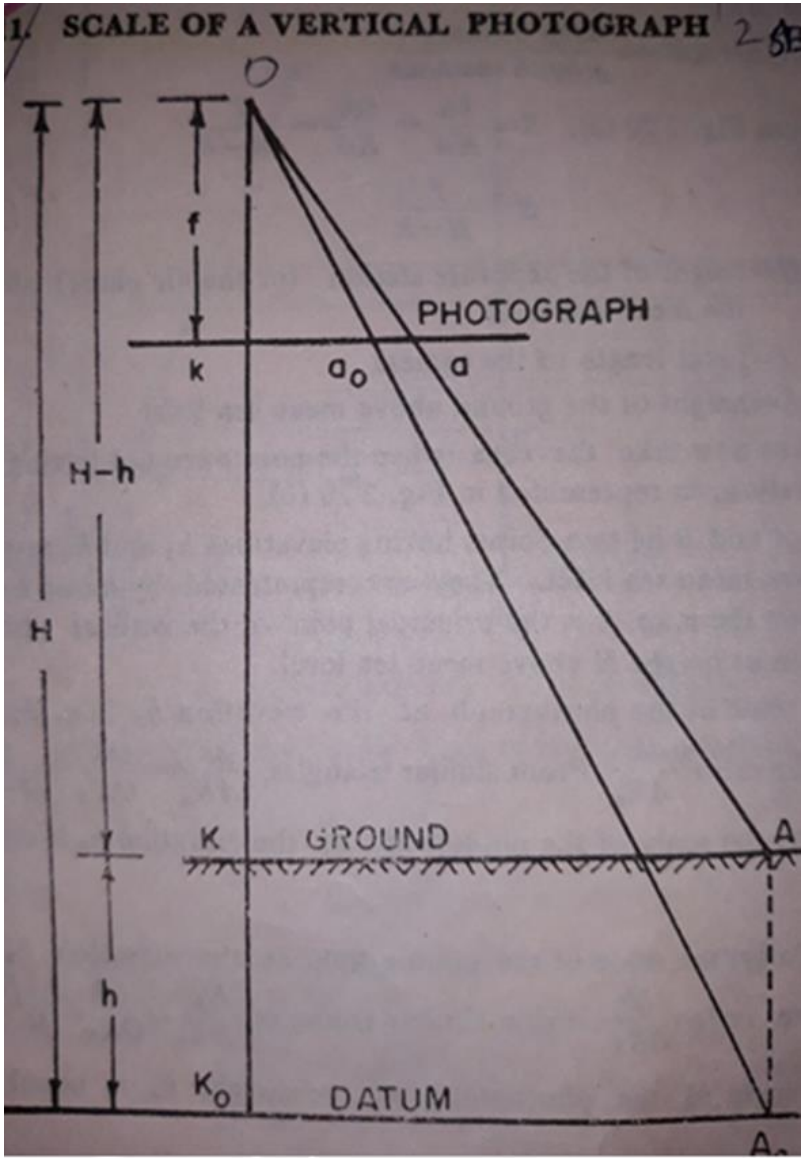
What do understand by the relief displacement (cont...)?

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

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

Focal length





Relief Displacement

Relief:

- Quantitative measurement of **vertical elevation change** in a landscape.

Ground Relief: Involves the vertical and horizontal dimension of land surface.



Relief Displacement

Relief Displacement of vertical Photographs:

Due to the **non horizontality of the ground**, the scale of the photographs varies from point to point, and is not constant.

Hence, **every point on the photographs is displaced from the true orthographic position**. This displacement is called relief displacement (d).

Orthographic Projection: Representing three dimensional objects in two dimensions

Calculate the amount of relief displacement.

- Following figure shows the **vertical section through the photograph** of AA⁰ along the line ka.

Let r=radial distance of a from k.

r_0= radial distance of a_0

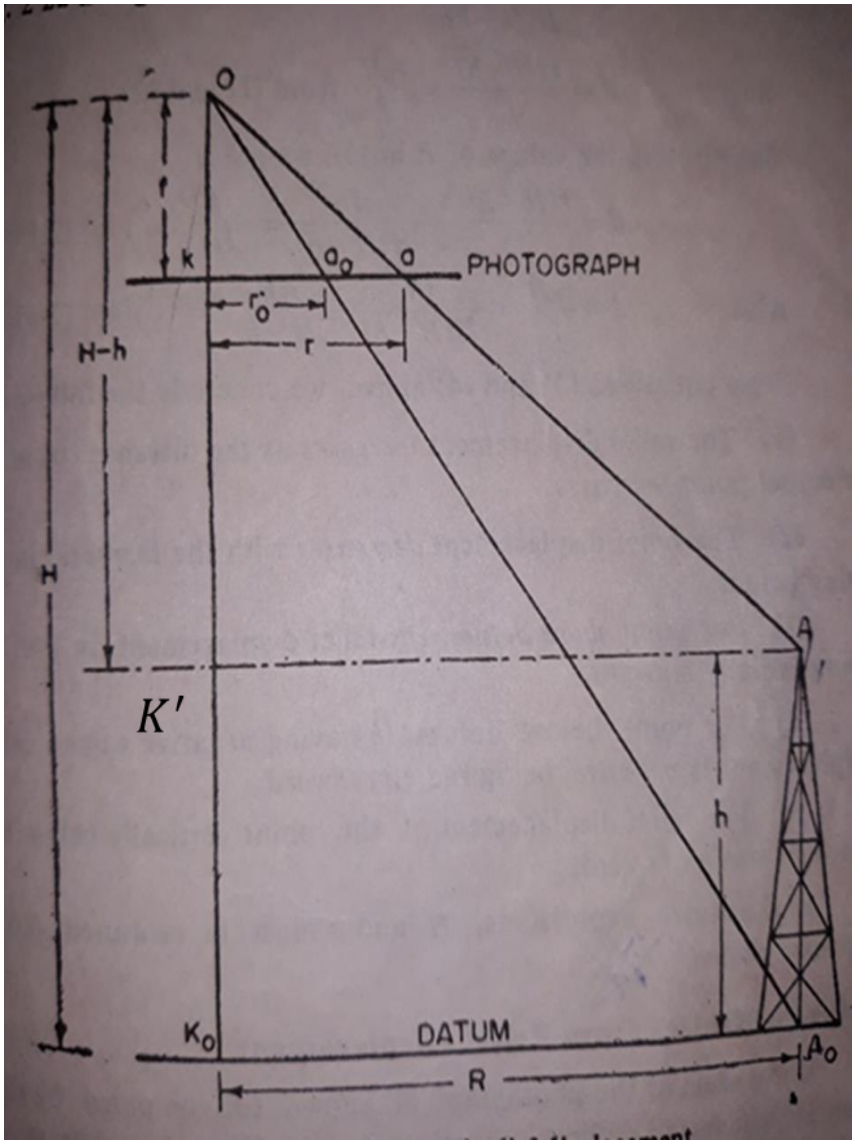
R =$K_o\ A_o$

Then from the **similar triangle**

ΔOak and ΔOAK', $\frac{Ok}{OK'} = \frac{ka}{K'A}$

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

from which, **r** = $\frac{Rf}{H-h}$ **---- (1)**



Calculate the amount of relief displacement.

