REMOTE SENSING

Topic 3: Principles of Photographic and Digital Imaging Systems

Chapter 2: Avery and Berlin
Chapter 2: Lillesand and Keifer

Early Remote Sensing Systems

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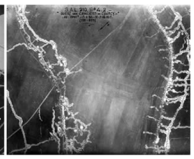
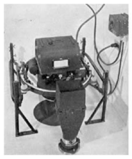

Satellite Remote Sensing

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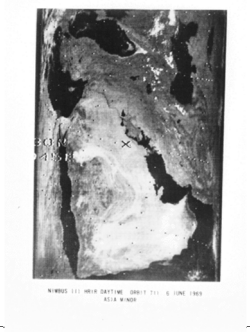
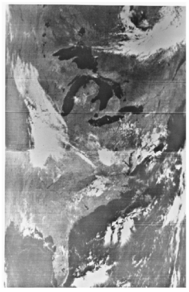
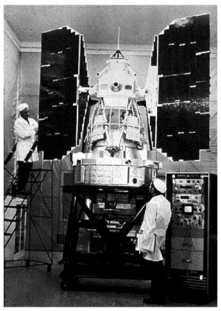


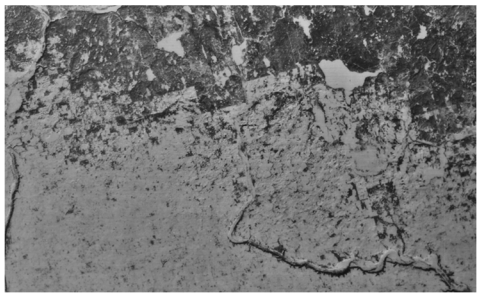


Spy Satellites

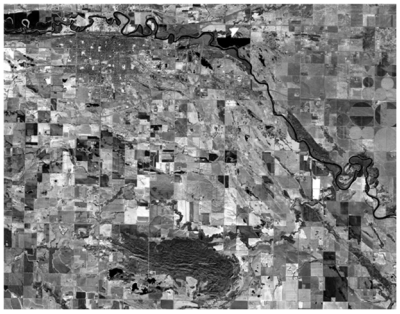
Earth Observation Satellites



Earth Observation Satellites



Earth Observation Satellites



Earth Observation Satellites

Earth Observation Satellites

The Re-invention

The Re-invention

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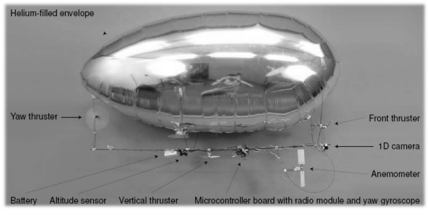


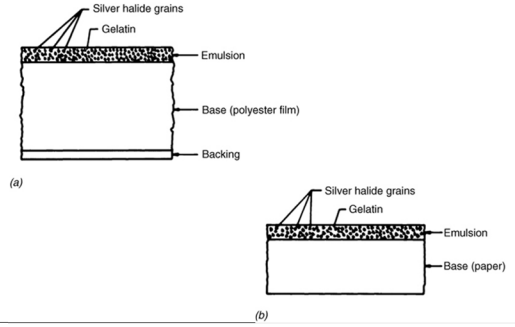
The Re-invention

The Re-invention

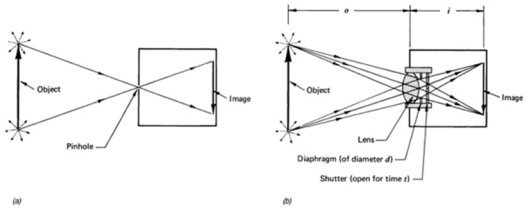
Six Advantages of Aerial Photography Over Ground OR Aerial Observation

1. Improved vantage point
2. Ability to stop action, permanent recording
3. Greater radiometric sensitivity/resolution
4. Greater spectral sensitivity/resolution
5. Greater spatial sensitivity/resolution
6. Photogrammetric Techniques

Basic B/W Film Photography



A Simple Camera



$1/f = 1/o + 1/i$

f = focal length of the camera o = object distance
i = image distance note: when o is v.big i = f

Exposure

- Exposure (E) at any point in a photograph is dependent on:

$$E = sd^2t / 4f^2$$

where: s = scene brightness d = diameter
t= time (shutter speed) f = focal length

So how do we control the range of exposure?

- Diameter of the lens opening (d) is adjusted by setting the aperture or f-stop F = f / d

$$E = st / 4F^2$$

- Shorter exposure times prevent blurring/image motion, but require high speed films (grainier)
- Longer exposure times allow more light, so slower (crisper) films can be used, but may result in blurring

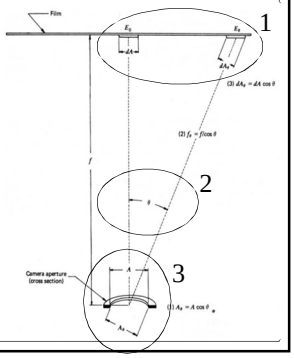
Extraneous Effects

- Exposure falloff is the result of :

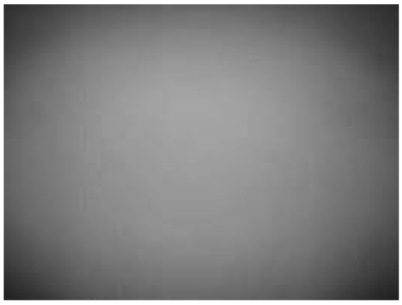
1.

2.

3.

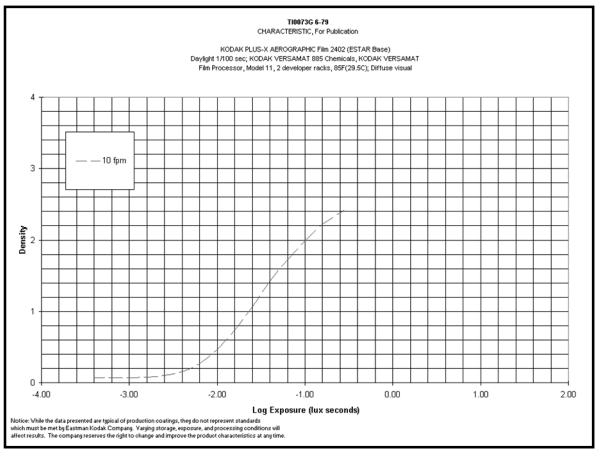


Effect of Exposure Falloff

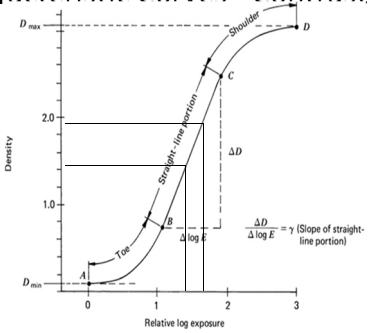


Film Density Measurements

- Film density is a measure of ?
- Determined using a _____?
- What are measures of film density used for?
  -
  -
  -
  -



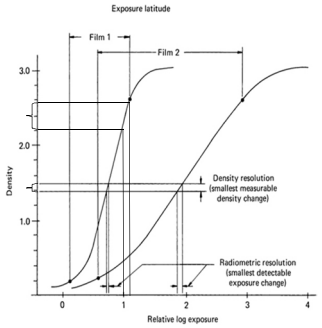
Characteristic Curves - Contrast



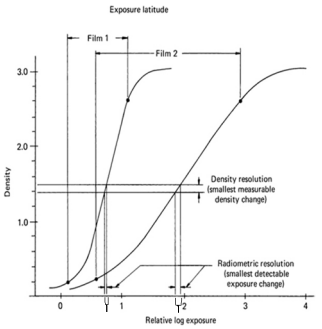
Characteristic Curves - Contrast

High Slope (γ)
High Contrast

Low Slope (γ)
Low Contrast



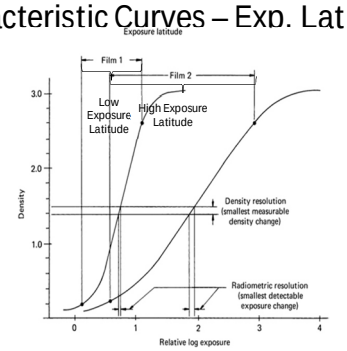
Characteristic Curves - Resolution



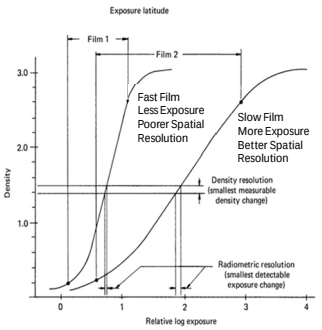
Better Radiometric Resolution

Poorer Radiometric Resolution

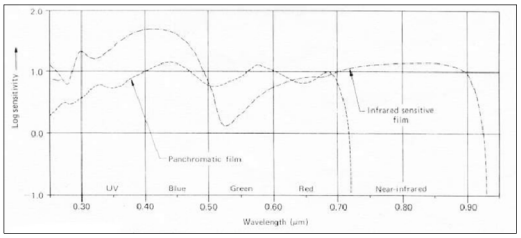
Characteristic Curves – Exp. Lat.



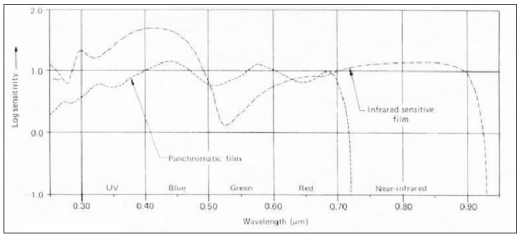
Characteristic Curves – Film Speed



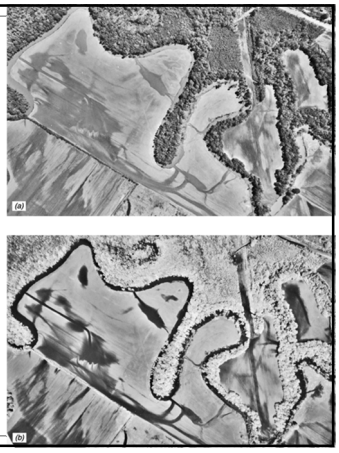
B/W Panchromatic Films



B/W Infrared Films



Panchromatic vs. Infrared Photo

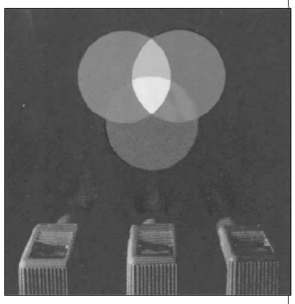


Colour Aerial Films

- **What are the advantages of colour photography?**
  1.
  2.
  3.

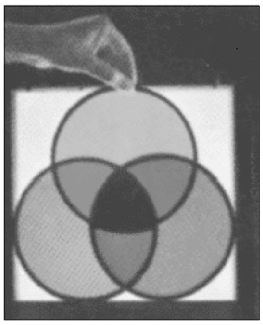
Colour Theory

- R, G, B are **additive primaries**



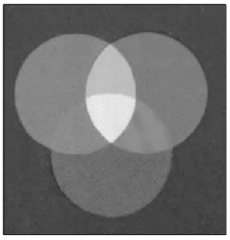
Colour Theory

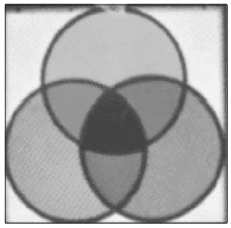
- Yellow, magenta, and cyan are **subtractive primaries**

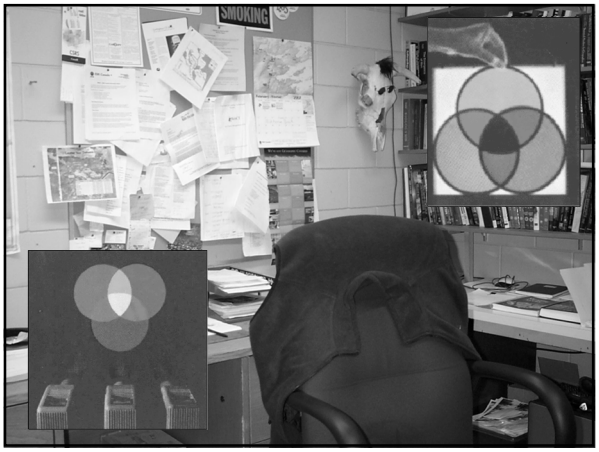


Colour Theory

- Complimentary colours are those that produce white light when combined





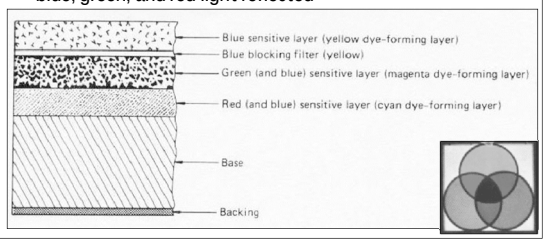


How Colour Film Works

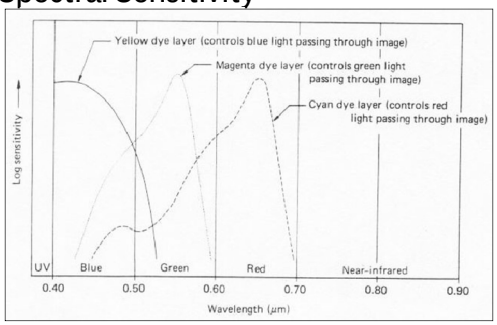
- Colour film is based on the principles of subtractive primary colours
- Yellow, magenta, and cyan dyes are used to filter differing proportions of blue, green, and red light
- The dyes are introduced into different layers of colour film each containing silver halide crystals modified by organic molecules known as spectral sensitizers
- The subtractive primaries are used to control the relative proportions of additive primaries reflected back to our eye

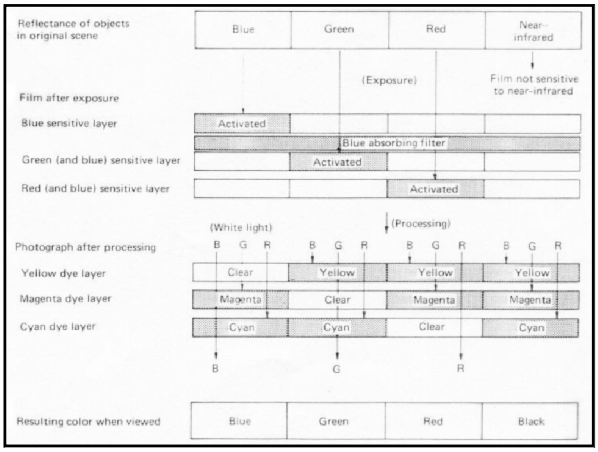
How Colour Film Works

- When developed, yellow, magenta, and cyan dyes are introduced **inversely proportional** to the amount of blue, green, and red light reflected



Spectral Sensitivity

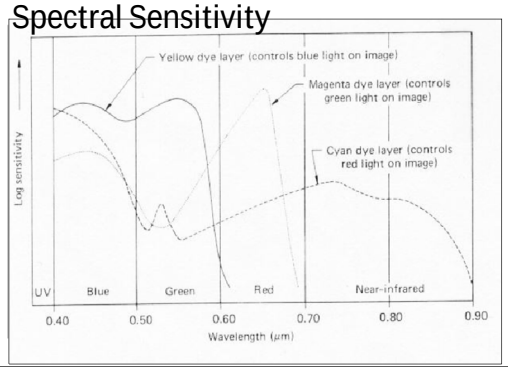




How Colour IR Film Works

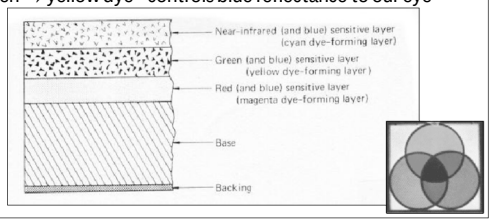
- Assignment of dyes to emulsion layers is arbitrary AND spectral sensitivity of emulsion layers can be controlled
- Y, M, and C dye layers still control B, G, and R light BUT are assigned to emulsion layers that now contain organic molecules sensitive to G, R and NIR light
- Also called “false colour” IR film

