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Cameras

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Module Objectives

- Understand how a video camera and lens create images
- Discuss application of different types of cameras
- Discuss functions of camera electronics

Module Outline

- General camera information
- Discussion of camera imagers and function
- Comparison of various types of cameras
- Discussion of assessment resolution categories
- Requirements for good camera assessment
- Summary

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Camera General Information

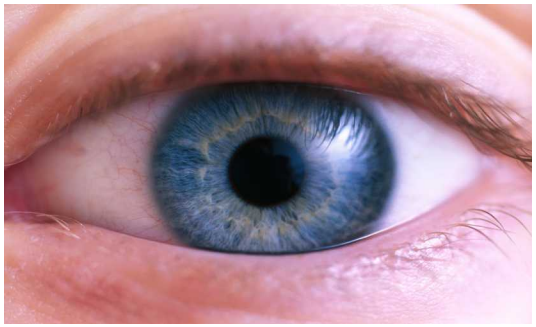
- Camera converts visual image to an electrical signal for transmission to the security system control console
- Major types
  - Solid state imagers
  - Thermal cameras or thermal imagers
- Camera placement depends on appropriate lens selection to adequately assess a defined area, zone, or sector

Video Composite Signal

- Made up from a number of horizontal lines on the television screen, which are laid down (scanned) from the top to the bottom of the screen
- A video picture is made up from a number of still images displayed every second

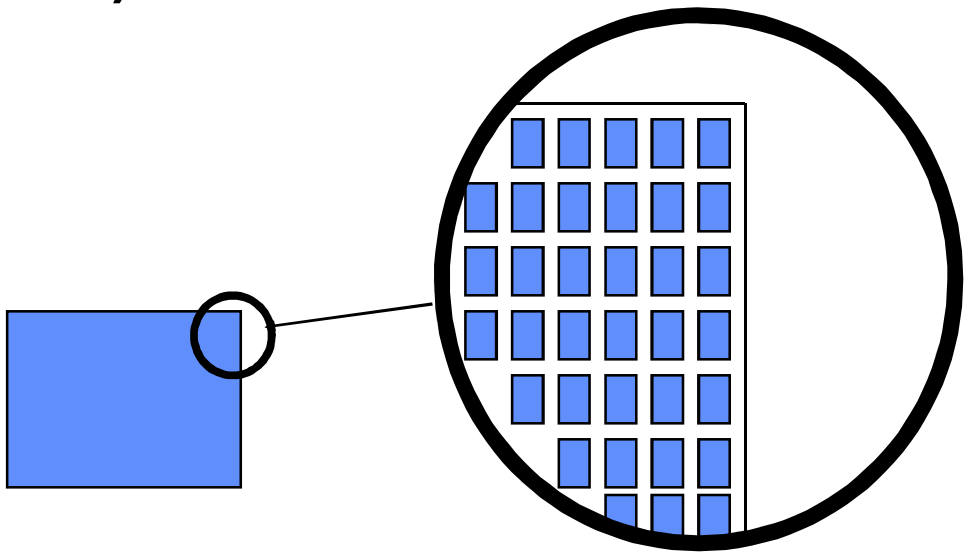
Persistence of Vision (Human Eye)

- Human eye retains an impression of an image for a fraction of a second after it has disappeared
- A series of still images presented at 14 images per second gives the human eye an impression of continuous movement
  - This would present a very distracting flicker
- A rate of 60 images US (50 images European and elsewhere) per second eliminates flicker



Solid State Imagers

- **Current solid state cameras**
  - **Charge Coupled Device (CCD)**
  - **Complementary Metal Oxide Semiconductor (CMOS)**
- **Two-dimensional arrays of discrete light sensors (pixels)**



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Types of Cameras

- Black & white
- Color
- Day/night - higher resolution at night
- Infrared, Infrared-enhanced B&W
- Intensified
- Thermal

Cameras of different technologies used together can provide a wide spectrum of solutions for specific applications -- particularly at low light levels or for an obscure scene.

Types of Cameras (cont.)

- Solid State Imager has pixel array that converts light energy to electronic charge
- Several solid state imagers available -- factors include:
  - Resolution, sensitivity, color, B&W, IR enhanced, thermal
- Quality cameras are usually in the
  - ~470 lines rez color
  - ~570 lines B&W
- New technology digital cameras have 520 to 2200 lines color - digital with memory
- Infrared enhanced can provide very distinguishable images with low power illuminators

Desirable Camera Characteristics

- High sensitivity to provide best video image with lighting conditions present
- Control circuits (AGC, auto iris) to maintain video image quality over range of day/night lighting conditions
- Maintains picture quality while motion is present
- Long life, durability, reliability & resistant to environmental effects

Examples of Interior Camera Types

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Examples of Exterior Cameras

Many are interior cameras (with no housing) that are mounted in an environmental enclosure

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Color vs. Black / White Images

Color

Black/ White

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Color vs. Black & White Cameras

- Color enhances daylight scenes
  - More of what the human eye expects
- Color at night can be problematic
  - Sodium vapor lights cause gold-orange color monitor images at night
- Color camera resolution 18% less than B&W cameras
- B&W provides sharper image at night due to higher resolution

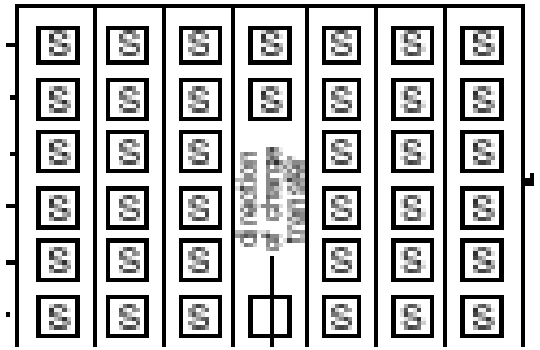
Color vs. Black & White Cameras (cont.)

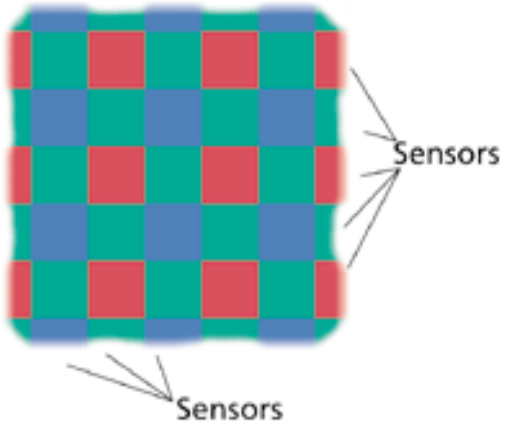
- Black & white camera images provide higher resolution sensitivity, contrast, brightness, and sharper nighttime image
- To improve color camera sensitivity at night, some models have adjustable image charging time (integrating)
- Increases amount of charge on imager pixels to make image brighter

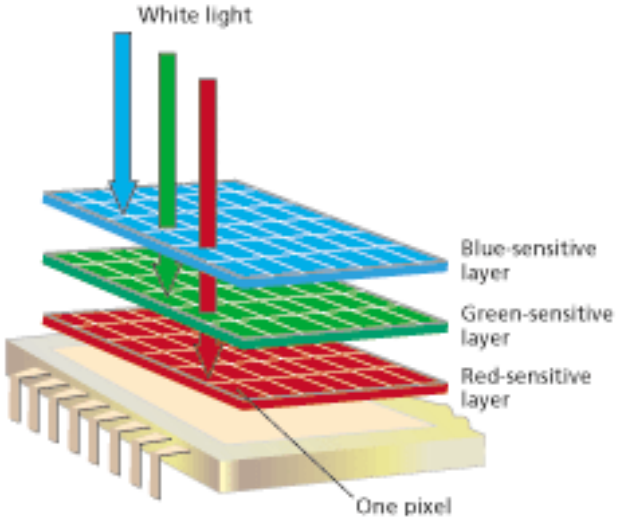
Imager Resolution: Color vs. B&W

B&W - all of the pixels in grey scale

Color - pattern of 3 elements for red-blue-green image display







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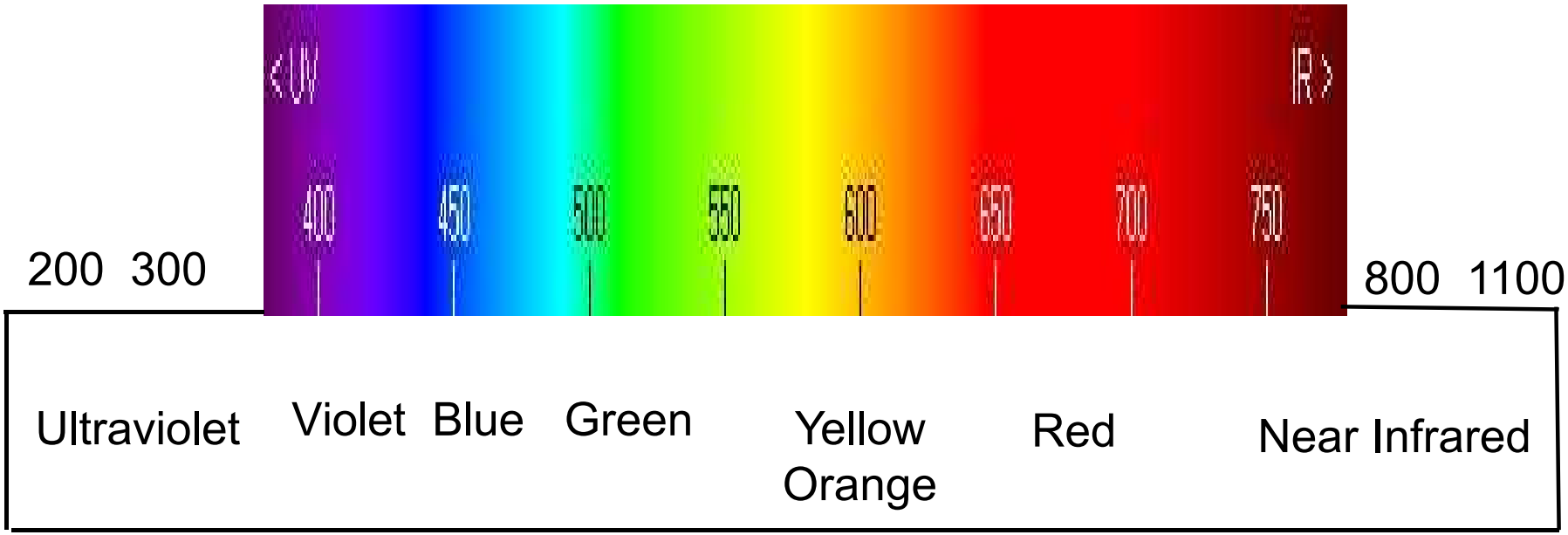
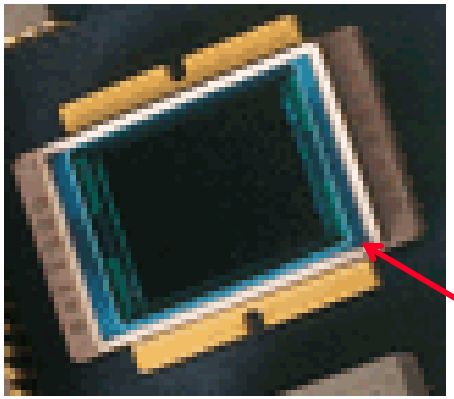
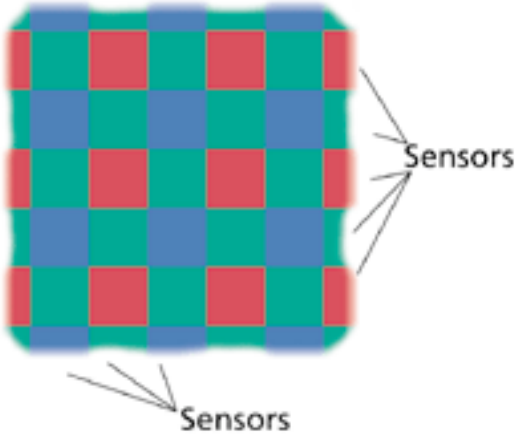
Wave Length Chart