- Following figure shows the **vertical section through the photograph** of AA⁰ along the line ka.

Let r=radial distance a from k.

r_0= radial distance of a_0

R =K_o A_o

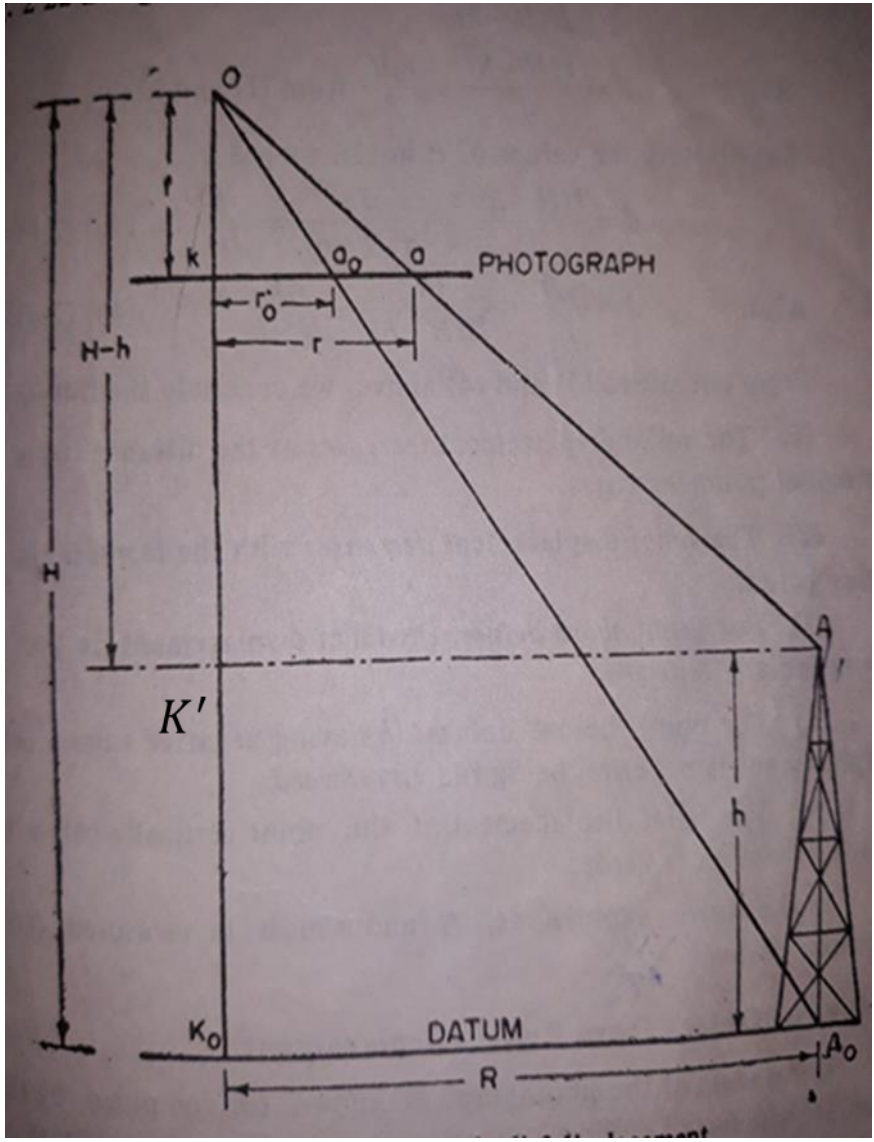
Again, from similar triangle

Δ Oa_ok and Δ O$A_o K_o$,

$$\frac{Ok}{OK_0} = \frac{ka_0}{K_0A_0}$$

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

from which we get, $r_0 = \frac{Rf}{H}$ ------- (2)



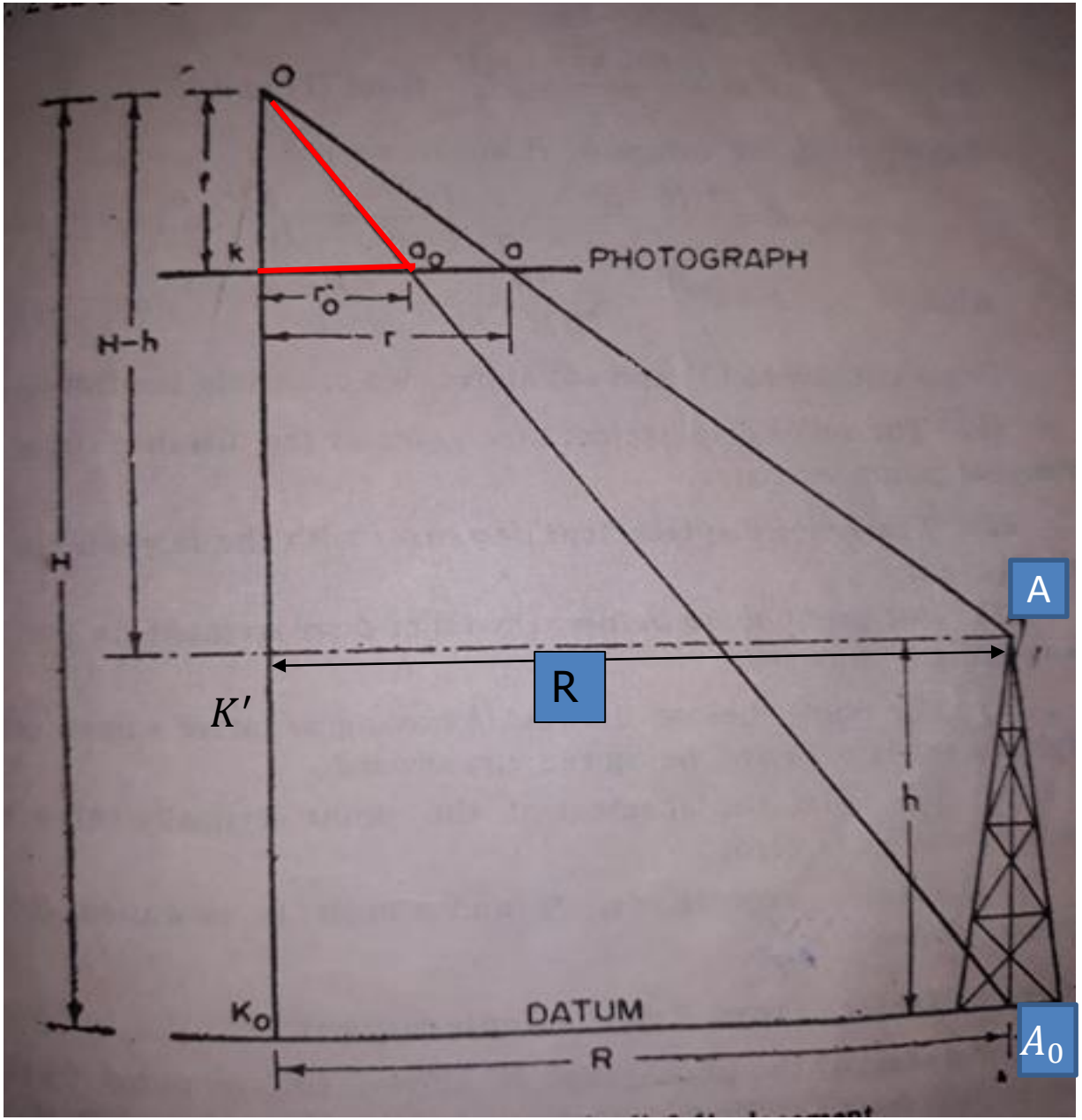
Calculate the amount of relief displacement.