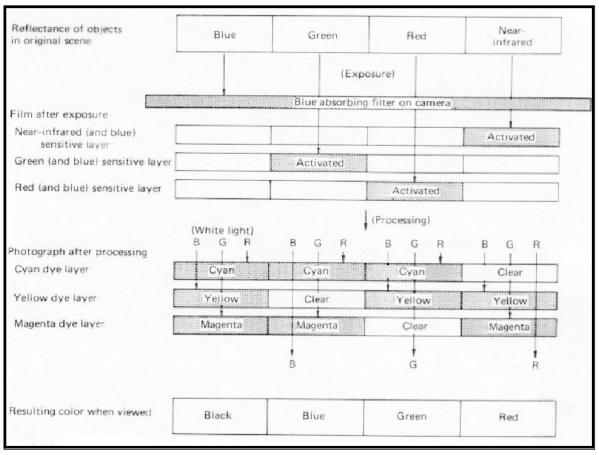
Spectral Sensitivity

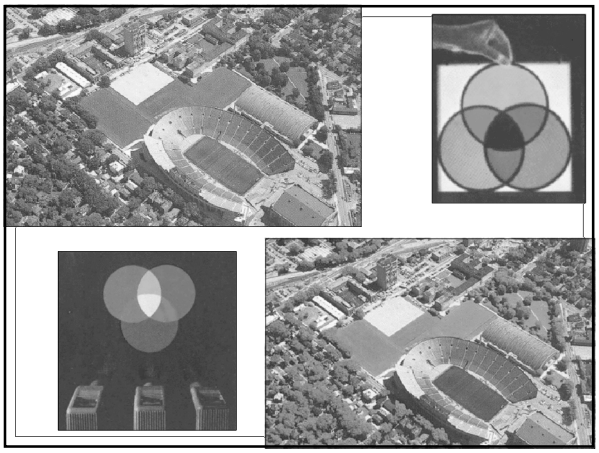


How Colour IR Film Works

- Blue wavelengths are filtered out of incoming light using a filter placed in front of the camera lens
- Near infrared → cyan dye - controls red reflectance to our eye
- Red → magenta dye - controls green reflectance to our eye
- Green → yellow dye - controls blue reflectance to our eye







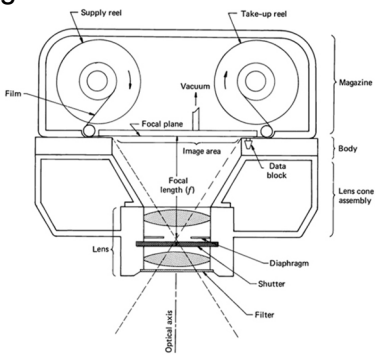
Filters

- Made of glass or gelatin
- Wavelength selectors
  - Example
    - yellow filter absorbs blue wavelengths
    - allows green and red to pass through
    - commonly used to reduce haze
- High vs. low pass
- Reduce exposure, so adjustments necessary

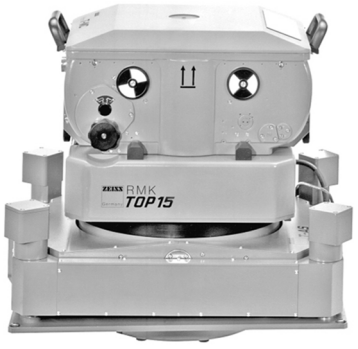
Aerial Cameras

- Wide variety can be used
  - Hand-held 35 mm (D)SLR cameras
  - Hand-held digital cameras
  - Single lens frame cameras
  - Multi-lens frame camera
  - Strip Camera
  - Panoramic Camera
  - Analog and digital video recorders