Filters

- IR cut files are generally placed in front of the imager chip
- A detector acquiring color images separates colors by placing a small color filter over individual sensors





Day / Night Cameras

Need new Pix

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Day / Night Cameras

- Some cameras provide color images during the day and black & white during the night
  - Sensor measures ambient light level and controls switching from day to night mode (can adjust light level when switchover occurs)
  - Camera monitors video level and switches when scene is too dark
- Can mechanically remove IR cut filter to allow camera in B&W mode to see near IR illumination
  - Increases amount of scene illumination reaching camera imager

Digital Camera

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Electronic Shutter Control Cameras

- Some cameras slow shutter speed at night to obtain enough scene illumination
- Lengthens image capture time to gather more energy on the camera imager
  - Some cameras can slow shutter speed to ~ 4 seconds
  - For good assessment, shutter speed should be less than ¼ second

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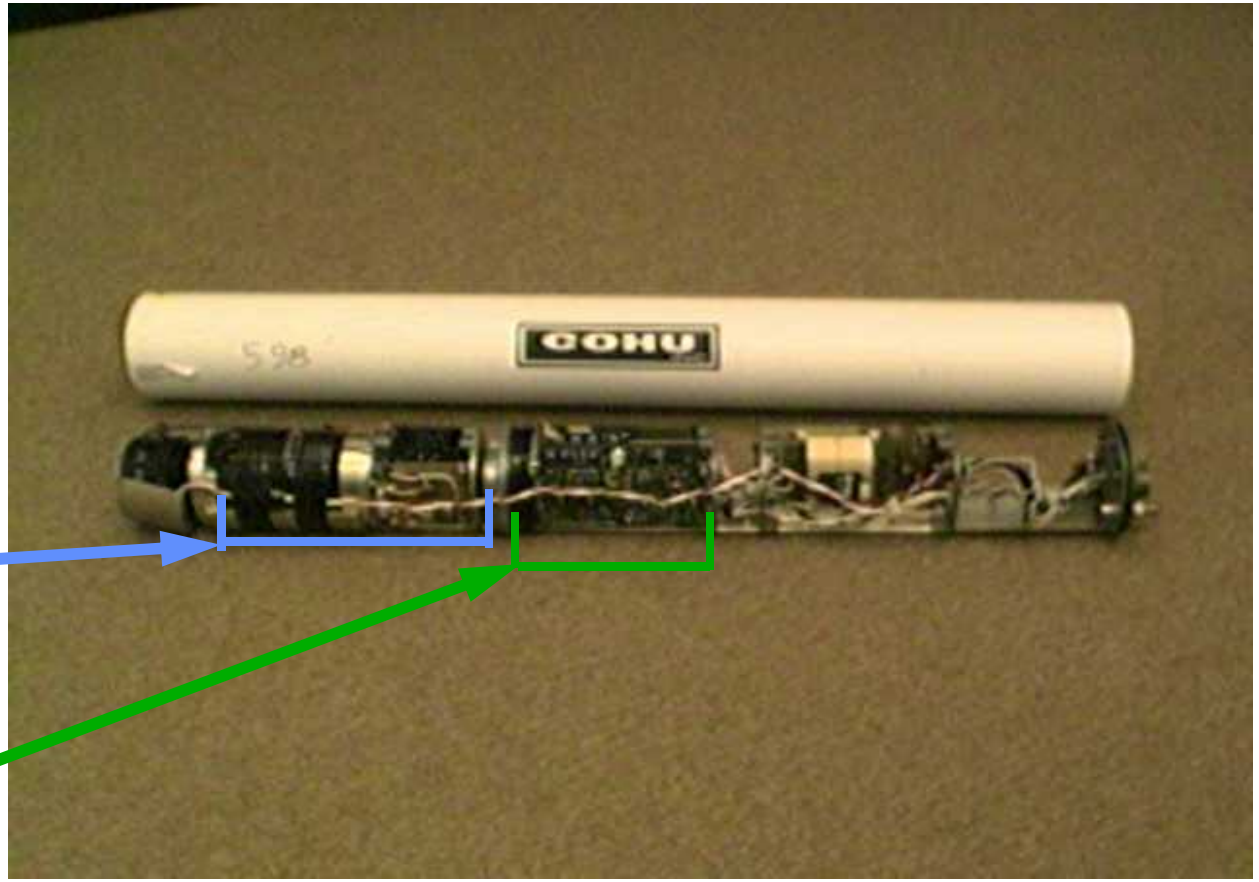
Intensified Low-light Camera



