

[Course Introduction](#)

CCTV Systems and Control Design

[CCTV System Application Criteria](#)

[CCTV Design Elements](#)

[Lighting Requirements](#)

[Cameras](#)

[Lenses](#)

[CCTV Monitors](#)

[Design Requirements](#)

[Posttest](#)

Security PACE Book 4 - CCTV Systems and Control Design

CCTV Systems and Control Design is Book Four in this PACE series on Security Basics. It covers the application criteria, design elements, components and requirements necessary to design an effective CCTV system.

Learning Objective

After completing this PACE Book, you should be able to:

- ◆ describe situations in which CCTV systems offer distinct advantages for surveillance
- ◆ identify the six (6) design elements to consider when designing a CCTV system
- ◆ list and describe the three (3) related quantities when considering light levels
- ◆ describe the process of measuring quantities of light and define the factors involved
- ◆ recognize calculations to determine light levels and reflected light requirements
- ◆ list advantages of CCD (Charge-Coupled Device) image sensors
- ◆ list and compare the most common CCD technologies
- ◆ identify the seven (7) factors to consider when selecting a camera
- ◆ define the three (3) factors determining image size
- ◆ given a chart and examples of image sizes and distances, determine the appropriate focal length
- ◆ specify formulas used in calculating focal length and image width and height
- ◆ given the appropriate camera focal length, select the required CCTV monitor
- ◆ identify the questions to ask customers about system function, system management and system when planning a CCTV system
- ◆ given a set of customer requirements, select an appropriate camera configuration and transmission medium for the application

Use the Menu at left to navigate through the course.

CCTV System Application Criteria

Effective CCTV System Applications

A remote corner of a parking lot requires security coverage 24 hours a day, year round. A warehouse storing high explosives demands constant surveillance. These are just two situations in which CCTV (Closed Circuit Television) offers distinct advantages in providing surveillance. There are many other situations as well, and in Book 4 of the PACE series on Security Basics, we will examine the necessary steps in designing an effective CCTV application.

Human observers are costly and valuable resources. CCTV allows security managers to use this resource judiciously. There are a number of common situations where human safety, concealed observation, or resource management are better served with CCTV rather than human observers. These situations include:

- ◆ Observation of remote areas (parking lots, garages)
- ◆ Observation of hazardous areas (radioactive waste dumps, chemical storage areas)
- ◆ Discreet or concealed observation (loading docks, lobby areas)
- ◆ Sustained observation of areas with infrequent activity (warehouses, rail yards)
- ◆ Simultaneous observation of multiple areas (high-rise

buildings, multiple building campuses)

Effective CCTV System Applications



CCTV Design Elements

Elements of a CCTV System

Designing a CCTV system requires the planner to fit a number of important pieces together. Individually, these pieces are crucial, but how they interact with every other piece is just as important. As suggested in Figure 4-2, there are six (6) design elements to consider when designing any CCTV system:

- ◆ scene, environment
- ◆ camera
- ◆ lens
- ◆ transmission medium
- ