Remote Sensing and Image Processing

Aerial Photography and Photogrammetry

Structure

- **Definitions of Remote Sensing**
- Origins of remote sensing
- Types of aerial photograph
- Photogrammetry
- Parallax
- Human vision
- Conclusions

Definitions of Remote Sensing

Can be very general, e.g.
"The acquisition of physical data of an object **without touch or contact**" (Lintz and Simonett, 1976)
"The observation of a target by a device **some distance away**" (Barrett and Curtis, 1982)

Definitions of Remote Sensing

Or more specific, e.g.
"The use of **electromagnetic radiation sensors** to record images of **the environment**, which can be interpreted to yield **useful information**" (Curran, 1985)

Definitions of Remote Sensing

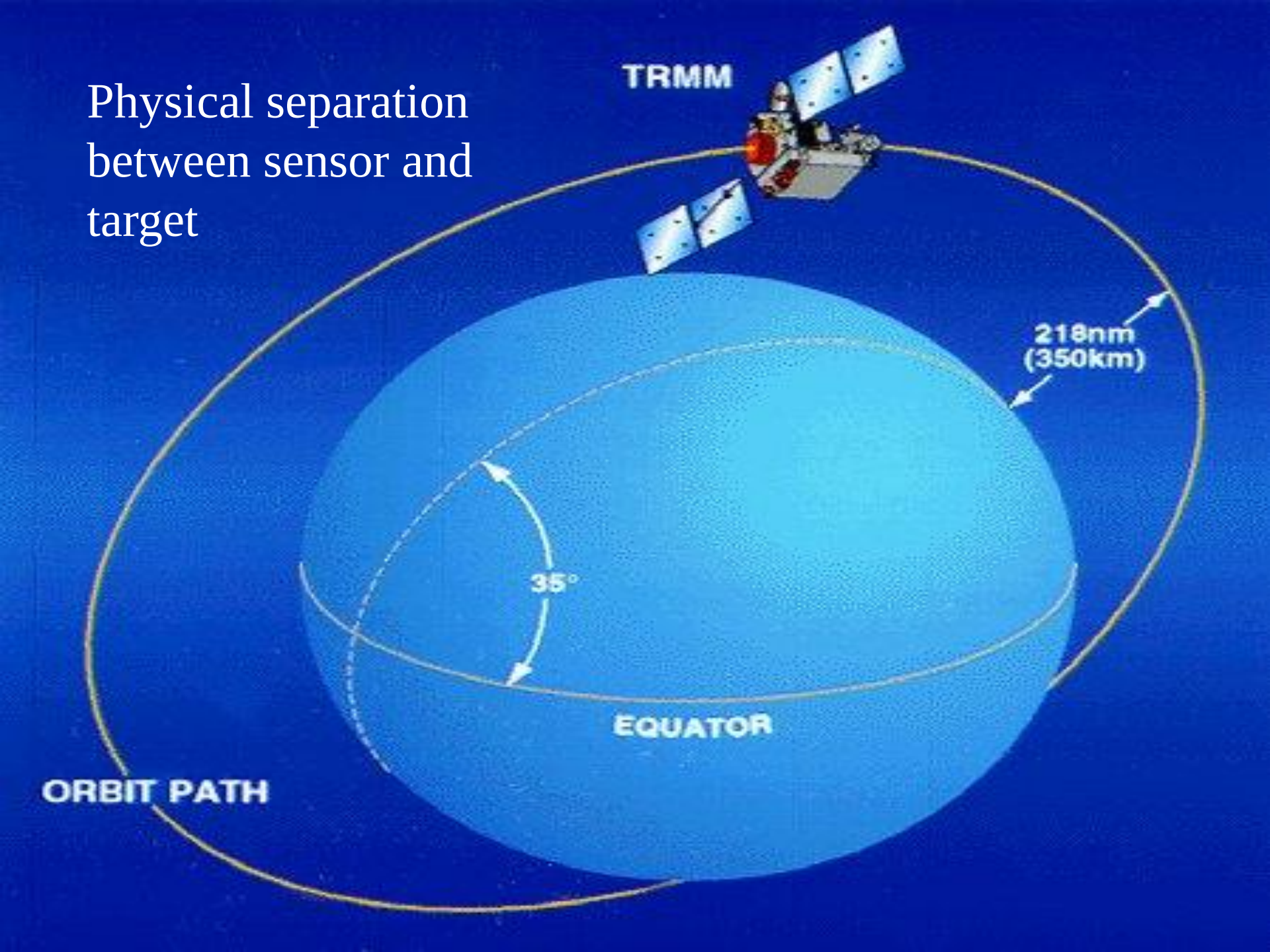
Or more specific, e.g.
"The use of sensors, normally operating at wavelengths from the **visible to the microwave**, to collect information about the Earth's **atmosphere, oceans, land and ice surfaces**" (Harris, 1987)

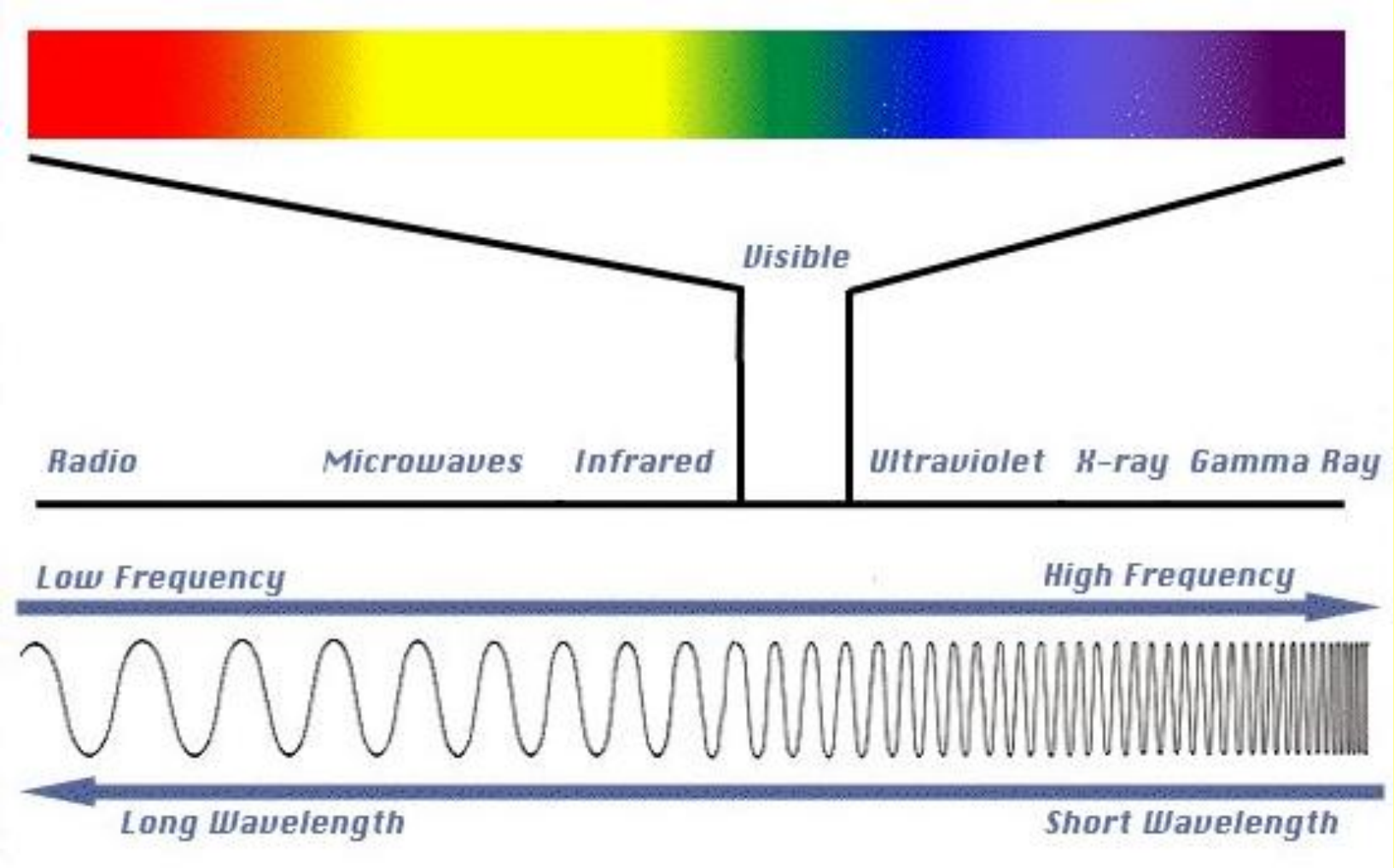
Definitions of Remote Sensing

Main characteristics

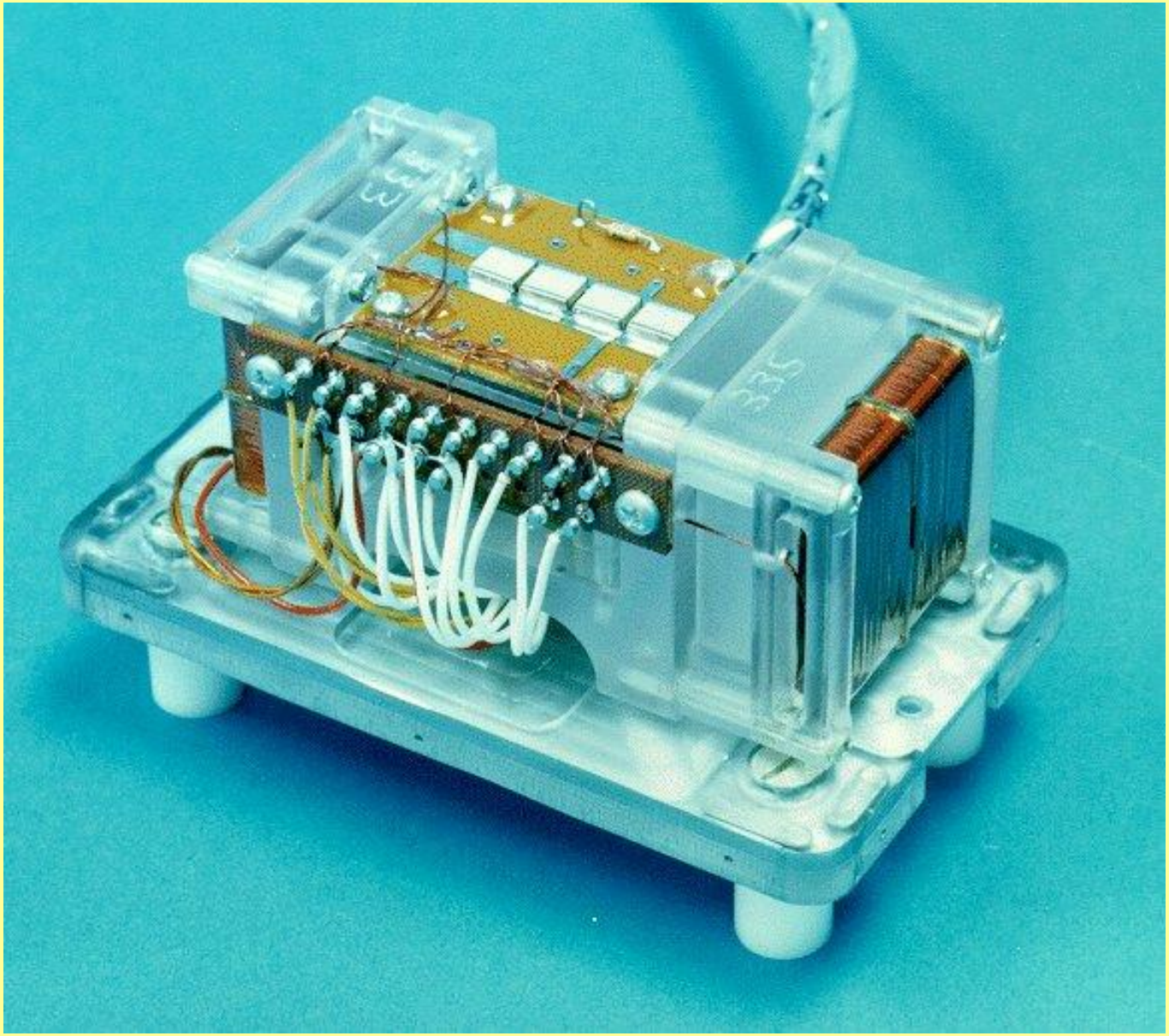
- Physical separation between sensor and target
- Medium = electromagnetic radiation (sonar is an exception)
- Device to sample and measure radiation (sensor)
- Target is the terrestrial environment (atmosphere, oceans, land surface)

Physical separation between sensor and target

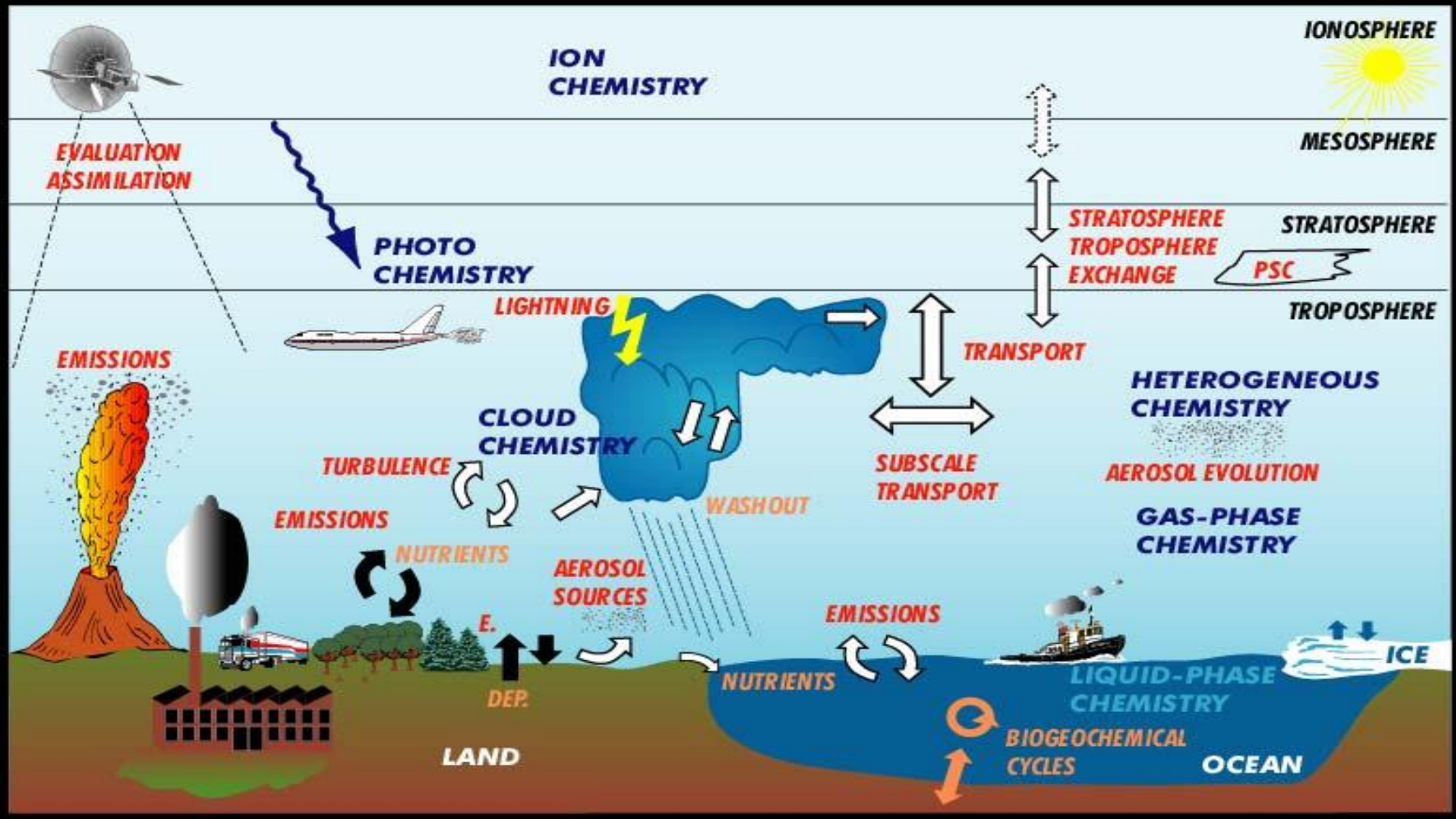




Medium = electromagnetic radiation (sonar is an exception)



Device to sample and measure radiation (sensor)



Target is the terrestrial environment (atmosphere, oceans, land surface)

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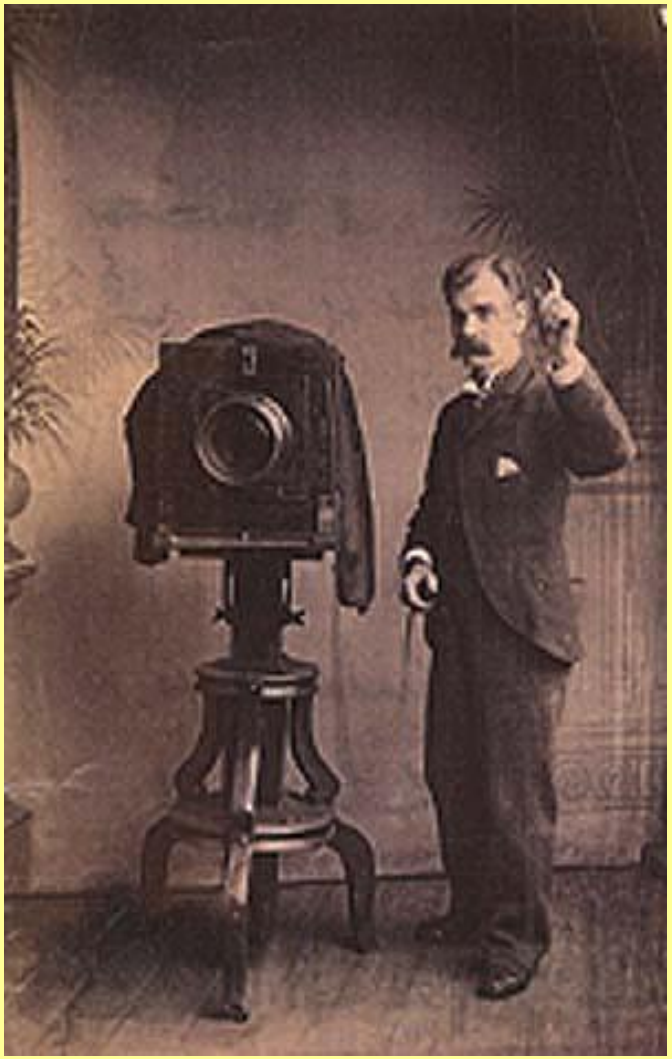
Origins of Remote Sensing

Remote sensing began with aerial photography

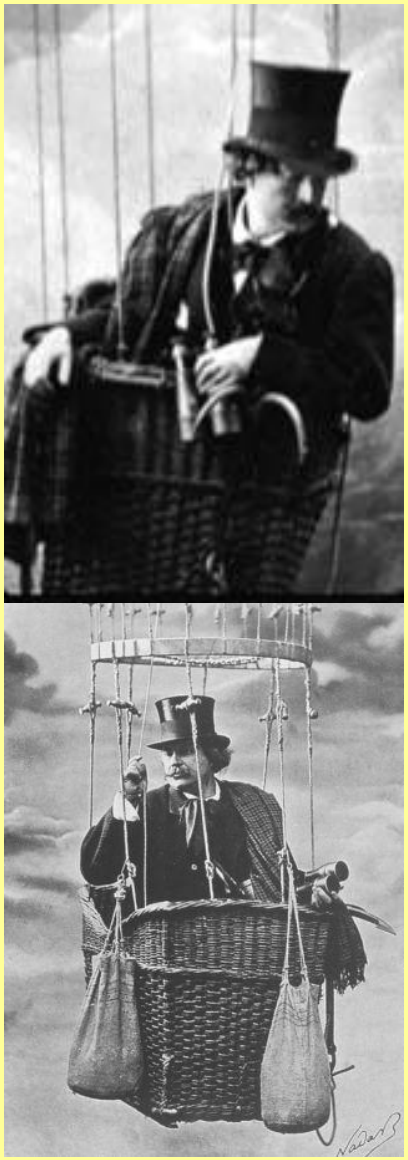
Origins of Remote Sensing

First photographs taken in 1839

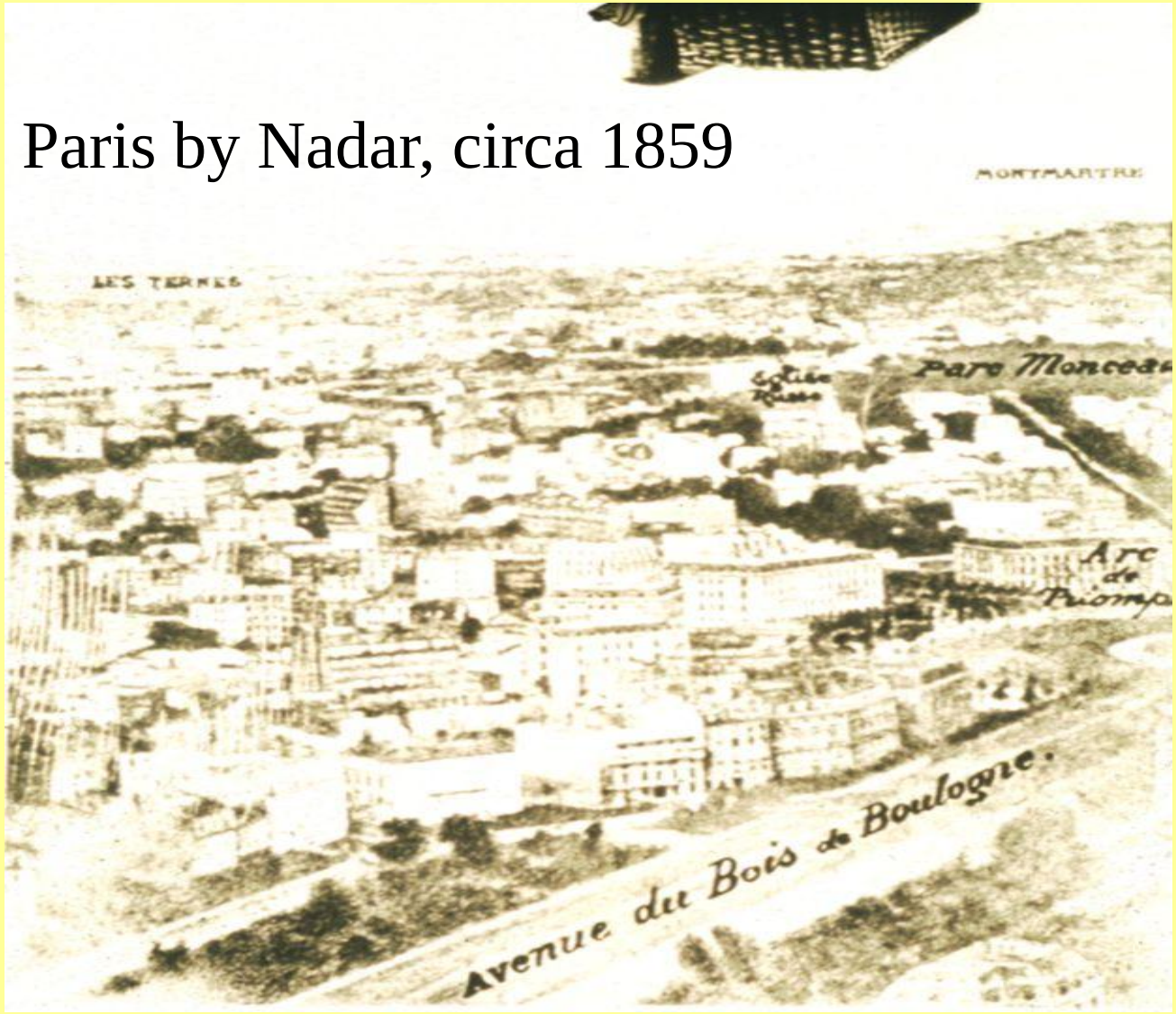


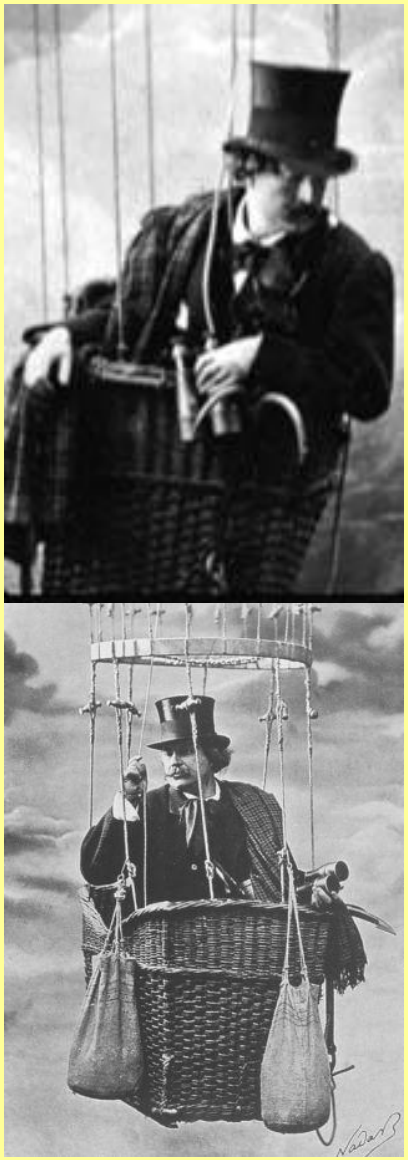
Origins of Remote Sensing

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



Paris by Nadar, circa 1859

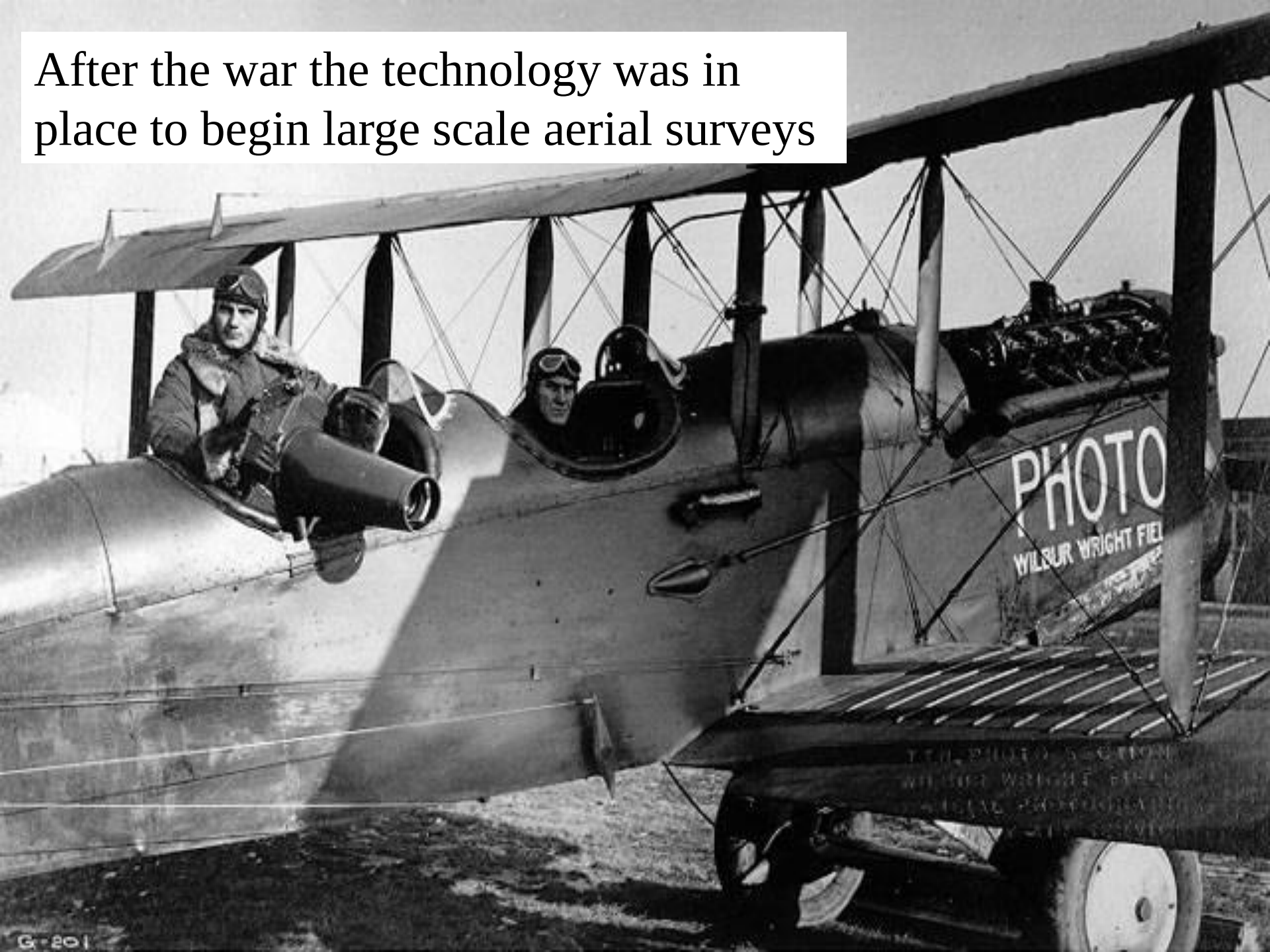




Boston by Black and King (1860)


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

After the war the technology was in place to begin large scale aerial surveys



Structure

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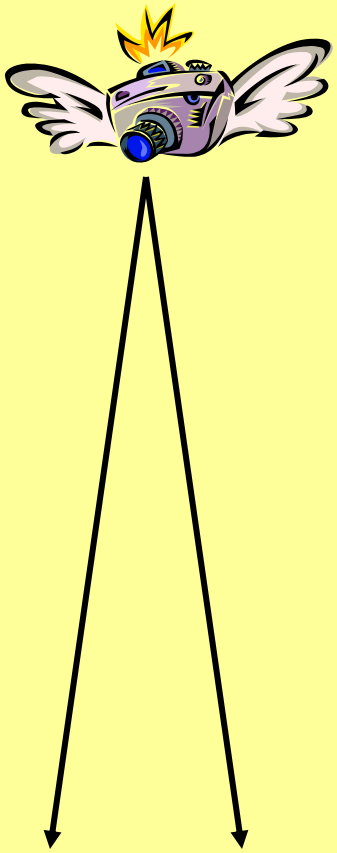
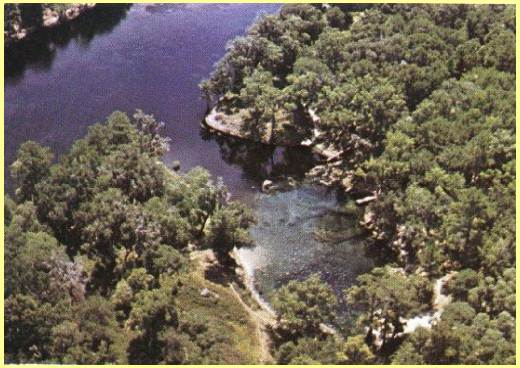
Types of aerial photograph

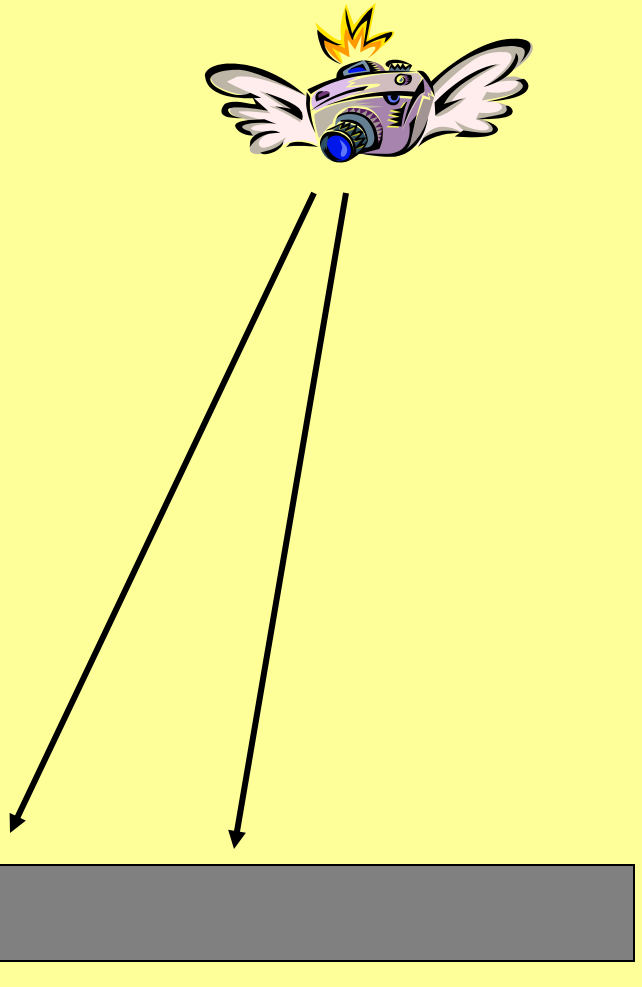
- Vertical
- Low oblique
- High oblique



Types of aerial photograph

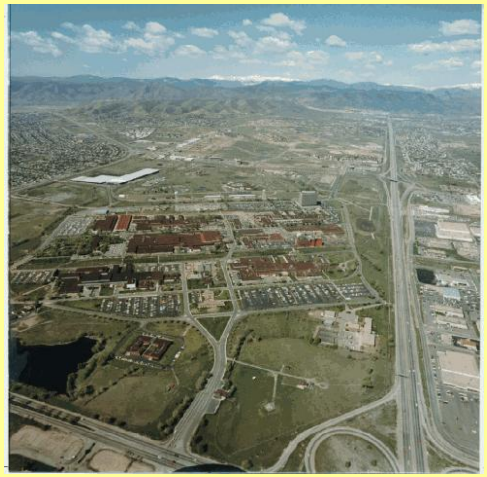
- Vertical
- Low oblique (no horizon)
- High oblique





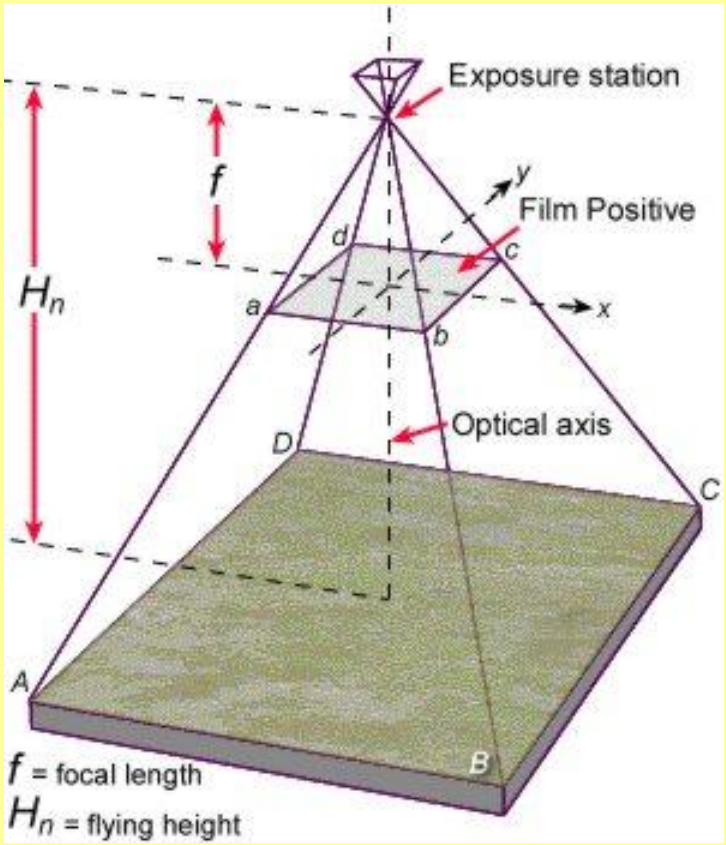
Types of aerial photograph

- Vertical
- Low oblique
- High oblique



Types of aerial photograph

Vertical is most important as it has minimum distortion and can be used for taking measurements

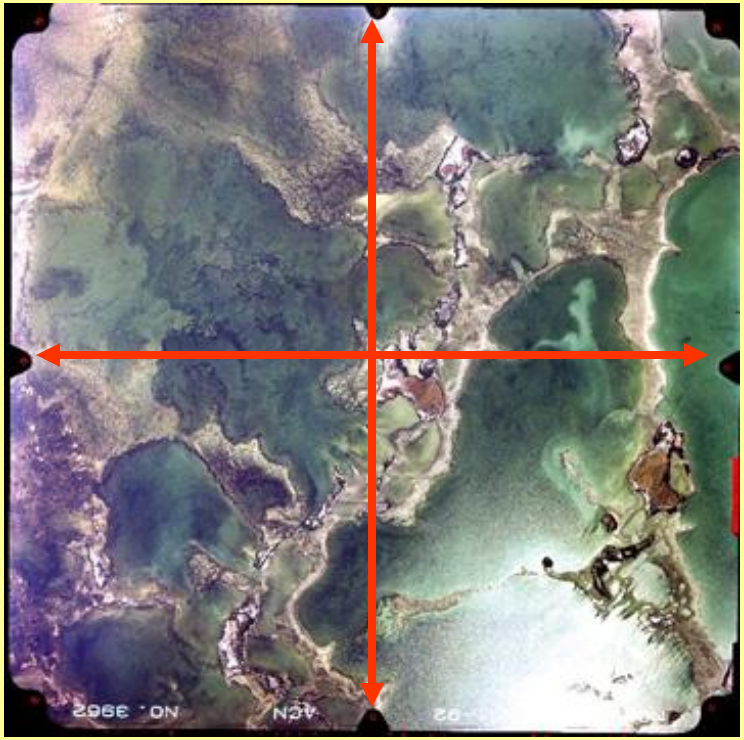


Types of aerial photograph

Fiducial marks

Types of aerial photograph

Fiducial axes



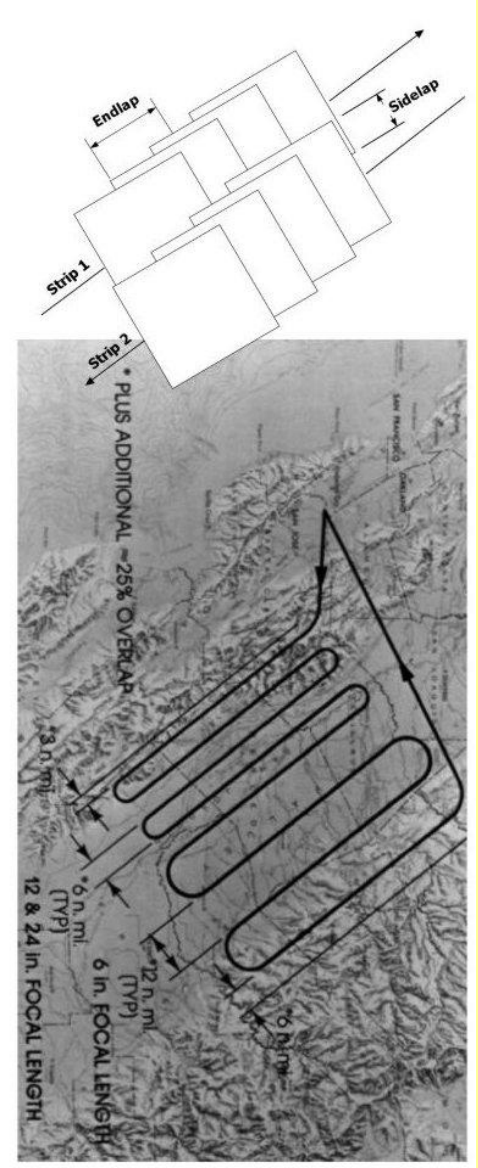
Types of aerial photograph

Principal point

Marginal information

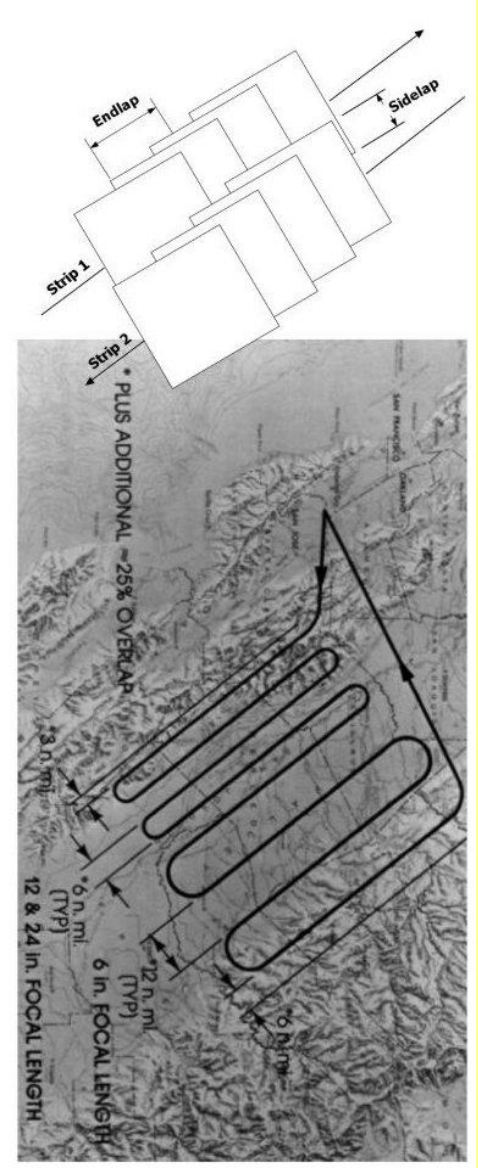
Types of aerial photograph

An aerial photograph mission will be flown in strips, shutter timing set for 60% endlap (needed for parallax) and strips spaced for 30% sidelap (to avoid missing bits)



Types of aerial photograph

- Endlap (or forelap) is the important bit
- It ensures every point on the ground appears in at least two photographs
- Distance between principal point of adjacent photographs is known as the “air base”



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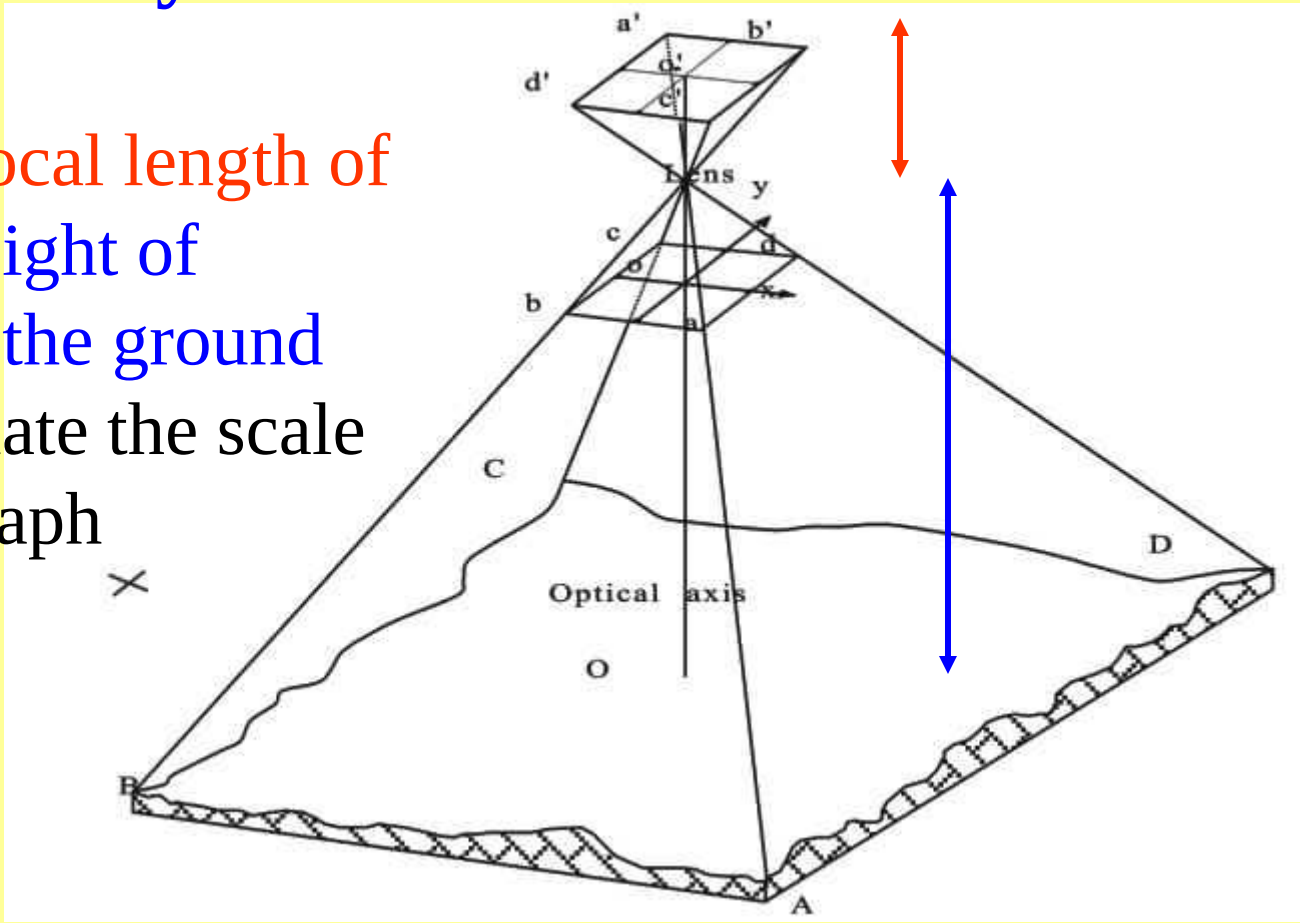
Photogrammetry

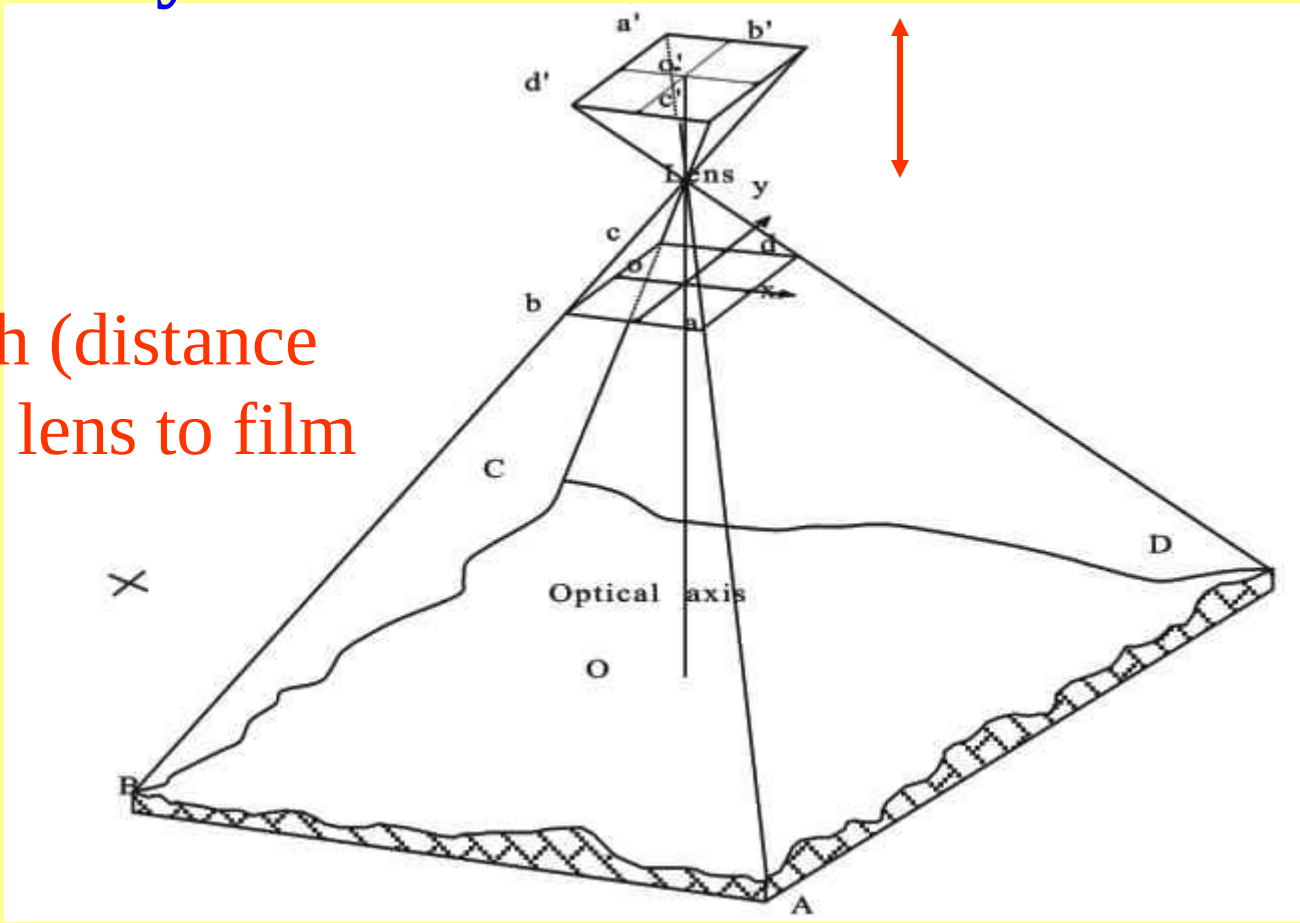
If you know focal length of camera and height of aircraft above the ground you can calculate the scale of the photograph



Photogrammetry

Scale = f/H-h

f = focal length (distance from centre of lens to film surface)