Intensifier Section

Camera Section

Intensified Low-light Camera (cont.)

- Intensified Camera - Photon amplifier bombards luminescent (green) screen. Standard camera focused on green screen to create video signal
- Responds to near IR illumination from stars, moon and artificial lighting
- Cameras are light receivers only - do not emit IR light
- Much more expensive than standard camera
- Requires frequent intensifier replacement & maintenance
  - Intensifier has limited life of ~ 2500 - 3500 hrs
- Bright light sources in scene can distort images

Thermal Imager Camera

- Converts thermal radiance to a video signal
- Uses emitted thermal / infrare
  - (3 - 5) or (7 - 14) micron waveband

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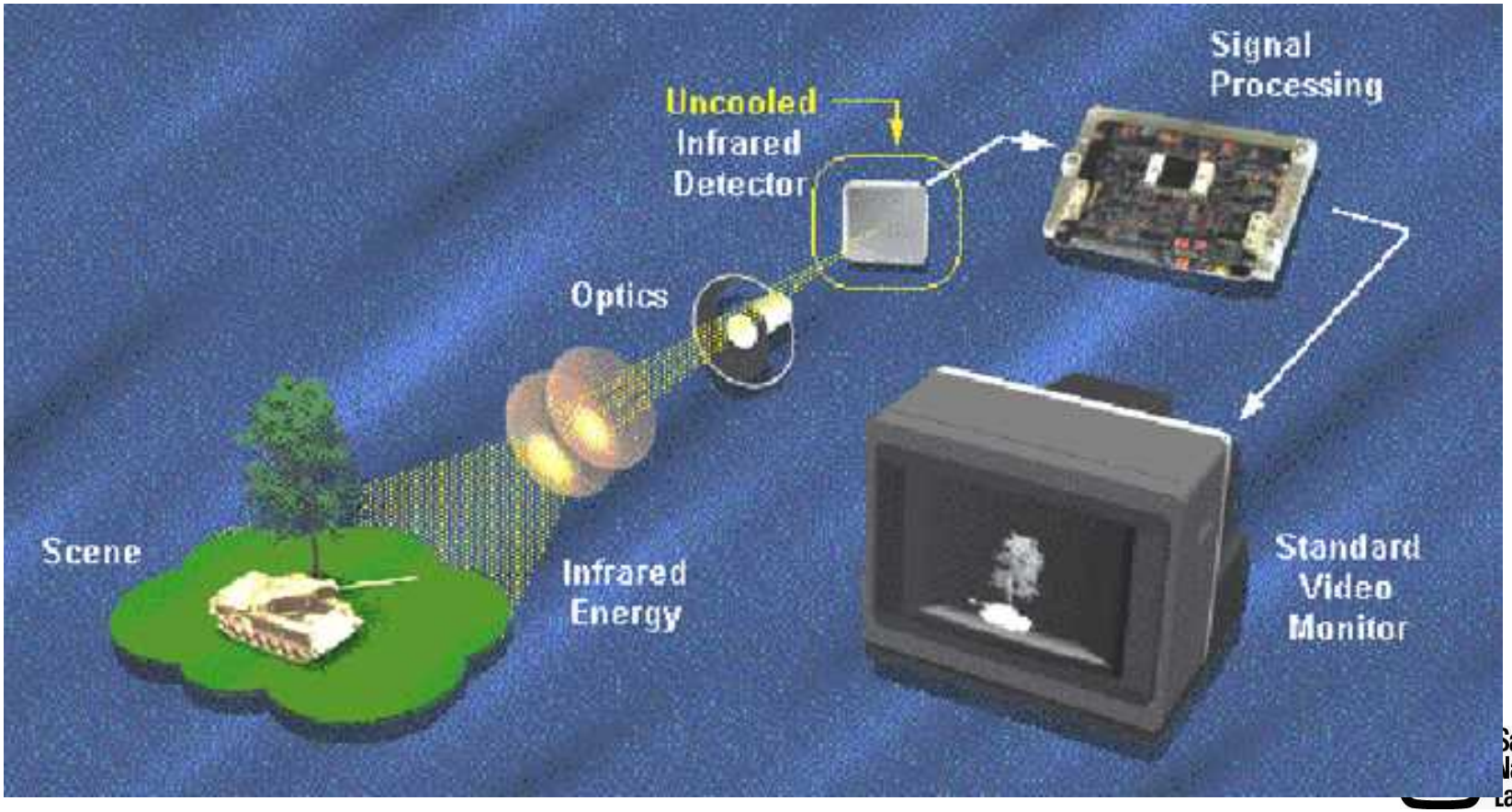
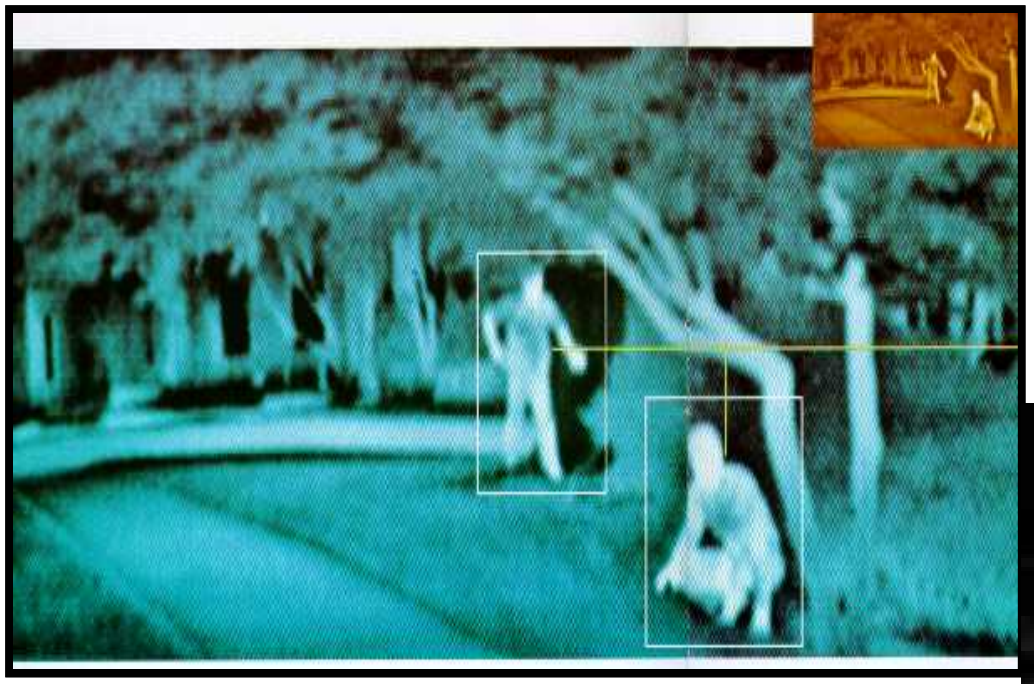


