

# Surveying and Geomatics

## Unit-5

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Designation: Assistant Professor

Department: Civil Engineering

# PHOTOGRAMMETRY

Photogrammetric surveying or photogrammetry is the branch of surveying in which maps are prepared from photo-graphs taken from ground or air stations.

With an advancement of the photogrammetric techniques,

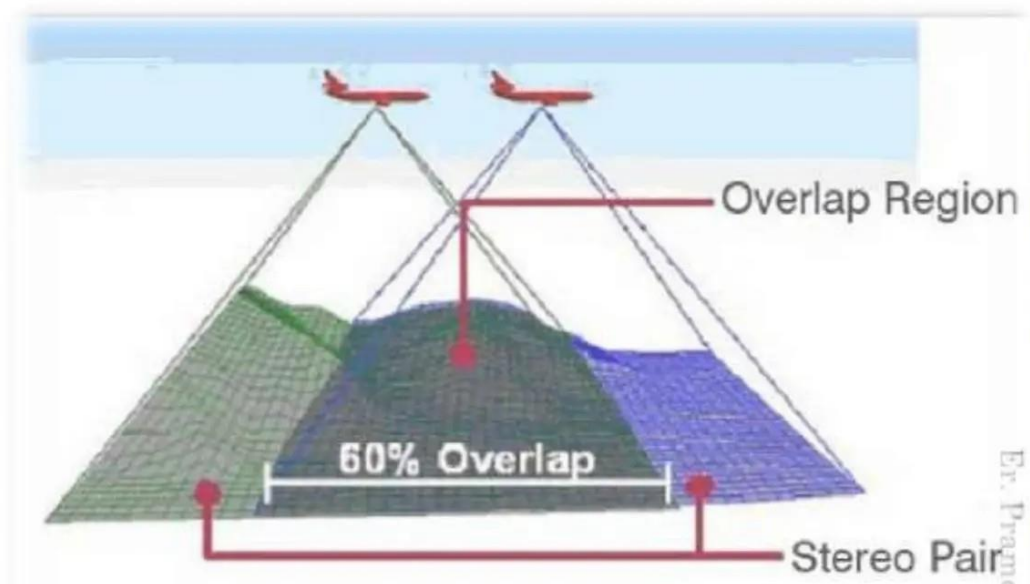
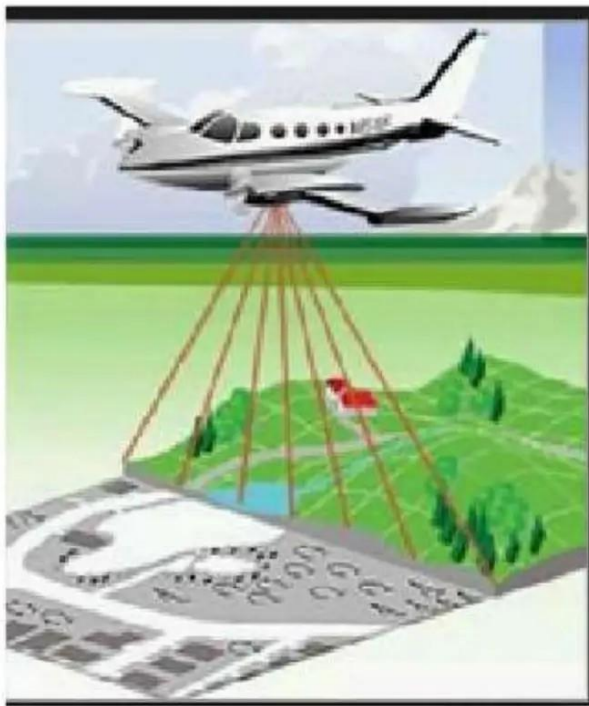
# Photogrammetric Survey



Er. Pramesh Hada



Photogrammetric Survey



# INTRODUCTION

Is the science of making measurements from photographs, especially for recovering the exact positions of surface points.

photographs are also being used for the interpretation of geology, classification of soils and crops, etc.

Used to recover the motion pathways of designated reference

points located on any moving object, on its components and in the immediately adjacent environment.

Photogrammetry may employ high-speed imaging and remote sensing in order to detect, measure and record complex 2-D and 3-D motion fields.

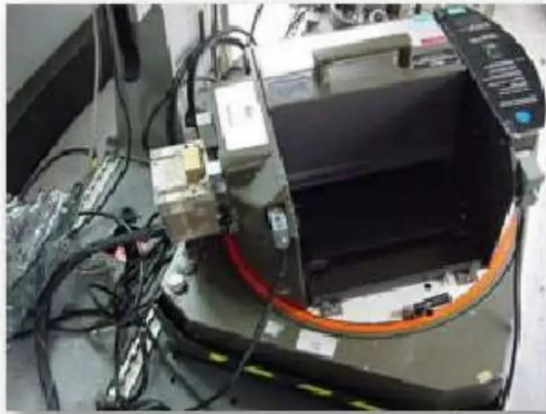
Now a days devices- drone camera, aircraft, phototheodolite, digital camera etc.



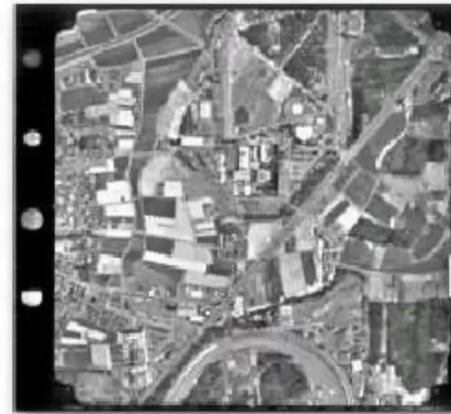


## DRONE CAMERA

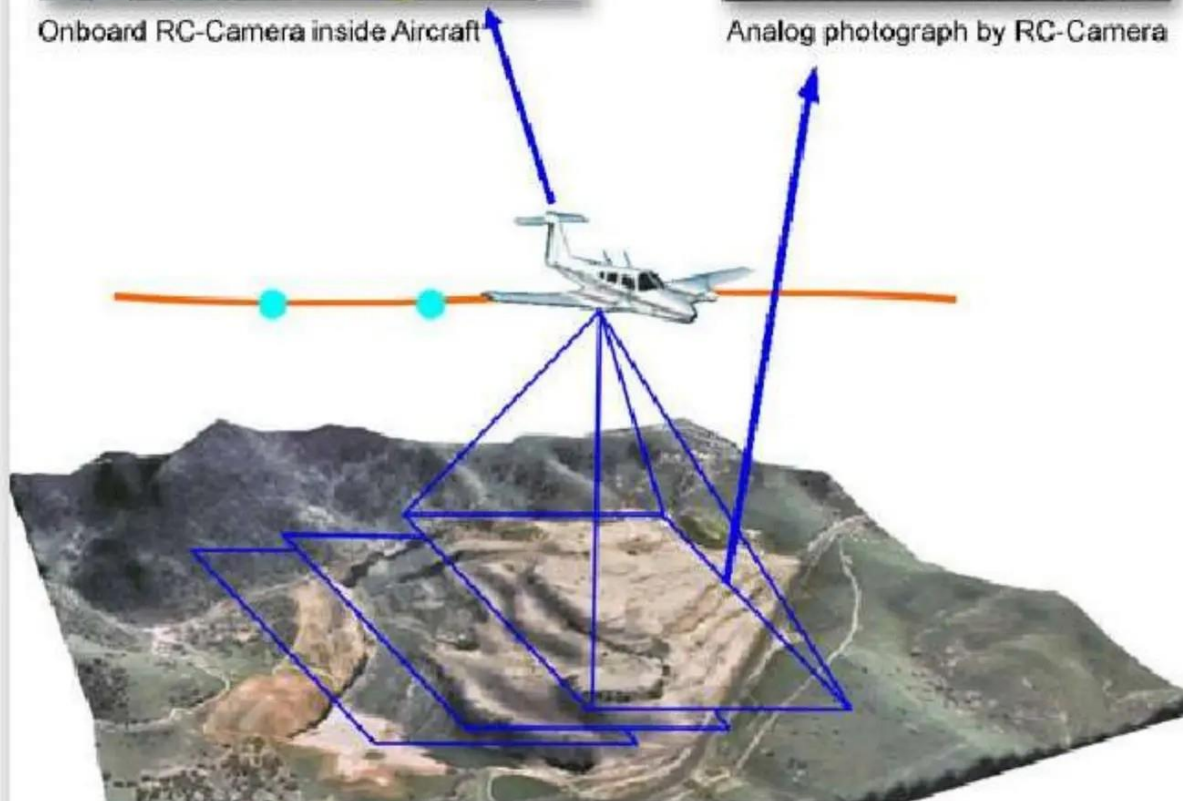




Onboard RC-Camera inside Aircraft



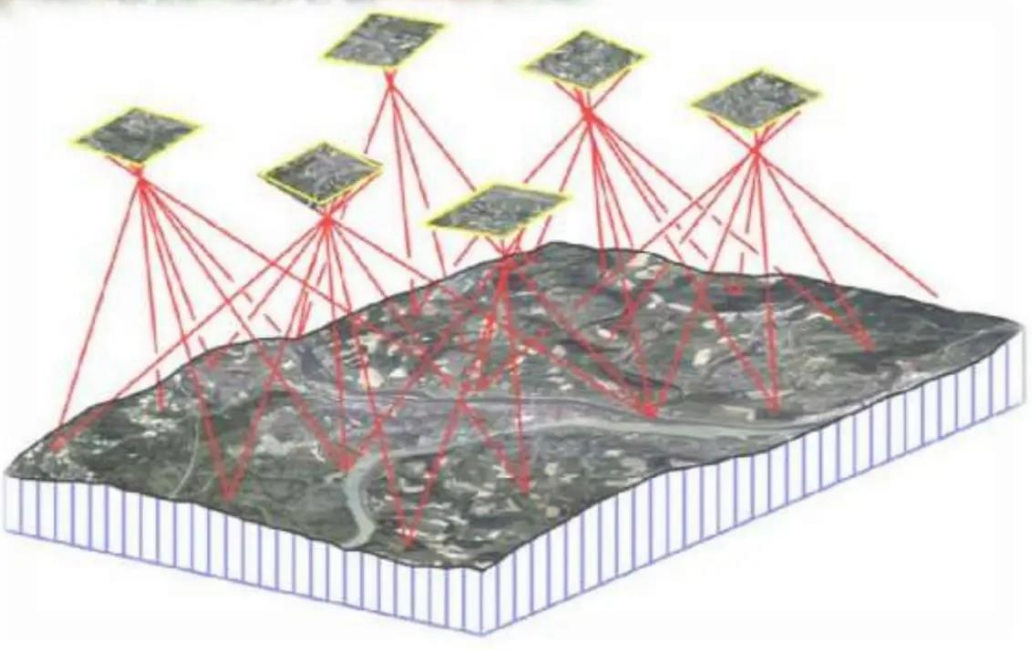
Analog photograph by RC-Camera



A general view of photographing by RC-Camera



Ex. 1 from St. Ilada, Asst. Professor, nec



# INTRODUCTION

Photogrammetry is the practice of determining the geometric properties of objects from photographic images.

Is the making of precise measurements from photographs; the making of maps from photographs, especially from aerial surveying.



LOW ALTITUDE AERIAL PHOTOGRAPH FOR USE  
IN PHOTOGRAMMETRY - LOCATION THREE  
ARCH BAY, LAGUNA BEACH CA.

- The science of using aerial photography and other remote sensing imagery to obtain measurement of natural and man-made features on the earth.
- In this method, object are measured without being touched.

## Broadly Photogrammetry Requires:

Planing & taking the photographs

Processing the photographs

Measuring the photographs & Reducing

the measurement to produce end results.

## Field Application of Photogrammetry :

Used to conduct topographical survey or engineering surveys.

Suitable for mountainous and hilly terrain with little vegetation.

Used for geological mapping which includes identification of land forms, rock type & rock structures.

Used for projects demanding higher accuracy, since it provides accurate measurements.

Used in urban and regional planning applications.

Used mostly in Planning/designing in transport planning, bridge, pipeline, hydropower, urban planning, security and strategic planning, disaster management, natural resources management, city models, conservation of archaeological sites etc.

## Importance/application of photogrammetry

Its applications include satellite tracking of the relative positioning alterations in all Earth environments.

The quantitative results of photogrammetry are used to guide and match the results of computational models of the natural systems, thus helping to invalidate or confirm new theories, to design novel vehicles or new methods for predicting or/and controlling the consequences of earthquakes, tsunamis, any other weather types.

Photogrammetry also helps for the solving of triangulation, trilateration and multidimensional scaling.

In the simplest example, the distance between two points that lie on a plane parallel to the photographic image plane can be determined by measuring their distance on the image, if the scale ( $s$ ) of the image is known.



## Importance/application of photogrammetry

Used in different fields, such as topographic mapping, architecture, engineering, manufacturing, quality control, police investigation, and geology, as well as by archaeologists to quickly produce plans of large or complex sites and by meteorologists.

### Advantage

- Covers large area
- Less time consuming/fast
- Can 'reach' inaccessible and restricted area
- Cheap/cost effective for large area and in a long run
- Easy to interpret, understand

### Disadvantage

- Complex system, highly trained human resource needed
- Costly at the time of installation/initiation
- Heavy and sophisticated equipments needed
- Lengthy administrative procedure for getting permission to fly
- Weather dependent



# PRINCIPLE OF PHOTOGRAMMETRY

Principle of photogrammetric survey in its simplest form is very similar to that of the plane table survey.

Only difference is that the most of the work which in plane table survey is executed in the field, but here is done in office.

The principal point of each photograph is used as a fixed station and rays are drawn to get points of intersections very similar to those used in plane table.

Is suitable for topographical or engineering surveys and also for those projects demanding higher accuracy.

It is unsuitable for dense forest & others due to the difficulty of identifying points upon the pair of photographs.



# TYPES OF PHOTOGRAMMETRY / PHOTOGRAPHS

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The photographs used in photogrammetry may be broadly classified into two types depending upon the camera position at the time of photography.

The types are-

Terrestrial Photographs

Aerial Photographs

## Terrestrial Photographs

Photographs taken from camera station at a fixed position on or near the ground is known as Terrestrial Photographs.

The photographs are taken by means of a phototheodolite which is combination of a camera and a theodolite.

Based on the principle that “if the directions of same objects photographed from two extremities of measured base are known, their position can be located by the intersection of two rays to the same object.



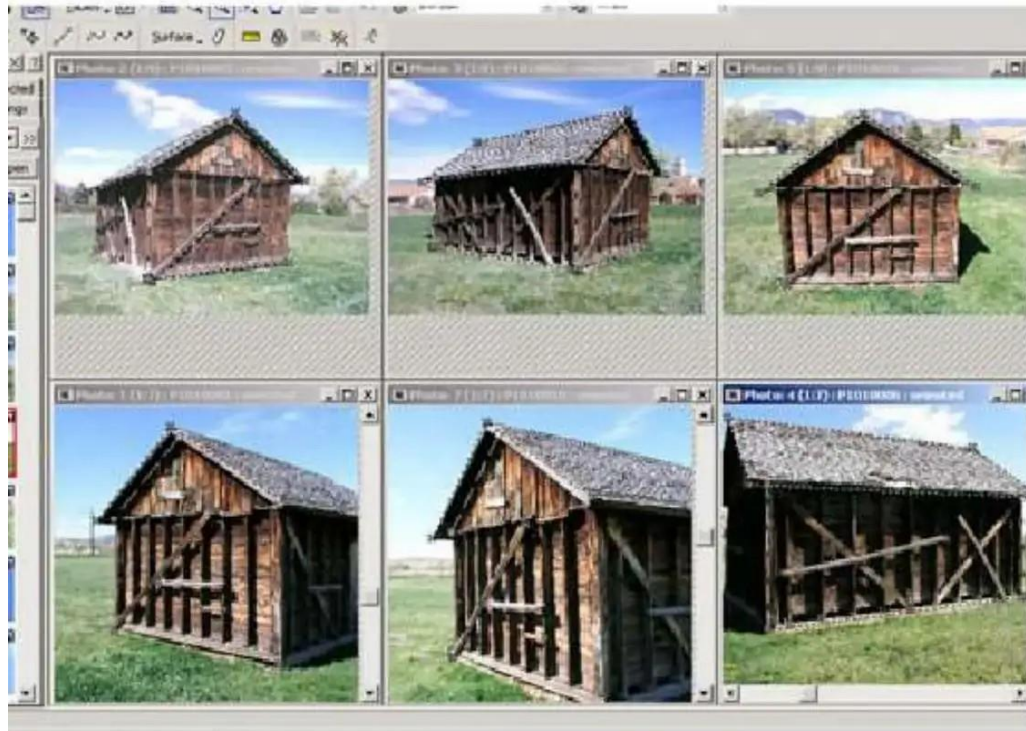
# TERRESTRIAL PHOTOGRAPHS



Dr. Purnesh Hada, Asst. 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.





Er. Pramesh Ha



# TERRESTRIAL PHOTOGRAPHS

Difference between this and plane tabling is that more details are at once obtained from the photographs and their subsequent plotting etc. is done by the office while in plane tabling all the detailing is done in the field itself.

Fig A and B are the two stations at the ends of base AB.

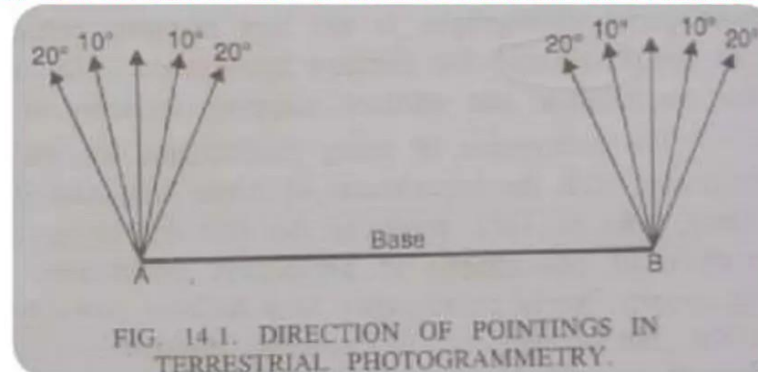
Arrows indicate the directions of horizontal pointing (in plan) of the camera.

For each pair of pictures taken from the two ends, the camera axis is kept parallel to each other.

From economy and speed point of view, minimum number of photographs should be used to cover the whole area and to achieve this, it is essential to select the best positions of the camera stations.

Study of the area should be done from the existing maps, and a ground reconnaissance should be made. Selection of actual stations depends upon the size and ruggedness of the area.

These photographs provides the front view of elevation & are generally used for the survey of structure & Architectural Monuments.