Hence, the relief displacement, d is given by,

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

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

Calculation of d



Relief Displacement

From equation (1) & (2), we get, $\mathbf{R = \frac{r(H-h)}{f} = \frac{r_0 H}{f}}$

Substituting the values R in equation (3), we get,

$\mathbf{d = \frac{r(H-h)}{f} \times \frac{fh}{H(H-h)}}$ **or** $\mathbf{d = \frac{rh}{H}}$

or $\mathbf{d = \frac{r_0 H}{f} \times \frac{fh}{H(H-h)}}$ **or,** $\mathbf{d = \frac{r_0 h}{(H-h)}}$

Here, **H and h must be measured above the same datum**.

Height of the object from the relief displacement,

we know the **scale of photo,** $\mathbf{S = \frac{f}{H}}$

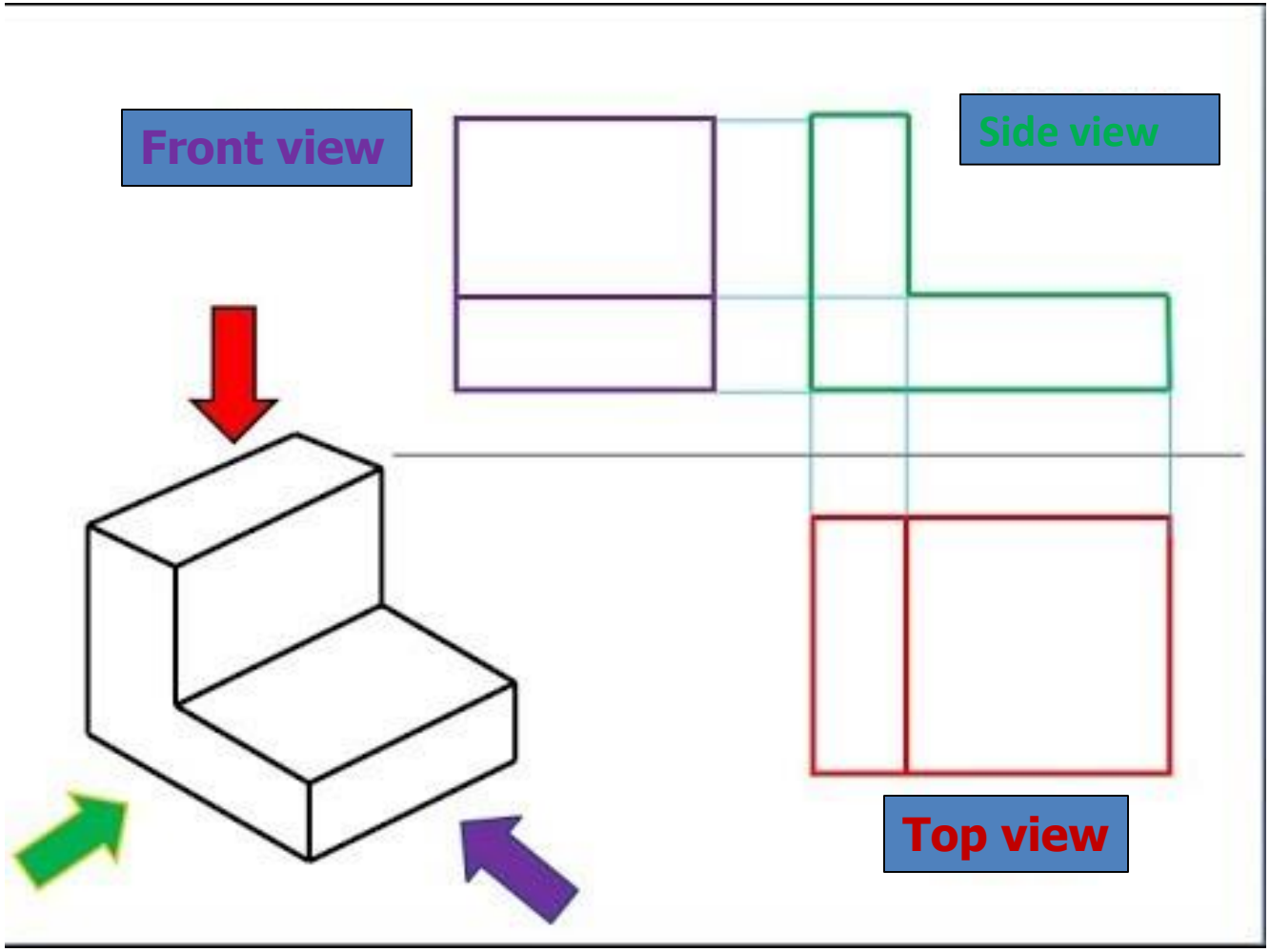
$d = \frac{rh}{H}$, hence $\mathbf{h = \frac{dH}{r}}$