Thermal Imager Camera (cont.)

- Thermal IR - Night vision device
- Responds to differences in temperatures against a background temperature reference
- Passive device - Requires no illumination to produce video image
- Picture based on temperatures of objects in scene
- Cameras are relatively expensive

Thermal Image Examples



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Thermal Camera vs. Visible Camera Video

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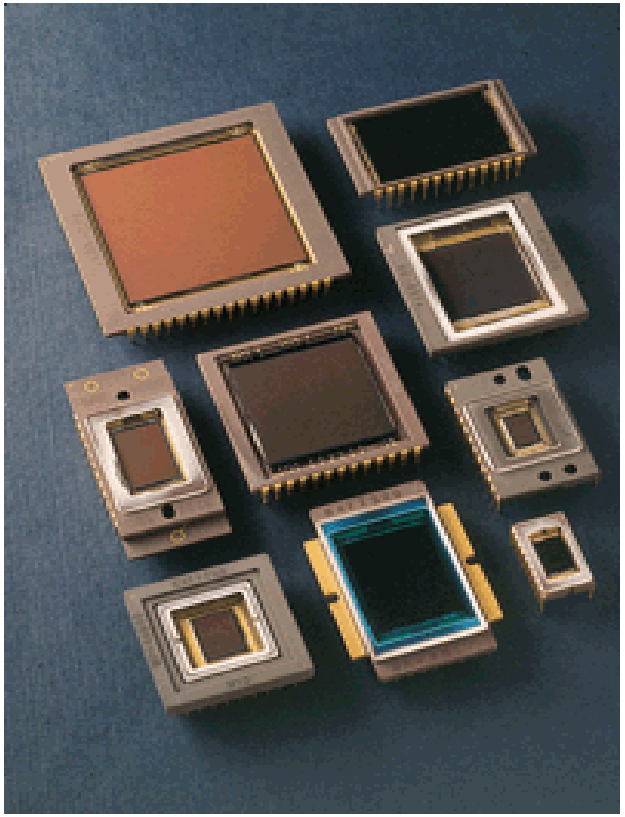
Camera Imager Device

- In solid-state cameras, horizontal resolution determined by the number and spacing of discrete sensor elements in imager horizontal dimension
- In practice, resolution determined by reading resolution chart image on monitor screen
- Vertical resolution dependant on number of scan lines



Courtesy of Kodak

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Camera Imager Device (cont.)

- Vertical resolution about 450 lines
- Quality standard color cameras have 470 horizontal lines resolution & B&W have 570 lines
- New digital color camera designs have 520 - 2200 horizontal lines

Camera Imager Device (cont.)