# AERIAL PHOTOGRAPHS

Photographs taken from a **Aerial camera mounted on a aerial vehicle**

Used for various **purpose**, mainly information extraction on the **ground surface**

Aerial photographs are **obtained from the aerial cameras mounted on aerial vehicle**(aeroplane for the purpose of photography)

Used for **various purpose**, mainly information extraction on the **ground surface**

Photographs are taken **from camera station in the air with the axis of camera vertical or nearly vertical.**

Is the branch of **photogrammetry** where the photographs are **taken from air station.**

This is the **best mapping procedure yet developed for large objects and are useful for military intelligence.**

For this, **aerial camera is used which are fixed on flying aircraft.**





Er. Pramesh Mishra, Asst. Professor, IIT

## AERIAL PHOTOGRAPHS

# AERIAL PHOTOGRAPHS

According to the direction of the camera axis at the time of exposure aerial photographs may be classified into:

Vertical photographs

Oblique photographs

Vertical photographs

These photographs are taken from the air with the axis of the Camera vertical or nearly vertical .

A truly vertical Photograph closely resembles a map.

These are utilized for the compilation of topographic and engineering surveys on various scales.

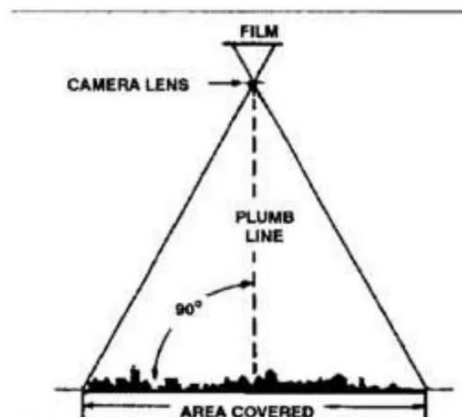
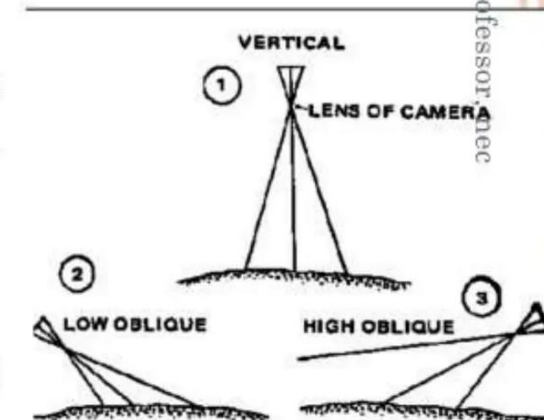
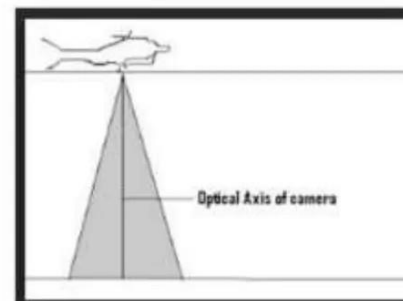
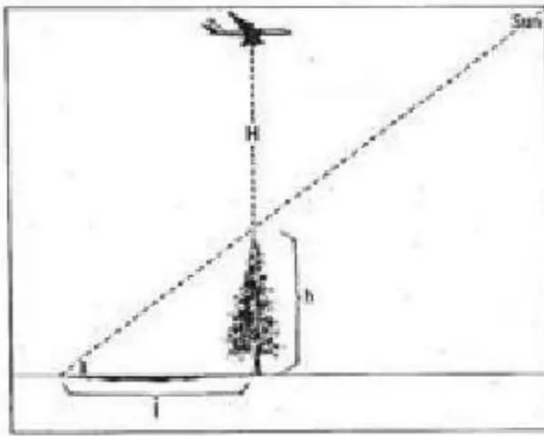
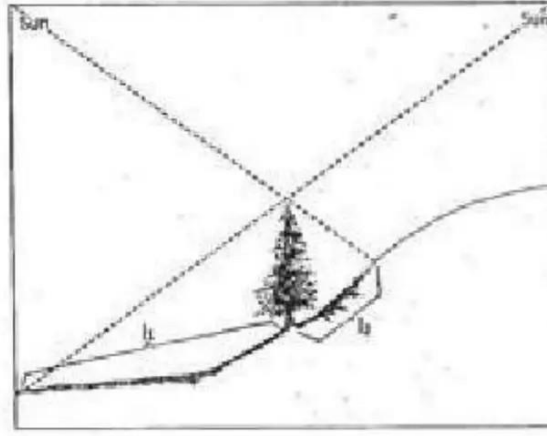


Figure 8-1. Relationship of the vertical aerial photograph with the ground.

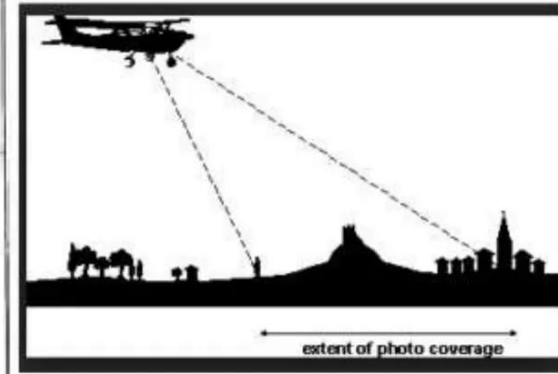




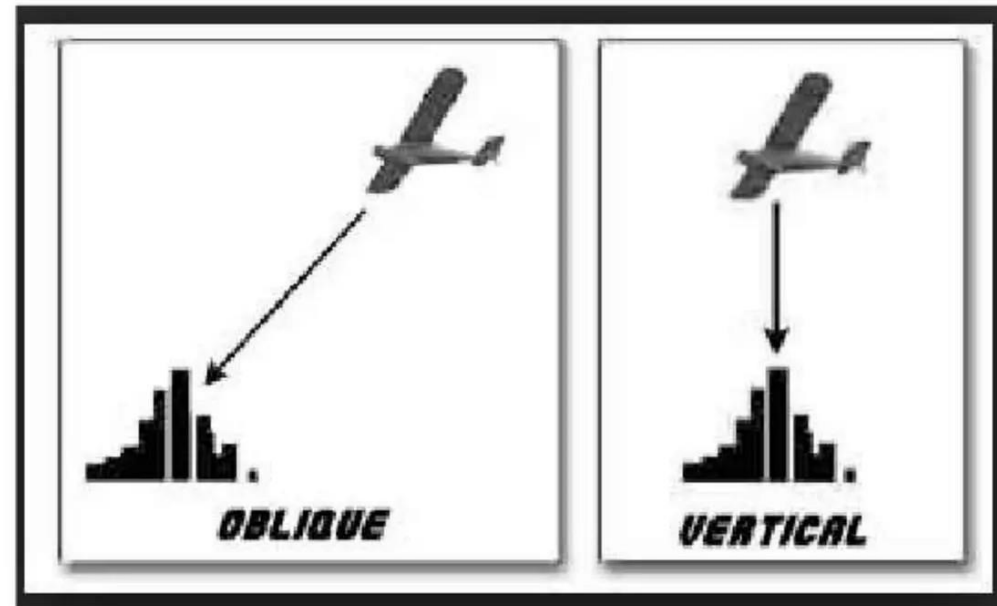
Vertical photographs



Oblique photographs



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# OBLIQUE PHOTOGRAPHS

Photographs are taken from air with the axis of the camera intentionally tilted from the vertical.

An oblique photograph covers larger area of the ground but clarity of details diminishes towards the far end of the photograph.

Depending upon the angle of obliquity, oblique photographs may be further divided into two categories.

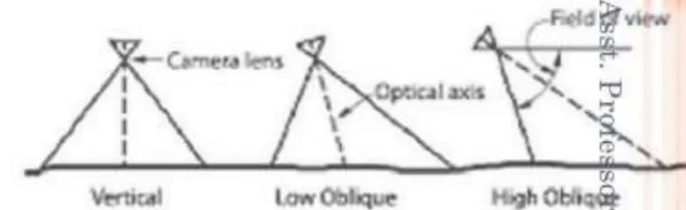
## Low oblique photographs :

An oblique photograph which does not show the horizon, is known as low oblique photograph.

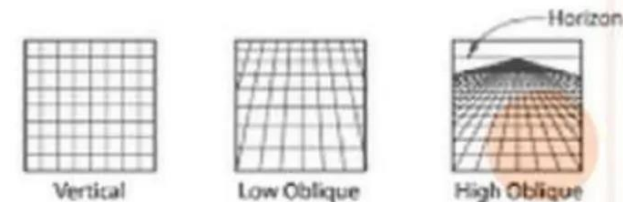
Such photographs are generally used to compile reconnaissance maps of inaccessible areas.

## High oblique photograph:

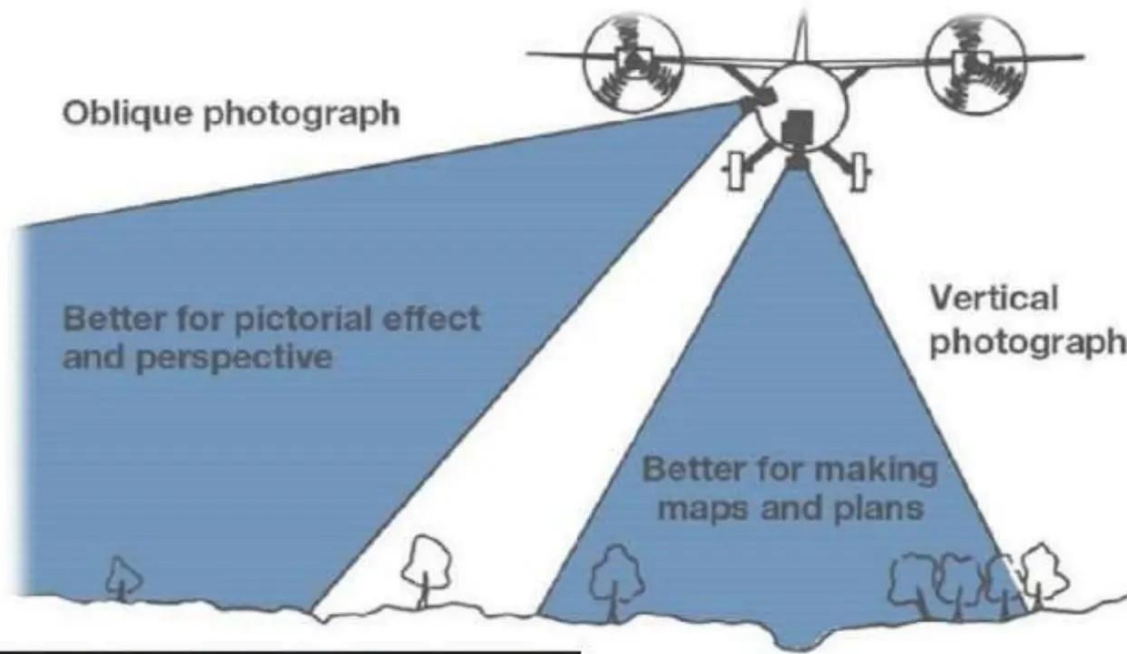
- An oblique photograph which is sufficiently tilted to show the horizon, is known as high oblique photograph.
- Such photographs were previously used for the extension of planimetric and height control in areas having scanty ground control.