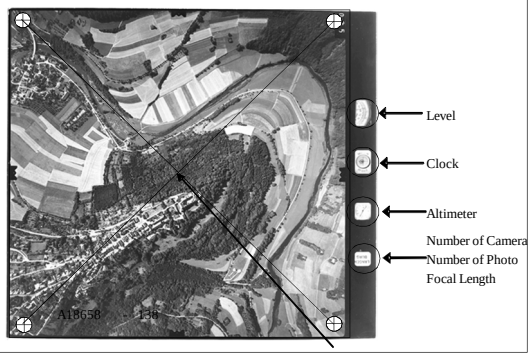
Single Lens Frame Camera



Single Lens Frame Camera



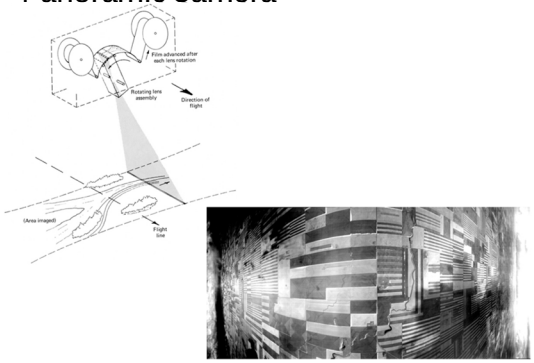
Standard 9 in. Vertical Photo



Multi-Lens Frame Camera

Strip Camera

Panoramic Camera



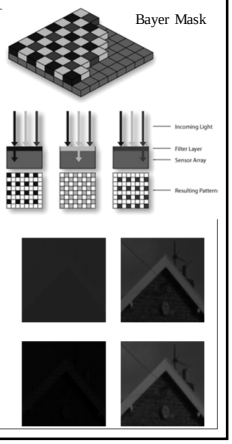
Digital Imaging

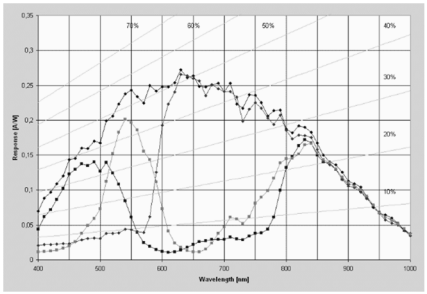
- Utilize an rectangular array of solid-state detectors; either CCDs or CMOS
- Size of array (# photosites or pixels) determines image resolution

- Advantages:
  - Increased spectral and radiometric resolution
  - Ability to digitally process/analyze imagery
  - Linear response to incident energy
  - Can record GPS position
  - Greater storage capacity

Digital Imaging

- Photo-sites are actually "colour blind"
- Filter is used to control λ detected at each photo-site
- Called a Bayer mask
  - in each 4x4 pixel area: 2 green, one red, one blue
- Interpolation algorithm is used to fill in the resulting checker board pattern with missing colours

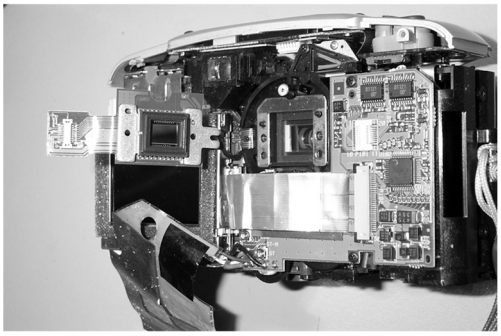




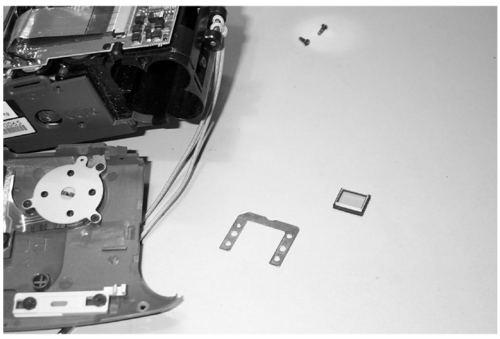
Large Format Digital Aerial Cameras

- Gyro- stabilized, w/ computer controlled IMC
- Eight-camera system, 12 bit radiometric res.
- Four panchromatic bands mosaicked into 14,000 x 8000 (112 Mega pixel) image
- Other 4 bands are B, G, R, and NIR at 3000 x 2000 (6 M pixel)

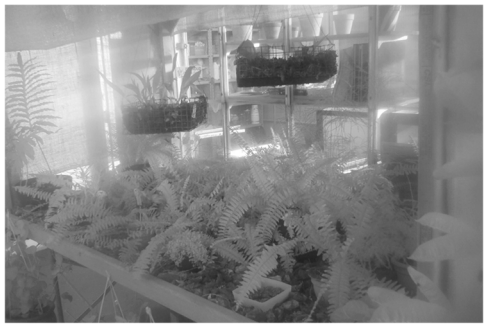
Hand-held Digital Cameras



NIR Conversion of Kodak DC3400



NIR w/ a Kodak DC3400 Digital Camera



NIR w/ a Kodak DC3400 Digital Camera

NIR w/ a Kodak DC3400 Digital Camera

NIR w/ Sony DCS W300