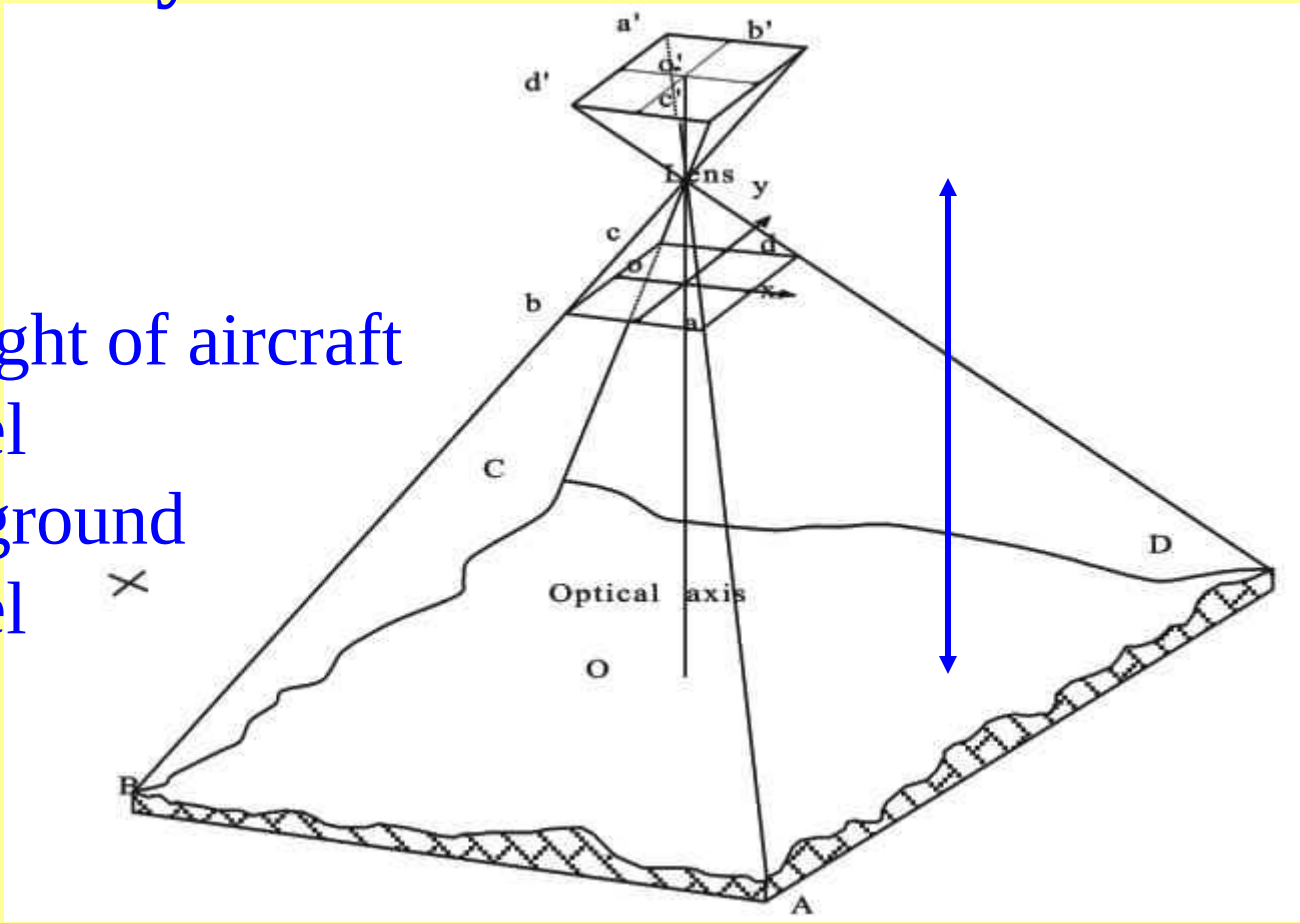


Photogrammetry

Scale = f/H-h

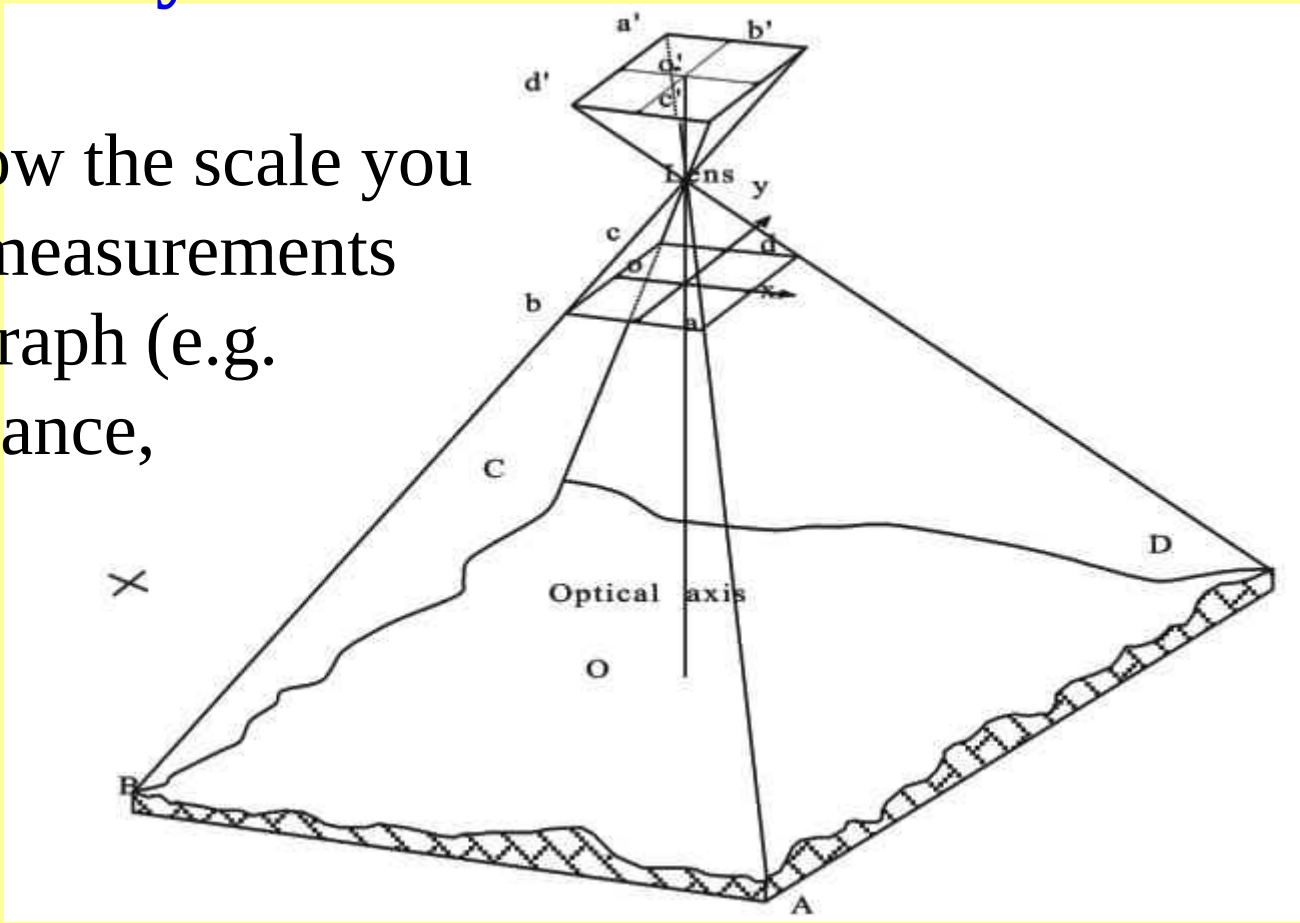
H = flying height of aircraft above sea level

h = height of ground above sea level



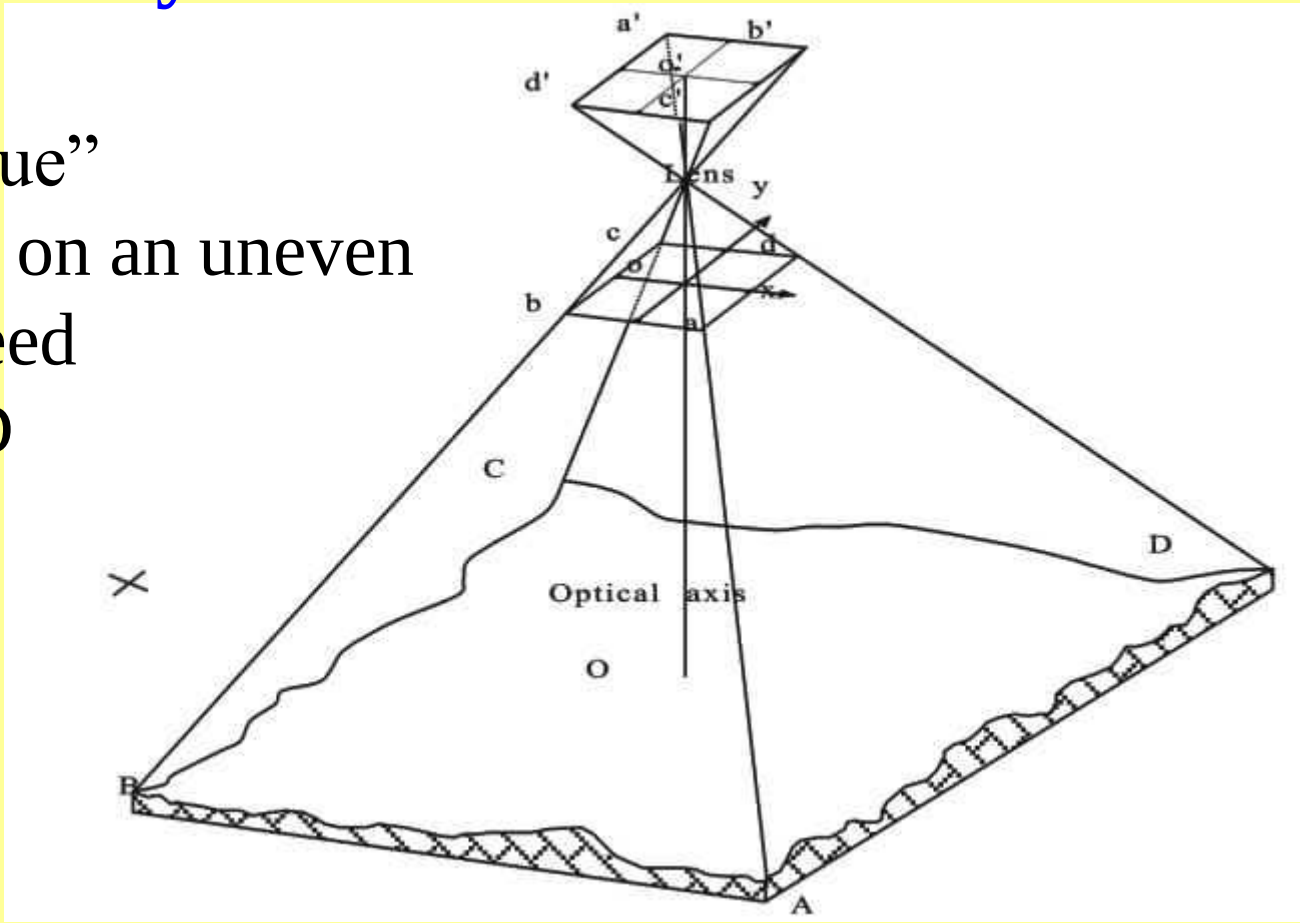
Photogrammetry

When you know the scale you can take 2-D measurements from a photograph (e.g. horizontal distance, horizontal area, etc.)



Photogrammetry

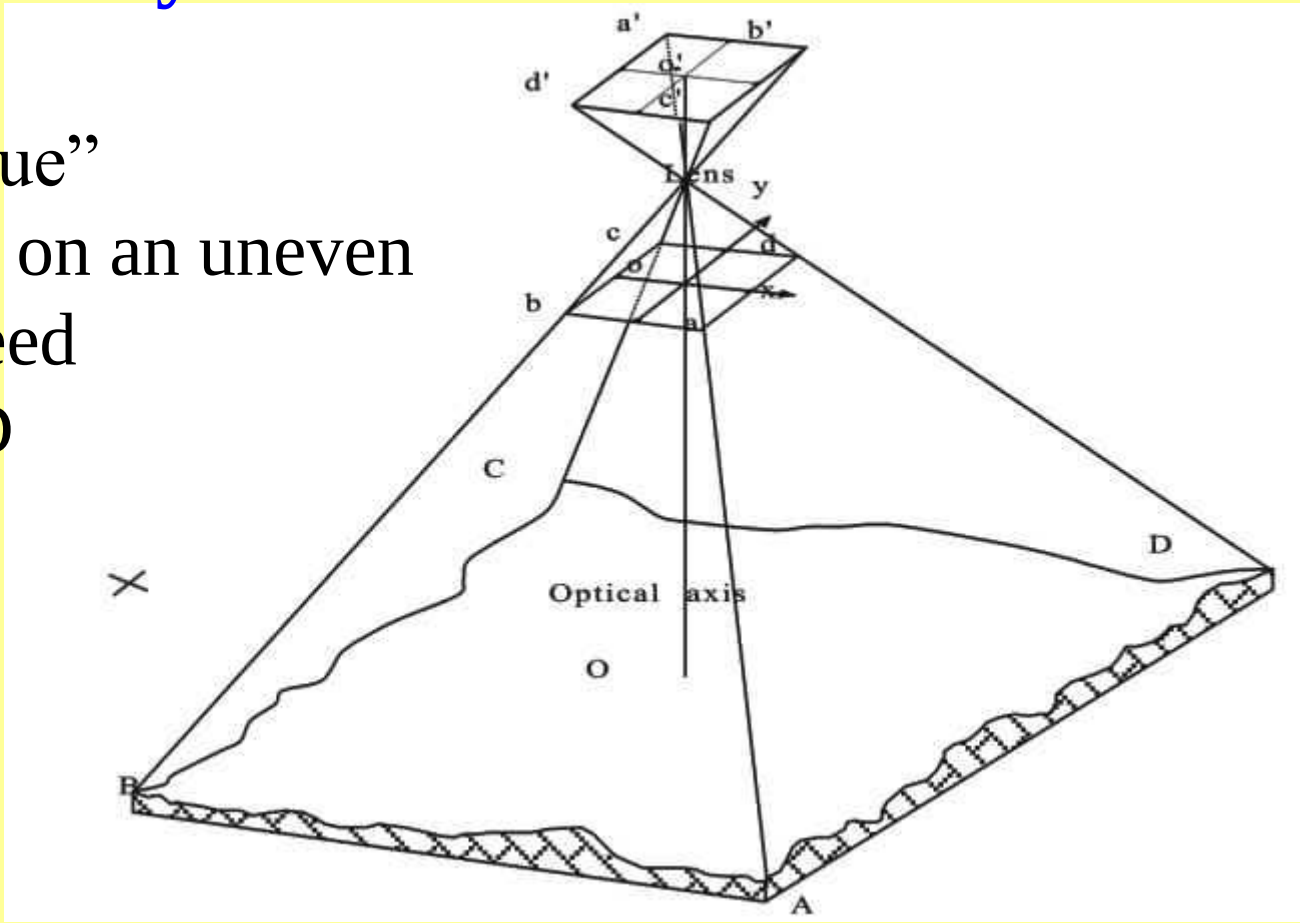
But to take “true” measurements on an uneven surface you need to work in 3-D