Camera orientation for various types of aerial photographs



How a grid of section lines appears on various types of photos.



Vertical photo



OBLIQUE AERIAL PHOTOGRAPHY



# THE PHOTO-THEODOLITE

## CONSTRUCTION AND USE OF PHOTOTHEODOLITE (PU 2006)

Is a combination of camera and theodolite mounted on the same tripod,

Used in terrestrial photogrammetry for mapmaking and other purposes.

Photographs obtained are used for the construction of topographic maps, classification of soil, interpretation of geology.

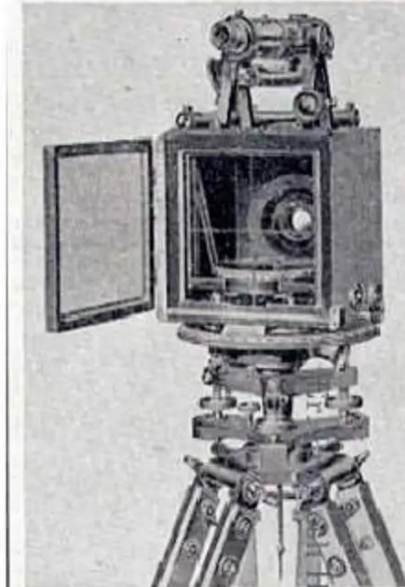
While taking the photographs the camera axis is kept parallel to each other.

It consists of :

- A camera box of fixed focus type

- A hollow rectangular frame placed vertically to the rear side

- The sensitized photographic plate.



**PHOTO-THEODOLITE.** An instrument which gives true photographic perspectives in a vertical plane and has a mechanism for recording on the negative the information necessary for interpreting the photographs and plotting the ground plans.

Asst. Professor, nec

## THE PHOTO-THEODOLITE

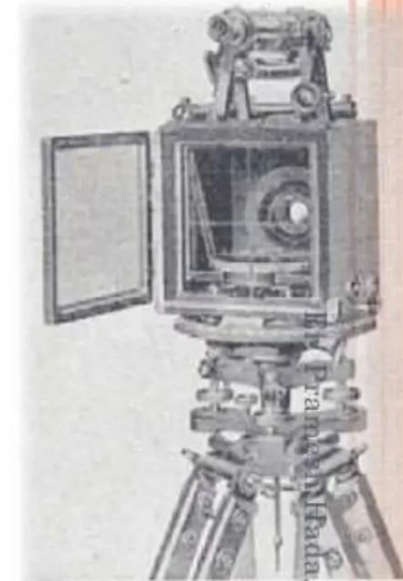
Camera box is supported on the tripod and is furnished with an inner and outer axis each of which is fitted with a clamp and fine adjusting screw.

The graduated horizontal circle carries verniers reading to single minutes. These are supported on a levelling head carrying three foot screws.

On the top of the box, a telescope is fitted.

The telescope can be rotated in a vertical plane about a horizontal axis and is fitted with vertical arc with verniers, clamp & slow motion screw.

The line of sight of the telescope is set in the same vertical plane as the optical axis of camera.



**PHOTO-THEODOLITE.** An instrument which gives true photographic perspectives in a vertical plane and has mechanism for recording on the negative the information necessary for interpreting the photographs and plotting the ground shown.

Professor, nec



# AERIAL PHOTOGRAPH / CAMERA (PU2006)

Aerial camera are used to have aerial photographs which are fixed on flying aircraft.

Primary function of the terrestrial camera as well as the aerial camera is the same, i.e., that of taking pictures.

Aerial camera is mounted on a fast moving aeroplane, its requirements are quite different.

Aerial camera requires :

Fast Lens

High speed & sufficient shutter

High speed emulsion for the film

A Magazine to hold large rolls of film

Aerial camera is considered to be a surveying instrument of great precision.



## AERIAL PHOTOGRAPH / CAMERA (PU2006)

An aerial camera consists of following essential parts

**lens assembly** consists of **lenses**, the **diaphragm**, **shutter** and the **filter**. (Fig-6,8,9)

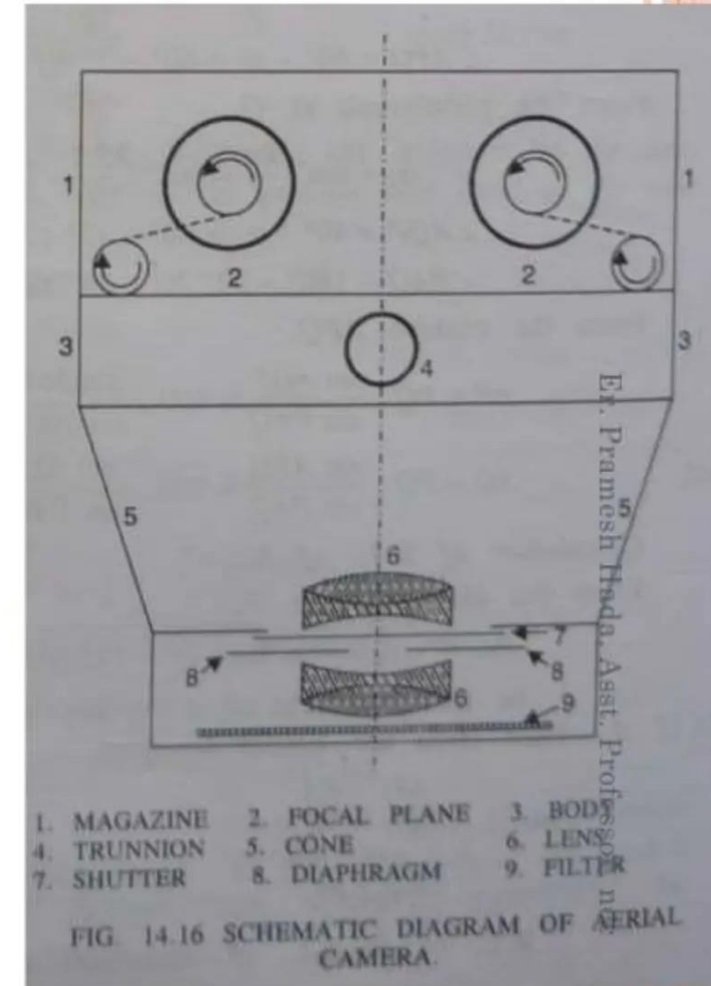
**Camera cone** which supports the entire lens assembly including the filter. (fig - 5)

**focal (2)** plane exactly above the collimation mark.

**camera body (3)** provided at the top of cone which acts as an integral **part to preserve the interior orientation**.

**Drive mechanism** which is housed in camera body & used for winding and tripping the shutter, operating the vacuum system for flattening the film, winding the film.

The **magazine (1)** which **holds the exposed and unexposed films & houses the film flattening device at the focal plane**.





JAPANESE AERIAL CAMERAS



GOWLAND DELUXE 4x5 AERIAL CAMERA  
WITH FOCUS TUBE

Er. Praveesh Hada, Asst. Professor, nec



There are three types of Aerial Camera :

**Super wide angle camera** -  $f=100\text{mm}$

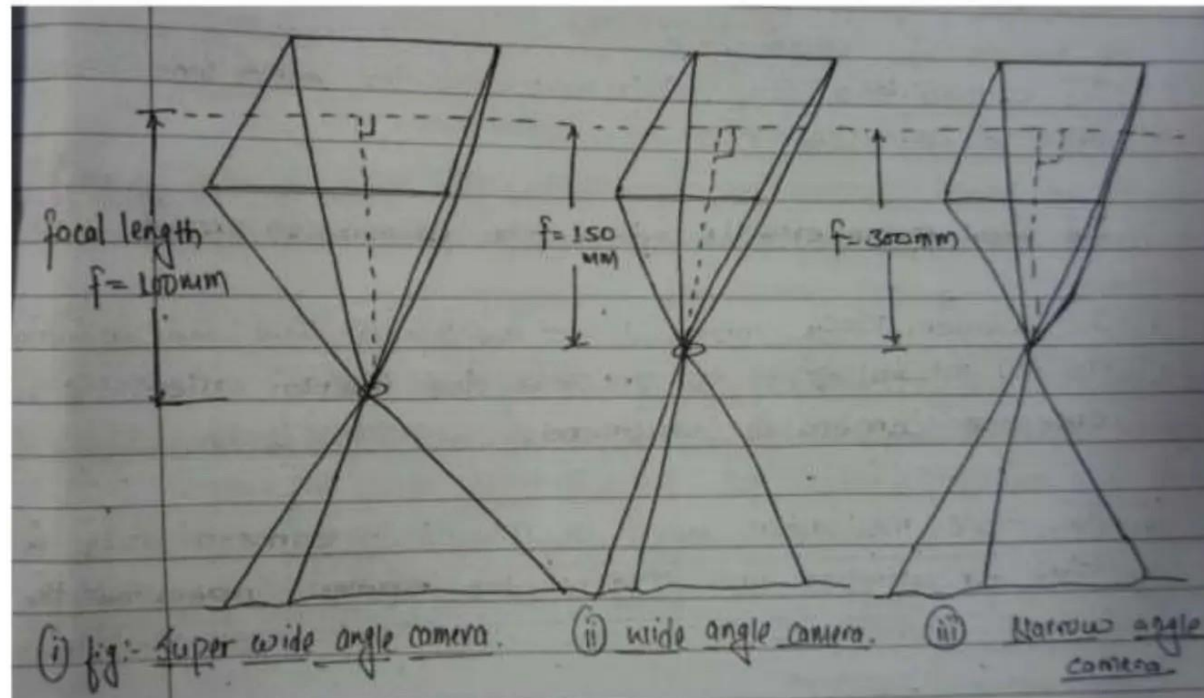
(used in flat areas like terai of nepal & in plain areas)

**Wide angle camera** -  $f=150\text{mm}$

(Used in hilly areas)

**Narrow angle camera** -  $f=300\text{mm}$

(Used in higher himalayas, sky scrappers & city like New york)



# DETERMINATION OF A SCALE OF THE VERTICAL

## PHOTOGRAPH (NUMERICAL IMP)

The scale of the vertical photograph is the ratio of a distance on the photo to the corresponding distance to the ground.

Let N = Perspective centre

H = flying height of the camera

f = focal length of camera

h = height of ground above mean sea level

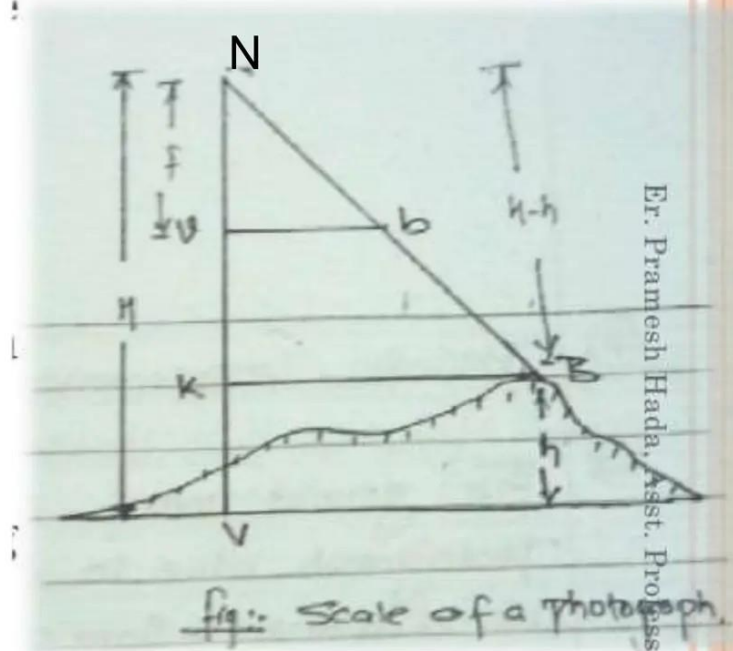
Construction :

Draw BK perpendicular to NV meeting at K

From similar triangles Nvb and NKB,

$$\frac{Nb}{KB} = \frac{NV}{NK} = \frac{f}{H-h}$$

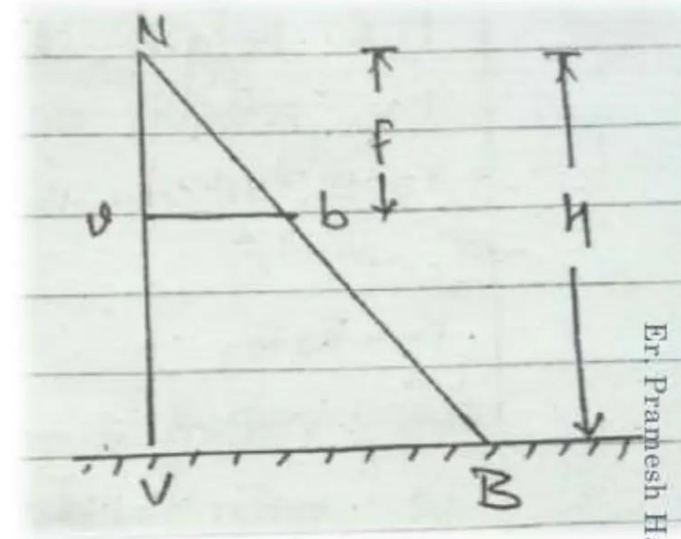
$$\text{Scale of Photograph ( } S_A \text{ )} = \frac{f}{H-h}$$



## SCALE OF THE VERTICAL PHOTOGRAPH

If the terrain is perfectly flat or plane at the mean sea level then ,  $h=0$ ,

So, Scale of photograph =  $\frac{f}{H}$



This shows, the scale of vertical photographs over the flat terrain is the ratio of the photo distance to the ground distance.

Note : Relation between Photoscale & Mapscale

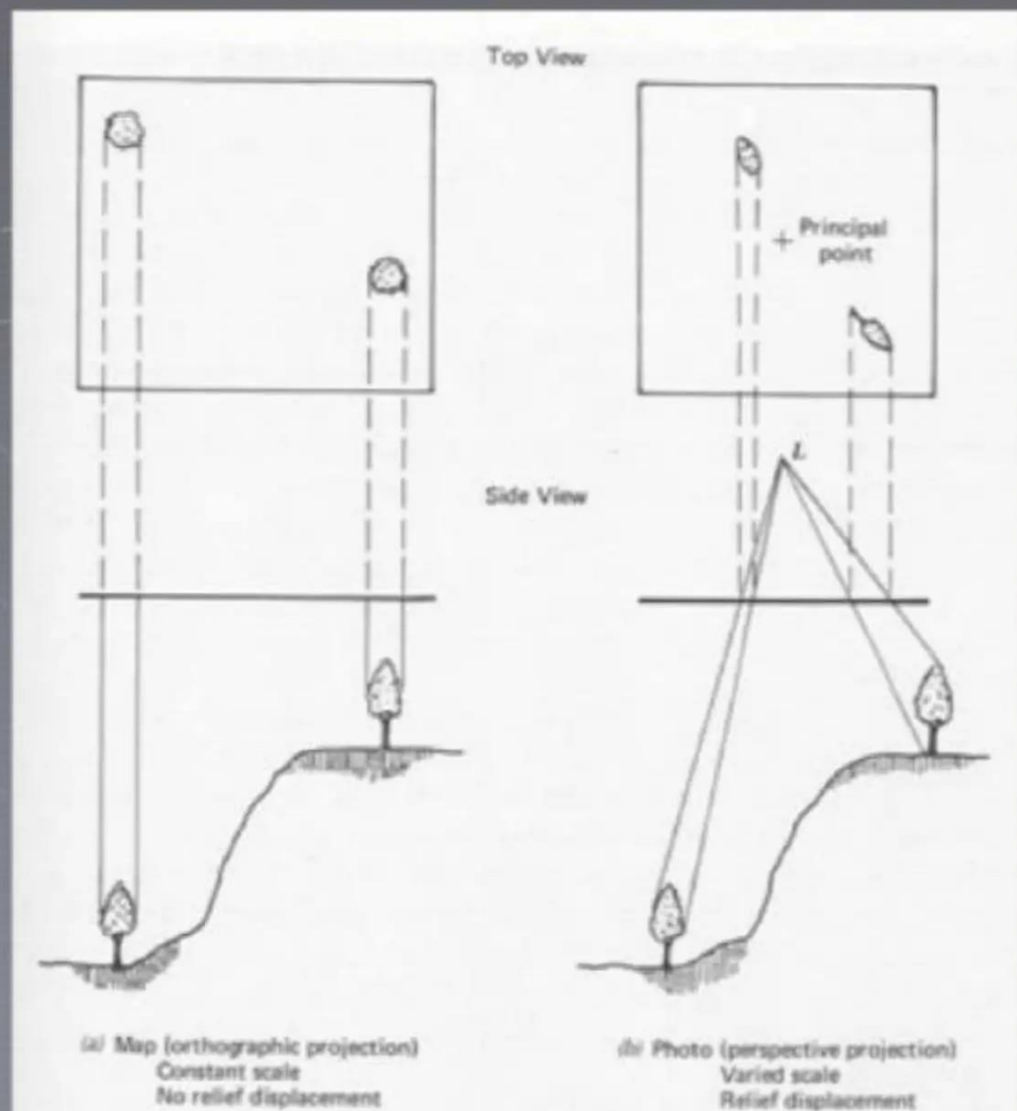
$$\frac{\text{Photo scale}}{\text{Map scale}} = \frac{\text{Photo distance}}{\text{Map Distance}}$$

## RELIEF DISPLACEMENT (2008,2010,2011)

- The scale of an aerial photograph is partly a function of flying height.
- Thus, variations in elevation cause variations in scale on aerial photographs.
- Specifically, the higher the elevation of an object, the farther the object will be displaced from its actual position away from the principal point of the photograph (the point on the ground surface that is directly below the camera lens).
- The lower the elevation of an object, the more it will be displaced toward the principal point. This effect, called relief displacement, is illustrated in the diagram below.
- Note that the effect increases with distance from the principal point.

