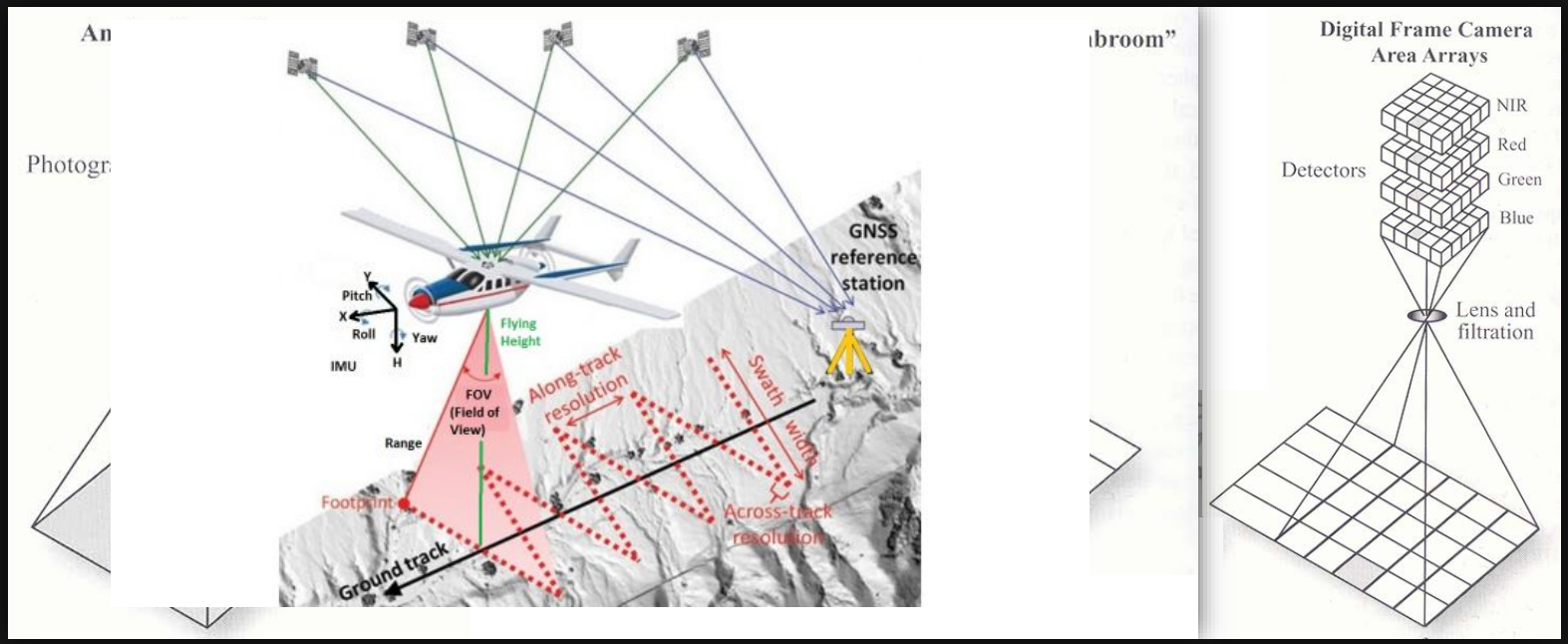
Aerial photography: Principles

Frame capture sensors: Analog film and digital cameras

Overview

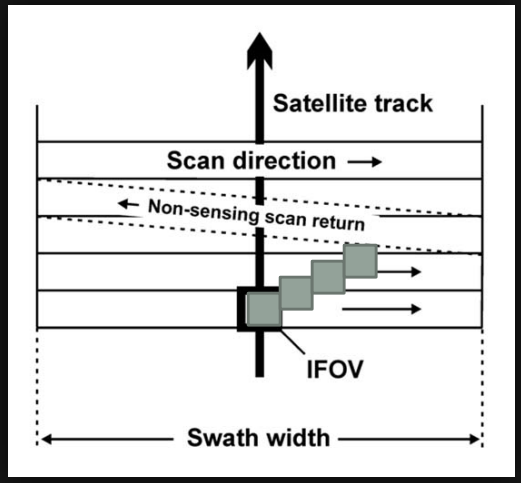
- Introduction
  - Frame vs scanning sensors
- Cameras (film and digital)
- Photogrammetry
- Orthophotos

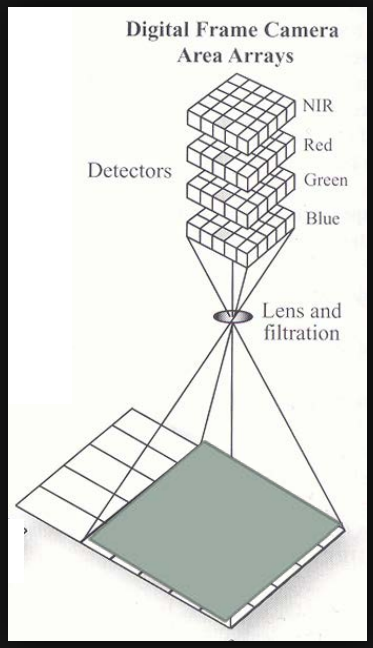
- Air photos are collected using a frame-based sensor, while most other remote sensing products are obtained using a scanning or pushbroom sensor (e.g., LiDAR uses a scanning approach).



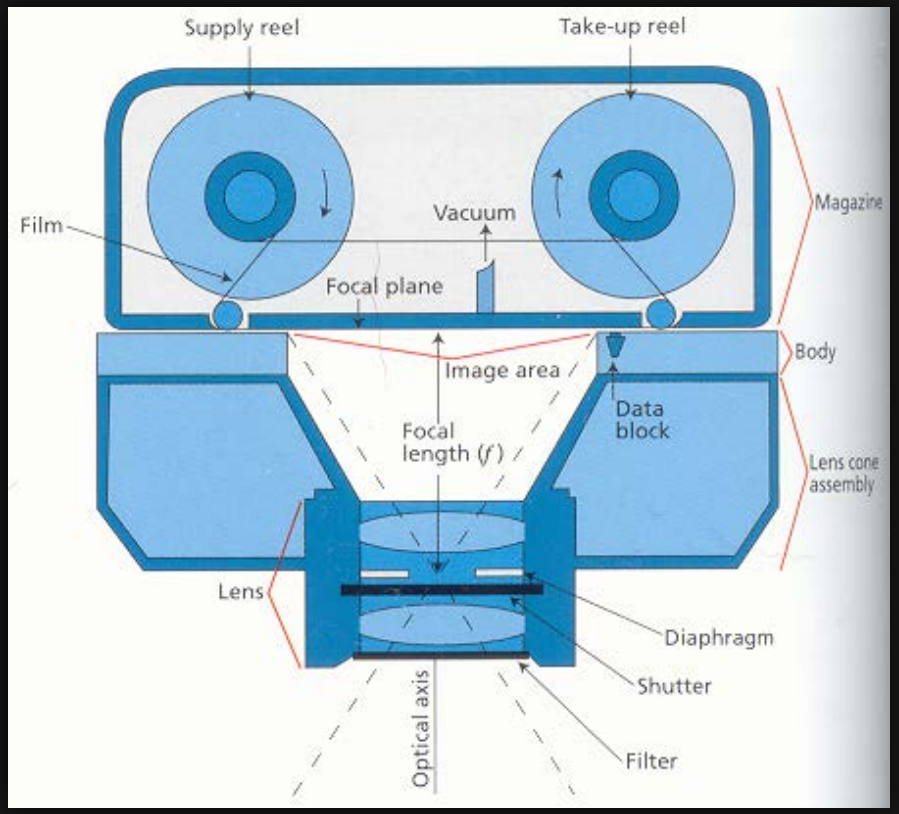
Frames versus scans

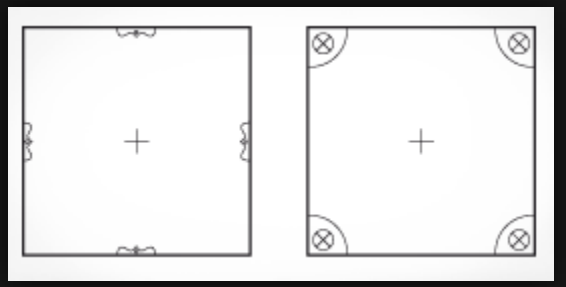
- What is a significant benefit of frame-based sensors over scanning sensors?
  - Hint: geometry





Frames versus scans

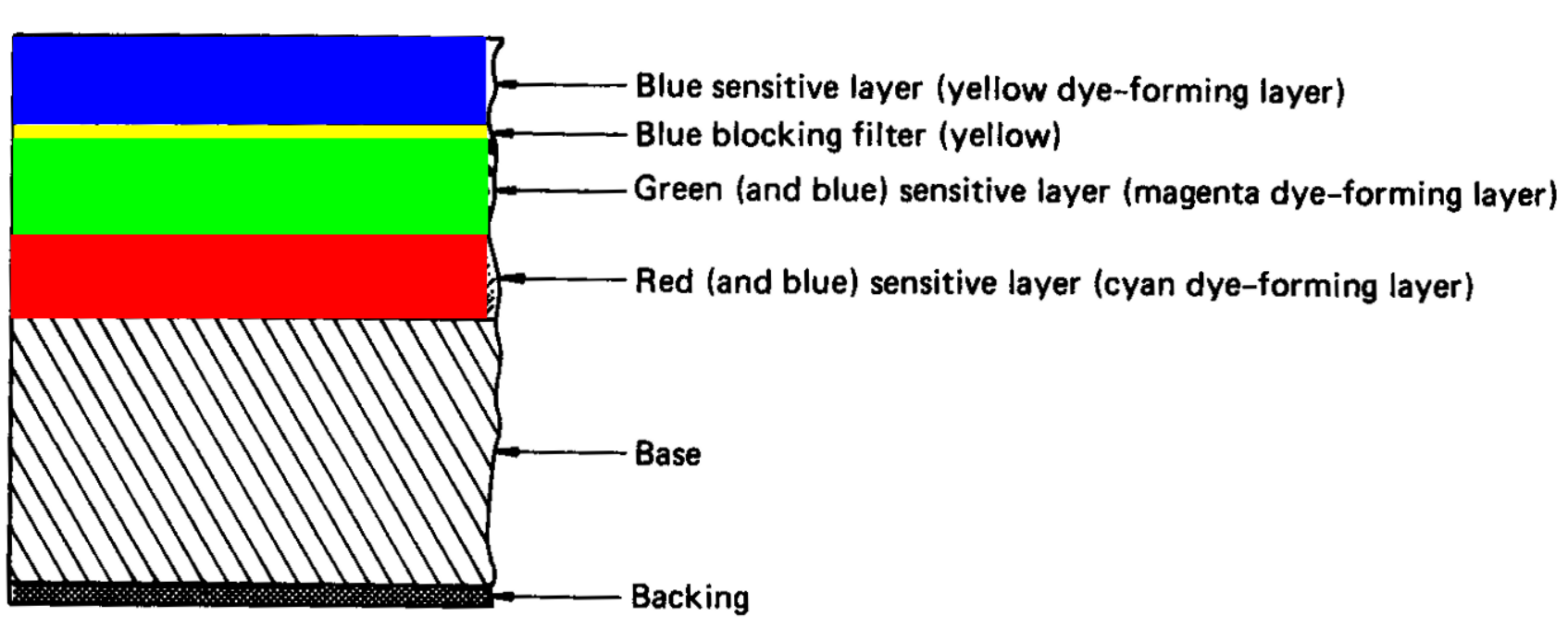




Every aerial mapping camera superimposes fiducial marks on each photo. The fiducial marks can be used to determine the principal point (+) of the photo, as well as to determine if the photo is distorted (compare the measured distances between the fiducial marks to the known distances).

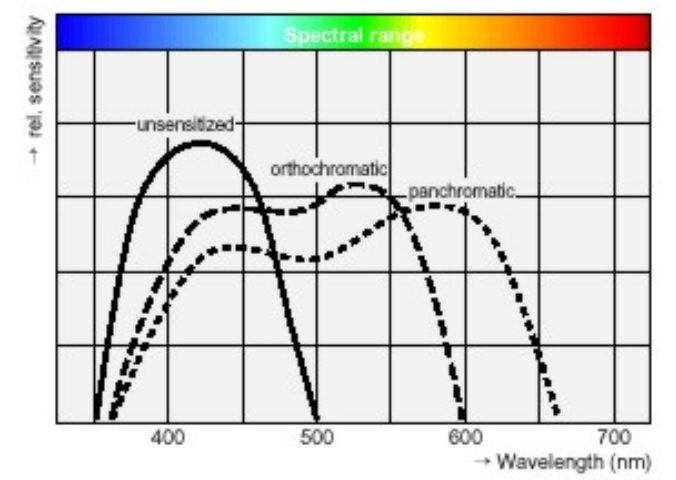
Aerial mapping cameras

Example aerial photo specifications Go to page 17 Section 2-02.1

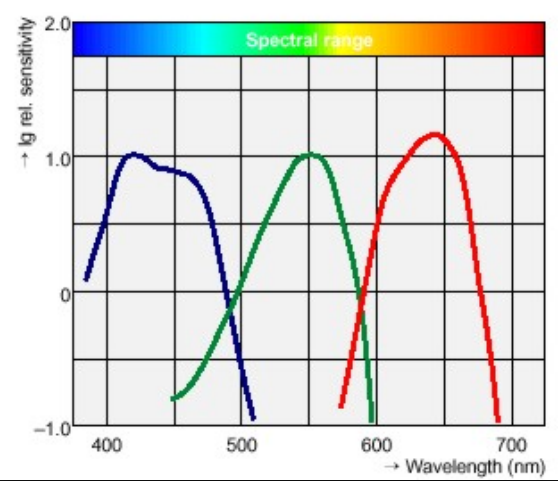


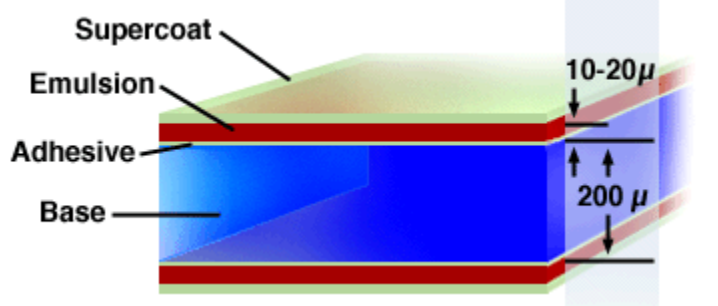
Colour film characteristics

Panchromatic film
(black and white)

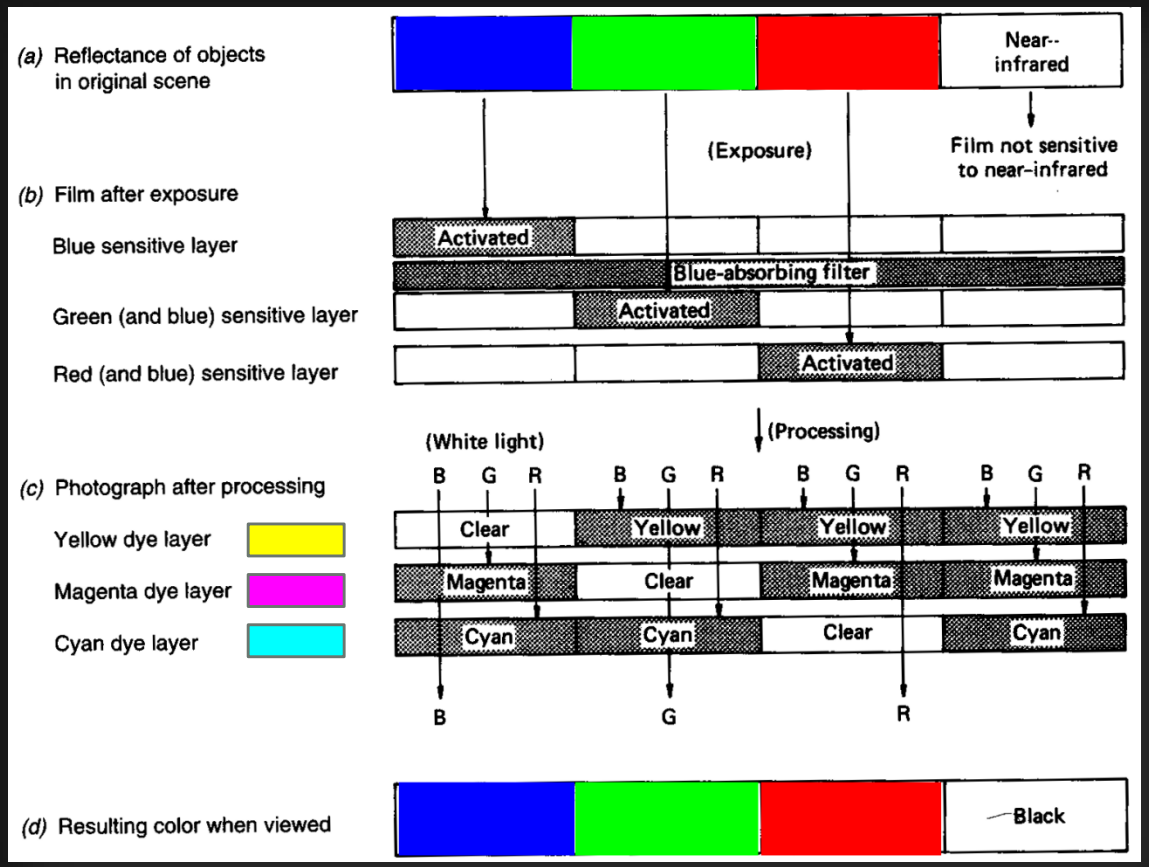


Colour film



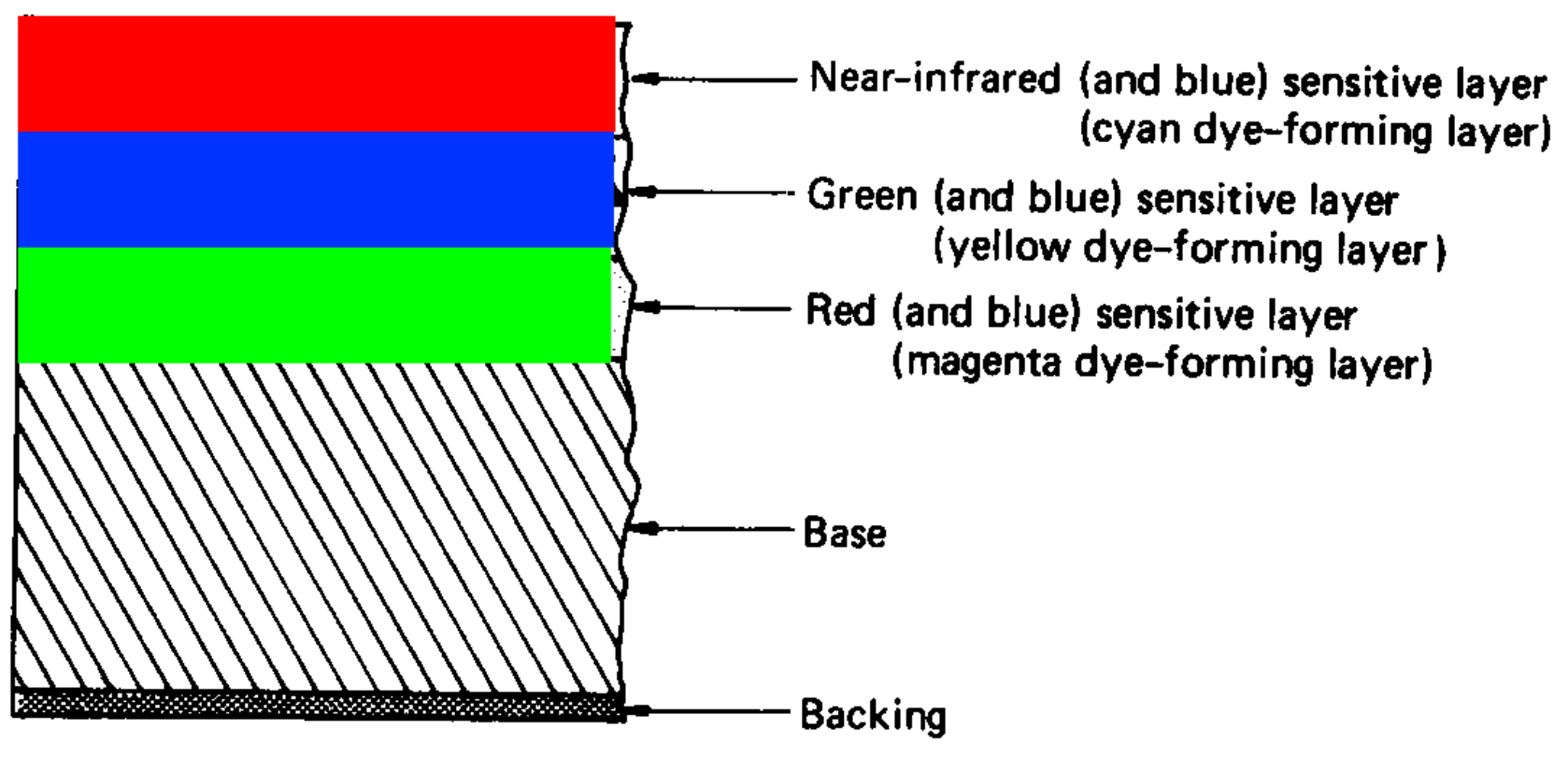


Film spectral sensitivities

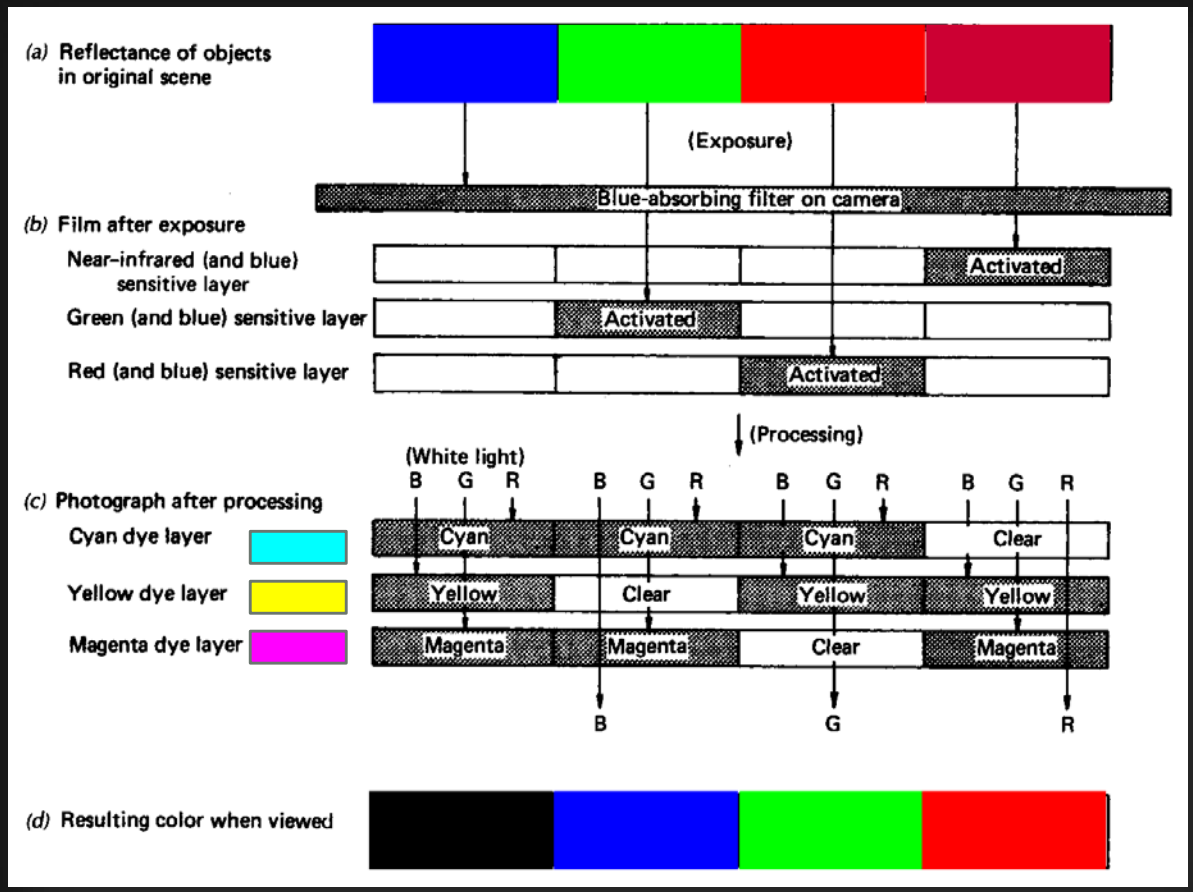


Colour film processing

Blue-absorbing filter is placed in front of the film (e.g., on the lens)

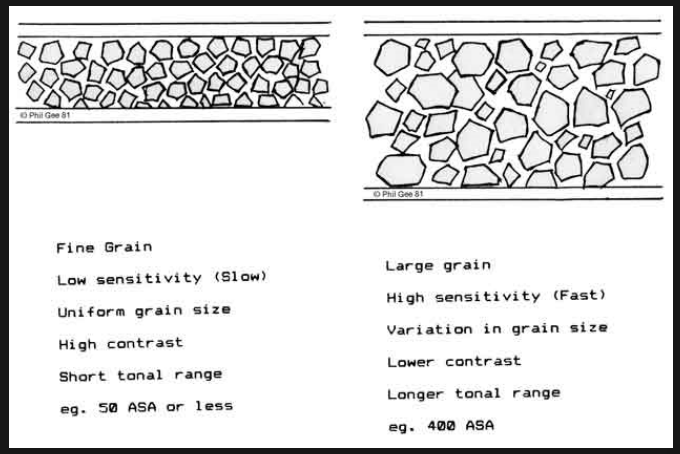


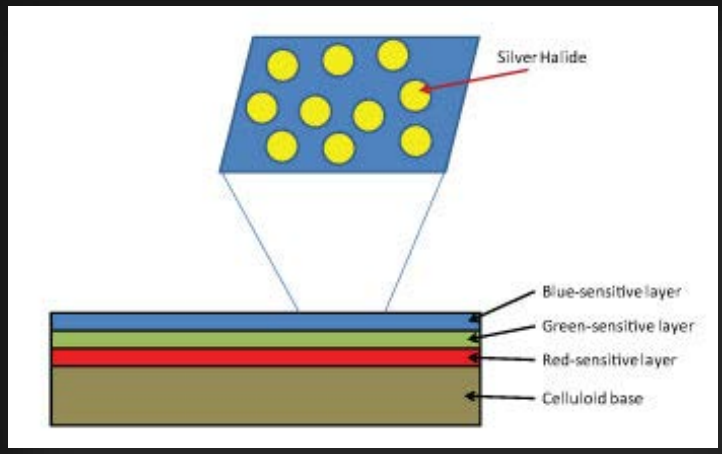
Colour IR film characteristics



Colour IR film processing

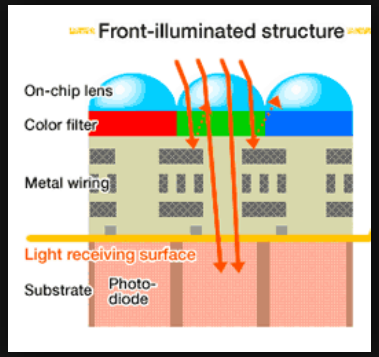
- When working with film we need to be concerned with its sensitivity - how little light (photons) is required to activate the film's crystals and what range of light can be detected. The sensitivity is related to the speed of the film. The finer the crystal the 'slower' the film. Larger grains are more sensitive with a bigger dynamic range, but larger grains result in lower spatial resolution. Finer grains produce higher resolution, but with less sensitivity.

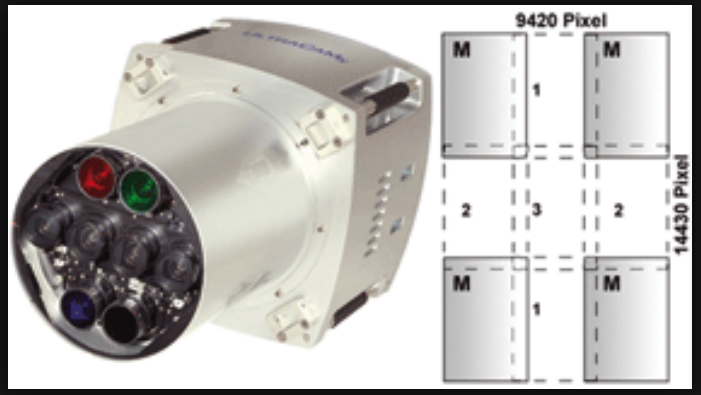




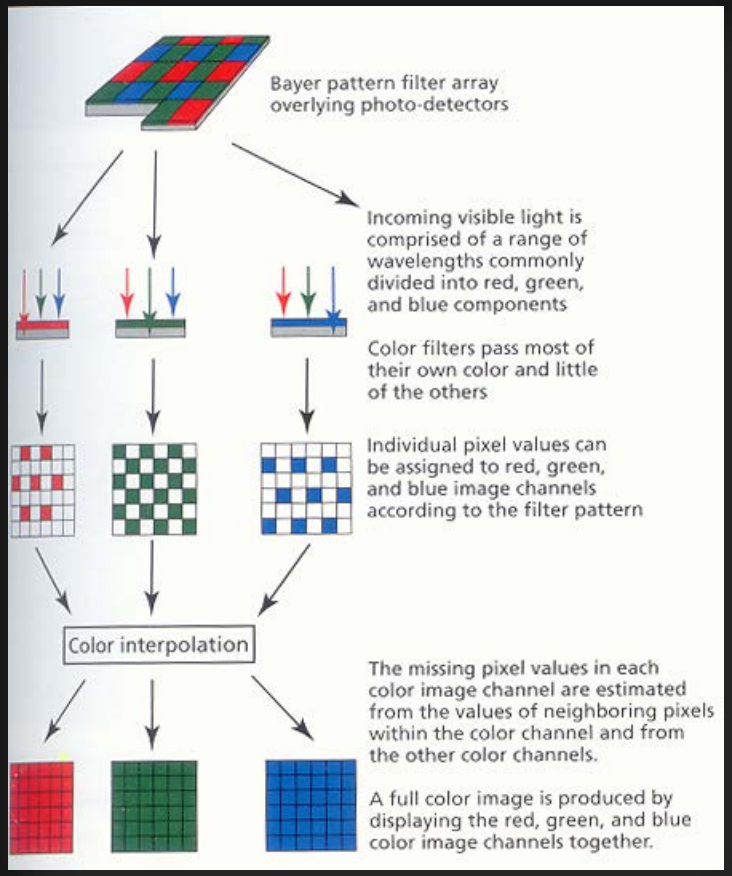
Film sensitivity

10 MB pixel camera





216 MB pixel camera, capturing both panchromatic and multispectral images



Digital cameras

Panchromatic film

IR film

Film characteristics

Panchromatic film

IR film

Film characteristics

Natural colour film

IR colour film

Film characteristics

Natural colour film

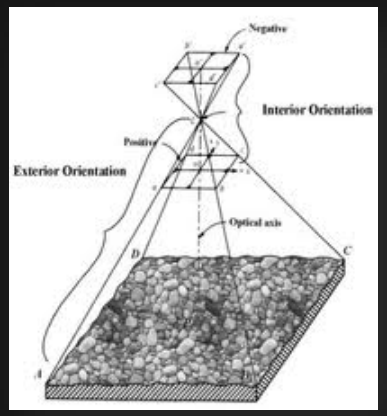
IR colour film

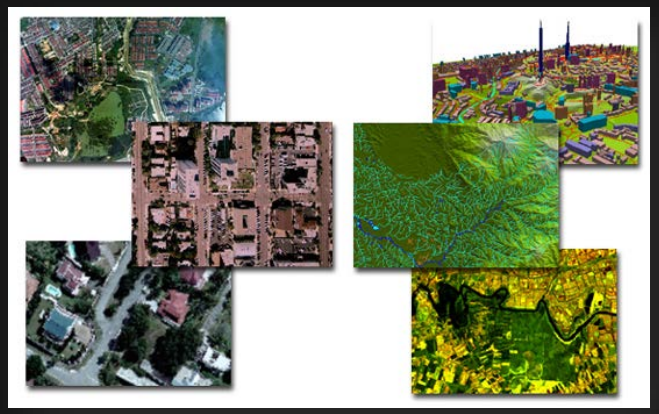
Film characteristics

- **Photogrammetry**: geometric properties about objects are determined from photographic images. Photogrammetry is as old as modern photography and can be dated to the mid-nineteenth century.
- Photogrammetry allows for the extraction of three-dimensional features from remotely sensed data (close-range, aerial, orbital, etc.).

The science of photo geometry

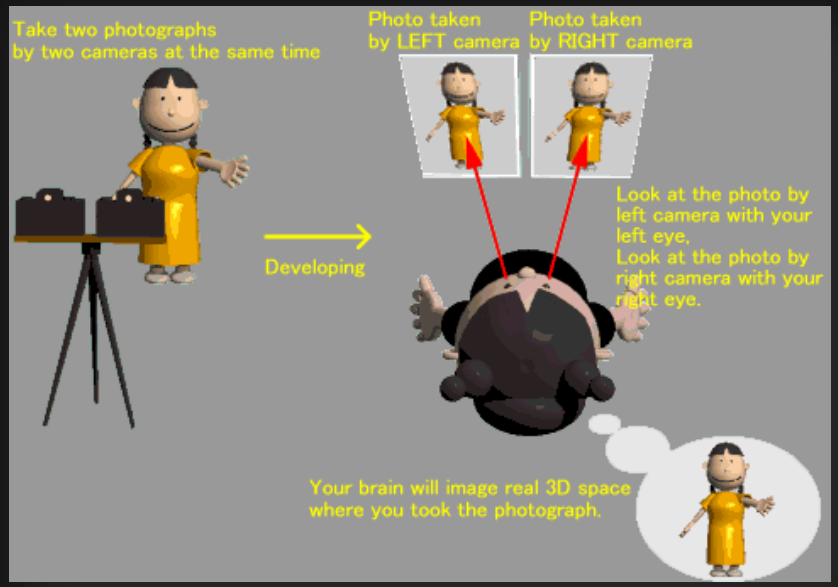
- The majority of aerial photos are taken for photogrammetric purposes (e.g., to provide information to be used in the creation of a topographic map).
- To meet those purposes, stereo aerial photographs are required.