Relief Displacement

Write down **the important findings** of from the equations of relief displacement, ie d= $\frac{rh}{H}$, and d= $\frac{r_0 h}{(H-h)}$

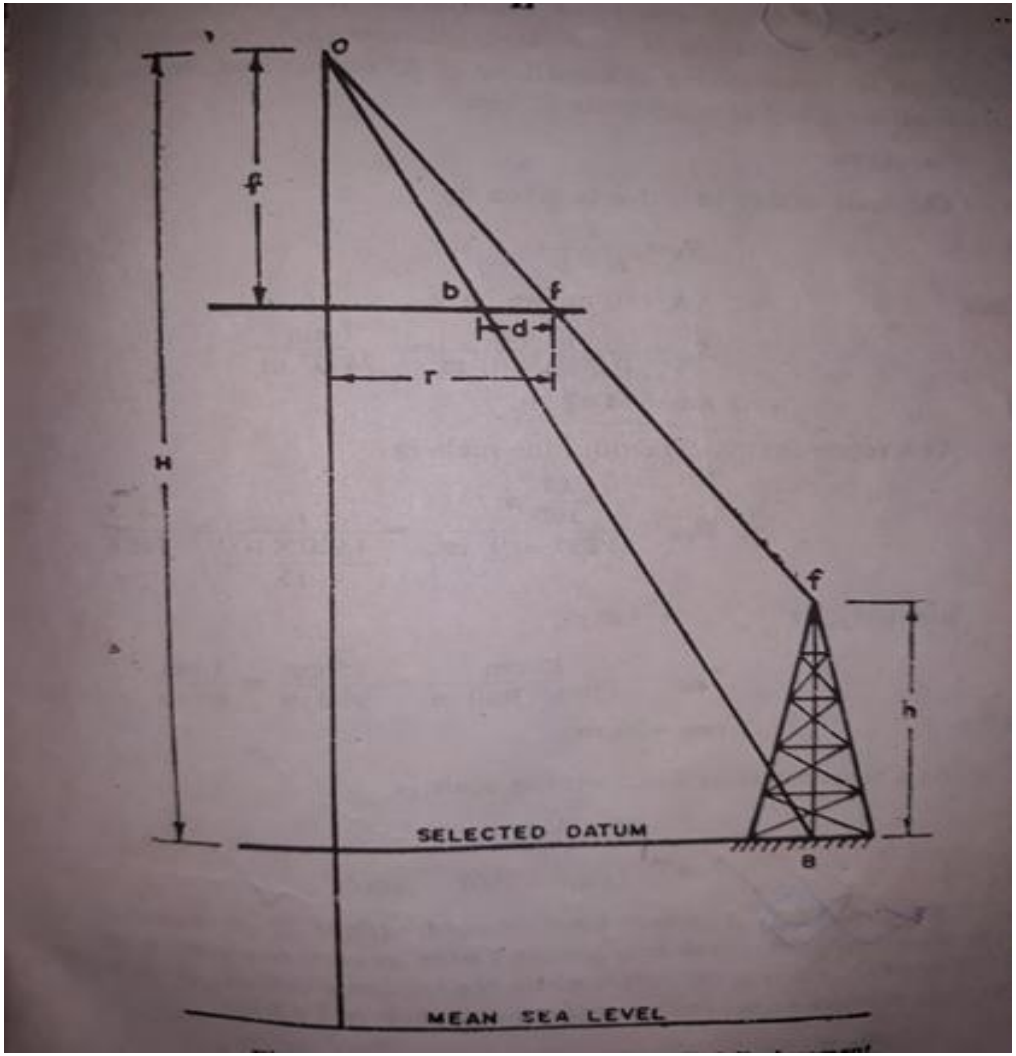
- **d increases** as the distance from the principle point increases.
- **d decreases** with the increase in the flying height.
- From point **above datum**, the d is **+ve** being radially outward.
- From point below the datum, d is **–ve,** being radially inward.
- d of the point vertically below the exposure station is **zero**.

Orthographic Projection



Height of object h $= \frac{dH}{r}$

r, d can be measured from the photograph if scale of photo is known.



Problem-5: The distance from the principal point to an **image** on a photographs is 6.44 cm and the elevation of the **object** above the datum is 250m. What is the relief displacement of the point if the **datum scale** is 1/10,000 and the **focal length** of the camera is 20cm.

Solution:

Datum scale is given by, $S_d = \frac{1}{10{,}000} = \frac{f}{H} = \frac{\frac{20}{100}m}{H\ m}$

from which, H= $\frac{20}{100}$ x 10,000 = 2000 m above msl.

Again, relief displacement **d=** $\frac{rh}{H} = \frac{6.44x250}{2000}$ = 0.805 cm

Problem-6: A vertical photo of a flat area having an average **elevation** of 250m above m s l, was taken with a camera having a **focal length** of 20cm. A section of line AB, **250m long** in the measures **8.50cm on the photograph**. A tower of TB in the area also appears on the photographs. The distance between image of **top and bottom** of the tower measures 0.46cm on the photographs. The distance of the image of **top of the tower from the principle point** is 6.46cm on the photographs. Determine the height of the tower.

Solution: from the following figure,

$$\text{Scale} = \frac{\textit{Photo diatance}}{\textit{Ground distance}} = \frac{f}{H}$$

Where H= height of the camera above the selected datum

Let the average ground be selected datum.

Now, $\frac{8.50\ cm}{250.00\ m} = \frac{20\ cm}{H\ m}$ or, $H = \frac{20\ x\ 250}{8.50} = 588.2$ m

Height of tower above its base is given by,

$$h = \frac{dH}{r} = \frac{0.46x588.2}{6.46} = 41.89 \text{ m}$$

Discussed in the last class:

- Scale of vertical photographs
- Relief displacement
- Conditions for preparation of map from vertical photograph

Today we are going to discussed:

- Overlapping of Aerial photographs.
- Reasons for overlapping
- Number of photographs covering an area of ground.
- Nos of photos to cover length and width of the area.
- Distortions of vertical photos due to flight.

Aerial photographs

Conditions for preparation of maps from the vertical photographs:

a. **Plumb points of preceding and succeeding prints, should be visible** in each photographs for compilation.

b. Photographs taken along each strip, **should have desired overlap** of photographs in the given strip.

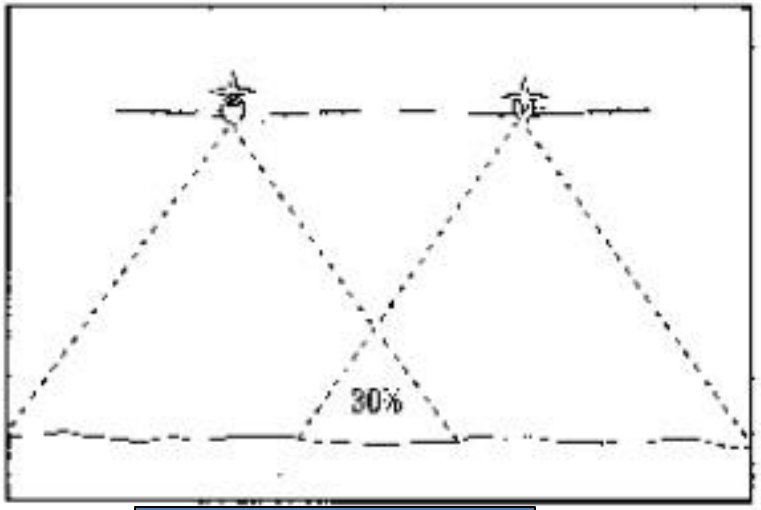
c. Photographs should have **desired side lap** between the adjacent strips.

Overlapping of the Aerial Photographs

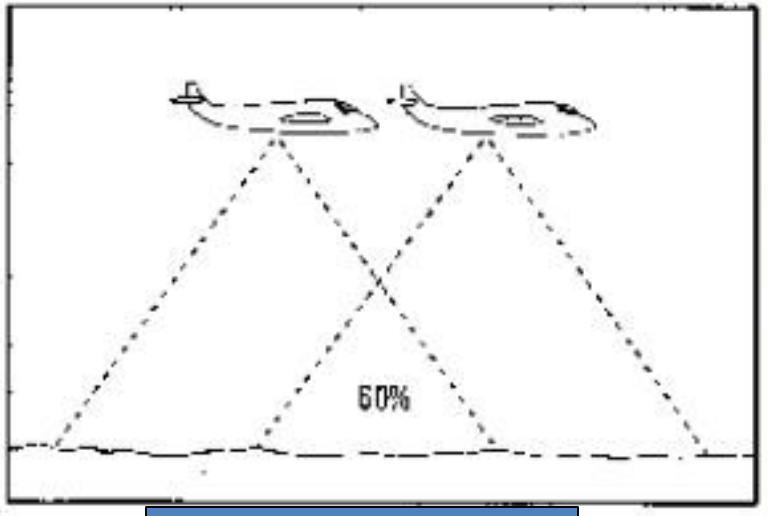
Overlap/Forward Overlap/Longitudinal overlap:

- **Along a given flight line** photographs are **taken at a such frequencies** as to cause successive photographs to overlap each other by **55 to 65%.**
- Since overlap is more than 50%, alternate photographs will **overlap** by **10 to 30%.**
- Entire area may be examined stereoscopically.

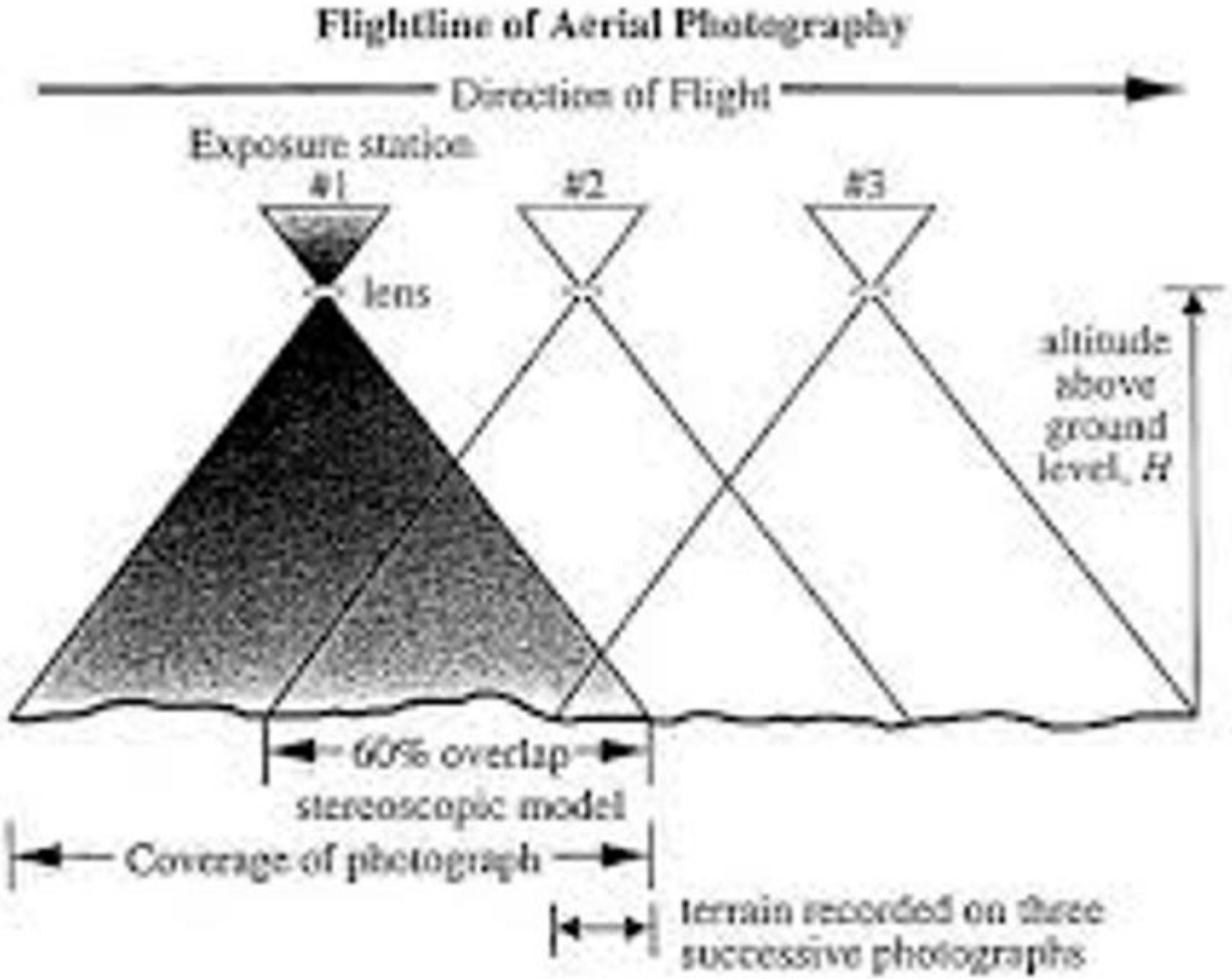
Overlaps



Lateral Overlap



Forward Overlap


Flightline of Aerial Photography
Direction of Flight
Exposure station
#1
#2
#3
lens
altitude above ground level, H
60% overlap
stereoscopic model
Coverage of photograph
Terrain recorded on three successive photographs

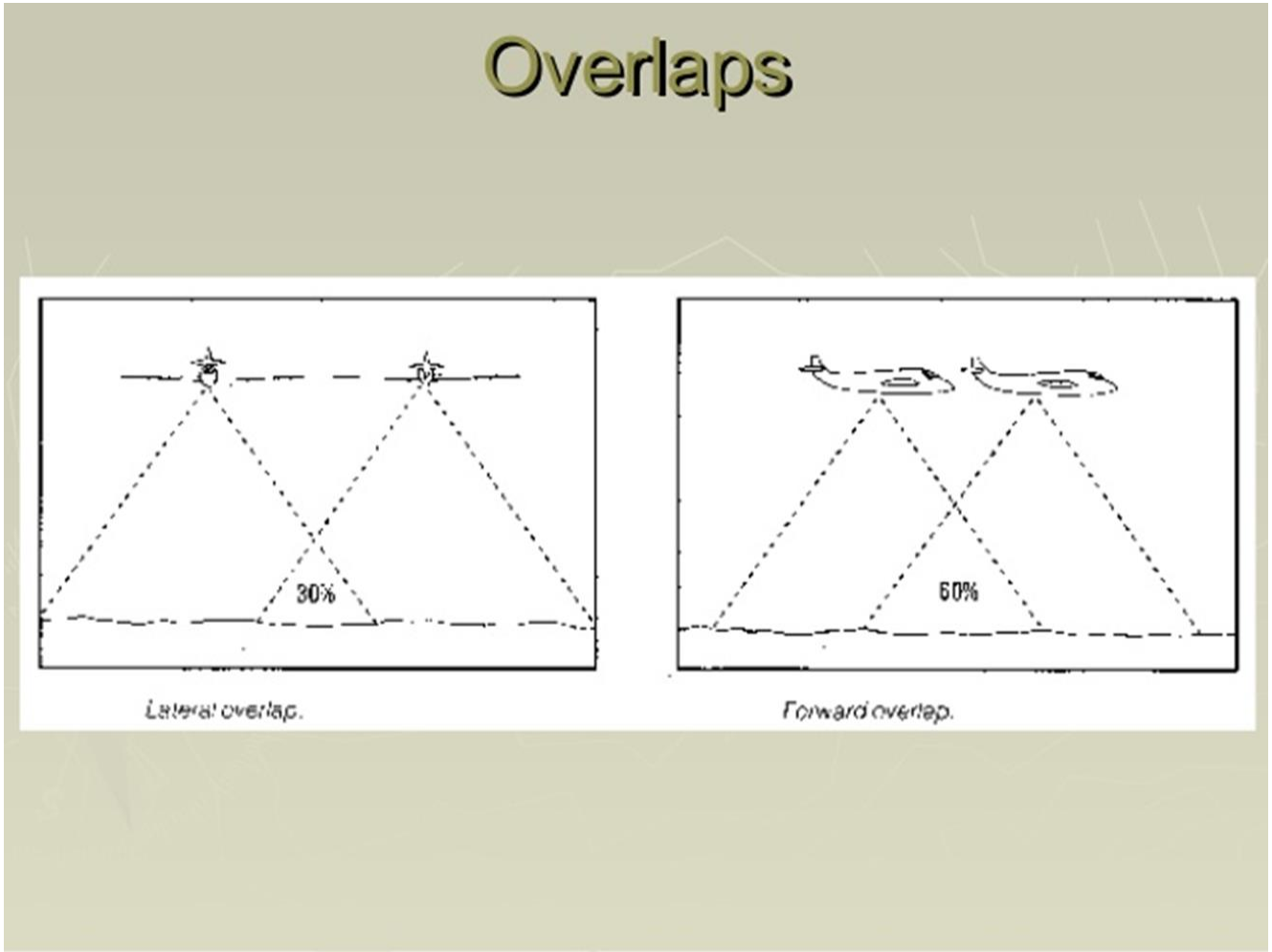
Stereo imaging is a technique for **creating or enhancing the illusion of depth in an image** by means of stereopsis for binocular vision.

Depth perception is the visual ability **to perceive the world in three dimension (3D)** and the distance of an object.



Side lap/Lateral overlap

Side lap/Lateral overlap: Lap between adjacent flight lines is called side lap or lateral overlap. Side lap amounts about 15 to 35%.



Reasons for overlapping: (TORAV)

- **Tying the different print** accurately.
- **Overcoming the distortions and displacements** effectively while constructing maps.
- **Reducing the chance of taking again new photographs**, which is costly and time consuming.
- **Avoiding the gaps between the flight strips** by having side lap.
- **Viewing the object from more than one angle** ie stereoscopically.

Aerial photograph

Number of photographs required to cover a given area:

N= A/a

A= Total area ground to be photographed

a = net ground area covered by each photograph **= LxW**

L= net ground distance corresponding to l.

where, **l**= length of photograph in the direction of flight.

$$L = (1 - p_l)\, s\, l$$

where, p_l= % of overlap between successive photographs in the direction of flight.

s =scale of photograph= $\frac{f\ cm}{H\ m}$ (ie.1 cm=s meters)

Aerial photograph

W= net ground distance corresponding to w

where, **w**= width of photograph normal to flight path.

W=(1- p_w)sw

where, p_w= % of side lap between photographs of adjacent flight lines.

s=scale of photograph.

a= LxW

= (1-p_l)sl X (1-p_w)sw

= lws^2 (1-p_l)(1-p_w)

N=A/a

Problem-7: The scale of the aerial photograph is 1 cm= 100 m. The photograph size is 20 cm x 20 cm. Determine the number of photograph required to cover an area of 100 sq. km if the longitudinal lap is 60% and the side lap is 30%.