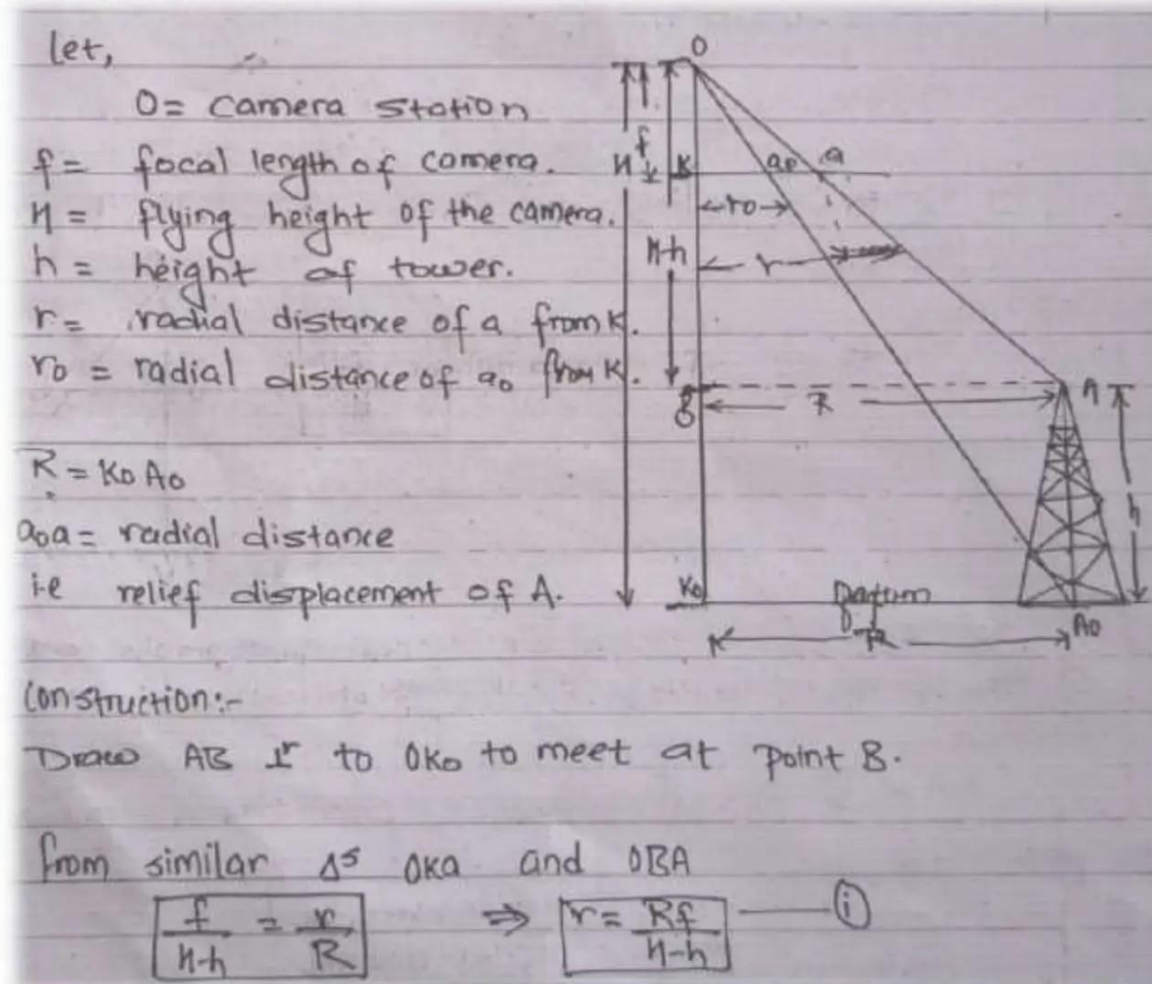


# Relief Displacement



## Determine an expression for determining the relief displacement on a vertical photograph (PU 08,10,11,12)

- Ground relief is shown in perspective on the photograph due to which every point on the photograph is displaced from their true orthographic position.
- This Displacement is called **relief displacement**.
- It is denoted by  $d$ .



relief d

## Determine an expression for determining the relief displacement on a vertical photograph (PU 08,10,11,12)

from similar  $\Delta OKaO$  and  $OKoAo$

$$\frac{f}{h} = \frac{r_o}{R}$$

$$\Rightarrow r_o = \frac{Rf}{h} \quad \text{--- (2)}$$

Hence, Relief displacement  $[d] = r - r_o$

$$\text{or, } d = \frac{Rf}{h-h} - \frac{Rf}{h}$$

$$\text{or, } d = \frac{hRf - hRf + Rfh}{h(h-h)}$$

$$\text{or, } d = \frac{Rfh}{h(h-h)} \quad \text{--- (3)} \quad d = \frac{r_o h}{(h-h)}$$

But,  $R = \frac{r(h-h)}{f} = \frac{r_o h}{f}$  [from eqn (1), (2)]

Substituting the value of R in eqn (3)

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

$$\text{Also, } d = \frac{r_o h}{f} \times \frac{fh}{h(h-h)} = \frac{r_o h}{(h-h)}$$

from eqn (3) and (4) we conclude that,

From equations (3) and (4) above, we conclude the following :

- Relief displacement increases as the distance from the principal point increases.
- Relief displacement decreases with the increase in the flying height.
- For point above datum, the relief displacement is positive being radially outward.
- For point below datum (having negative value), relief displacement is negative, being radially inward.
- Relief displacement of the point vertically below the exposure station is zero.

## TILT DISPLACEMENT

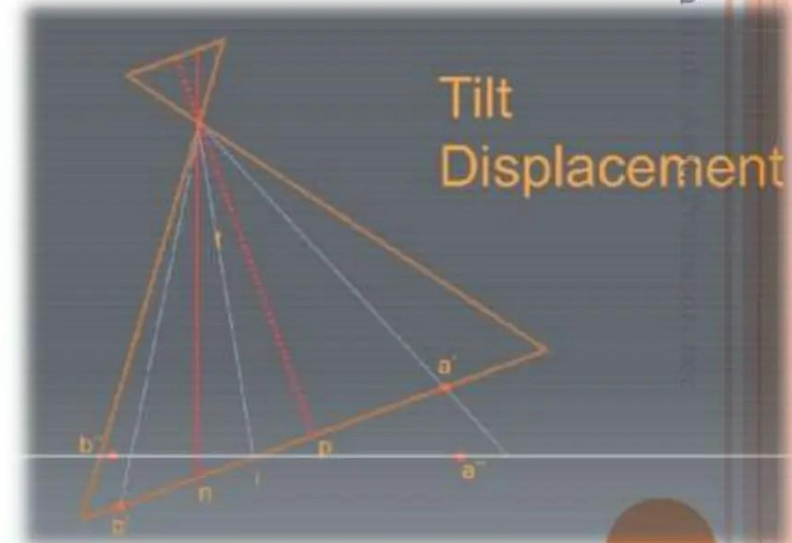
Defined as the difference between the distance of the image of a point on the tilted photograph from the isocentre and the distance of the image of the same point on the photograph from the isocentre if there had been no tilt.

An error in the position of a point on the photograph due to indeliberate tilting of the aircraft

Due to instability of aircraft

May be due to tilting of the aircraft along the flight line and/or perpendicular to the flight line

Increases radially from the isocenter

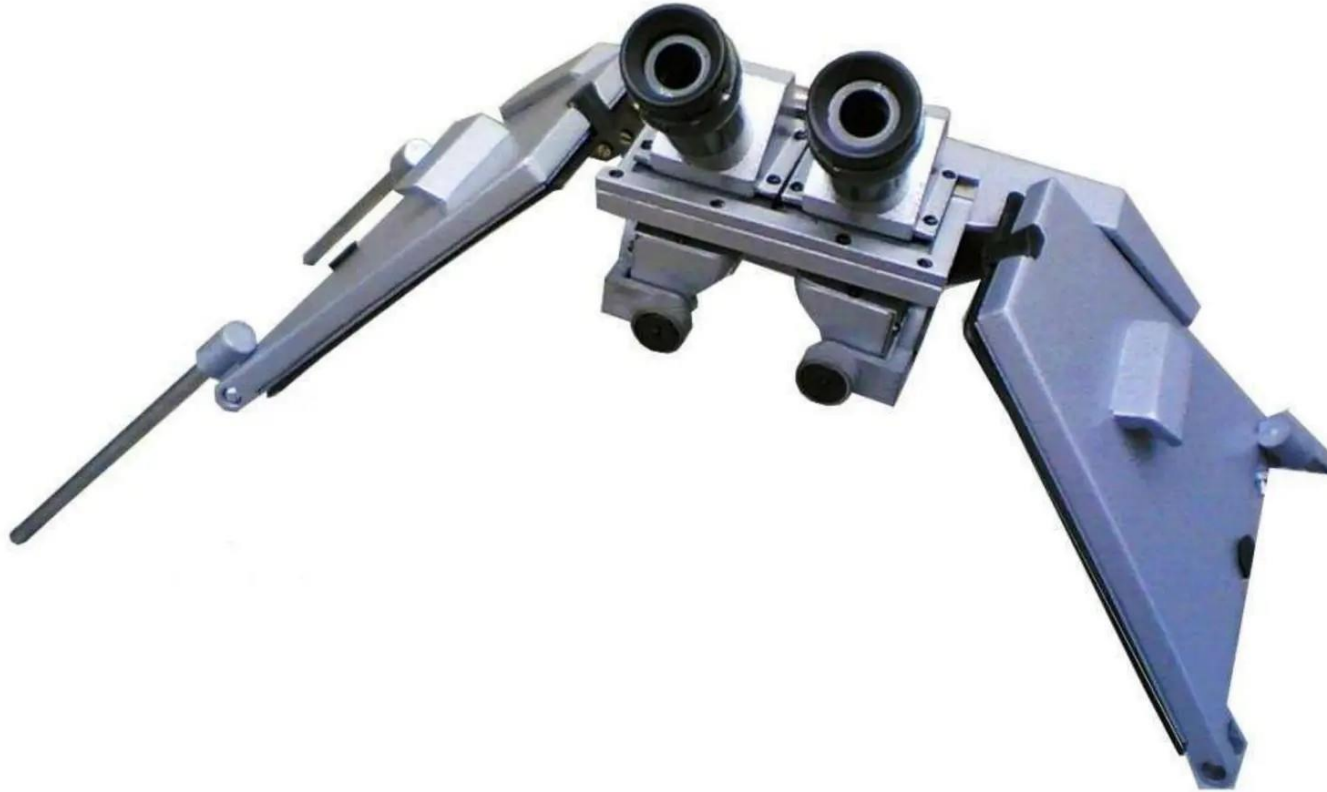


## Tilt Effect on Image Scale



Er. Pramesh Hada, Asst. Professor, nec

# STEREOSCOPES



# Principle of stereoscope

Two separate photo viewed in stereoscope the image of left photograph viewed by left eye and the image of right photograph viewed by right eye is fused together in brain to provide 3- dimensional view. This is called stereoscopic fusion

## Parallax in Aerial Stereoscopic View

- In normal binocular vision the apparent movement of a point viewed first with one eye and then with the other is known as ***Parallax***.
- Parallax is displacement of two images in successive photographs.

