Northern Technical University
Technical college of Kirkuk
Surveying Tech. Eng. Dept.

2nd Stage (Photogrammetry Survey I)

Topic 1 : Introduction of Photogrammetry

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outline

- **Definition**
- **Introduction of Photogrammetry**
- **History of Photogrammetry**
- **Types of photographs**
- **Why Photogrammetry**
- **Applications of Photogrammetry**

Definition

- **Photogrammetry**
- Photogrammetry is the art, science, and technology of obtaining reliable information about physical objects and the environment through processes of recording, measuring, and interpreting photographic images and patterns of recorded radiant electromagnetic energy and other phenomena.

- Photogrammetry
- photo=picture
- grammetry=measurement
- Photogrammetry=photo-measurement

Introduction of Photogrammetry

Measurements of photogrammetry:

Distance, area, elevations

Products of photogrammetry:

- Digital elevation models
- Orthophotos
- Thematic GIS maps

History of Photogrammetry

History Photogrammetry

History of Photogrammetry

Paris by Nadar, circa 1858

1858 Gasper Felix Tournachon "Nadar" takes photograph of village of Petit Bicetre in France from a balloon.

History of Photogrammetry

World War One was a major impetus to development of aerial photography

Types of photographs

- **Two basic classification of photography**

1-Terrestrial photogrammetry

is an important type of the science of photogrammetry. It deals with photographs taken with **cameras located** on the surface of the earth. The cameras may be **handheld, mounted on tripods, or suspended from towers or other specially designed mounts.**

Terrestrial photogrammetry

(a) (b) (c)

Terrestrial photogrammetry

Terrestrial photogrammetry can be further classified :

- **close-range photogrammetry** if camera-object distance is somewhere between 1:10m to 100m
- **macrophotogrammetry** if the camera-object distance is in the 0.10 to 0.01 m range
- **microphotogrammetry** when the photos are exposed through a microscope

Terrestrial photogrammetry

<u>Two basic camera types are employed in terrestrial photogrammetry these are</u>:

- **Matric cameras**

Are designed and calibrated specifically for photogrammetric measurement.

- **Non-Matric cameras**

Are represent by a variety of fairly high quality hand-held cameras used by amateur and professional photographers to take good pictorial quality.

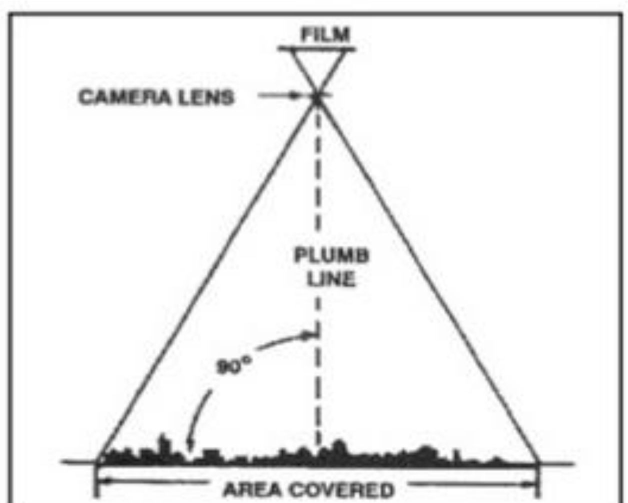
Aerial photography(AP)

2-Aerial photography:

is the taking of photographs of the ground from an elevated position.

<u>Types of Aerial photography</u>

1. **Vertical photograph**: AP taken with the optical axis of the camera perpendicular to the horizontal plane. Ground features appear in the photo in much the same way as the map of similar scale.



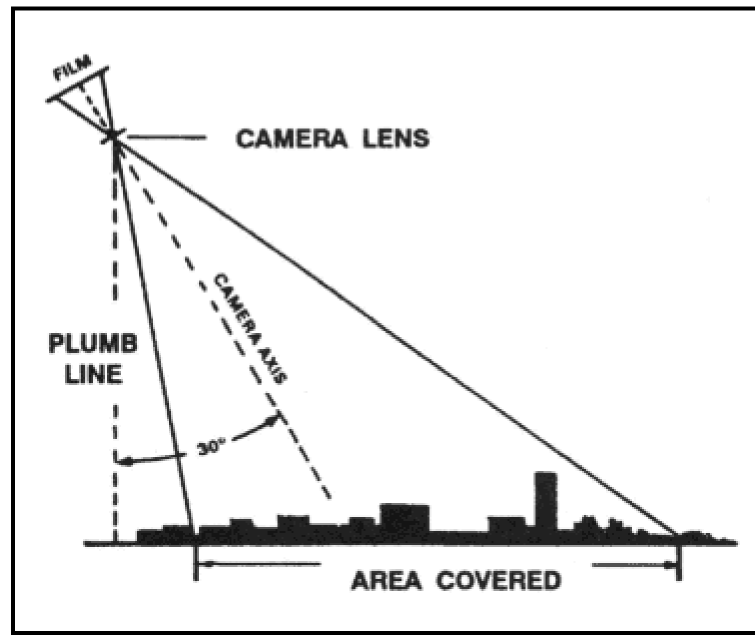
Types of Aerial photography

Characteristics of Vertical photograph :

1. The lens axis is perpendicular to the surface of the earth.
2. It covers a relatively small area.
3. The shape of the ground area covered on a single vertical photo closely approximates a square or rectangle.
4. Being a view from above, it gives an unfamiliar view of the ground.
5. Distance and directions may approach the accuracy of maps if taken over flat terrain.
6. Relief is not readily apparent.

Types of Aerial photography

2. **Oblique photograph:** AP taken with the camera axis tilted intentionally between the horizontal and vertical plane.



- Two types:

a)Low oblique: The horizon does not show in the picture and the optical axis is generally less than 30° from the vertical.

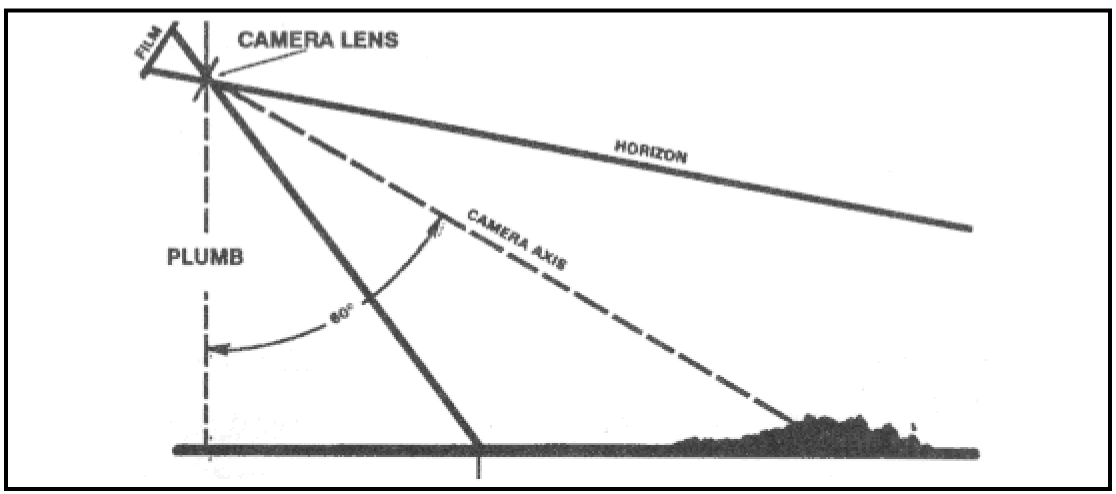
Types of Aerial photography

Characteristics of Low oblique:

1. It covers a relatively small area.
2. The ground area covered is a trapezoid, although the photo is square or rectangular.
3. The objects have a more familiar view, comparable to viewing from the top of a high hill or tall building.
4. No scale is applicable to the entire photograph, and distance cannot be measured.
5. Relief is discernible but distorted.
6. It does not show the horizon.

Types of Aerial photography

- **b)High oblique:** Horizon is seen in the AP and optical axis has an angle of 60° with the vertical.

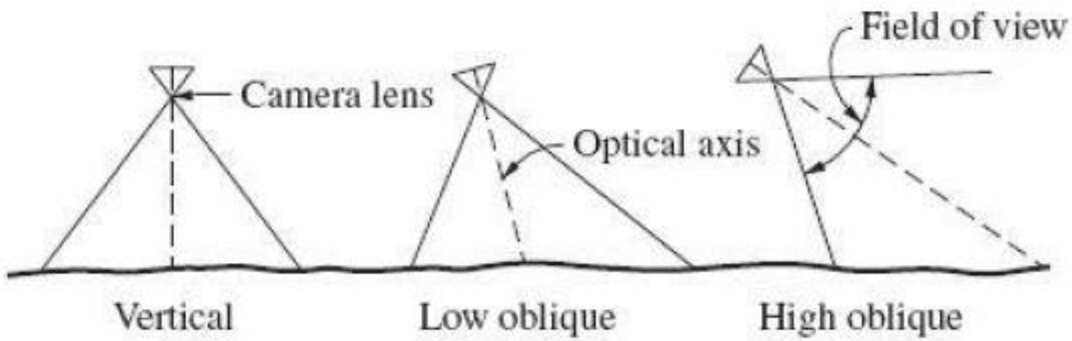


Types of Aerial photography

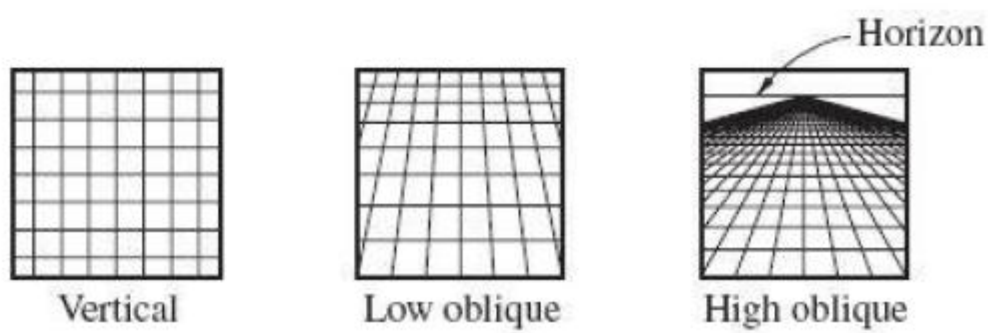
Characteristics of High oblique:

1. It covers a very large area (not all usable).
2. The ground area covered is a trapezoid, but the photograph is square or rectangular.
3. The view varies from the very familiar to unfamiliar, depending on the height at which the photograph is taken.
4. Distances and directions are not measured on this photograph for the same reasons that they are not measured on the low oblique.
5. Relief may be quite discernible but distorted as in any oblique view. The relief is not apparent in a high altitude, high oblique.
6. The horizon is always visible.