Solution: here, l = 20 cm; w= 20 cm; p_l= 0.60**;** p_w= 0.30

$$\mathbf{s} = = \frac{f\ cm}{H\ m} = 100 \text{ (ie. 1cm=100 meters)}$$

Actual ground length covered by each photograph is,

$$L = (1 - p_l)\ s\ l = (1.0 - 0.6)\ 100 \times 20 = 0.4\ km$$

Actual ground width covered by each photograph is,

$$W=(1- p_w)sw = (1.0 - 0.3)\ 100x\ 20 = 1.4\ km$$

Problem-4, solution (cont…)

Now, net ground area covered by each photograph is,

$$\mathbf{a = L \times W} = 0.8 \times 1.4 = 1.12 \text{ sq. km}$$

Hence, number of photograph is required is,

$$N = \frac{A}{a} = \frac{100}{1.12} = 90$$

Number of photographs required to cover a rectangular dimensions (ie. Length and width) of the ground.

Let,

L_1= dimension (length) of the area **parallel** to the direction of flight.

L_2= dimension (width) of the **area normal** to the direction of flight.

N_1= number of photographs in each strip.

N_2= number of strips required.

N = total number of photographs to cover the whole area.

Now, net length covered by each photograph,

$$L = (1 - p_l)\, sl$$

(cont..)

Number of photographs in each strip is given by,

$$N_1 = \frac{L_1}{L} + 1 = \frac{L_1}{(1 - p_l)\ sl} + 1$$

Similarly, net width covered by each photograph,

$$W = (1 - p_w)sw$$

Hence, **number of the strips** required are given by,

$$N_2 = \frac{L_2}{W} + 1 = \frac{L_2}{(1 - p_w)sw} + 1$$

Thus, **number of photographs required** is,

$$N = N_1 \times N_2 = \left\{\frac{L_1}{(1 - p_l)\ sl} + 1\right\} \times \left\{\frac{L_2}{(1 - p_w)sw} + 1\right\}$$


-7
-6
-4
-5
-3
-2
-0
-1

Problem-8: The scale of an aerial photography is 1 cm = 100 m. 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:

Here, L_1 = 10 km; L_2 = 10 km

Number of photographs in each strip is given by,

$$N_1 = \frac{L_1}{L} + 1 = \frac{L_1}{(1 - p_l)\ \text{sl}} + 1 = \frac{10{,}000}{(1 - 0.6)\ 100\text{x}20} + 1 = 12.5+1=13.5 \approx 14$$

Number flight lines required is given by,

$$N_2 = \frac{L_2}{W} + 1 = \frac{L_2}{(1 - p_w)\text{sw}} + 1 = \frac{10{,}000}{(1 - 0.2)\ 100\ \text{x}\ 20} + 1 = 7.6=1=8.6 \approx 9$$

Problem-5, Solution (cont..)

Here, number of photograph required will be,

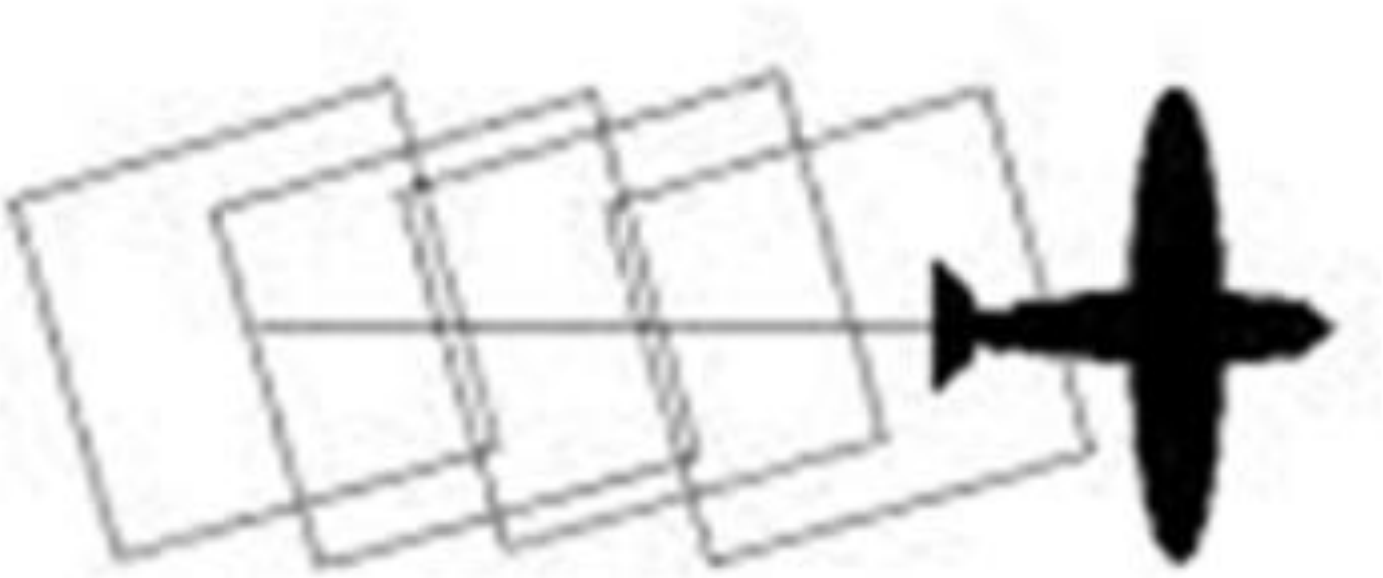
$$N = N_1 \times N_2 = 14 \times 8 = 126$$

Distortions due to flight
Crab and drift

Crab:

- Designate the **angle formed** between **the flight line and the edges of the photographed** in the direction of flight.
- At the time of exposure, if the **focal plane** of the camera is **not square with the direction of flight**, crab is caused in the photographs.
- Arrangements are always made to **rotate the camera about the vertical axis** of the camera mount.
- Should be **eliminated** as it reduces the effective coverages of the photographs.

Crab



Crab is the condition caused by the **failure to orient the camera** with respect to the planned flight line.

Crab should not affect **more than 5%** of the photograph

Aerial photographs

Drift:

- **Caused by** the **failure of the photographs** to **stay on the predetermine flight line.**

- If an **ac is set without considering the wind velocity**, it will drift from its course and thereby photographs also.

- If drift is excessive (more than 5^0), **refights will have to be made** for serious gapping between adjacent flight lines.