# BASIC TERMS USED IN PHOTOGRAMMETRY

## Tilted Photograph:

An aerial photograph taken with a camera having its optical axis tilted usually less than  $3^\circ$  from the vertical is known as tilted photograph.

## Exposure (or air) station (O):

The exact position of the front nodal point of the lens in the air at the instant of exposure.

## Flying height (H): (2009)

The elevation of the air station above the mean sea level is known as flying height of the aircraft.

## Nadir Point (Plumb Point): (2009)

The point where a plumb line dropped from the front nodal point strikes the photograph

## Camera Axis : (2006)

It is the line passing through the centre of the camera lens perpendicular both to the camera plate (negative) and the picture plane (photography).





# BASIC TERMS USED IN PHOTOGRAMMETRY

## Fiducial mark - 2006,2007 (Reference mark)

A fiducial mark is one of two, three or four marks, located in contact with the photographic emulsion in a camera image plane to provide a reference line or lines for the plate measurement of images.

## Iso centre (2006)

The point in which the bisector of the angle of tilt meets the photographs is known as Isocentre.

It lies on the principal line at a distance of  $f \tan t/2$  from the principal point.

## Principal Point

The point where a perpendicular dropped from the front nodal point strikes the photographs is known as principal point of photograph

## Focal length -

It is the perpendicular distance from the centre of the camera lens to either the picture plane or the camera plate.

Tilt : The deviation of a plate from the horizontal plane at the time of exposure is known as tilt.

Horizontal Point (h): The point of intersection of the principal line (VIP) and the horizontal line (oh) through the perspective centre O is known as horizontal point.