- **Solid-state cameras degrade little with age**
- **With periodic maintenance, can operate reliably in exterior applications for over 20 years**
- **Imager resolution stated in pixels not lines**
- **Converting pixels to lines of horizontal resolution**

  - multiply horizontal pixels by .75

  So, 760 pixels x .75 = 570 lines

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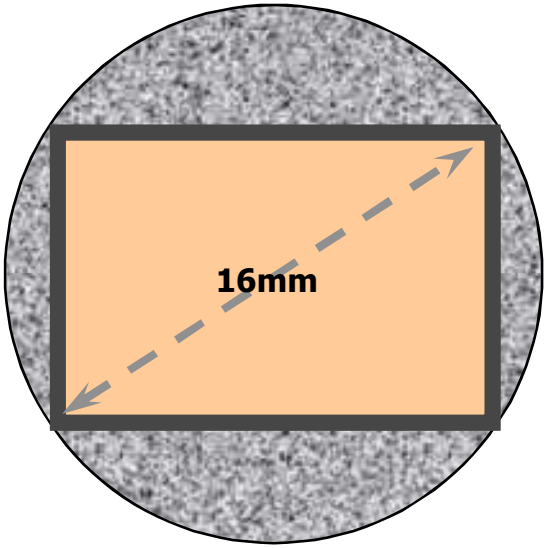
Camera Imager Format

- Imager format - Size of imager photosensitive surface
- Common imager formats today: 2/3, 1/2, 1/3, 1/4, 1/6, 1/8 inch
- Early CCTV cameras had 1-inch imagers and today cameras with 2/3 inch formats getting rare in analog cameras
- Format is diagonal measurement of imager rectangle
- Standard video camera imagers have a 4:3 horizontal to vertical size ratio
- Imagers for HDTV cameras have a 16:9 horizontal to vertical size ratio

Camera Imager Formats (cont.)



- Imager Formats width of imager (*Wi*) V
  - 1 inch = 16 mm diameter = 9.6 mm X12.8 mm
  - 2/3 inch = 11 mm diameter = 6.6 mm X 8.8 mm
  - 1/2 inch = 8 mm diameter = 4.8 mm X 6.4 mm VARIES
  - 1/3 inch = 6 mm diameter = 3.6 mm X 4.8 mm VARIES
  - 1/4 inch = 4 mm diameter = 2.4 mm X 3.2 mm
  - 1/6 inch = 3 mm diameter = 1.8 mm X 2.4 mm
  - 1/8 inch = 2 mm diameter = 1.2 mm X 1.6 mm

Image Device Formats (cont.)

- English to metric size conversion not equivalent size
- English dimension larger due to old tube type imager relationships
- A 1-inch tube-type imager had a 16mm (.63 inch) active area

Scene Contrast

- **Contrast** - Difference between the white and black levels in a video waveform or in a image
- **High contrast** - Large difference between the white and black levels
- **Low contrast** - Small difference between white and black levels and appears grey

High

Low

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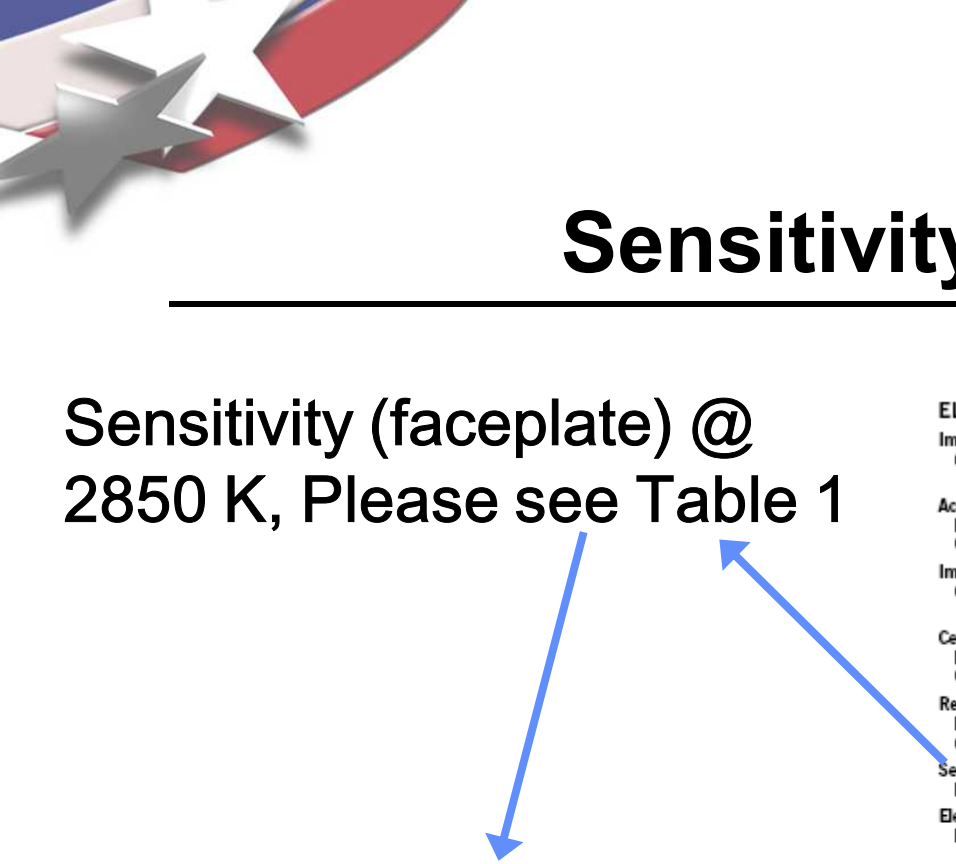
Camera Sensitivity