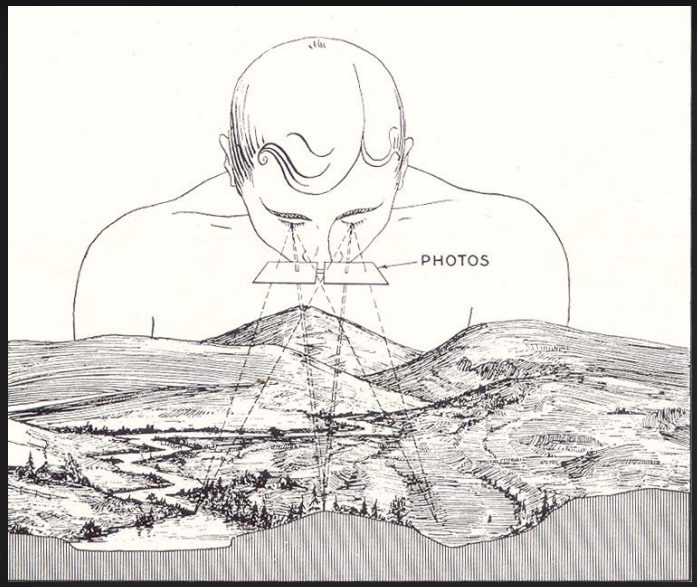




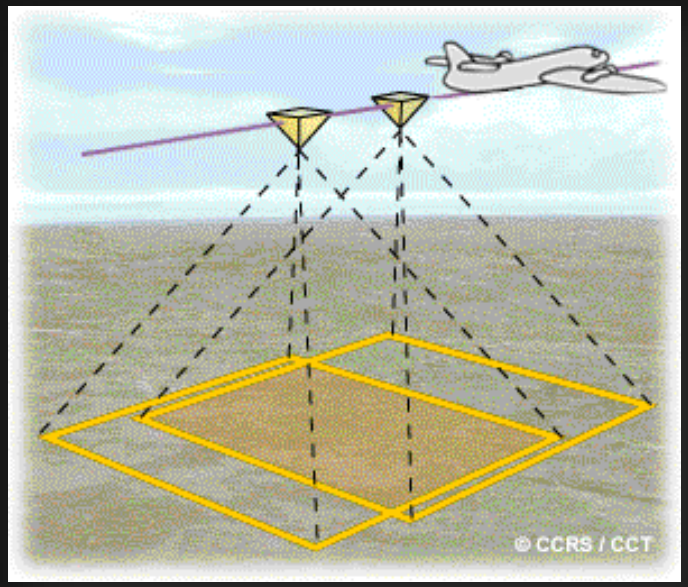
Obtaining aerial photos

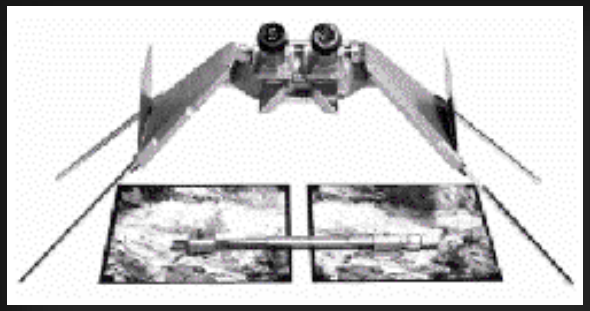
- How is it that we can use overlapping photos to view a landscape in 3-D?

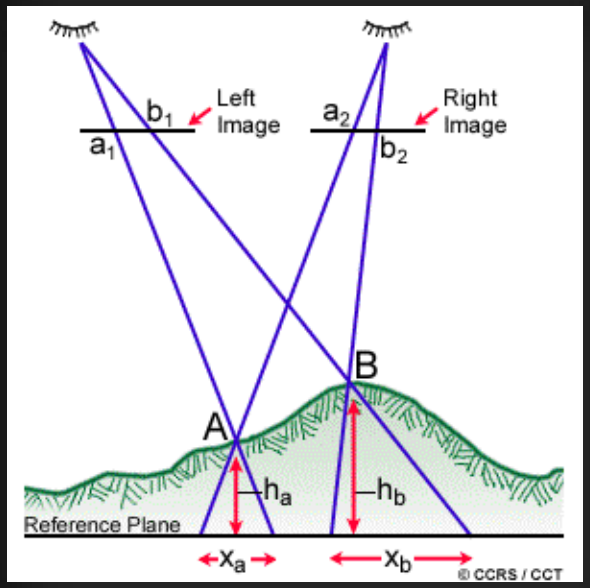




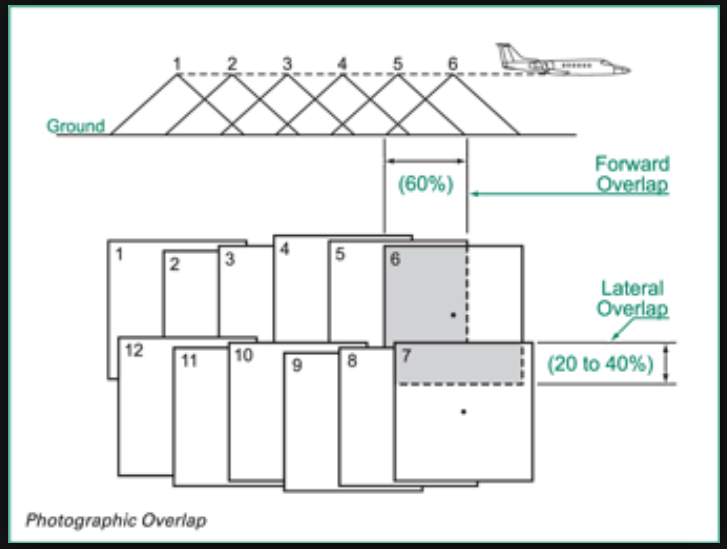
Stereo vision

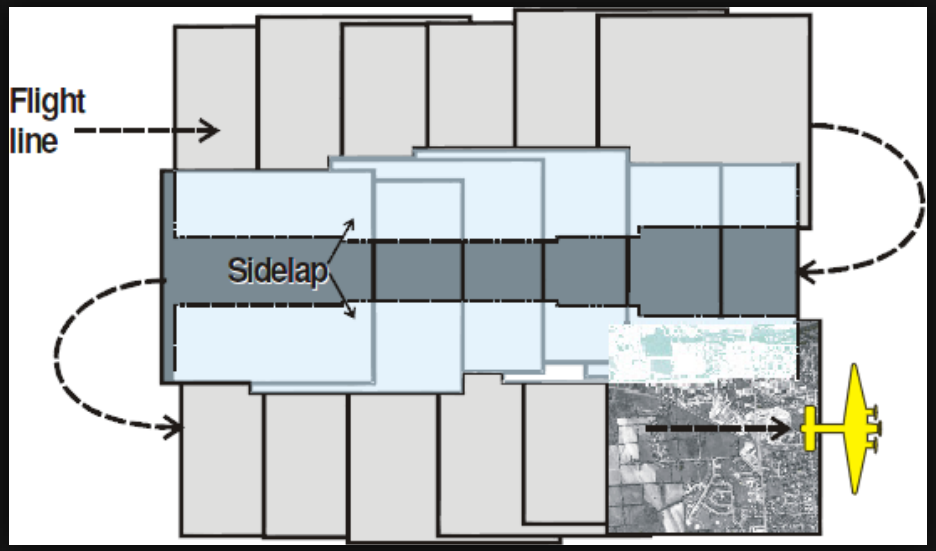


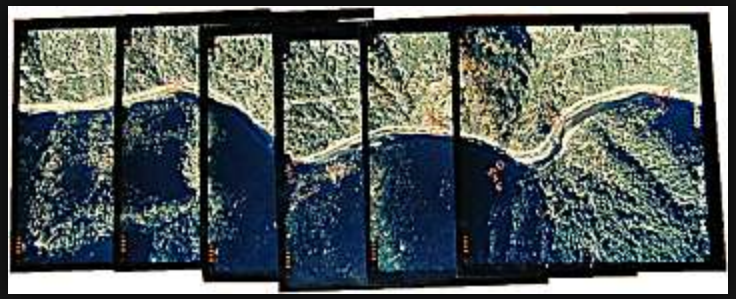




Stereo photography

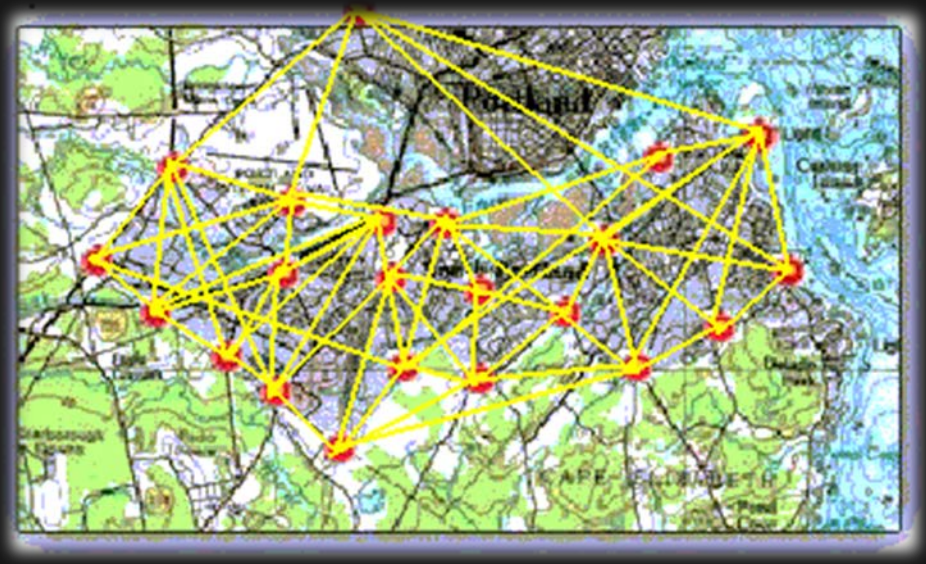


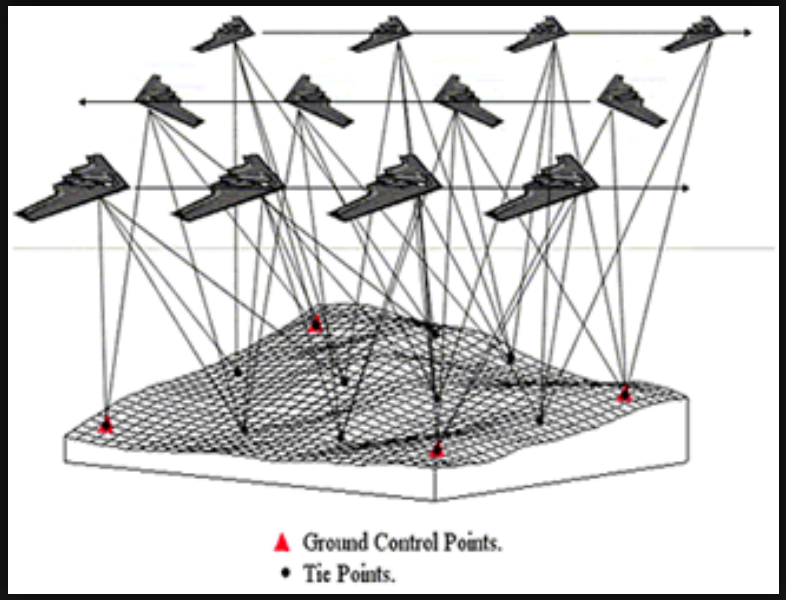




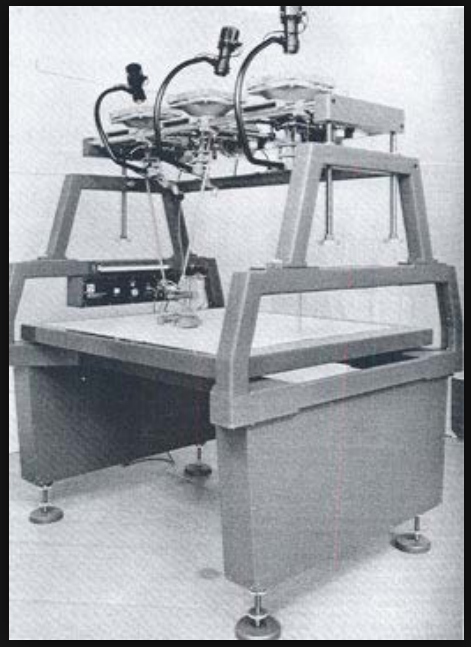
Obtaining stereo coverage

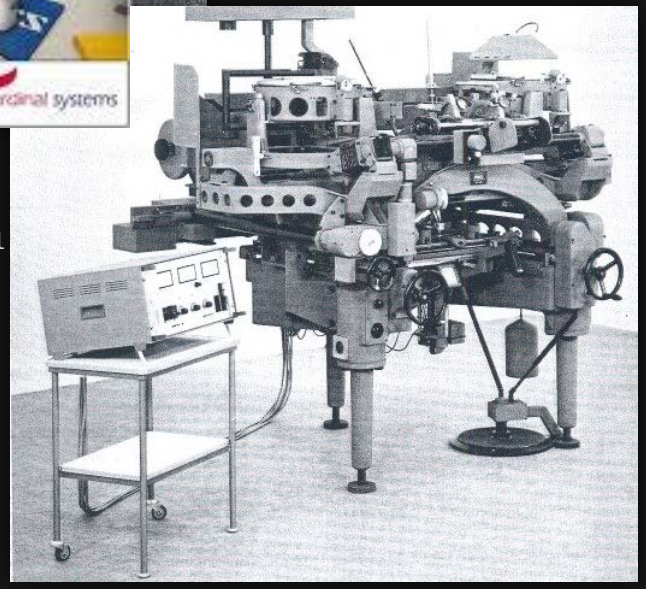
Photogrammetric control surveys





Producing topographic maps

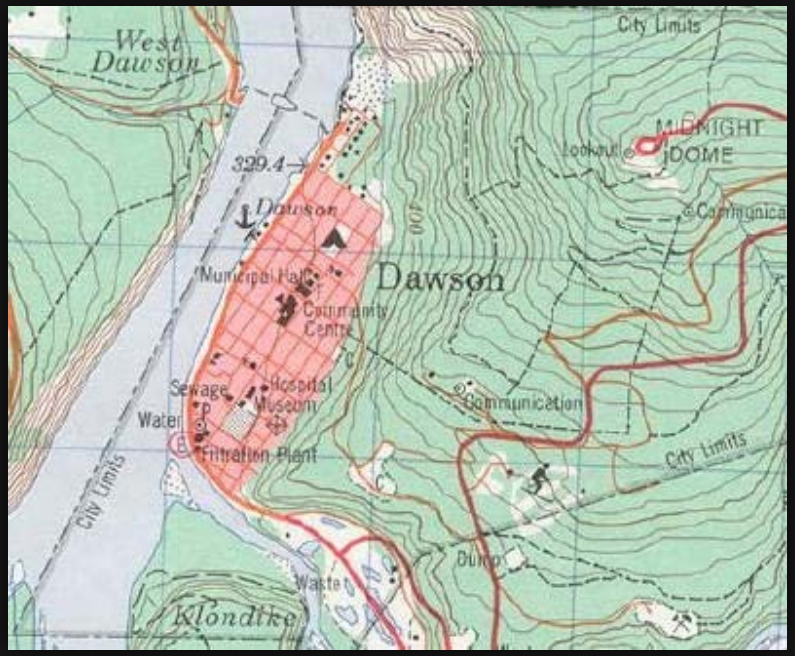


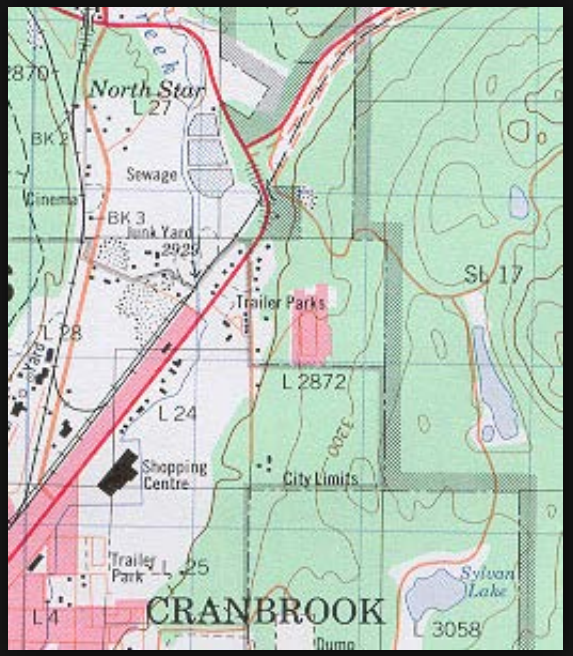


Very sophisticated devices
used to derive precise coordinate information

Now, most photogrammetric projects
are completed using softcopy
photogrammetric software.

Stereoplotters



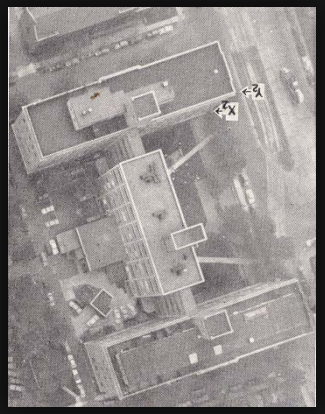


Topographic maps

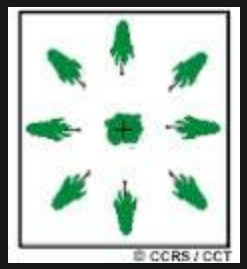
- Compare the map and photograph below. Both show the same gas pipeline, which passes through hilly terrain. Note the deformation of the pipeline route in the photo relative to the shape of the route on the topographic map. The deformation in the photo is caused by relief displacement. A single photo does not serve well as a source for topographic mapping.