Types of Aerial photography



Camera orientation for various types of aerial photographs

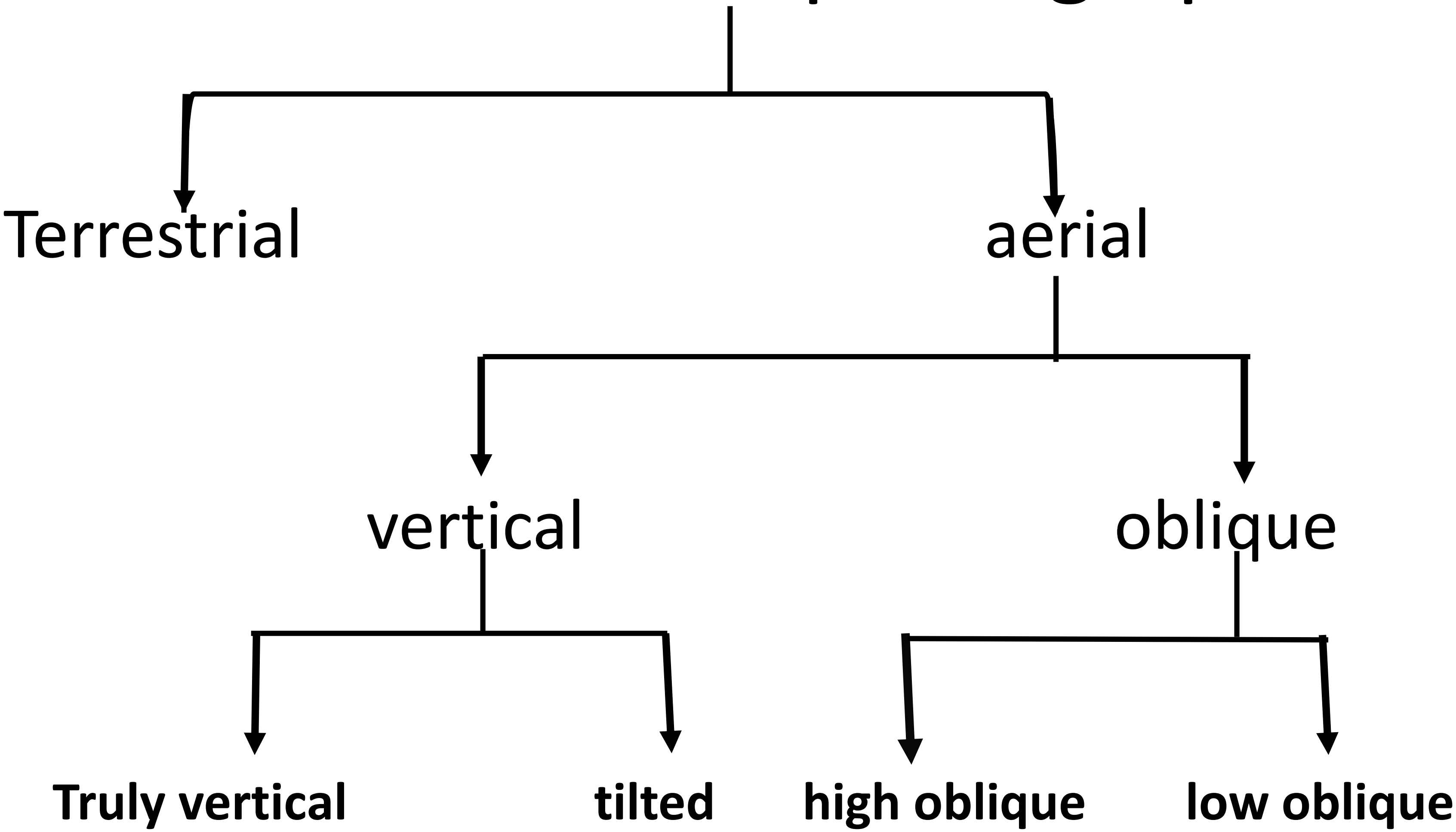


Vertical AP

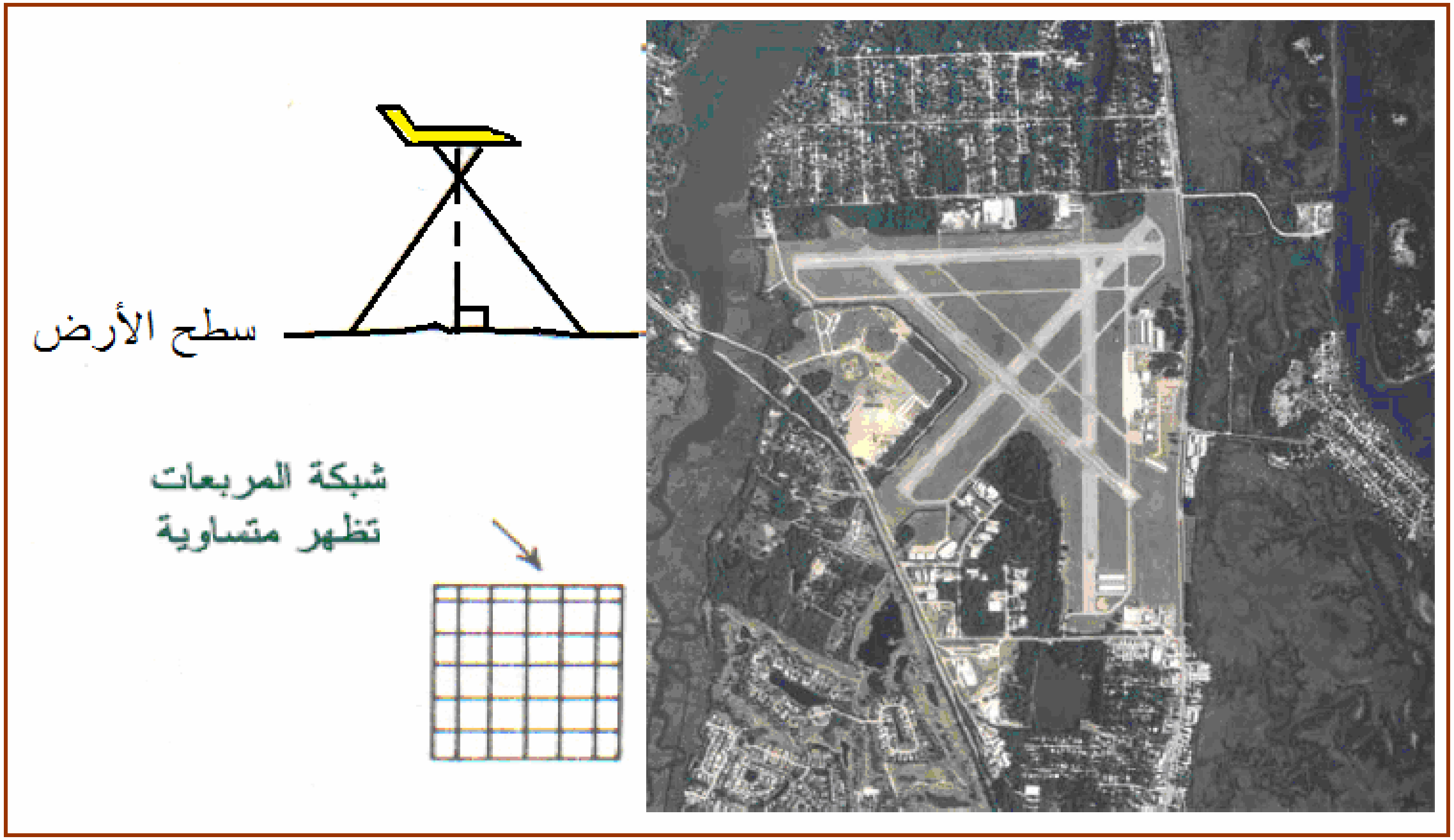
Low oblique AP

High oblique AP

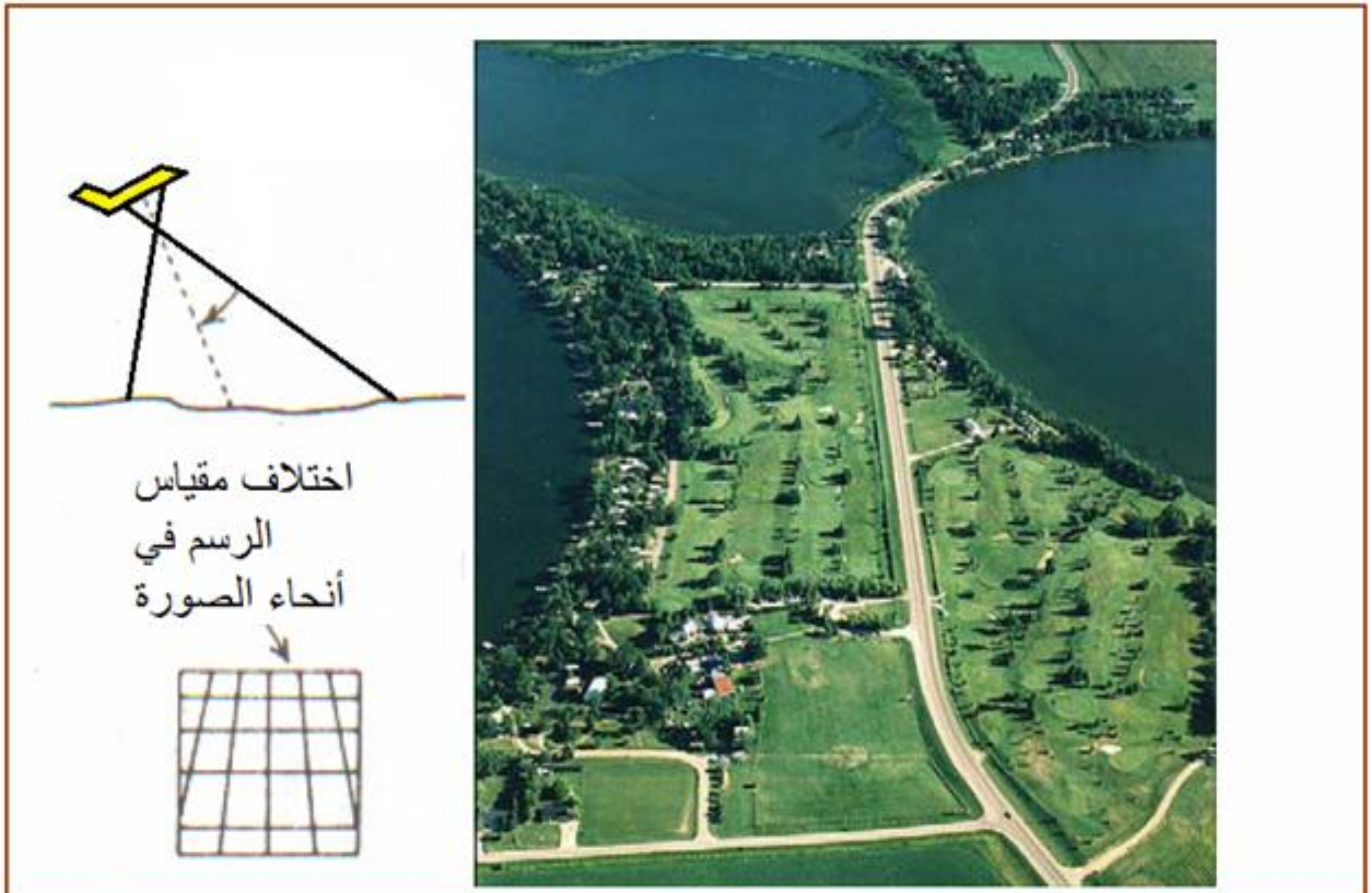
Classification of photographs



1-Vertical



2-Low oblique



3-High oblique

Why Photogrammetry

1-extracting geometrical information and producing maps.

2-cheaper than terrestrial methods.

3-extracting qualitative information.

4-high speed of map generation.

Applications of Photogrammetry

1. To prepare planimetric topographical maps (Surveying/mapping).
2. To determine the space position of ground objects.
3. For acquisition of military intelligence
4. To classify soil (Forestry/agriculture).
5. For the interpretation of geology (Geology/archaeology).
6. Assessment of crop damage due to floods or other natural calamities.
7. To prepare a composite picture of ground.
8. To relocate existing property boundaries.
9. In the field of medicine.

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2nd Stage
Photogrammetry

Topic 2 :
Geometry of Aerial Photographs & Types of Aerial Photogrammetry

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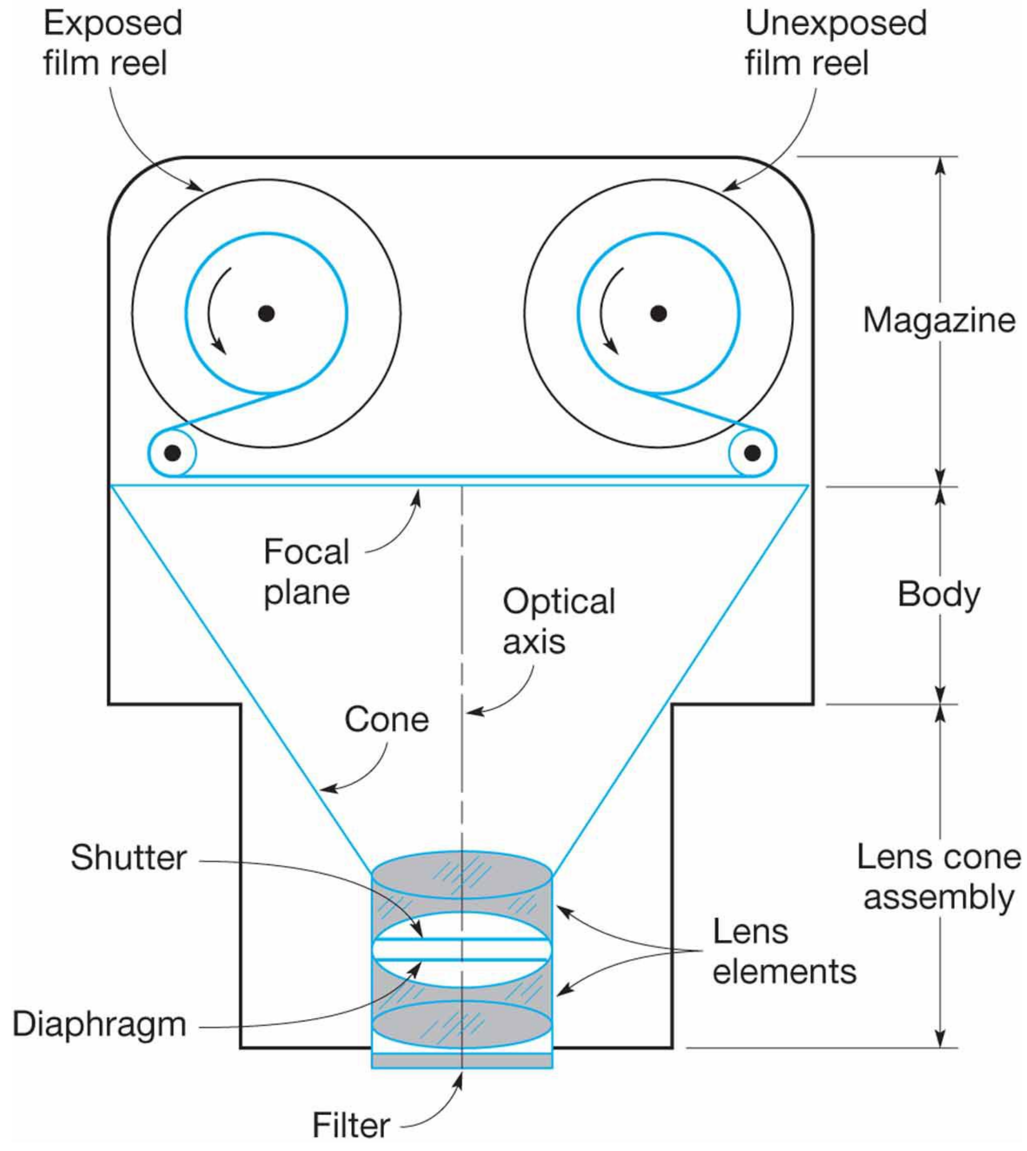
Components of a single frame film camera.

Three main parts:

1. Magazine
2. Body
3. Lens cone assembly



Aerial Cameras

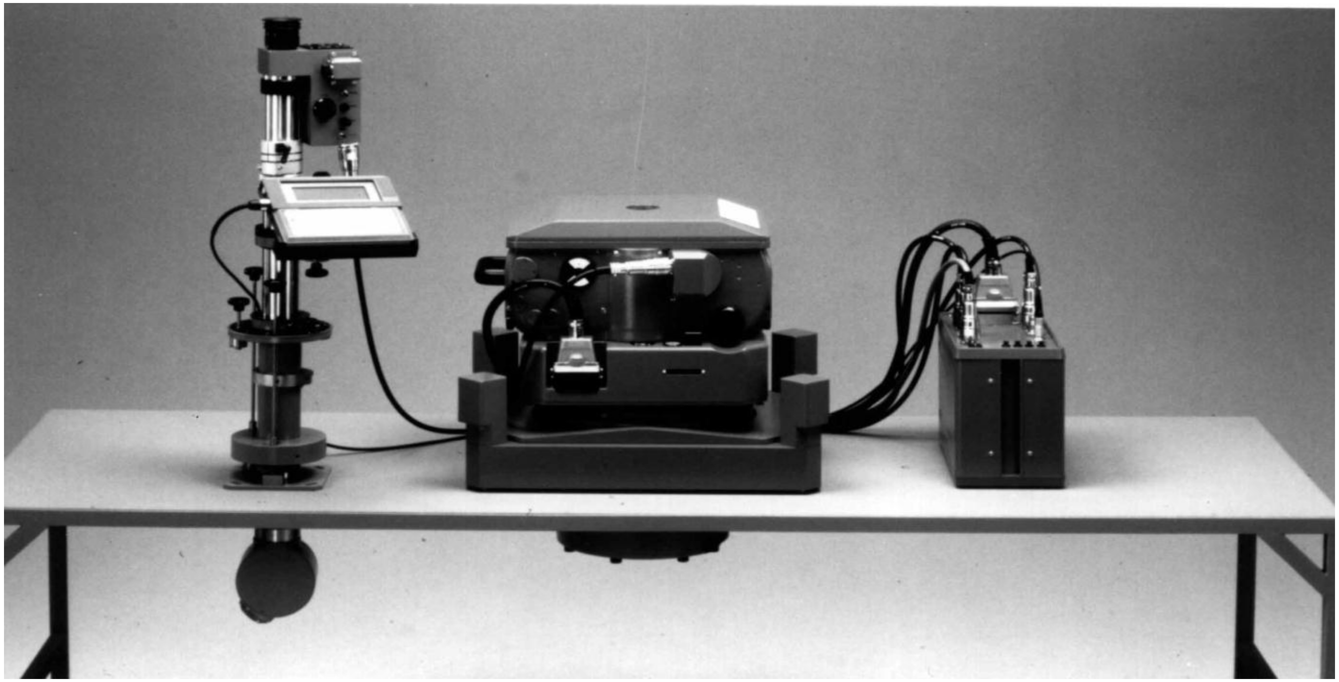
- **Aerial cameras must be:**
  - Geometrically stable
  - Have fast and efficient shutters
  - Have high geometric and optical quality lenses

Many factors determine the quality of aerial photography, such as

1. Design and quality of lens system.
2. Manufacturing the camera.
3. Photographic material.
4. Development process.
5. Weather conditions and sun angle during photo flight.

Types of Aerial camera

1. Single lens camera (Aerial mapping camera):



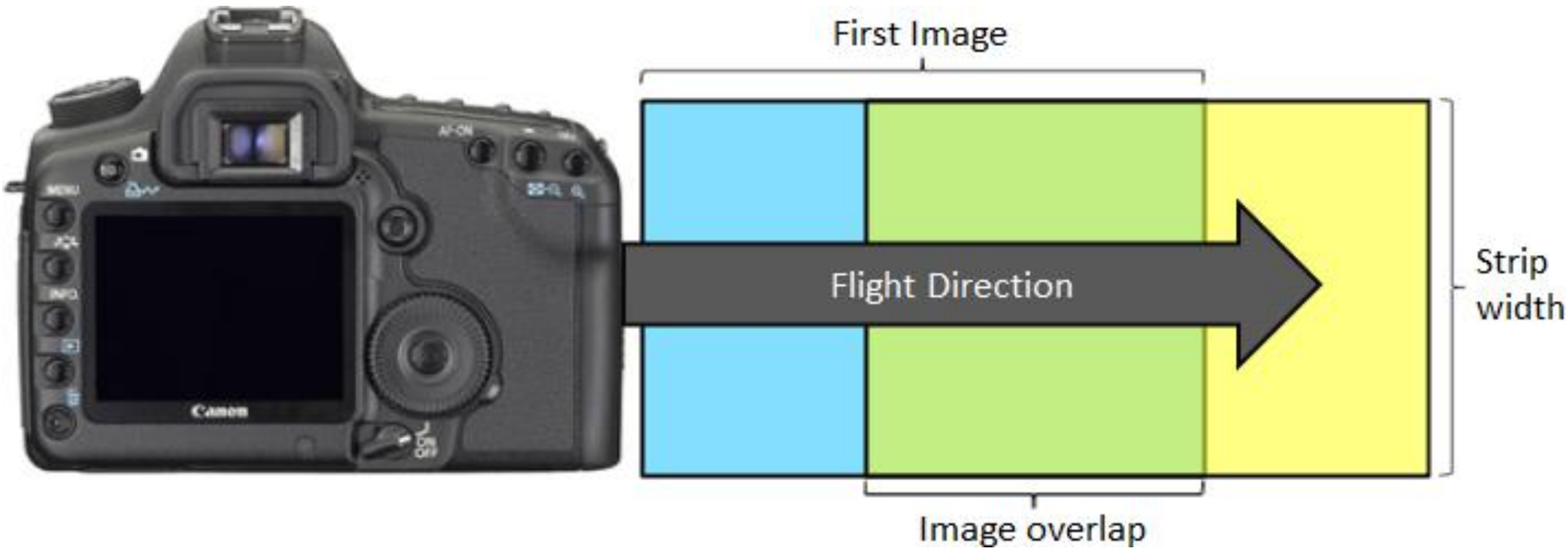
Aerial mapping cameras (also called as metric or cartographic cameras) are single lens frame cameras designed to provide high geometric image quality.

Types of Aerial camera

2- Multi lens (Bands) camera:

Types of Aerial camera

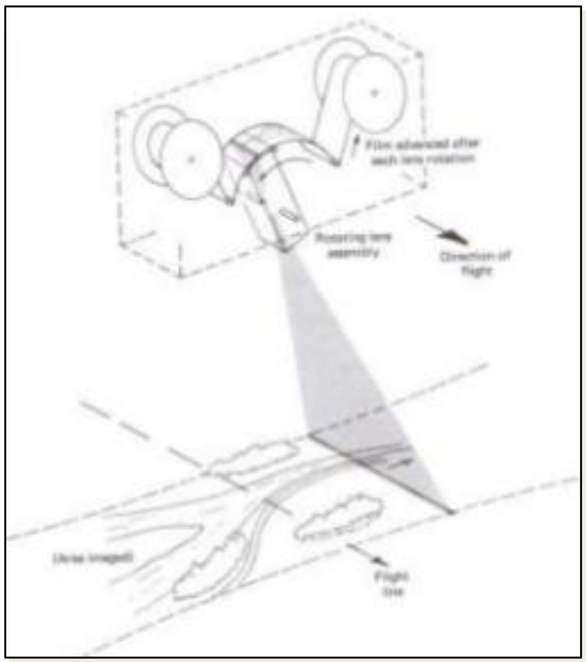
3- Strep camera:



Types of Aerial camera

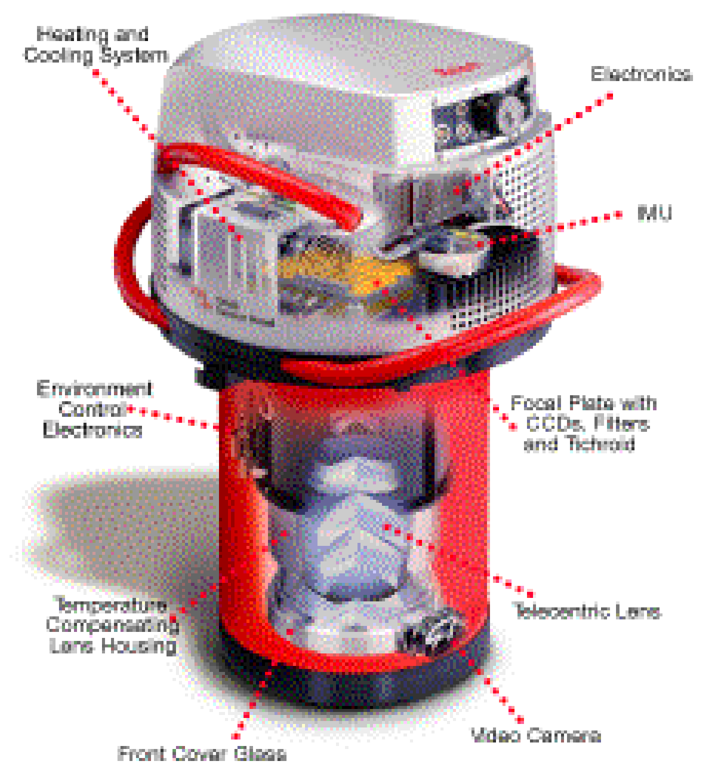
4- Panoramic camera:

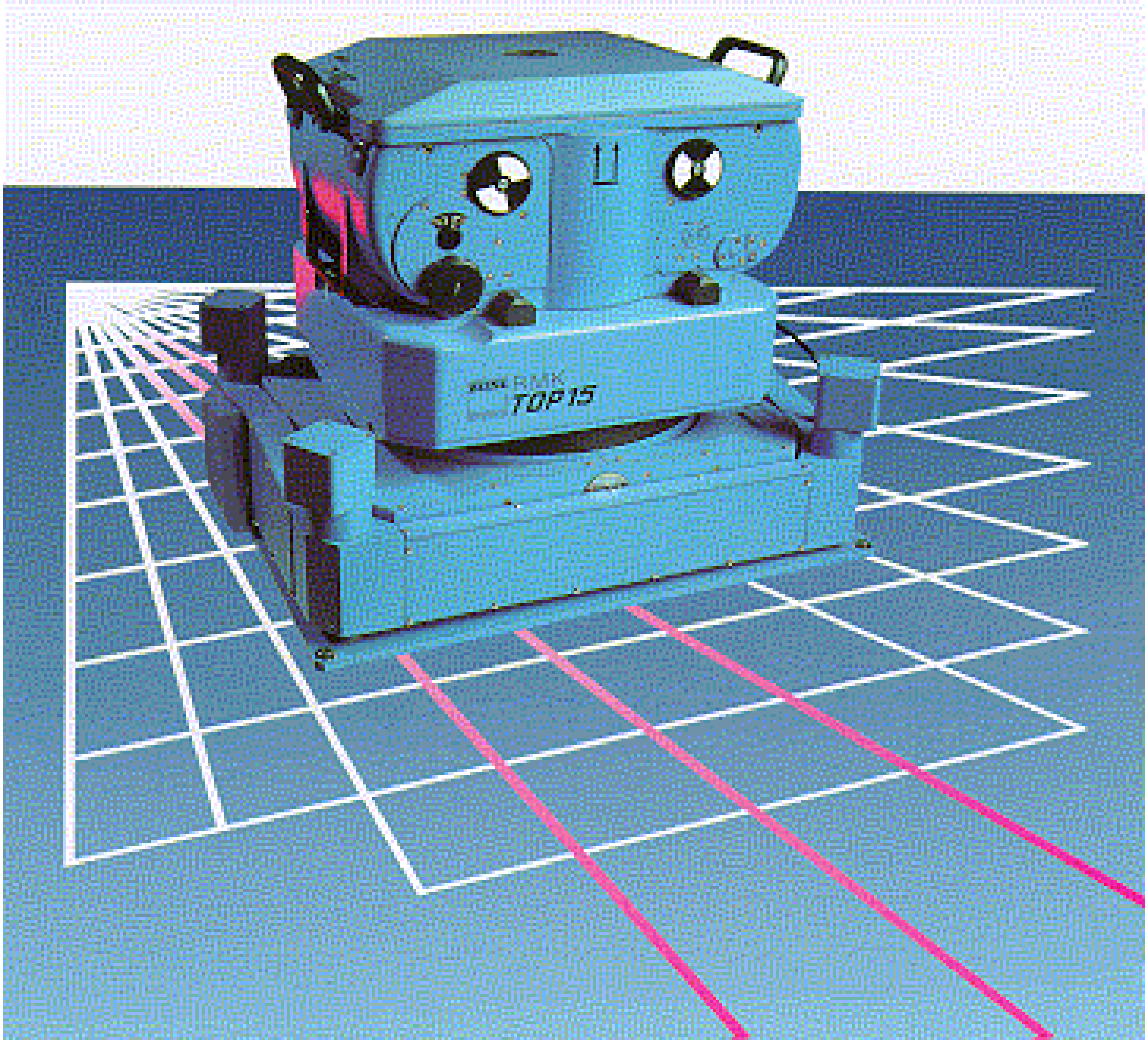
Camera with a rotating prism design contain a fixed lens and a flat film plane. Scanning is accomplished by rotating the prism in front of the lens.



Types of Aerial camera

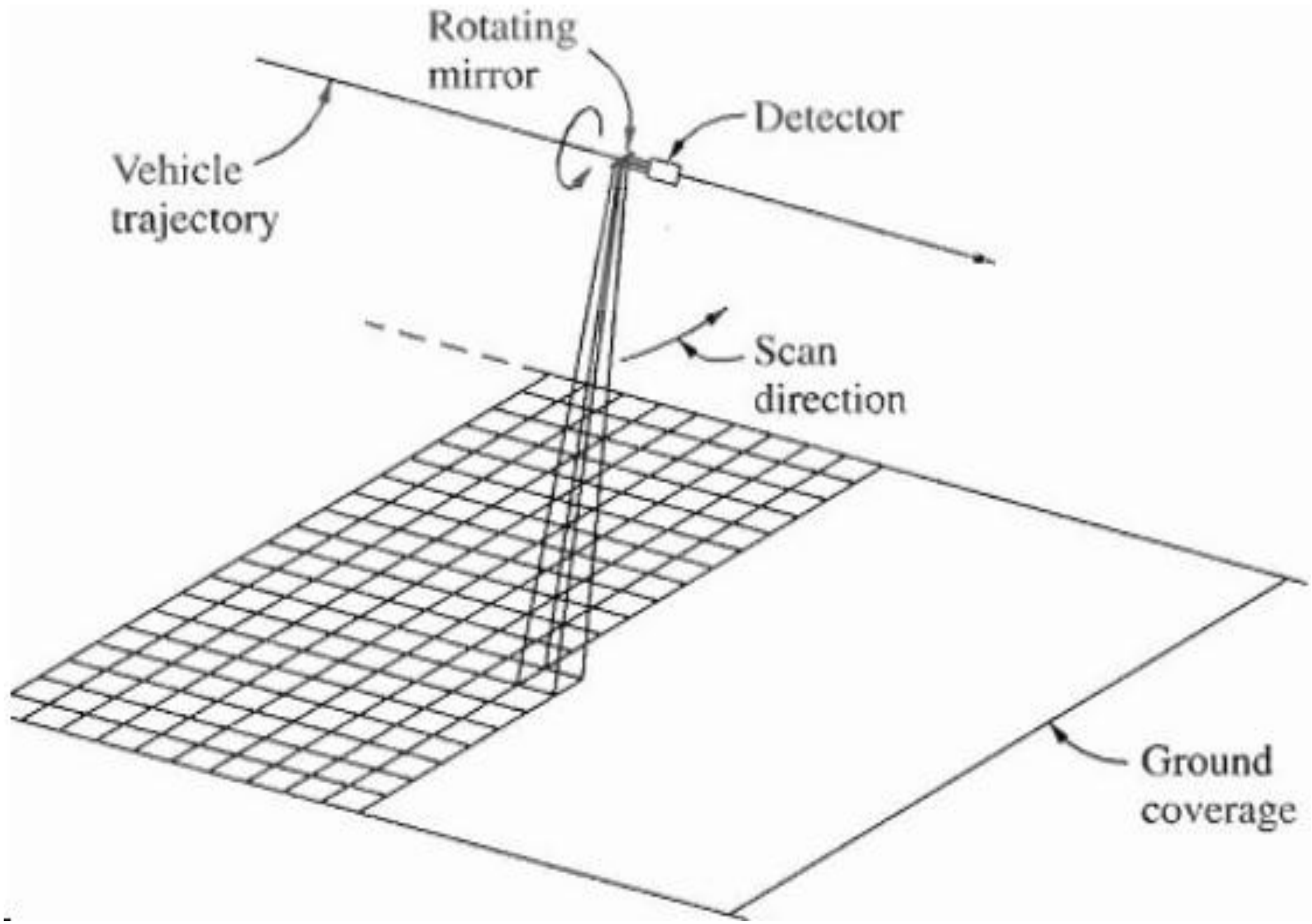
5- Digital camera:




TOP 15

Aerial Camera in action


EXPERIMENTAL


Rotating mirror
Detector
Vehicle trajectory
Scan direction
Ground coverage

Aerial photographs classification by the camera according to angle of view :

1. The camera angle normal:

The value of the angle **(< 75°)** degrees And the focal length between 170 to 305 mm add the dimensions of Aerial photographs 140 X 140 mm or 180 X 180 mm or 230 X 230 mm.

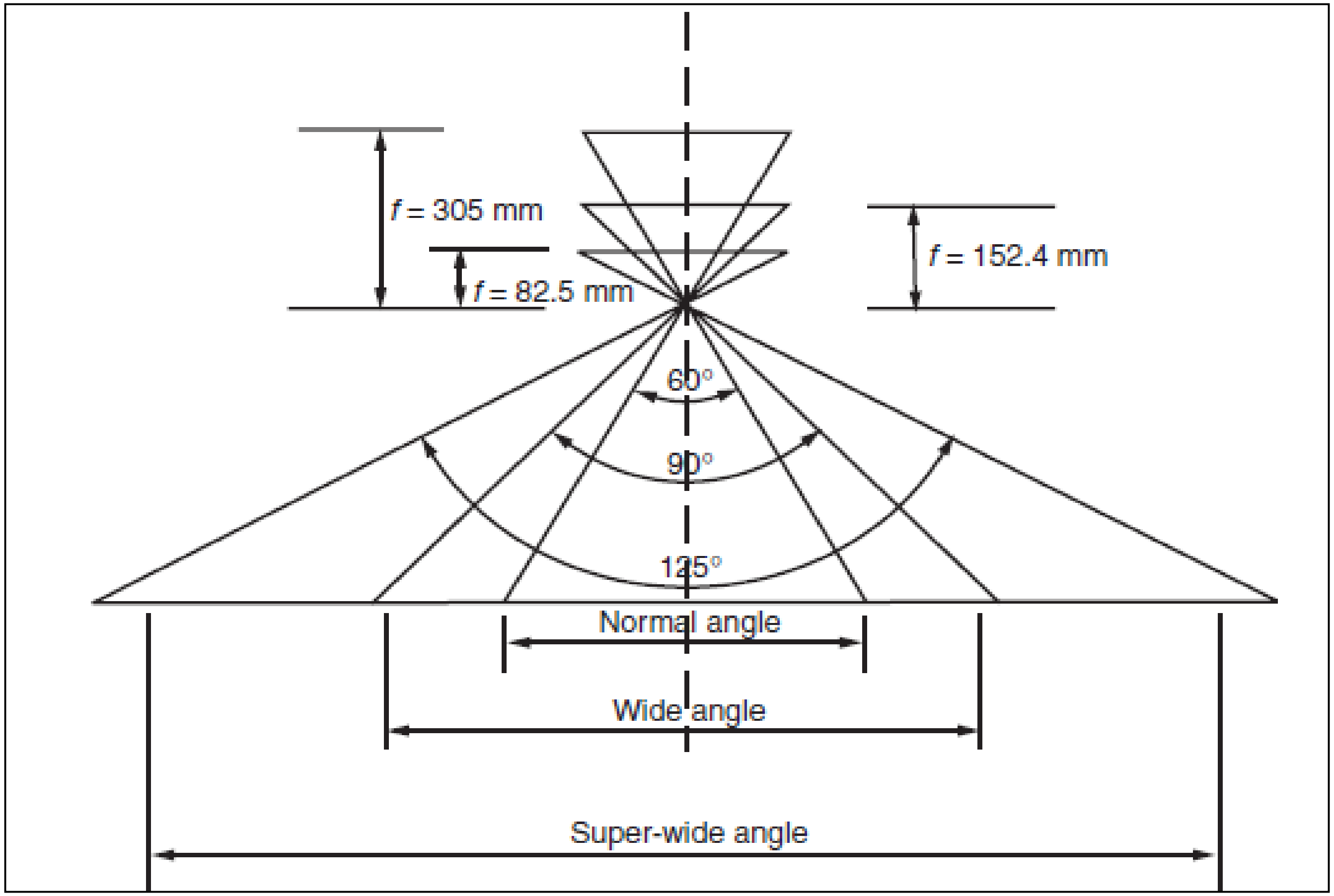
2. The camera angle wide:

The value of the angle **(up to 75°)** degrees and the focal length between 100 to102 mm and the dimensions of Aerial photographs 140 X 140 mm or 180X 180 mm or 230 X 230 mm.

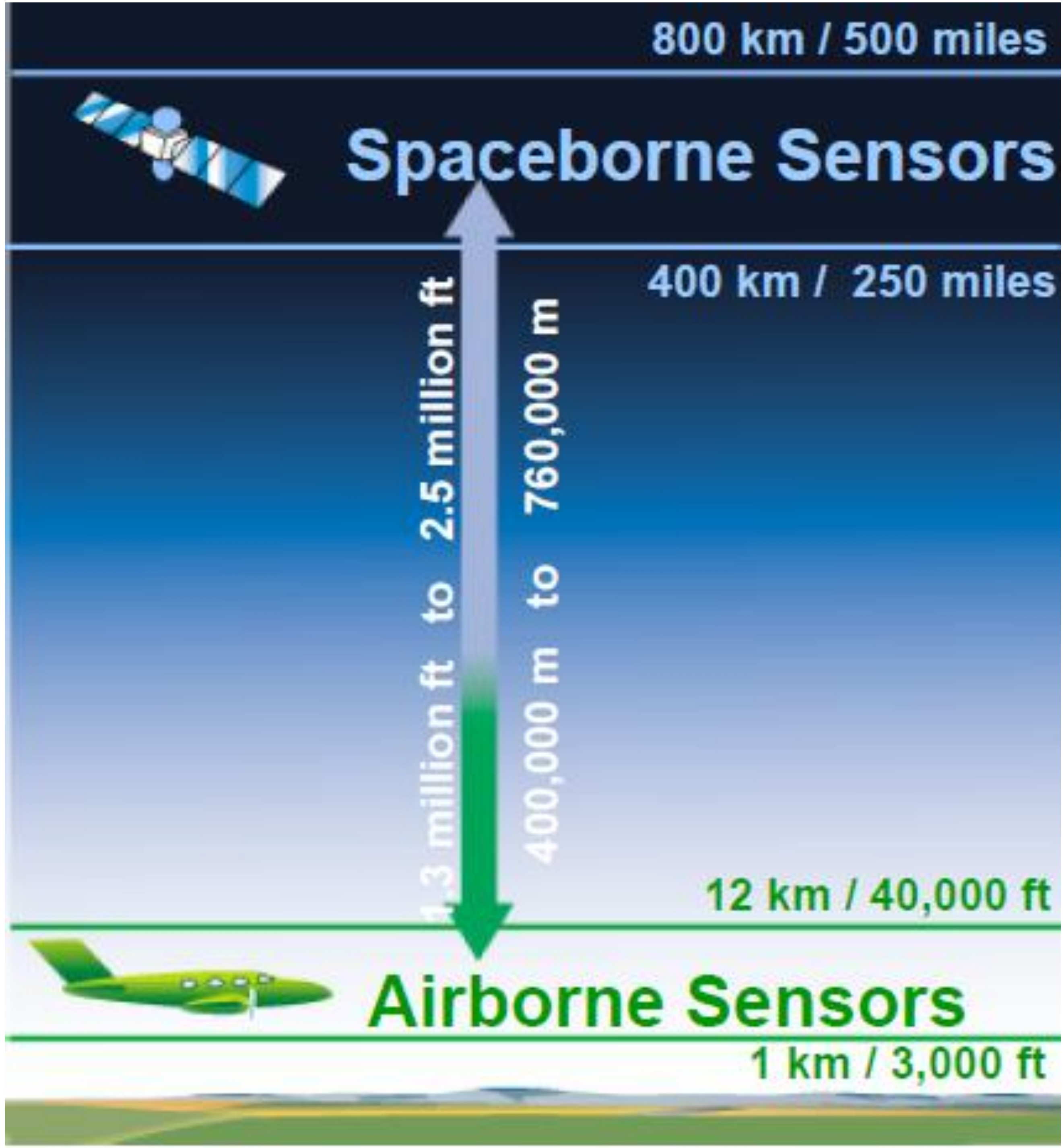
3. The camera super angel wide:

The value of the angle between **(120 to 135)** degrees And the focal length between 55 to 88.5 mm and the dimensions of Aerial photographs 180 X 180 mm or 230 X 230 mm.

Aerial photographs classification by the camera according to angle of view :



Airborne and Spaceborne Imagery



Geometry of vertical aerial photograph

- Tilt ≤ 3° from the vertical optical axis
- Scale is approximately constant throughout

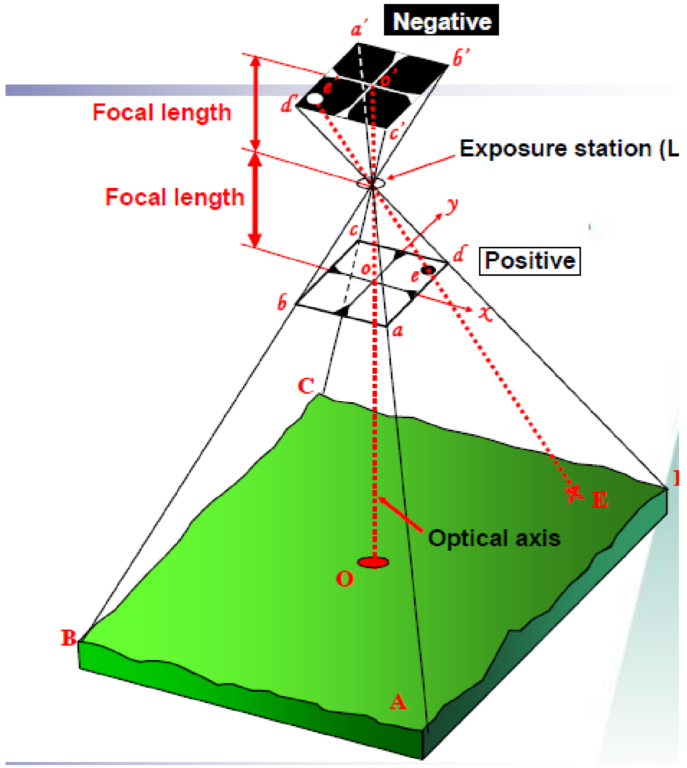
 the photo

- Within limitations, a vertical aerial photo can

Be Used as a map substitute

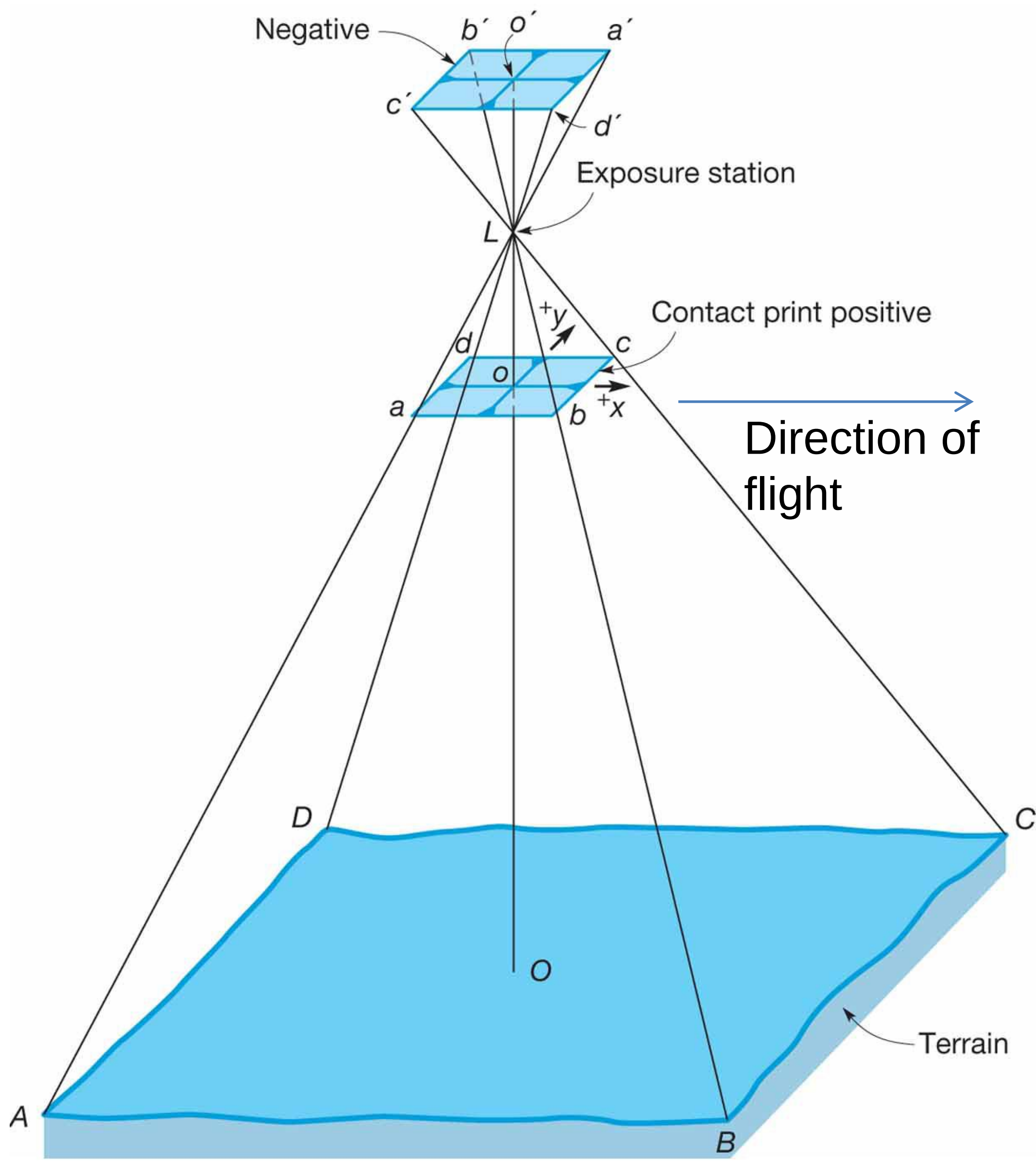
- Most common format is a 9*9 inch

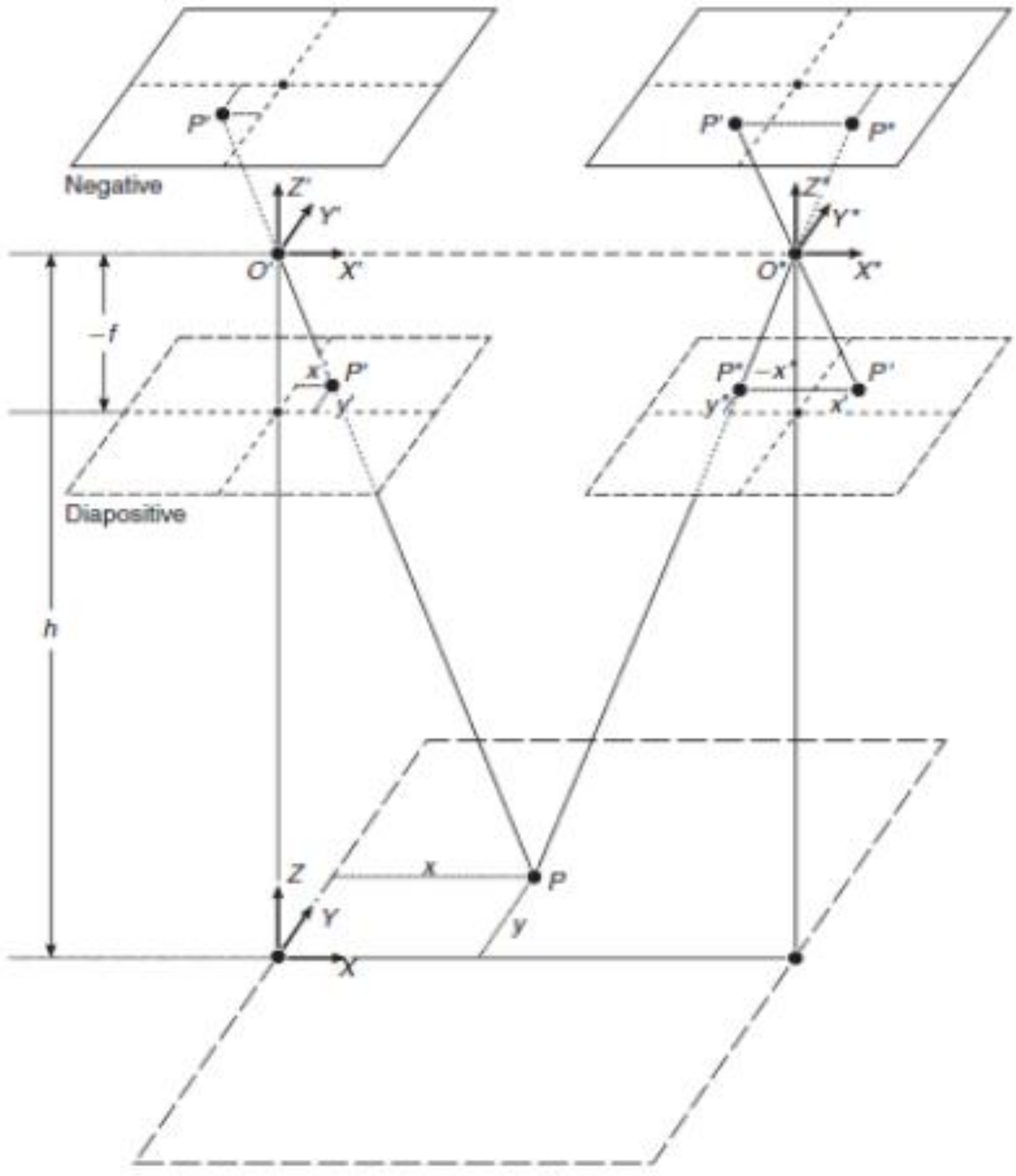
 photograph



Geometry of a vertical photographs

- The line LoO, the optical axis is assumed truly vertical
- The photocoordinate origin,o, is considered to be intersection of the tow lines joining the fiducial marks
- Geometric center of the photograph called ***principal point***





P'
Negative
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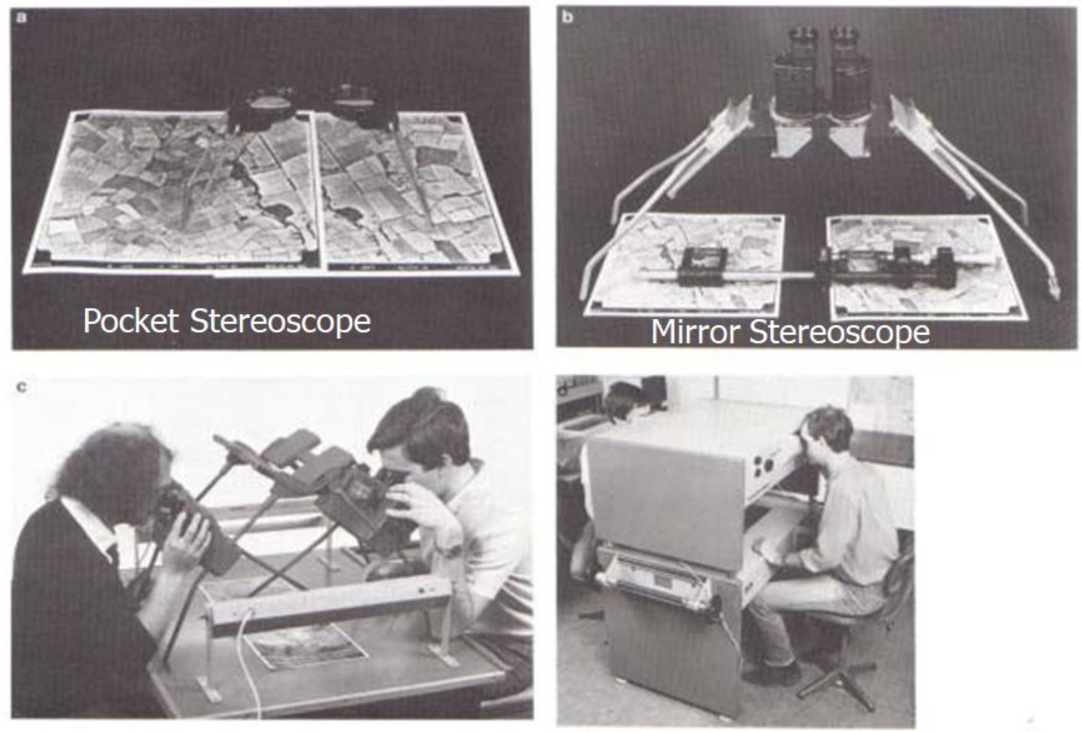
stereoscope

- A **stereoscope** is a device for viewing a stereoscopic pair of separate images, depicting left-eye and right-eye views of the same scene, as a single three-dimensional image.
- **Types of stereoscope:**

1. pocket stereoscope
2. Mirror stereoscope
3. Scanning stereoscope
4. Interpreter scope



Pocket Stereoscope

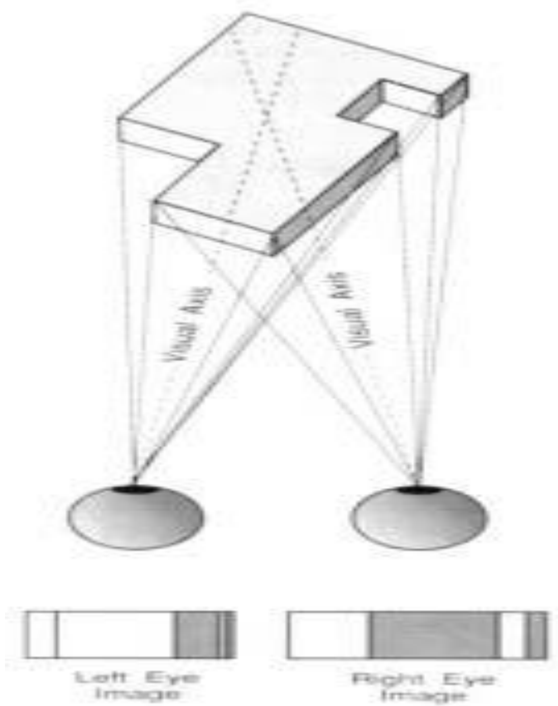
Mirror Stereoscope

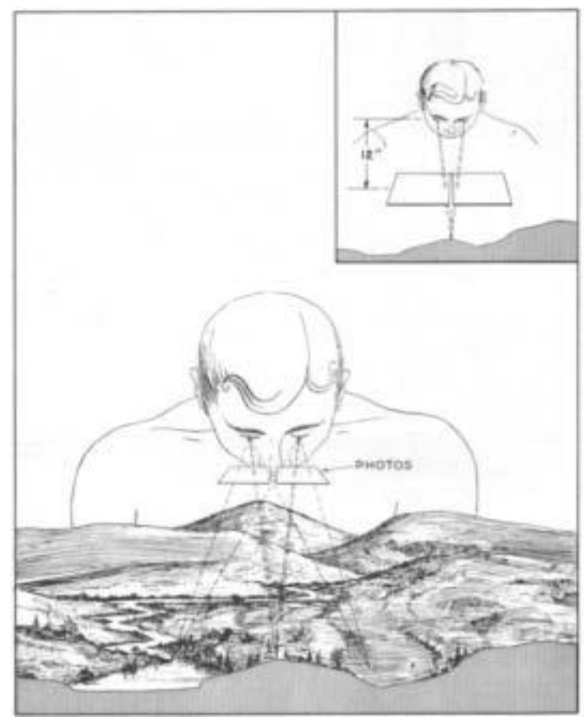
Scanning Stereoscope

((Carl ZeissInterpreterscope^

Stereoscopic View

- Our left and right eyes are recording information from two slightly differing viewpoints; the brain uses the effect of parallax to give us the perception of depth





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2nd Stage
Photogrammetry I

Topic 3 :
Scale of Photograph

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Scale of a Vertical Photograph

Scale of a photograph is the ratio of a distance on a photo to the same distance on the ground.

There are two methods which can be determine photo scale of an airphoto:

1. **<u>Arithmetic proportion</u>**

It is possible to determine photo scale by comparing an object or distance between two points on the airphoto (photo distance) with the same object or points on a topographic map (true ground distance).

$$photo\ scale\ (\boldsymbol{Ps}) = \frac{photo\ distance(ab)}{ground\ distance(AB)}$$

NOTE: both the photo distance and the ground distance must be in the same units

Scale of a Vertical Photograph

2. camera-altitude relationship:

It is possible to determine the photo scale by knowing the camera focal length and aircraft height.

The relationship between camera focal length and aircraft height above ground is given by :

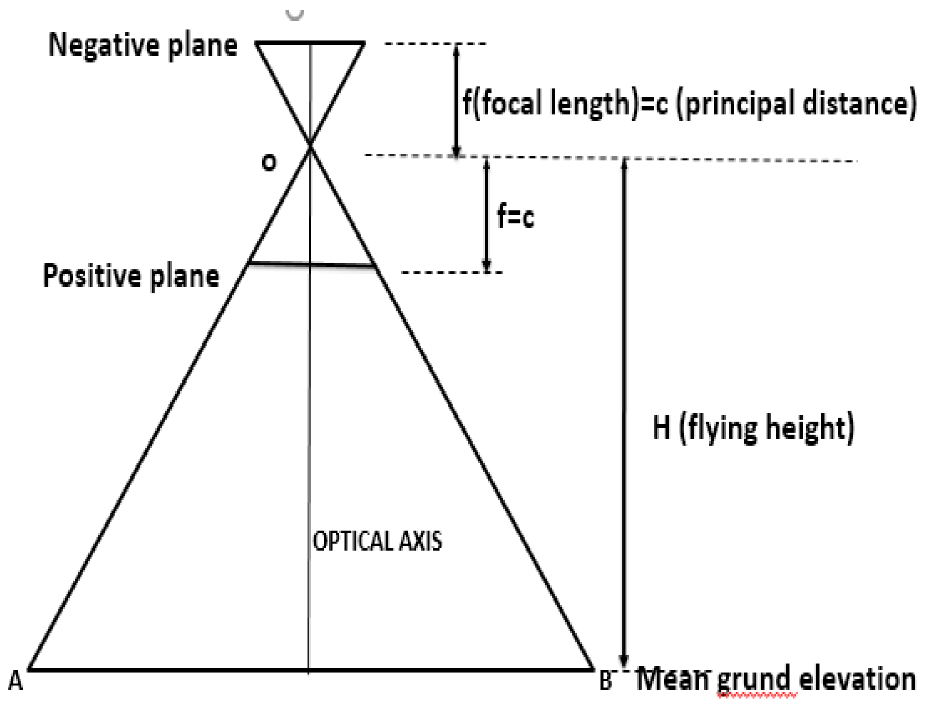
$$photo\ scale\ (\boldsymbol{Ps}) = \frac{focal\ length(f)}{flying\ heiht\ above\ ground(H)}$$

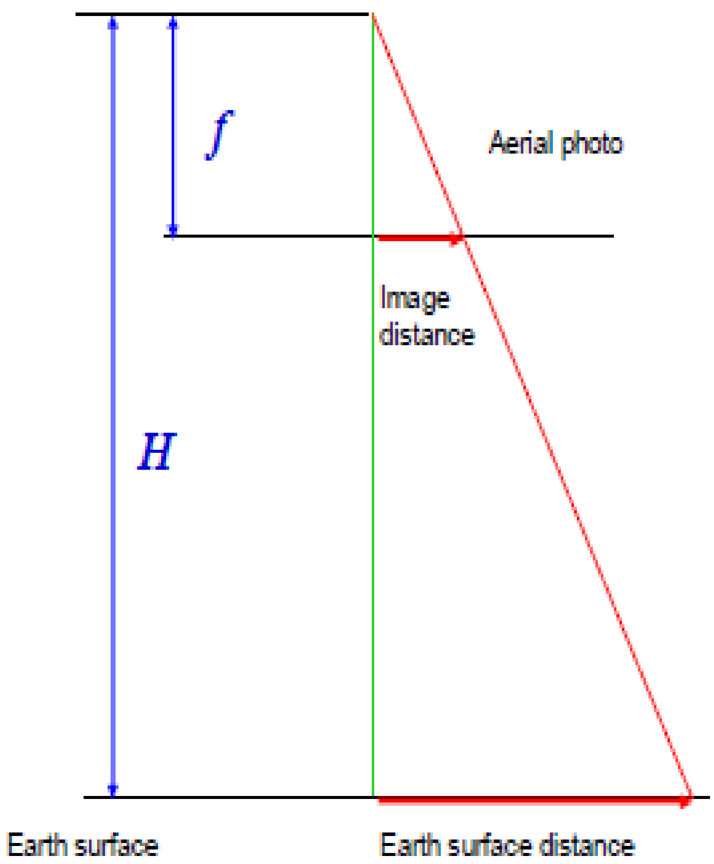
NOTE: both the camera focal length and aircraft Height must be in the same units

Scale of a vertical photograph over flat terrain

- On a map**, all point are supposed to be at the same scale**. However, due to the perspective projection of a photograph**, the variation in elevation** –thus the flying height above ground features, and **the effects of relief and tilt**, the scale of an aerial photograph **may vary considerably from one point to another**. A photograph may only present a **uniform scale** comparable to that of a map **if the camera is perfectly vertical at the time of exposure and the terrain is perfectly flat.** Since these condition are seldom fulfill, the **photographic scale** is usually considered **for individual points or the average of a set of points**. The first is referred to as point scale and the second is referred to as average scale.

Scale of a vertical photograph over flat terrain





The scale of a vertical photograph approximately equals to the ratio of the flying height above the ground (*H*) and the focal length of the camera lens (*f*)

$$Scale = \frac{imageDist}{surfaceDist} = \frac{f}{H}$$

Scale of a vertical photograph over variable terrain

- ***Point scale*** is the scale at a point with a specific elevation on the ground. This suggests every point on a vertical photograph at a different elevation will have a different scale. Therefore, a photograph taken over a rugged terrain will display a varying range of scales associated with variations in elevation of the ground.

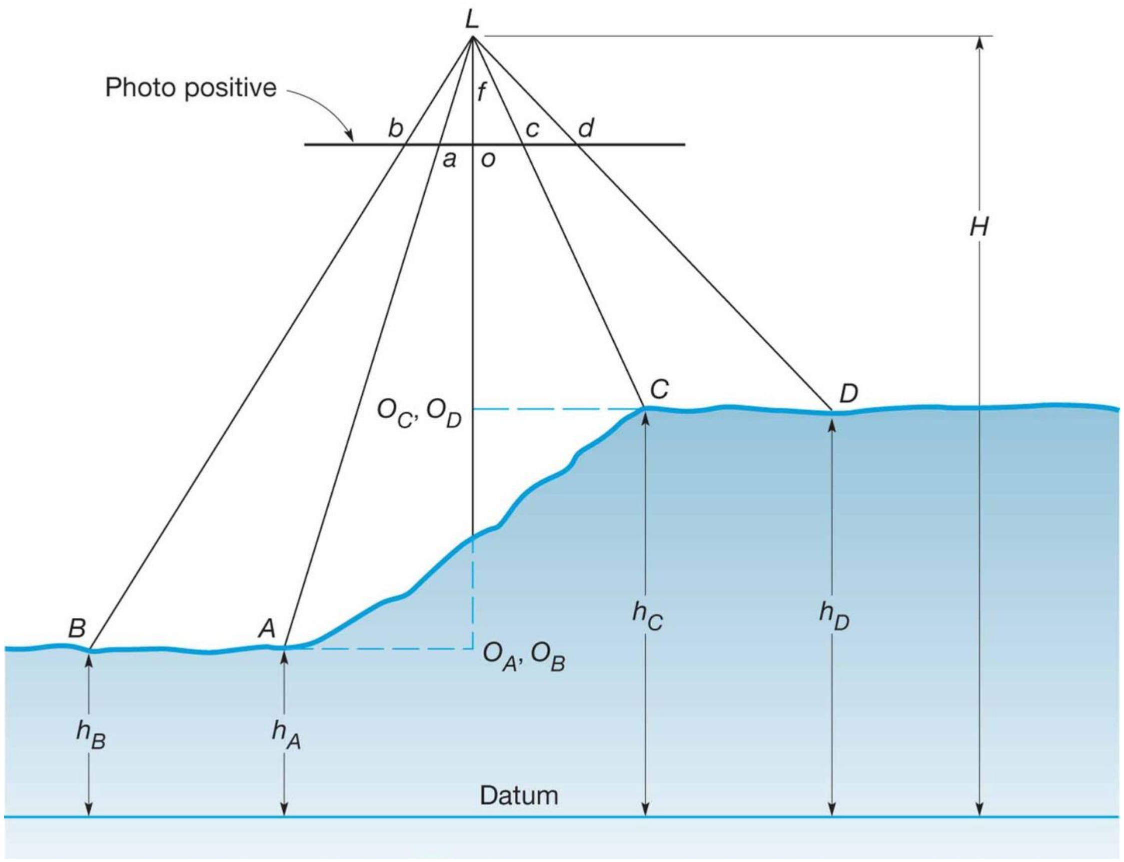
Scale of a photograph $(\boldsymbol{Ps}) = \frac{(\boldsymbol{f})}{(\boldsymbol{H}-\boldsymbol{h})}$

Where f is the focal length of the camera used to take the photograph, the distance between the lens and the focal plane

H is the flying height of the aircraft above mean sea level

h is the elevation of point above MSL

Scale of a vertical photograph over variable terrain



- Scale of a photograph $(Sp) = \frac{(f)}{(H-h)}$
- Average scale of a photograph $\left(s_{avg}\right) = \frac{(f)}{\left(H-h_{avg}\right)}$
- Minimum scale of a photograph $(s_{min}) = \frac{(f)}{(H-h_{min})}$
- Maximum scale of a photograph $(s_{max}) = \frac{(f)}{(H-h_{max})}$

Other methods of determining scale

There are other methods of scale determination which **do not require knowledge of focal length**, terrain elevation and flying height values. One of these method is measuring the ground distance between two points whose images **appear** on the photograph. After the corresponding photo distance is measured, the scale relationship is simply the ratio of the photo distance to the ground distance

$$(photo_{scale}) = \frac{photo\ distance}{map\ distance}$$

Note :the resulting scale is exact only at the elevation of ground line, and if the line is along slop ground, the resulting scale applies at approximately the average elevation the two and end points of the line.

Other methods of determining scale

- The scale of vertical photograph may also be determined if a map converging the same area as the photo is available. In this method it is necessary to measure, on the photograph and on the map, the distance between two well defined points which can be identified on both photo and map. Photographic scale can then be calculated from the following equation:

$$(photo_{scale}) = \frac{photo\ distance}{map\ distance} * \mathbf{map\ scale}$$

H.W2

Q1/A vertical aerial photograph is taken over flat terrain with a 152.4mm – focal length camera from an altitude of 1830m above ground what is the photo scale?

Q2/The horizontal distance AB between the centers of 2 street intersections was measured on the ground as 300m corresponding line ab appears on a vertical photograph and measures 95.8mm what is the photo scale at the ground elevation of this line?

Q3/A vertical photograph was taken at an altitude of 1500m above MSL determine the scale of the photograph for terrain lying at elevation of 750 m if the focal length of camera is 15cm?

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2nd Stage
Photogrammetry I

Topic 4 :
Coordinates

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Measurements on a Vertical Photograph

- **Coordinate systems** are using two or more numbers (coordinates) to determine the position of a point or other geometry in the space
- For cameras with side fiducial marks, the commonly adopted reference system for photographic coordinates is the rectangular axis system formed by joining opposite fiducial marks with straight lines,
- The origin(center of collimation) of the coordinate system is the intersection of fiducial lines.
- The x axis is usually designed as the fiducial lines most nearly parallel with the direction of flight, positive in the direction of flight.

- $\mathbf{ab} = \sqrt{(\boldsymbol{x_a} - \boldsymbol{x_b})^2 + (\boldsymbol{y_a} - \boldsymbol{y_b})^2}$

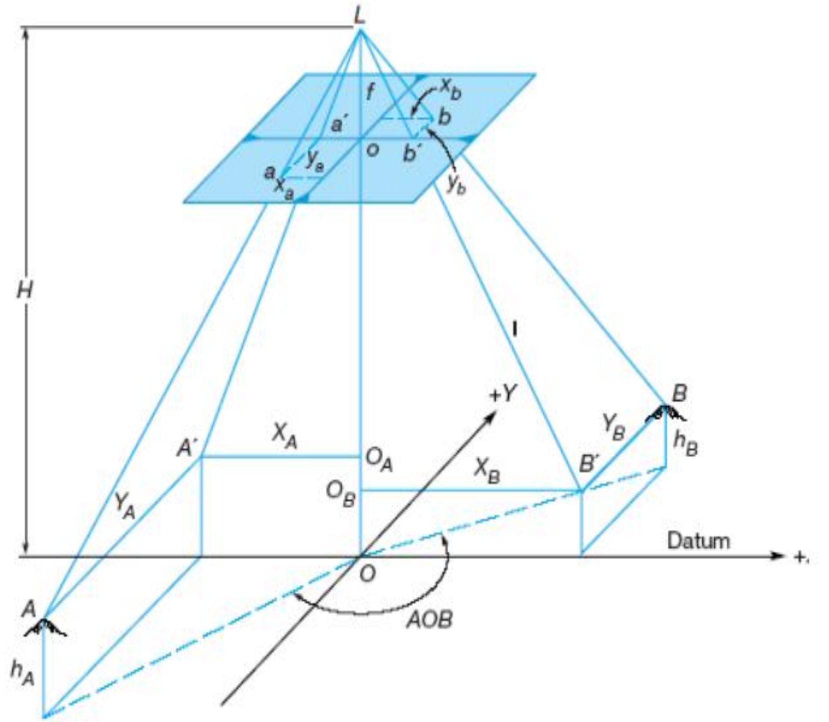
Determining horizontal ground distance, directions, and angles from photocoordinates on an aerial photograph taken over varied terrain

- When ***a photograph is taken vertically over flat terrain***, it will accurately represent the geometry of the imaged terrain and the scale will be constant throughout the entire photograph. In this case, the photograph may be used as a map and distances measured on the photograph may be corrected to ground distances by simply multiplying the measured values by the photo scale reciprocal. Similarly, angles may be directly measured on the photograph as accurately as they would be on a map.
- To determine distance and angles of points that are at ***different elevations on the ground***, we must first convert the photocoordinates of points on the photograph to a datum-level ground coordinate system. From similar triangles LO_AA´ and Loa´ in figure below, we obtain:

$$\frac{x_a}{X_A} = \frac{f}{H_{D-h_A}} \quad \text{therefore} \quad X_A = \frac{H_{D-h_A}}{f} x_a$$

And from similar triangles LA´A and La´a in figure below, we obtain:

$$\frac{y_a}{Y_A} = \frac{f}{H_{D-h_A}} \quad \text{therefore} \quad Y_A = \frac{H_{D-h}}{f} y_a$$



Where:

$\boldsymbol{H_D}$ is the flying altitude of the aircraft above the datum,

$\boldsymbol{h_A}$ is the ground elevation of point A above the datum,

$\boldsymbol{x_a}$ is the photocoordinate of point A measured on the photograph along the x-axis,

$\boldsymbol{y_a}$ is the photocoordinate of point A measured on the photograph along the y-axis,

$\boldsymbol{X_A}$ is the ground coordinate of point A along x-axis, and

$\boldsymbol{Y_A}$ is the ground coordinate of point A along y-axis, and.

In the above equations, the ground coordinate of ***any point on the photograph*** are obtained by simply multiplying the photocoordinates of that point(measured on the photograph) by the photo scale inverse (i.e., $\frac{\boldsymbol{H_{D-h_A}}}{\boldsymbol{f}}$).

therefore groundcoordinates for point B can be expressed as:

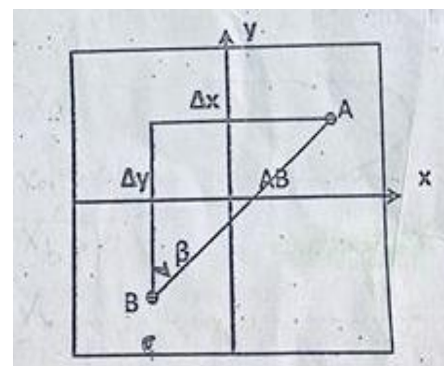
- $X_B = \frac{H_{D-h_B}}{f} x_b$ $Y_B = \frac{H_{D-h}}{f} y_b$
- Similarly, the ground coordinates for any point on the photograph can be determined as:

$$X = \frac{H_{D-h}}{f} x \qquad Y = \frac{H_{D-h}}{f} y$$

$$<AOB = \theta = \tan^{-1}\left(\frac{y_a}{y_b}\right)$$

- Once the ground coordinates of points A and B determined, the **horizontal distance between A and B** may be mathematically computed using Pythagorean theorem.

- $AB = \sqrt{(X_A - X_B)^2 + (Y_A - Y_B)^2}$
- $ab = \sqrt{(x_a - x_b)^2 + (y_a - y_b)^2}$
- $\beta = \tan^{-1}\left(\frac{\Delta x}{\Delta y}\right)$



direction of the ground

- The ground coordinates can also be used to determine the ***direction of the ground*** line passing through points A and B. if α is the angular direction of line AB measured clockwise from the +Y-axis, it can be computed trigonometrically from the ground coordinates as:

- **Direction B to A =α=tan^{-1}**$\left[\dfrac{X_A - X_B}{Y_A - Y_B}\right]$

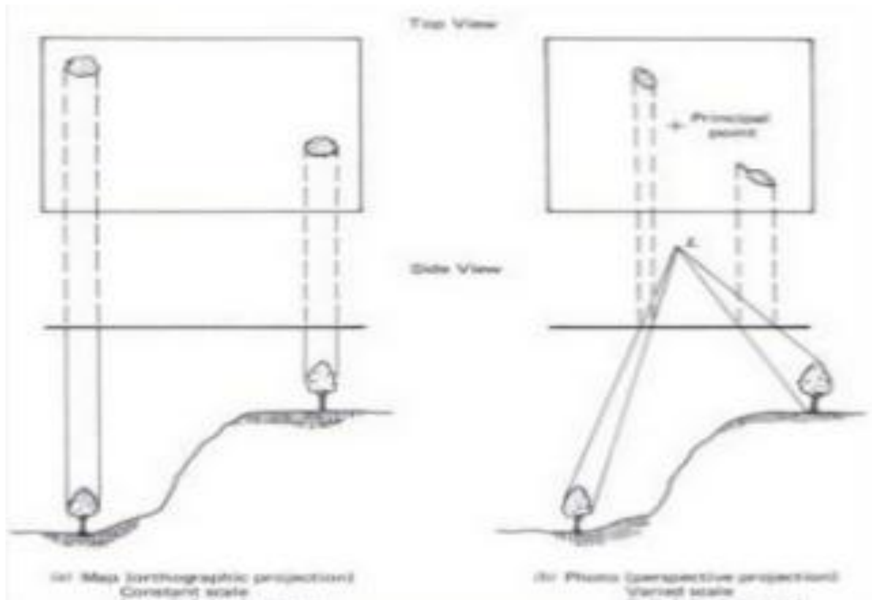
Topographic map

Map scale is ordinary interpreted as the ratio of a map distance to the corresponding distance on the ground.

$$\boldsymbol{map\ scale\ (Sm) = \frac{map\ distance(ab)}{ground\ distance(AB)}}$$

Difference between a map and an aerial photograph

Aerial Photograph	Map
It is a central Projection.	It is an orthogonal Projection.
An aerial photograph is geometrically incorrect. The distortion in the geometry is minimum at the center and increases towards the edges of the photographs.	A map is a geometrically correct representation of the part of the earth projected.
The scale of the photograph is not uniform.	The scale of the map is uniform through out the map extent.
Enlargement/reduction does not change the contents of the photographs and can easily be carried out.	Enlargement/reduction of the maps involves redrawing it afresh.
Aerial photography holds good for inaccessible and inhospitable areas.	The mapping of inaccessible and inhospitable areas is very difficult and sometimes it becomes impossible.


Top View
Principal point
Side View
Map (orthographic projection)
Constant scale
No relief displacement
Photo (perspective projection)
Varied scale
Relief displacement

H.W

Two points a and b on photograph of two ground points A and B were identified on a vertical photograph taken with a 152.4mm focal length camera. The photo coordinates of points a and b are x_a = 4.55 cm, y_a = -5.62 cm, x_b = 8.25 cm, and y_b = -7.75 cm. The horizontal distance between A and B is 1000 m. Find the flying height of the aircraft above datum?

Vertical Exaggeration in Stereoviewing

with three dimensional viewing of airphotos is vertical exaggeration. Objects in the image appear to be taller than in reality and slopes appear to be steeper. Apparent scale disparity between horizontal and vertical scales.Vertical exaggeration appear because of the difference in geometry when taking the airphotos and when viewing the airphotos

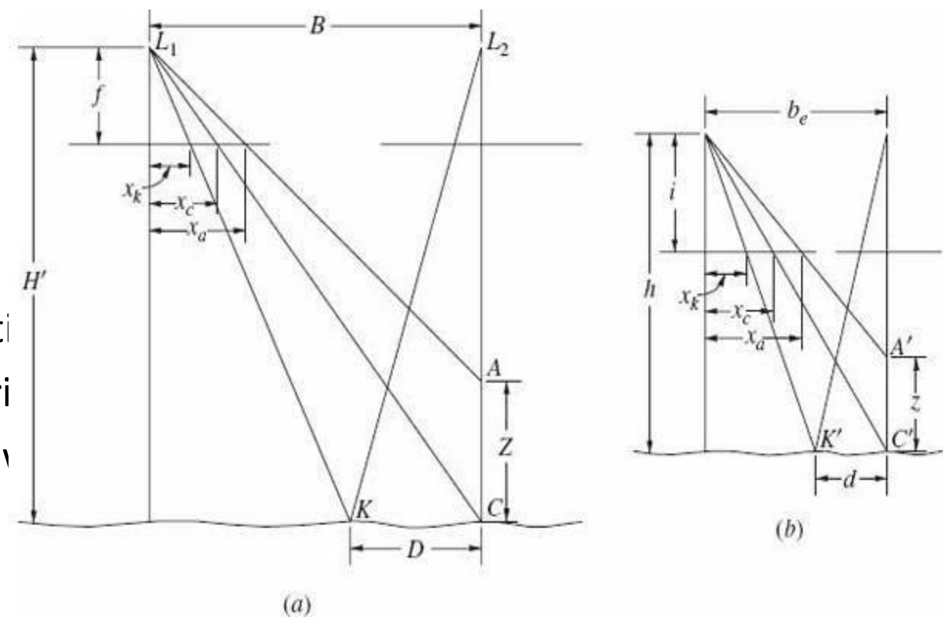
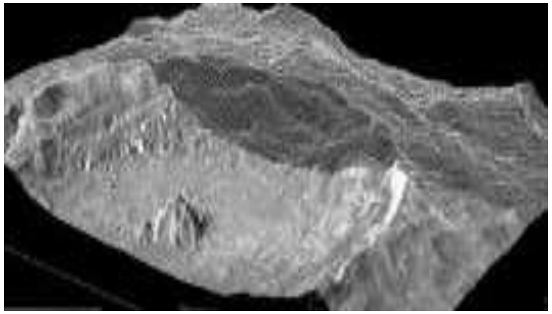


FIGURE 1 Simplistic diagrams for analyzing verti
exaggeration. (*a*) Geometry of overlapping aeri
photography. (*b*) Geometry of stereoscopic vie
of the photos of part (a).

Vertical Exaggeration - Causes

Stereoscopic Causes	Photographic Causes
• Viewing distance	Photographic scale
• Separation of photographs	Altitude above terrain
• Eye bas	Air base
• Magnification	Terrain relief



Vertical Exaggeration in Stereoviewing

An equation **for calculating vertical exaggeration** can be developed with reference to these figures. From similar triangles of [Fig.*a*](),

(*a*) $\frac{x_a}{B} = \frac{f}{H' - Z}$ from which $x_a = \frac{Bf}{H' - Z}$

(*b*) Also $\frac{x_c}{B} = \frac{f}{H'}$ from which $x_c = \frac{Bf}{H'}$

Subtracting (*b*) from (*a*) and reducing gives

(*c*) $$\boxed{x_a - x_c = Bf \frac{Z}{(H')^2 - H'Z}}$$

Also from similar triangles of [Fig.*b*]()

(*d*) $\frac{x_a}{b_e} = \frac{i}{h - z}$ from which $x_a = \frac{b_e i}{h - z}$

and $\frac{x_c}{b_e} = \frac{i}{h}$ from which $x_c = \frac{b_e i}{h}$

(*e*)

Subtracting (*e*) from (*d*) and reducing gives

$$\boxed{x_a - x_c = b_e i \frac{z}{h^2 - hz}}$$

(*f*)

[Equat]() $Bf \frac{Z}{(H')^2 - H'Z} = b_e i \frac{z}{h^2 - hz}$

Vertical Exaggeration in Stereoviewing

In the Equating (*c*) and (*f*), the values of *Z* and *z* are normally considerably smaller than the values of *H′* and *h*, respectively; thus $\frac{BfZ}{(H')^2} \approx \frac{b_e iz}{h^2}$ from which $\frac{z}{Z} = \frac{fh}{H'i} \frac{Bh}{H'b_e}$

(*g*)

Also from similar triangles of Figs.a and b

$$\frac{x_c - x_k}{D} = \frac{f}{H'} \quad \text{from which} \quad D = (x_c - x_k) = \frac{H'}{f}$$

and $\frac{x_c - x_k}{d} = \frac{i}{h}$ from which $d = (x_c - x_k)\frac{h}{i}$

(*h*)

(*i*) $\frac{d}{D} = \frac{fh}{H'i}$

Dividing (*i*) by (*h*) and reducing yields

Substituting (*i*) into (*g*) and reducing gives

(*k*) $\frac{z}{Z} = \frac{d}{D} \frac{Bh}{H'b_e}$

In Eq. (*k*), if the term ***Bh*/(*H′b*$_e$)** is equal to **1**, there is **no vertical exaggeration** of the stereomodel. (Recall that *Z* is equal to *D*.) Thus an expression for the magnitude of vertical exaggeration *V* is given by

$$\boxed{V \approx \frac{B}{H'} \frac{h}{b_e}}$$

(Equation 3-1)

where: B is the air base; H is the height of the aircraft above the ground; b is the eye base (approximately 6 cm) and h is the distance from the eye at which the stereo model is perceived (approximately 45 cm)

Vertical Exaggeration in Stereoviewing

An expression for **<u>the *B/H′* ratio</u>** can be developed with reference to Fig. 2. In this figure, ***G* represents the total ground coverage** of a vertical photo taken from an **altitude of *H′* above ground. Air base *B*** is the distance between exposures. From the figure,

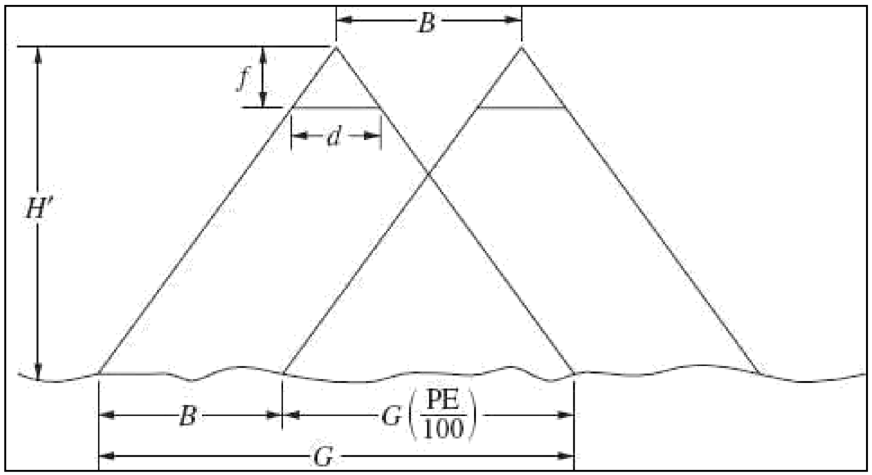


FIGURE 2 Base-height ratio (*B/H′*).

(*l*) $$B = G - G\frac{PE}{100} = G\left(1 - \frac{PE}{100}\right)$$

In Eq. (*l*), PE is the percentage of end lap, which gives the amount that the second photo overlaps the first. Also by similar triangles $\frac{H'}{G} = \frac{f}{d}$ from which $H' = \frac{fG}{d}$

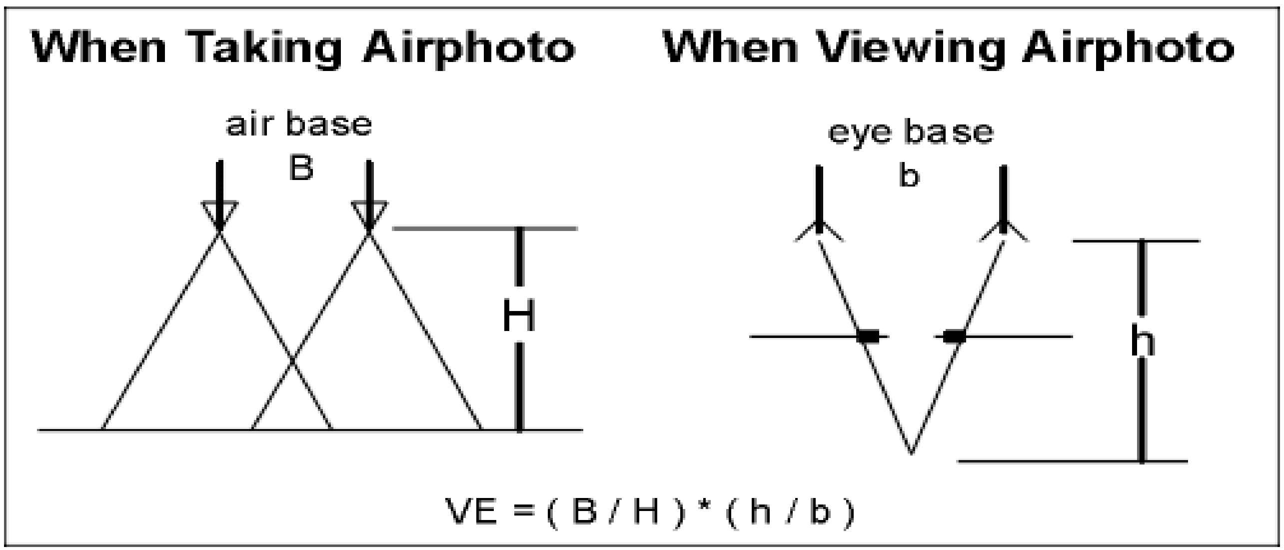
(*m*)

In Eq. (*m*), *f* is the gth and *d* its format dime q. (*l*) by Eq. (*m*) and reduc

$$\frac{B}{H'} = \left(1 - \frac{PE}{100}\right)\frac{d}{f}$$

(Equation 3-2)

Vertical Exaggeration



The ***stereoviewing base-height* ratio** varies due to differences in the distances between the eyes of users and varying dimensions of stereoscopes. It can, however, be approximated in the following way. Figure 3 show the relationships include in this approximation. With **an eye base, b_e, averaging about 65 mm in humans**, we need only to find the perceived distance from the eyes to the stereomodel, ***h* to make an approximation**. If the **distance between the photos is b_s,** and **the d** $h = i\frac{b_e}{b_e - b_s}$ **he stereoscope from the photos is *i***, then we can owing equation to estimate *h* by similar triangles:

(n)
$$\boxed{\frac{b_e}{h} = \frac{b_e - b_s}{i}}$$

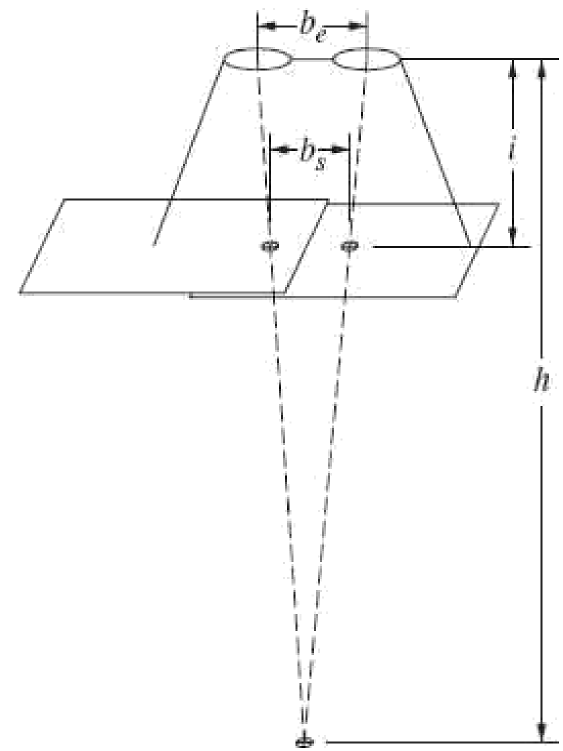


FIGURE 3 Eye base to perceived model height ratio.

Equation (*n*) can be used to form Eq. (3-3) to directly solve for the stereo-viewing **base-height ratio:**

(Equation 3-3)

Example 3-1

Estimate the stereoviewing base-height ratio if the height of the stereoscope above the photos is 10.00 cm, and the photos are placed 5.0 cm apart if b_e is equal to 6.5 cm.

Solution By Eq. (3-3)

$$\frac{b_e}{h} = \frac{b_e - b_s}{i} = \frac{(6.5\text{ cm} - 5.0\text{ cm})}{10.0\text{ cm}} = 0.15 \quad \blacktriangle$$

Example 3-2

Using the results of Example 3-1, cal $\frac{B}{H'} = \left(1 - \frac{60}{100}\right)\frac{230}{152.4} = 0.60$ te vertical exaggeration for vertical aerial photos taken with a 15 camera having a 23-cm-square format if the photos were taken with 60 percent end lap.

Solution By Eq. (3-2),

Vertical Exaggeration in Stereoviewing

From Example 3-1, b_e/h is approximately 0.15,

$$V = 0.60\left(\frac{1}{0.15}\right) = 4.0 \qquad \text{(approx.)}$$

Vertical Exaggeration in Stereoviewing

From Example 3-1, b_e/h is approximately 0.15,

$$V = 0.60\left(\frac{1}{0.15}\right) = 4.0 \qquad \text{(approx.)}$$

Note: If a 305-mm-focal-length camera had been used, the B/H' ratio would have been 0.30, and vertical exaggeration would have been reduced to 2.

H.W2

What is the approximate vertical exaggeration for a vertical photo taken with a 152.4-mm focal length camera having a 23-cm square format if the photos were taken with 53% endlap?

Northern Technical University (NTU)
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2nd Stage
Photogrammetry I

Topic 6

- Classification of aerial photographs
- Relief displacement

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outline

- ❖ **Classification of aerial photographs**
  - **Orientation of camera axis**
  - **Angular coverage**
  - **Emulsion type**
- ❖ **Relief displacement**

Classification of aerial photographs

•Orientation of camera axis

A-True vertical photograph: A photograph with the camera axis perfectly vertical (identical to plumb line through exposure center). Such photographs hardly exist in reality.

B-Near vertical photograph: A photograph with the camera axis nearly vertical. The deviation from the vertical is called tilt. It must not exceed mechanical limitations of stereoplotterto accommodate it. Gyroscopically controlled mounts provide stability of the camera so that the tilt is usually less than two to three degrees.