- **Sensitivity - Amount of usable camera output signal a camera can produce from a particular illumination level and Signal to Noise Ratio**
- **Sometimes expressed as scene illumination (lux / foot-candles)**

Sensitivity Example

Sensitivity (faceplate) @ 2850 K, Please see Table 1



ELECTRICAL

Image Area
6.4 x 4.8mm (corresponding to 1/2" format tube)

Active Picture Elements
RS-170: 768 (H) x 494 (V)
CCIR: 752 (H) x 582 (V)

Imager Type
On-chip microlens sensor interline transfer CCD

Cell Size
RS-170: 8.4 x 9.8 microns
CCIR: 8.6 x 8.3 microns

Resolution
RS-170: 580 (H) x 350 (V) TVL
CCIR: 560 (H) x 450 (V) TVL

Sensitivity (faceplate) @ 2850 K
Please see Table 1

Electronic Shutter
Eight steps from 1/50 or 1/60 to 1/10,000 second (1/50 or 1/60, 1/125, 1/250, 1/500, 1/1,000, 1/2,000, 1/4,000, 1/10,000 second)

Integration

Auto Lens
Separate lens video ratio tracks AGC peak/average adjustment to eliminate AGC/auto lens interaction
Power: +15V, 35mA maximum

Synchronization
Genlock, revert to variable phase line lock with zero crossing detector
Genlock, revert to crystal
Crystal Lock
H & V Drive
Asynchronous Reset
Internal Clock Speeds
RS-170: 28.6363 MHz
CCIR: 28.375 MHz

Power Requirements
12V AC or DC (standard)
24V AC or DC (optional)
115V AC (optional on RS-170 models, includes wall transformer and connector)
230V AC (optional on CCIR models, includes wall transformer and connector)
4.2 Watts DC power consumption
LED Power Indicator, Green

Lens Mount
"CS" mount, 16mm format
"C" mount with adapter (furnished)

Camera Mounts
1/4 - 20 threaded holes, top and bottom

Connectors
Video (BNC)
Power (2 circuit screw terminal)
Lens (3 pin mini-DIN)
External Sync (8 pin DIN)

ENVIRONMENTAL

Ambient Temperature Limits
Operating: –20° to +60°C (-4° to +158°F)
Storage: -30° to +70°C (-22° to +187°F)

Humidity
Up to 95% relative humidity

Vibration (less lens)
Sine vibration from 10 to 2,000 Hz, 5g peak, all 3-axis, 1/2 hour per axis per MIL-E 54007, para. 3.2.24.5.1.2, fig. 2, curve IIIA
Random vibration from 10 to 2,000

Table 1:

SENSITIVITY

	Full Spectrum	With IR Filter
Full Video, No AGC	0.039 fc (0.39 lux)	0.15 fc (1.5 lux)
80% Video, AGC On	0.001 fc (0.01 lux)	0.006 fc (0.06 lux)
30% Video, AGC On	0.0002 fc (0.002 lux)	0.0009 fc (0.009 lux)

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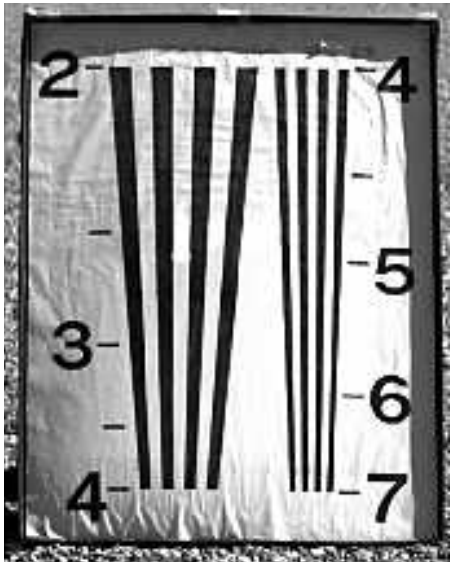
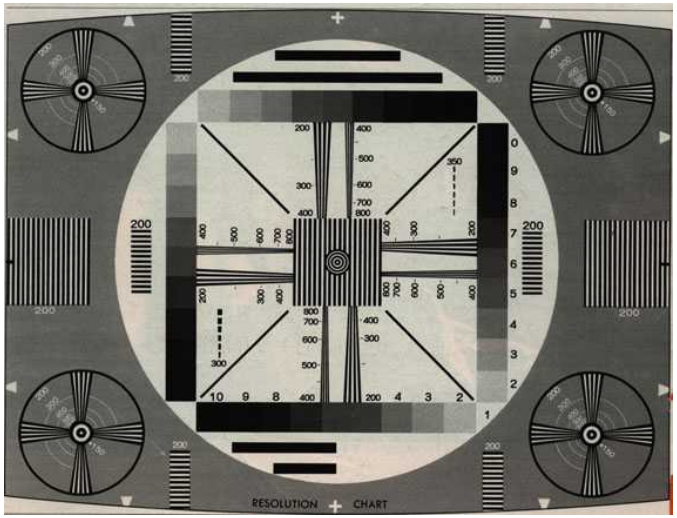
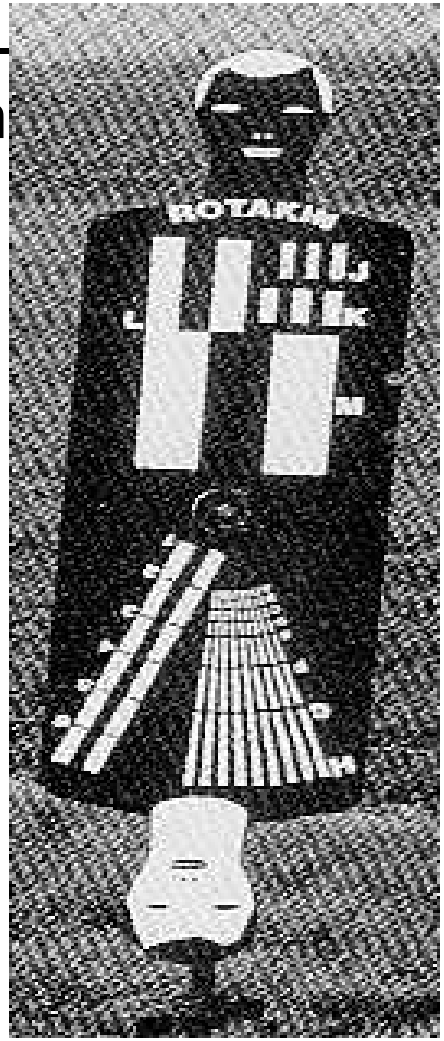
Camera Resolution