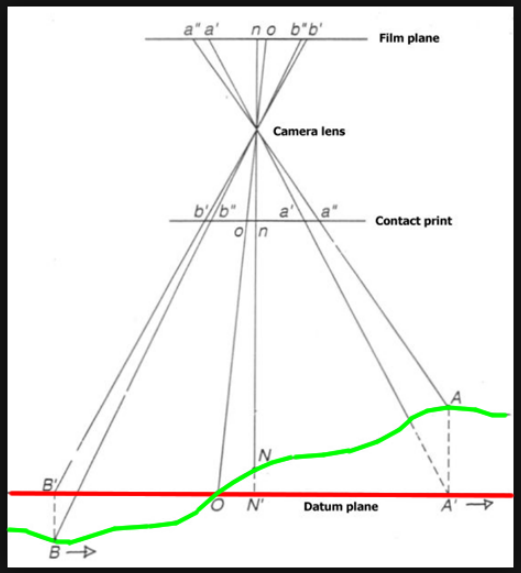
Air photo 'distortions'

- Relief displacement: the radial distance between where an object appears in an image versus where it should be according to a planimetric coordinate system (the datum plane). Displacement is radially outward for features above the nadir elevation, and inward for features below the nadir elevation (on the film plane).



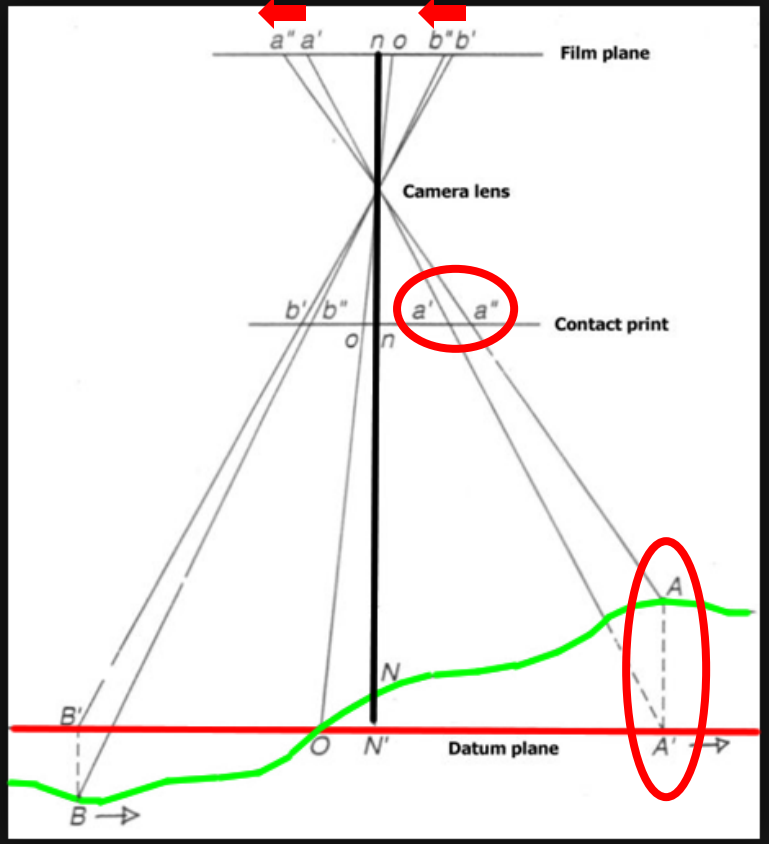
Relief displacement results in the tops of the buildings to appear as if they were leaning outwards from the centre of the photo.





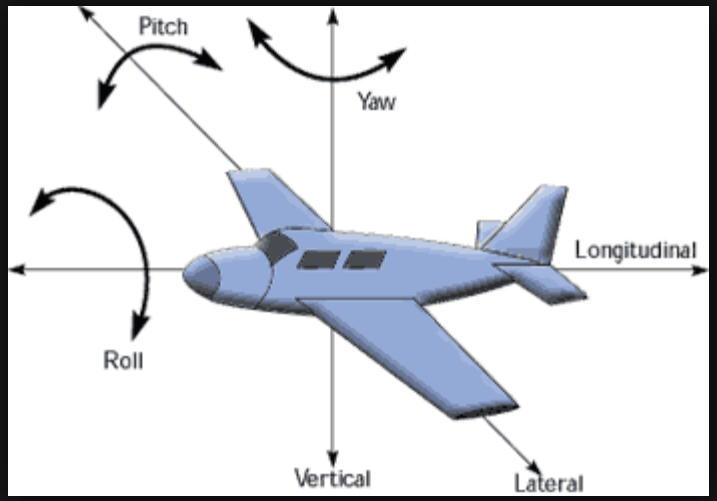
Air photo 'distortions'

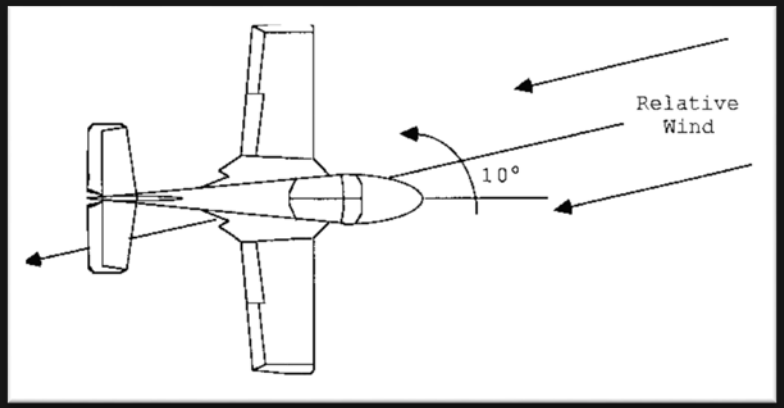
- Relief displacement—a simple explanation.
  - Consider point A. On a map (the 'datum plane'), A would appear at point A' (orthographically projected down from A). A photograph of the map would show A' at point a'. However, in the actual photograph A shows up at point a". Point a" is displaced outward from point a'.
  - Similarly, point B would appear at B' on a map. On the photo point b' (the photographed 'map' position of B) is further away from the nadir (represented as line N / n) than is point b" (the actual position of B in the aerial photo--B is displaced inward).



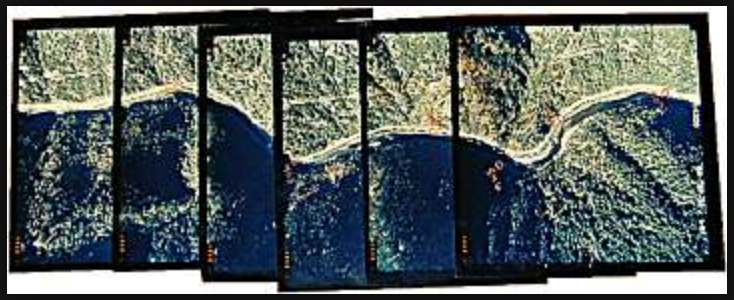
Air photo 'distortions'

Trying to fly the plane in a straight, level path is often difficult.





Yaw



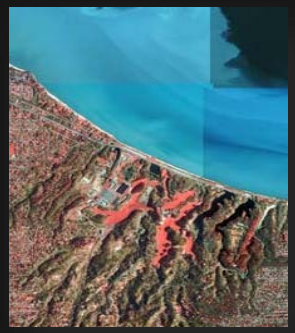
Notice how the photos don't line up, and how they are 'twisted' relative to each other, which indicates that the plane could not fly in a perfect straight line.

Air photo 'distortions'

- Orthophotos are created by (conceptually) draping the air photographs over a DEM, carefully mosaicing them together; removing the ‘distortions’ associated with the perspective projection, scale differences, etc. (i.e., by ensuring that the scale is constant everywhere in the photo).