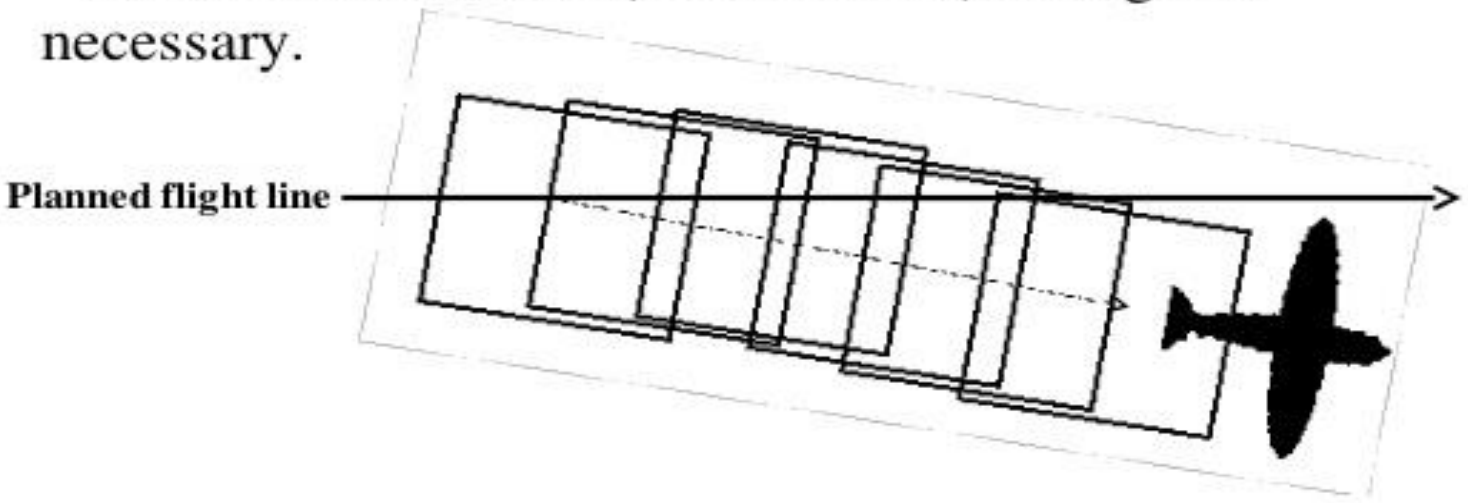
Drift

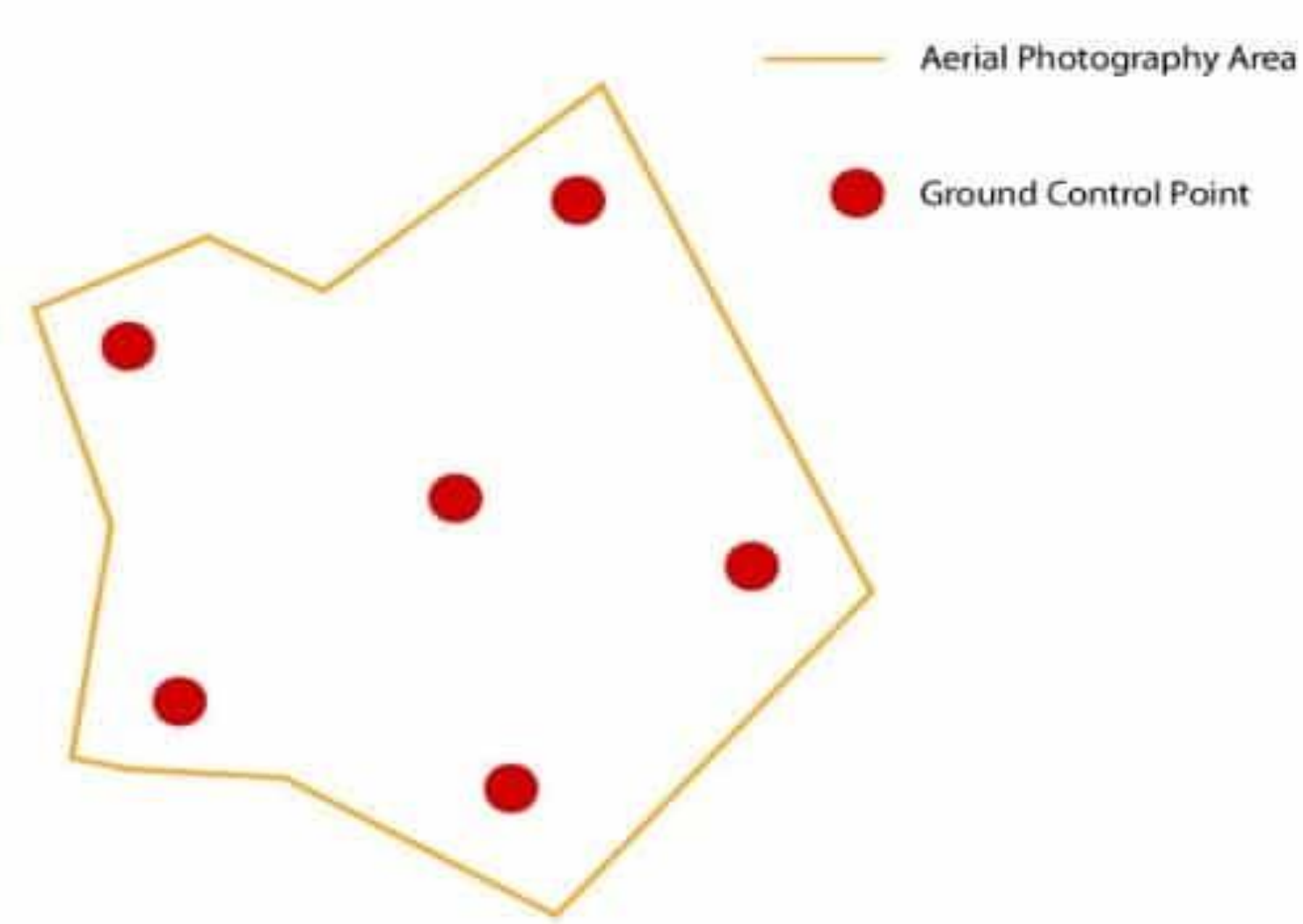
Drift

"Drift is the lateral shift or displacement of the aircraft from the planned flight line caused by the action of wind, navigational errors, or others like carelessness of the pilot

✓Drift may cause serious gap in the photographic coverage between adjoining strips of photographs.

✓For excessive drifts (more than 5^0), reflight is necessary.




Aerial Photography Area
Ground Control Point


-7
-6
-4
-5
-3
-2
-0
-1



Thank you