- **Resolution** - How well fine detail is seen in viewed image
- Measured using a resolution chart with black/white lines which thin and converge
- Points on converging lines calibrated to indicate resolution







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Camera Resolution (cont.)

- Units of measure are pixels or line pairs/mm
  - Stated as “horizontal or vertical TV lines”
- Resolution determined by viewing image of Rez Chart and observing where distinct black/white lines can no longer be distinguished and turns into a grey blur
- At that point, read against calibration and determine horizontal resolution

Camera Resolution (cont.)

- The higher the resolution the more details can be resolved in an image
- A camera's far field-of-view is limited by design criteria of requiring a target to occupy a certain number of horizontal TV lines or pixels in a camera's field of view
- Assessment system design criteria are different if the assessment operator is to detect, classify, or identify a human that creates an alarm

Signal-to-Noise Ratio (SNR)

- **Signal-to-Noise Ratio – Strength of video signal above electronic noise level**
- **Expressed in decibels (dB)**
- **The higher the SNR, the better rating**
- **With low SNR, the picture can appear grainy, snowy, and sparkles of color may be noticeable**
- **Noisy video produces poor quality pictures**
- **A good SNR would be > 50 db**

Automatic Gain Control (AGC)

- **Automatic Gain Control – Electronic circuit that maintains a preset video output signal by increasing camera video output to compensate for low light scene condition**

- **However, a large amount of video signal amplification can increase the amount of video noise in an image**

Auto-Iris and Electronic Shutter

- **Automatic Iris** – Output signal from the camera to the lens to automatically adjust the lens aperture to compensate for changes in scene illumination
- Two types of auto-iris control signals
  - Video – Based on the video signal from camera
  - DC – Based on voltage signal generated by camera
- **Electronic Shutter** – Camera adjusts the amount of time the imager is allowed to collect light energy without the use of an automatic iris

Summary - Requirements for Camera

- High sensitivity
- Good contrast
- Produces good picture in low light scenes
- High Signal-to-Noise Ratio (SNR)
- Automatic Gain Control (AGC)
- Automatic iris control and/or
- Electronic shutter
- High resolution
- Environment specifications
- High reliability

Additional Camera Considerations

- Camera vulnerabilities created by positioning errors in camera placement
- Resolution lower than expected
- Overt or covert tampering
- Environmental considerations
- System response time
- Number, location, lenses for cameras dependent on resolution expected
    - Detection, classification, or identification

Additional Camera Considerations (cont.)

- **Focus exterior camera at dusk when lots of red is in the sky or at night with artificial illumination**

Why?

  - **Focusing during daylight with small iris opening reduces depth of field**
  - **When iris is open at night, looking through a larger diameter portion of the lens causes defocus**
  - **Also, reds don't bend in a lens like visible light causing defocus at sunset**

Additional Camera Considerations (cont.)

Tamper & video loss detection

- Video authentication
- Physical protection of camera & cables
- Conduit with welded joints

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Additional Camera Considerations (cont.)

- Electronic supervision of video signal cable
- Rain, snow, and fog causes loss of usable images
  - Contingency plans required in advance
  - Use tactical surveillance PTZ or dome cameras
  - Posting security officers for visual observation

Additional Camera Considerations (cont.)

- Video Presence Detectors - Alarm if video scene brightness level increases or decreases abruptly from normal signal beyond preset values
- Video Sync Detectors - Amplitude is increased or decreased
- Detection circuits are normally at head-end console

Additional Camera Considerations (cont.)

Covert Tampering

- Tapping into video transmission cables and inserting pre-recorded video scene
- Placing picture in front of camera
- Switching video signal circuits to show another sector

Overt Tampering

- Blinding with bright light
- Covering camera
- Destroying camera
- Laser pointer
- Cutting cables

Module Objectives

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