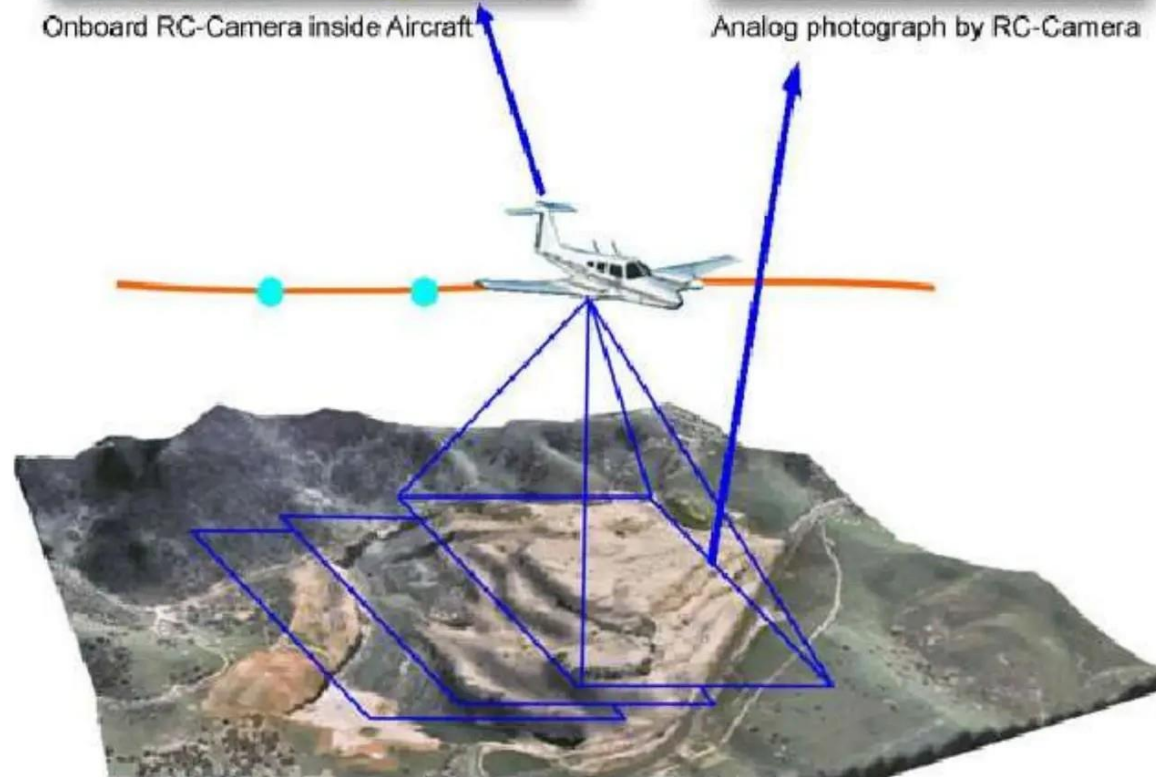




Onboard RC-Camera inside Aircraft



Analog photograph by RC-Camera

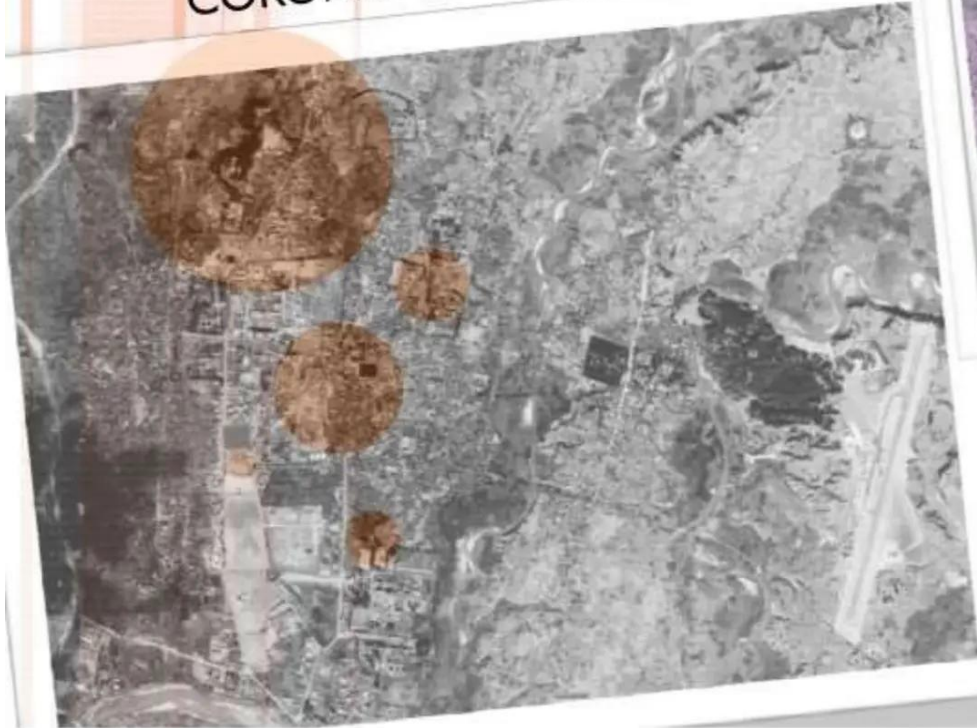


A general view of photographing by RC-Camera



# INTERPRETATIONS THROUGH MAPS AND AERIAL PHOTOS

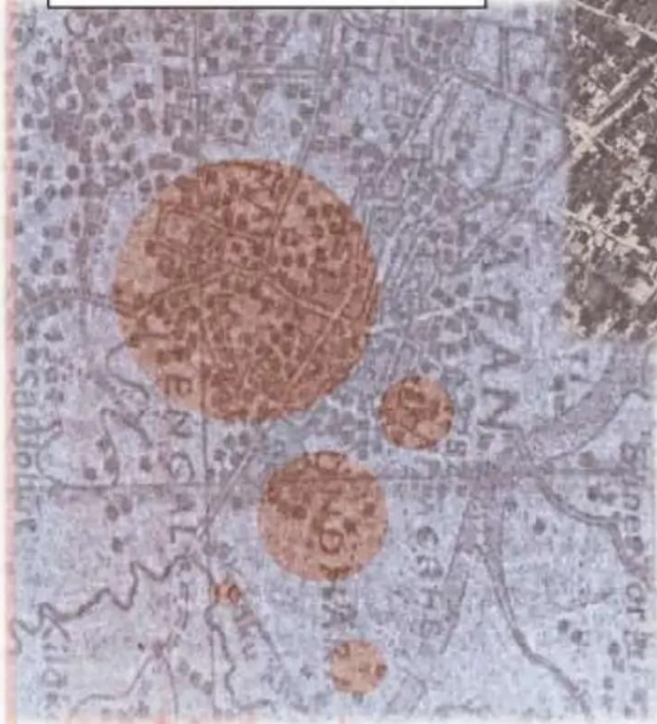
CORONA IMAGE 1969



SATELLITE IMAGE 2005

# INTERPRETATIONS THROUGH MAPS AND AERIAL PHOTOS

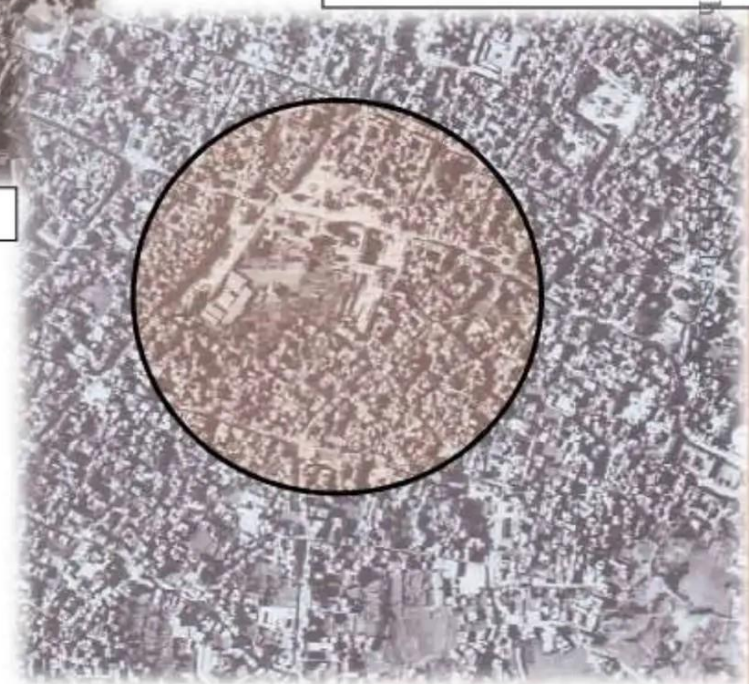
AERIAL IMAGE - 1957



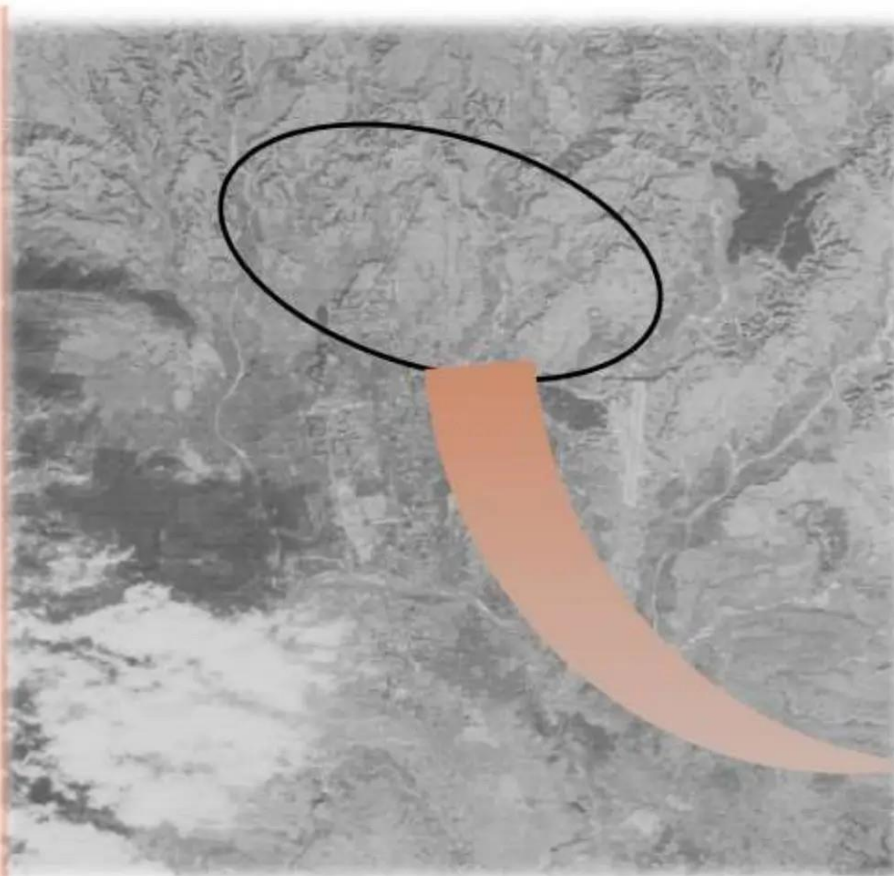
AERIAL IMAGE- 1981



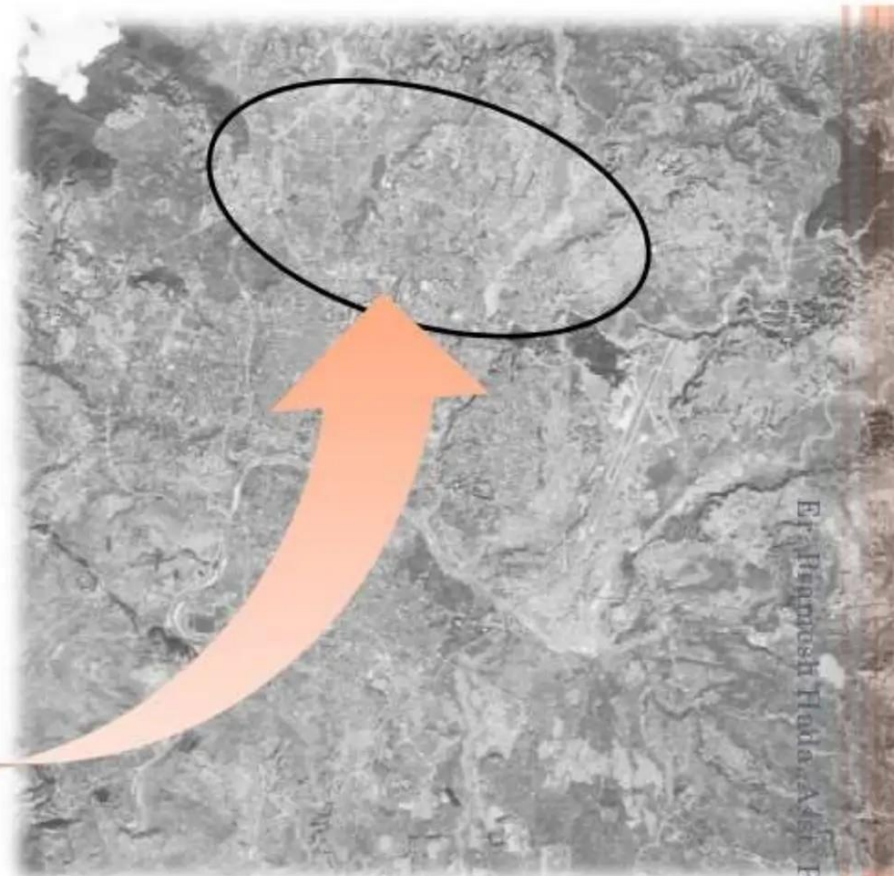
SATELLITE IMAGE- 1998



PATAN DURBAR SQUARE AREA



CORONA1M\_KATHMANDU 05FEB 1967



IRS1 CPAN1 04052A0\_23NOV1996  
OF KATHMANDU

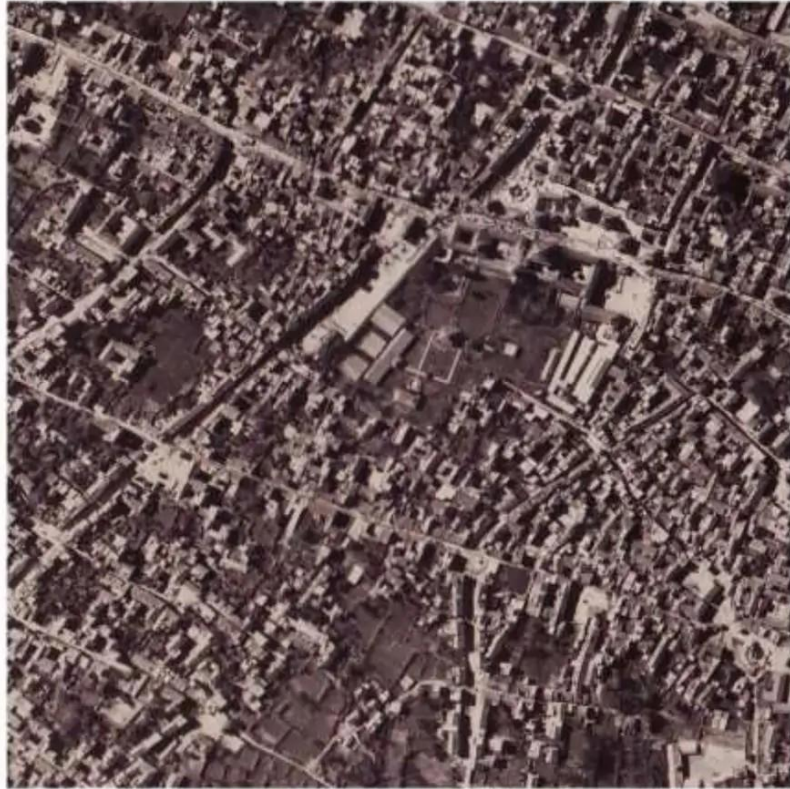


# PATAN DURBAR SQUARE AREA



AERIAL PHOTO 1957





AERIAL PHOTO 1981



AERIAL PHOTO 1998





Pranesh Hadani