Photogrammetry

But to take “true” measurements on an uneven surface you need to work in 3-D

You can do this thanks to parallax



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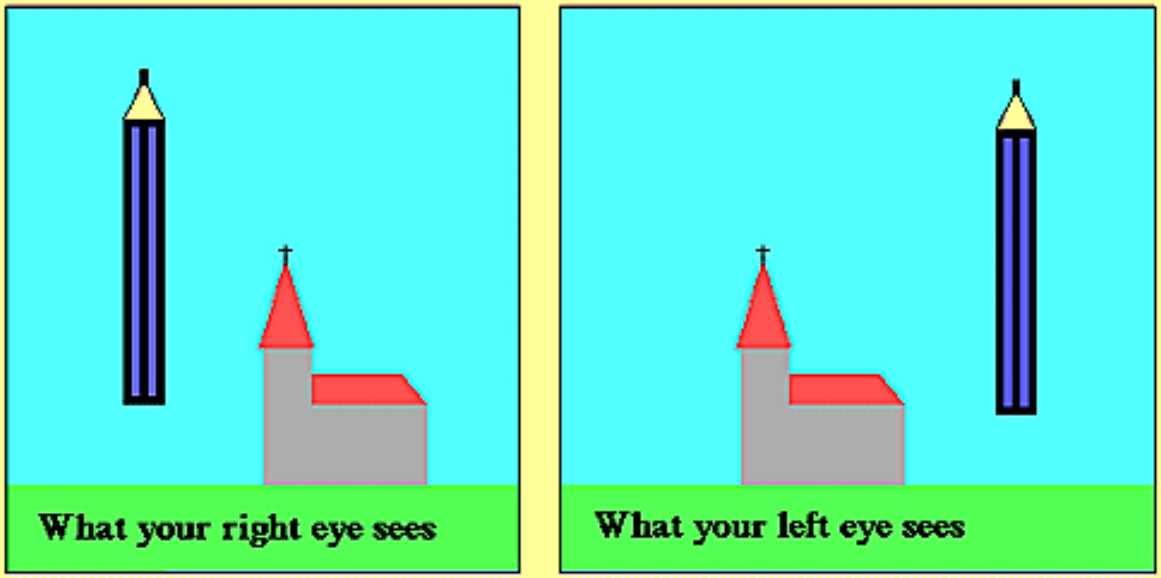
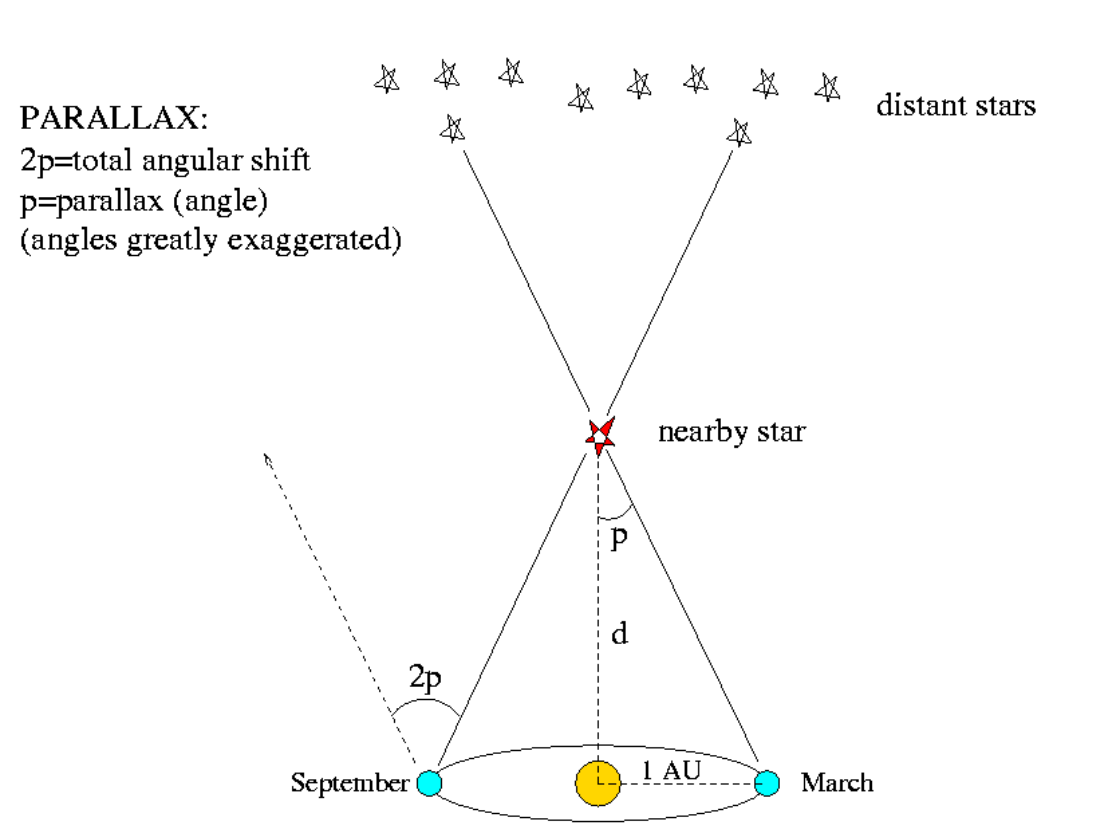
Parallax



Pencil is very displaced because it is close to observer

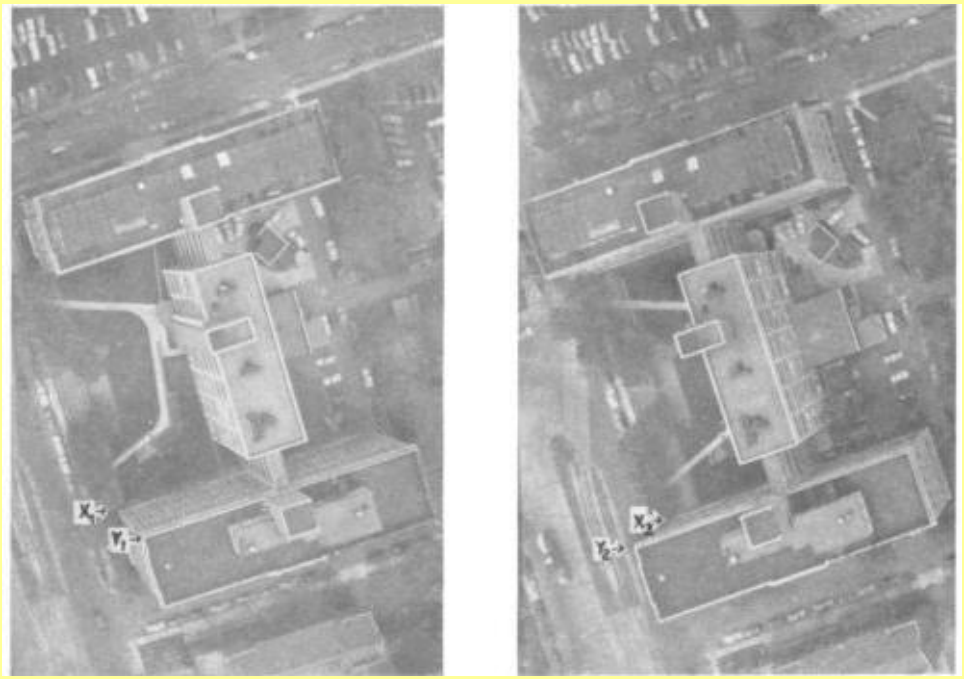
Church is less displaced because it is further away

Parallax



Parallax is used to find distance to stars, using two viewing points on either side of Earth's orbit

Parallax



The same principle can be used to find height of objects in stereopairs of vertical aerial photographs

Parallax

$$\text{Height of object} = \frac{H \cdot dP}{P + dP}$$

H = height of aircraft above ground
P = absolute parallax at base of object being measured*
dP = differential parallax

* For convenience the photo base length of a stereo pair is commonly substituted for absolute stereoscopic parallax (**P**)

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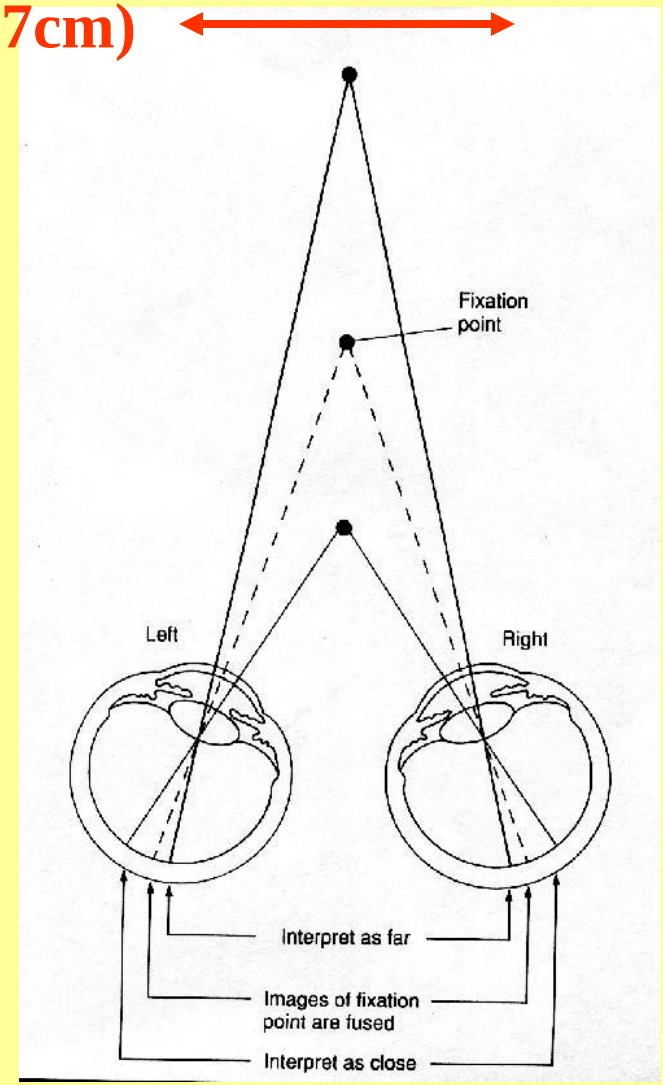
Human vision