Orthophotos

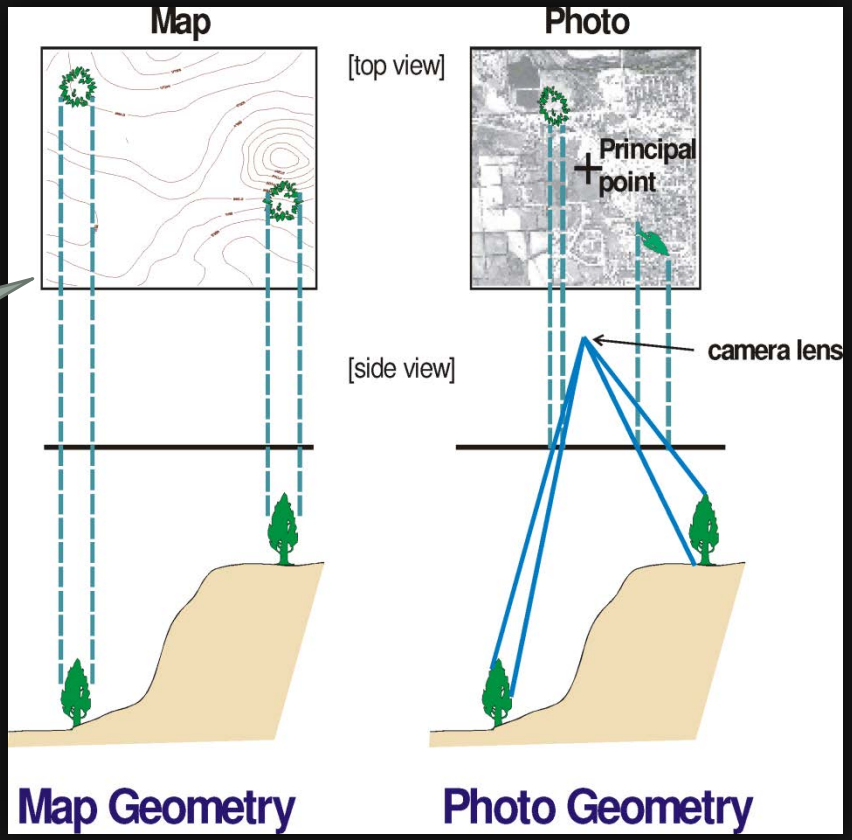
- Four basic operations or corrections must be applied to the standard vertical aerial photograph to produce an orthophoto:
  - standardization of scale across the image (i.e., use a DEM to normalized the distance from the camera to the 'ground')
  - removing the relief displacement to position the terrain in its true location.
  - assignment of ground coordinate values (e.g., UTM eastings and northings) to the image.
  - The final task involves the radiometric or tonal adjustments to allow the image to blend with neighboring images. (a complete example)



Orthophoto Construction

Orthophotos provide the same view of the landscape (an orthographic one) as do maps.

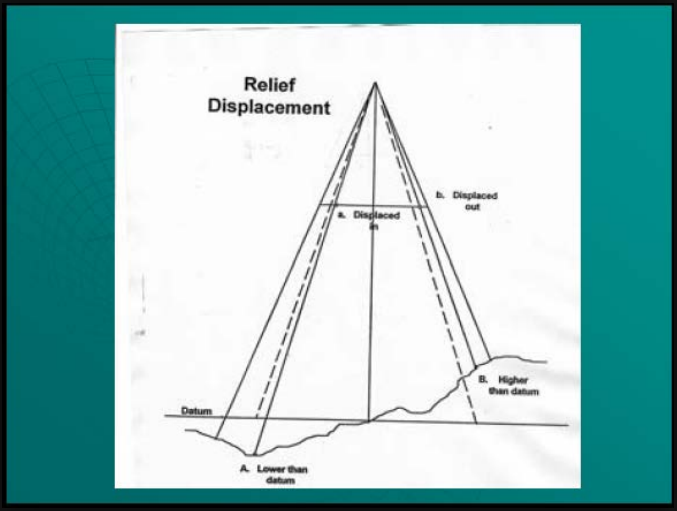
Orthophoto

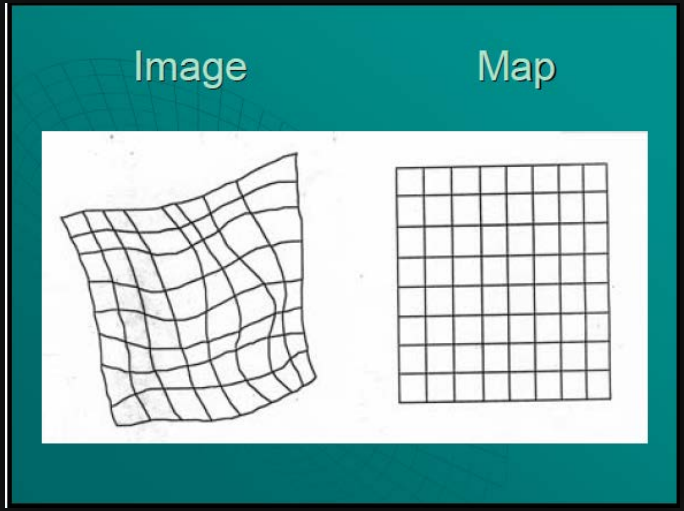


Aerial photos provide a perspective view of the Landscape.

Orthophotos

- Orthophotos are metric photos; aerial photos are not metric.

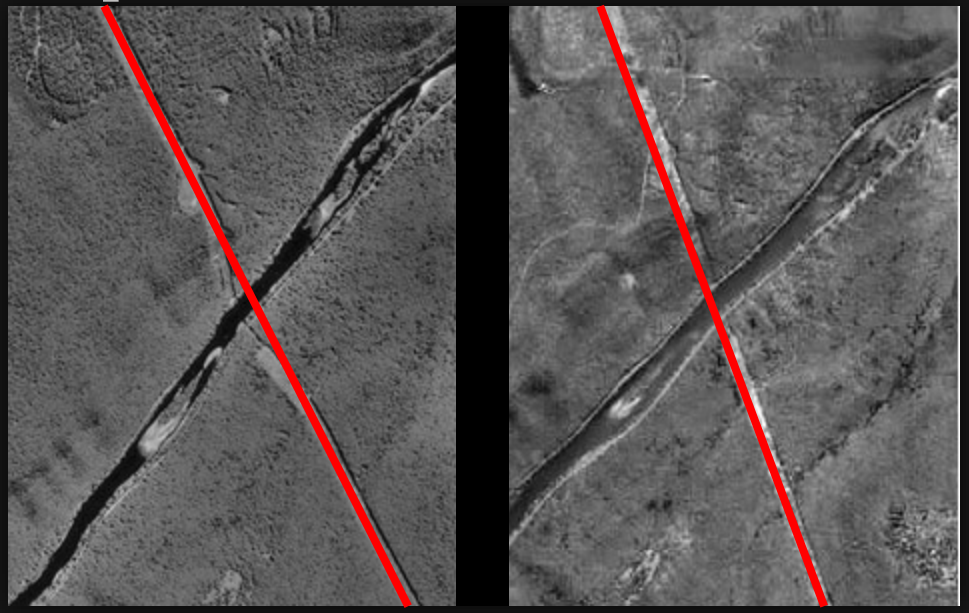




The qualities of aerial photos that enable us to see stereo images mean that any single aerial photo presents a non-metric view of the landscape.

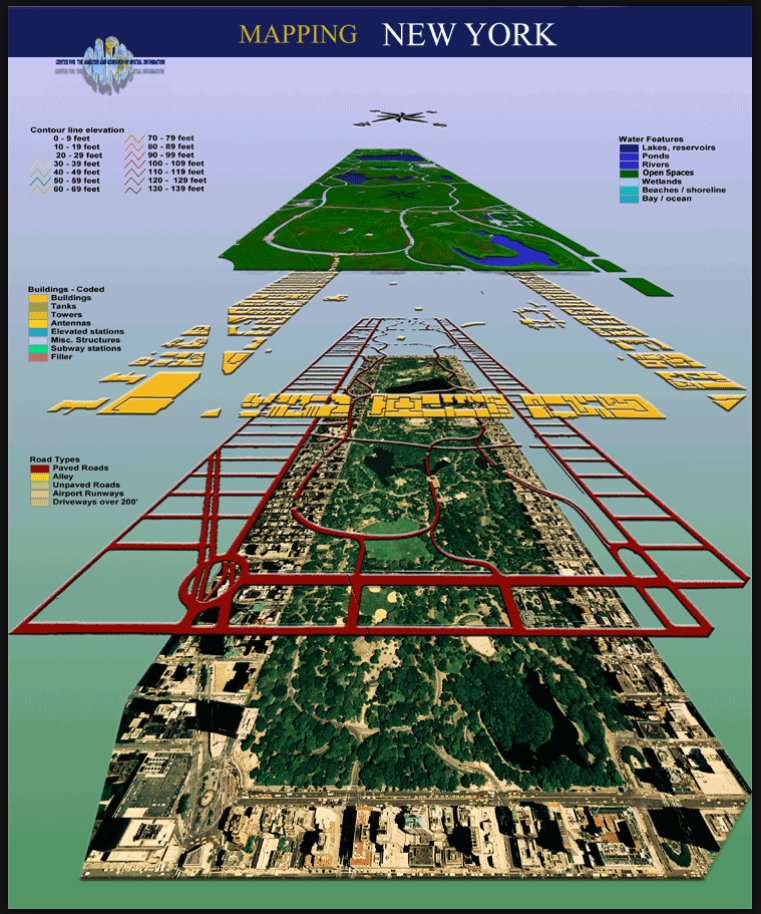
Orthophotos

- A comparison of an aerial photo with an orthophoto. Note how the linear feature is distorted in the aerial photo, but is straight (as it should be) in the orthophoto.



Orthophotos

- Using stereoplotters (analog or digital [softcopy]) many ‘layers’ of information can be derived from aerial photos; as well, if orthophotos are produced the resulting images can also be used in a GIS.



Aerial photos > GIS

- Introduction
  - Frame vs scanning sensors
- Cameras (film and digital)
- Photogrammetry
- Orthophotos

Summary