C-Oblique photograph: A photograph with the camera axis tilted between the vertical and horizontal. A high oblique photograph ***Thetotal area photographed with oblique is much larger than that of vertical photographs. The main application of oblique photographs is in reconnaissance.***

Orientation of camera axis

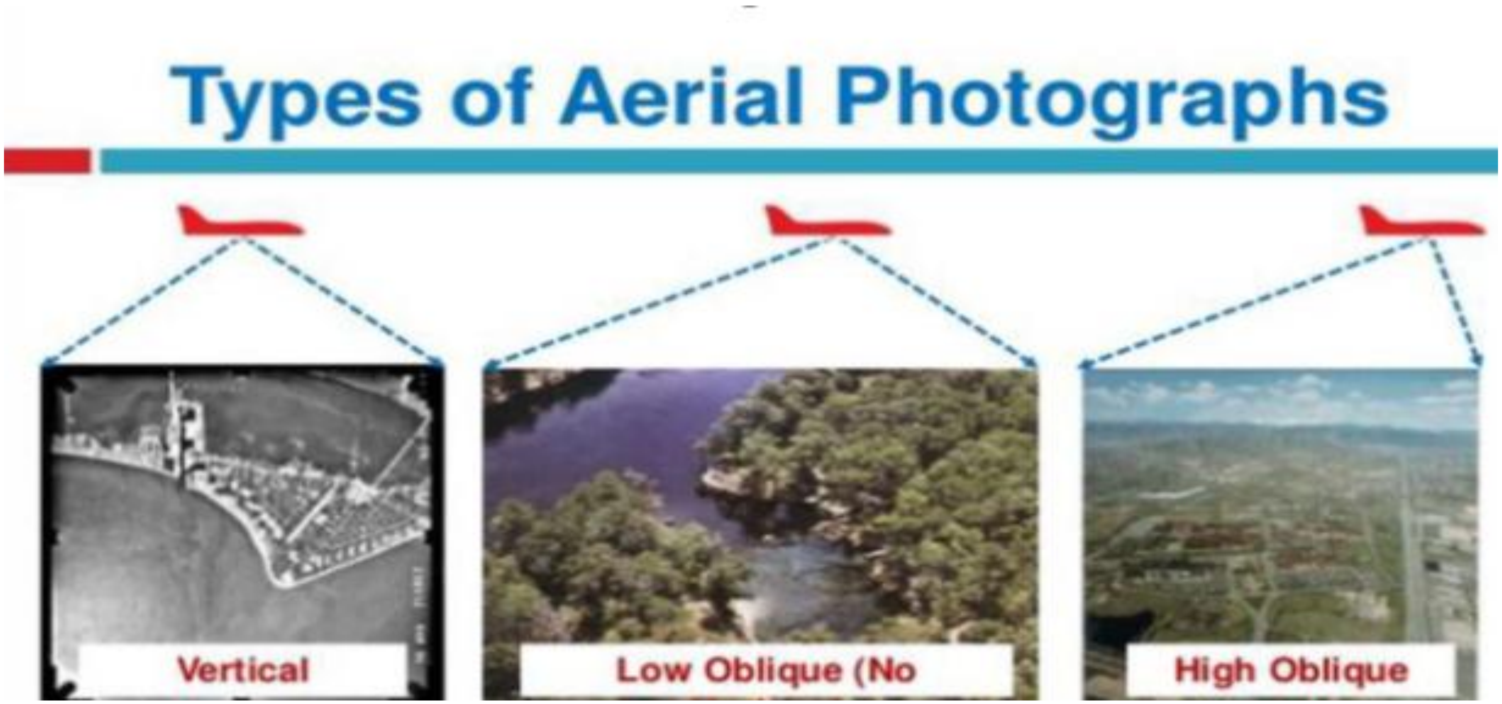


Figure :Classification of photographs according to camera orientation. In (a) the schematic diagram of a true vertical photograph is shown; (b) shows a low oblique and (c) depicts a high oblique photograph.

➢Angular coverage

•The angular coverage is a function of focal length and format size. Since the format size is almost exclusively 9 ×9"**the angular coverage depends on the focal length of the camera only**. Standard focal lengths and associated angular coverages are summarized in Table 2.1.

	super-wide	wide-angle	intermediate	Normal angle	Narrow angle
focal length [mm]	85	157	210	305	610
angular coverage [o]	119	82	64.	46	24

Table: Summary of photographs with different angular coverage

➢Emulsion type

The sensitivity range of the emulsion is used to classify photography into

•***Panchromatic black and white***: This is most widely used type of emulsion for photogrammetric mapping.

•***Color***: Color photography is mainly used for **interpretation purposes**. Recently, color is increasingly being used for mapping applications.

•***Infrared black and white: Since*** infrared is less affected by haze it is used in applications where **weather conditions may not be as favorable as for mapping missions.**

•***False color***: This is particular useful for interpretation, mainly for **analyzing vegetation** (e.g. crop disease) and water pollution.

صورة أبيض و أسود

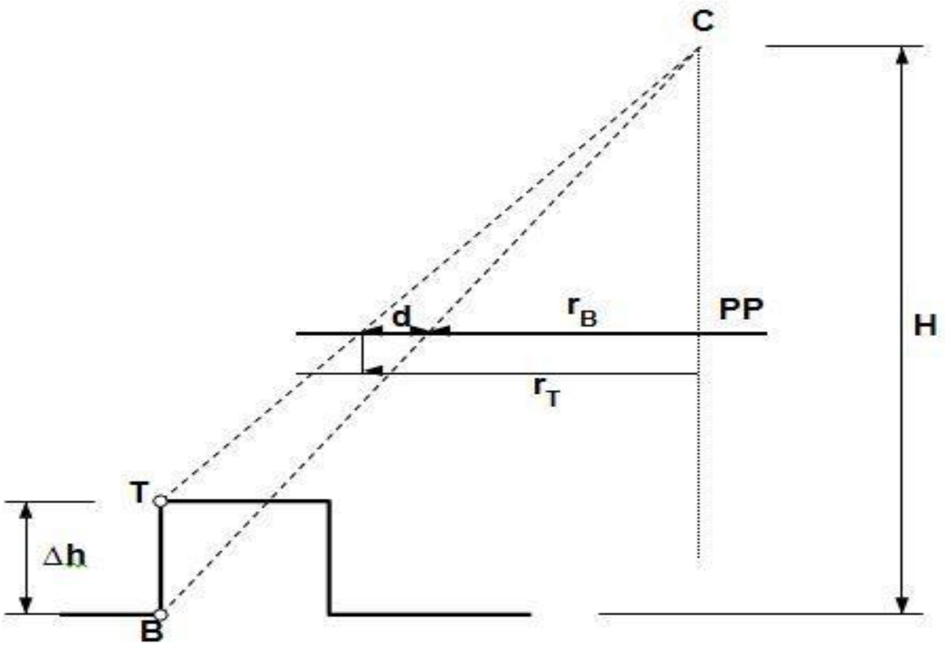
صورة ملونة عادية

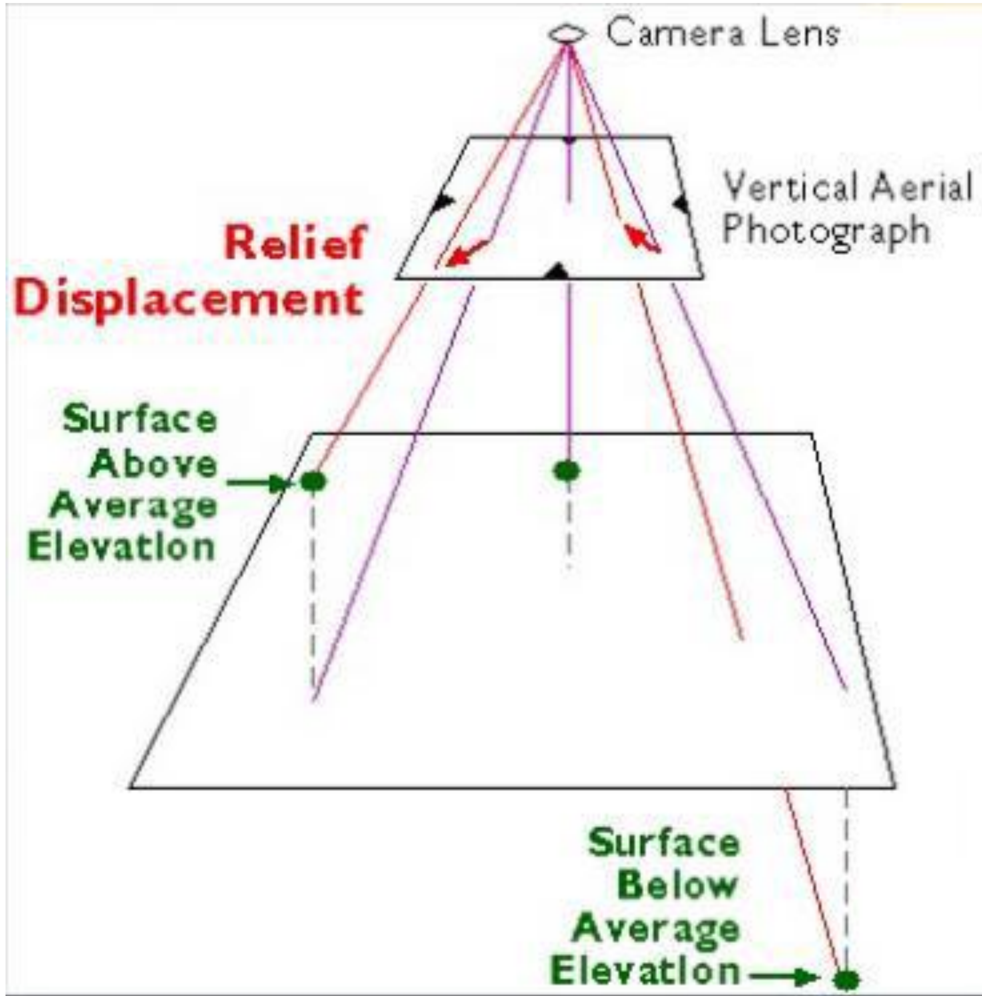
صورة ملونة عادية

صورة بالأشعة تحت الحمراء

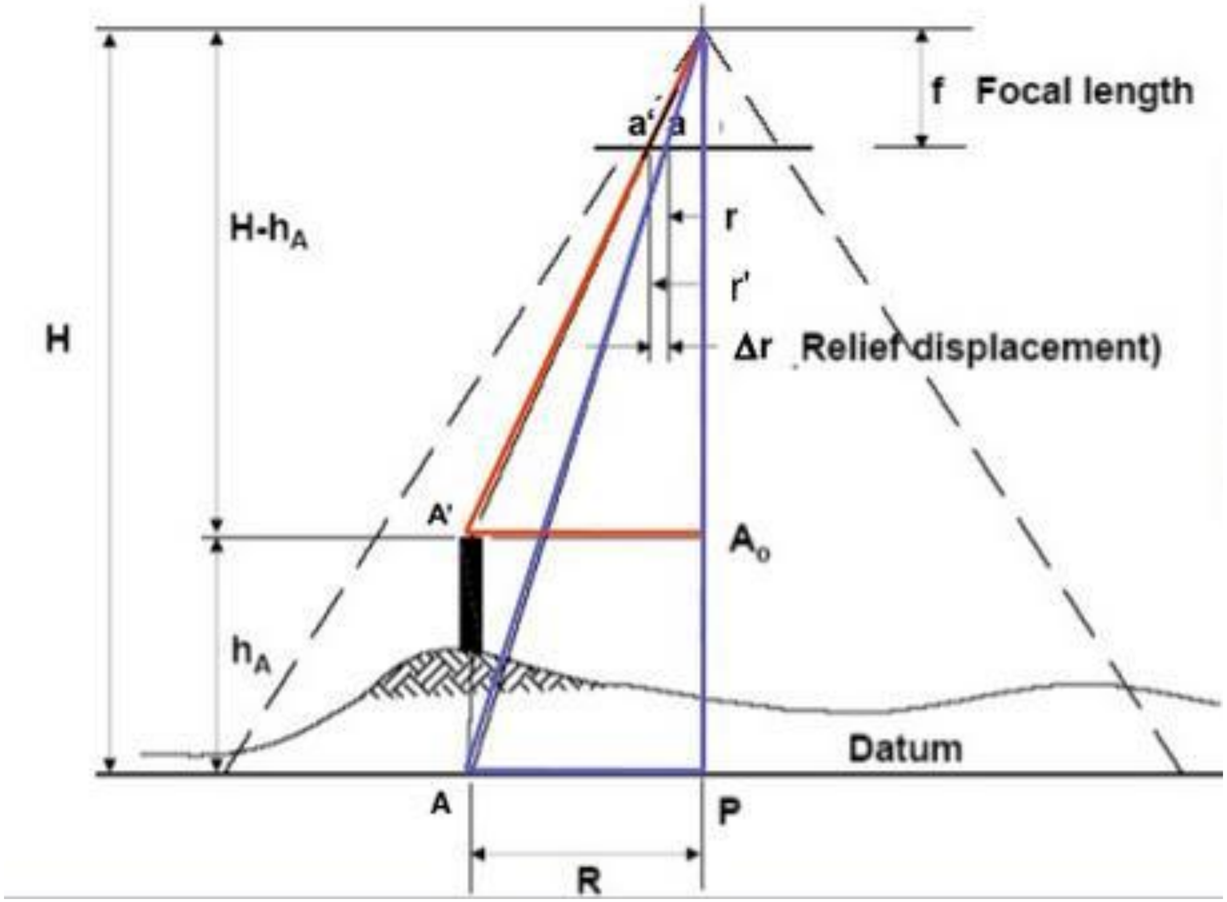
Relief displacement

The effect of relief does **not only cause a change in the scale but** can also be considered as a **component of image displacement**. illustrates this concept. Suppose point T is on top of a building and point B at the bottom. On a map, both points have identical X, Y coordinates; however, on the photograph they are imaged at different positions, namely in T and B. The distance d between the two photo points is **called relief displacement** because it is caused by the elevation difference Δh between T and B.




Camera Lens
Vertical Aerial Photograph
Relief Displacement
Surface Above Average Elevation
Surface Below Average Elevation

Relief Displacement



The magnitude of relief displacement for a true vertical photograph can be determined by the following equation:

$$d = \frac{r\Delta h}{H}' = \frac{r'\Delta h}{H}$$

$$r = \sqrt{x_T{}^2 + y_T{}^2} \quad , \; r' = \sqrt{x_B{}^2 + y_B{}^2}$$

, and Δh the elevation difference of two points on a vertical. Eq. can be used to determine the elevation Δh of a vertical object.

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

where:

r = radial distance from principal point to displaced image point

h = height above surface of the object point

H = flying height above the surface

- ***The direction of relief displacement is radial with respect to the center of photo, independent of camera tilt.***

-Calculate object height

$$h = \frac{dH}{r}$$

where:

- d = length of displaced object on the photo
- H = flying height above the surface
- r = radial distance from principal point to top of displaced object

Homework :-

Distance from principal point to an image on a photograph is (6.44cm) and elevation of the object above datum is (250m). what is the relief displacement of the point if the datum scale is (1/10000) and the focal length of camera is (20cm)?