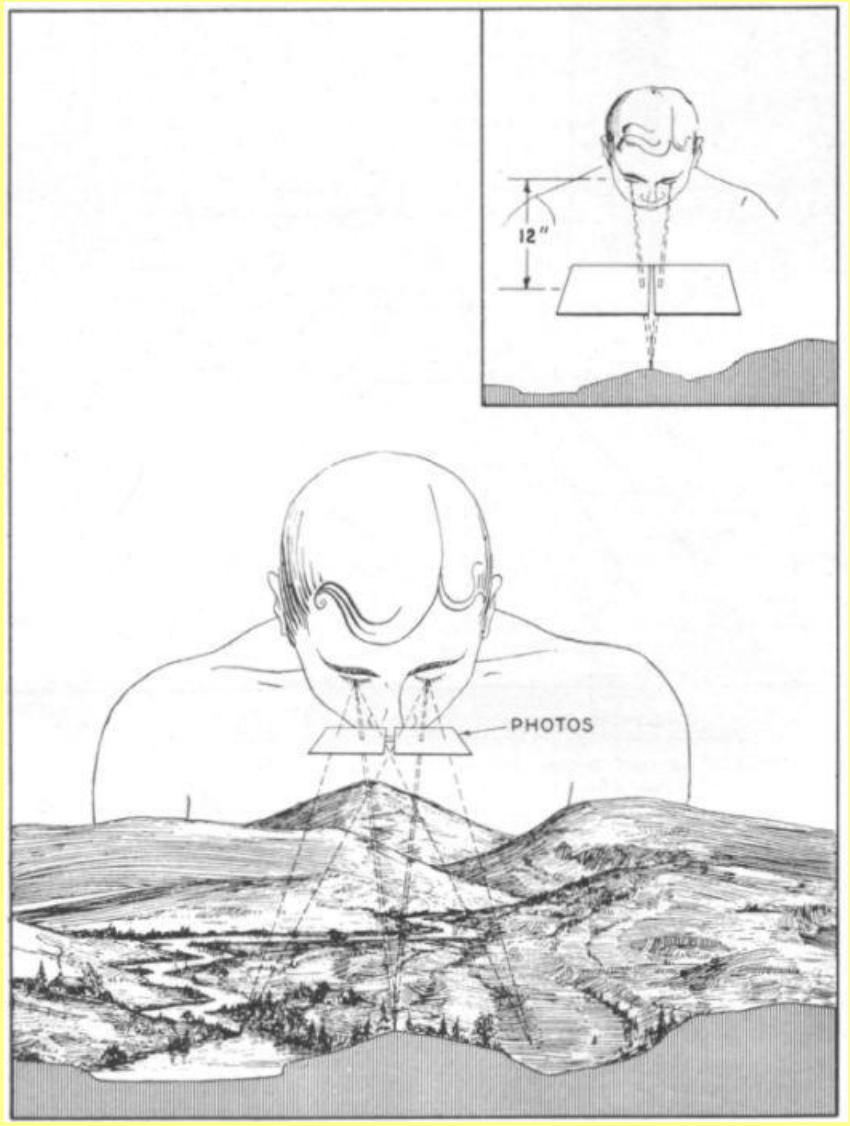
Human vision is binocular in most cases, and human eyes can resolve parallax as angle of convergence

This provides perception of "depth" and enables us to judge distances (up to 400m)



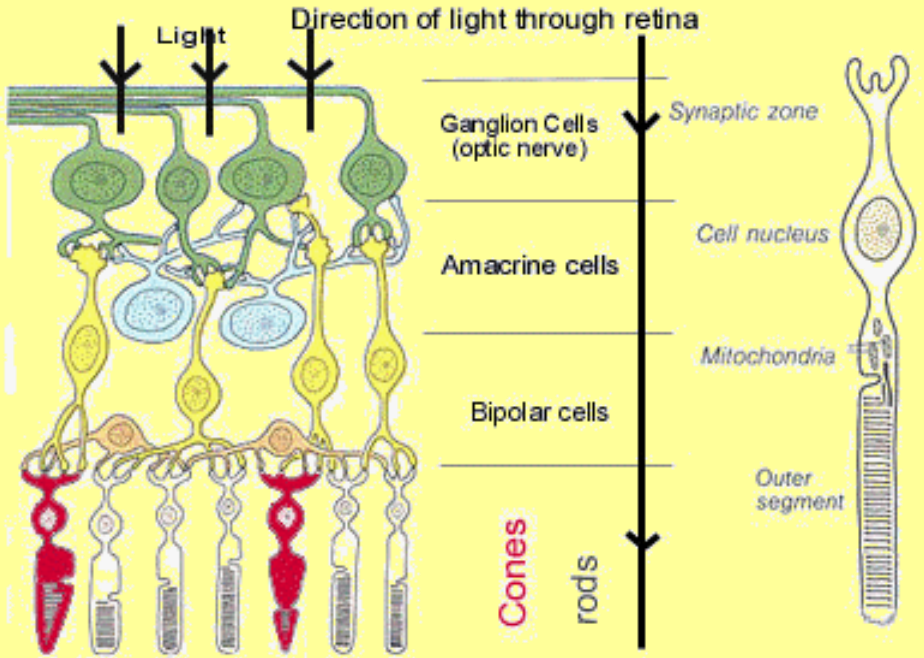
Human vision

3-D stereoptic viewing of the Earth's surface is possible using overlapping pairs of vertical stereo aerial photographs



Human vision

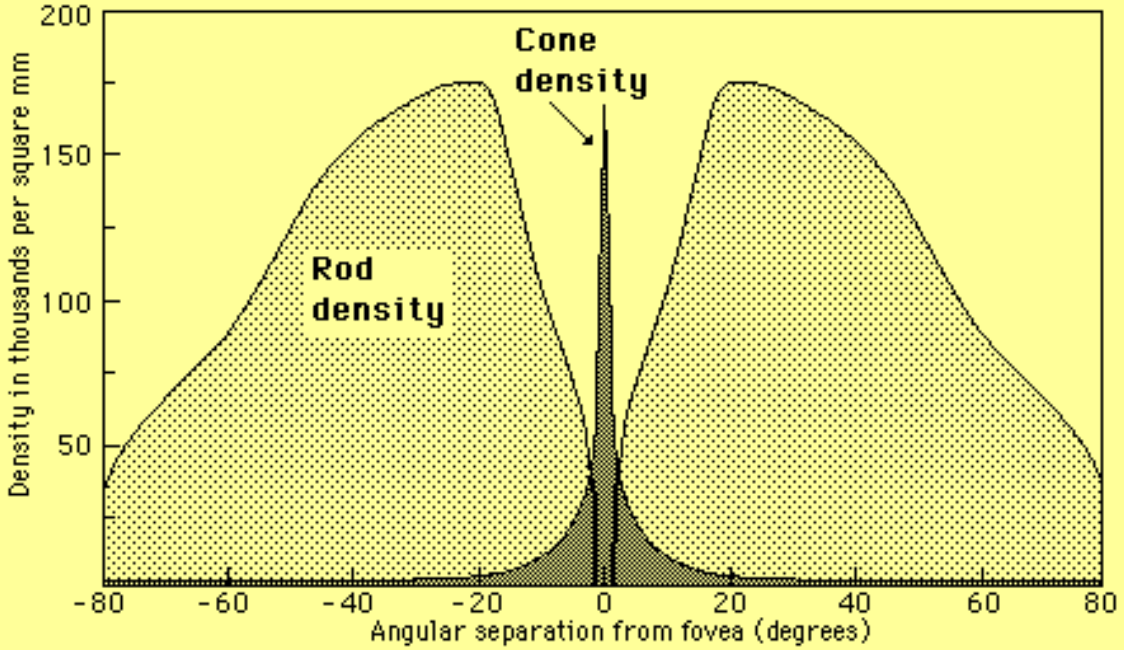
Two types of light-sensitive cells are present in the retina:



- Cones are sensitive to radiation of specific wavelengths (either red, green or blue)
- Rods are sensitive to all visible wavelengths

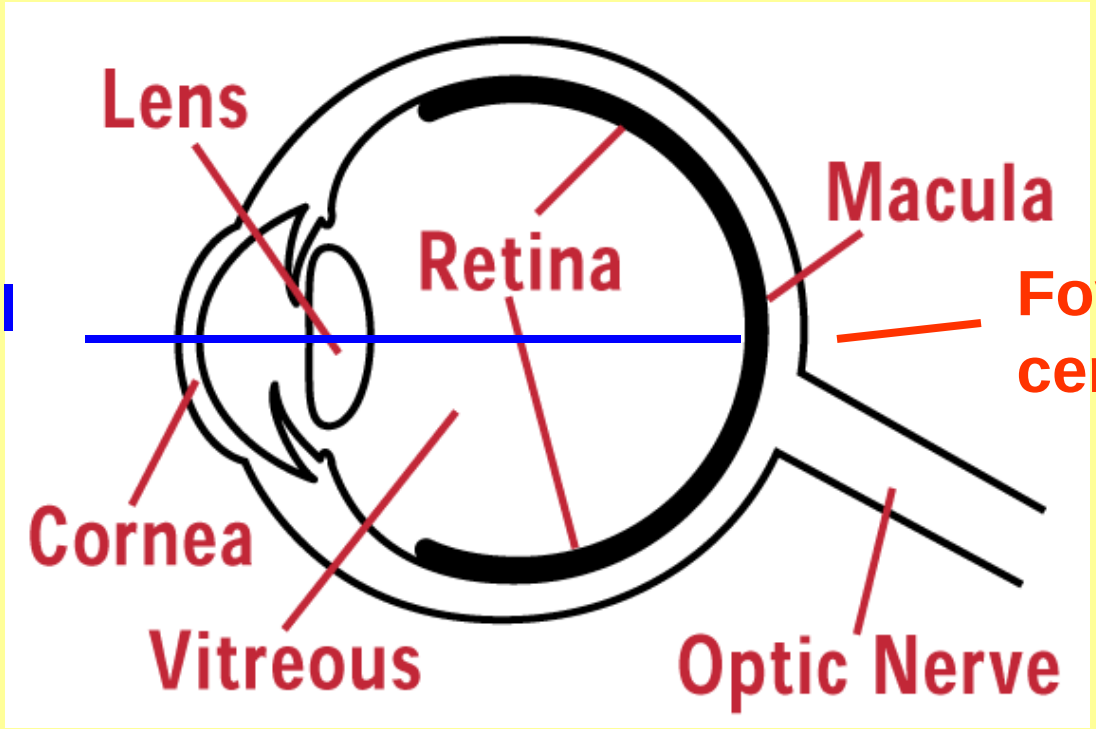
Human vision

Two types of light-sensitive cells are present in the retina:



- Cones are clustered around the *fovea centralis*
- Rods are widely distributed elsewhere

Human vision



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Conclusions

- Remote sensing involves collecting information about the Earth from a distance using electromagnetic sensors
- It evolved from aerial photography
- Vertical stereopairs of aerial photographs are used to take 3-D measurements by measuring parallax
- Human vision is binocular, enabling us to resolve parallax for depth perception
- Human vision includes perception of colour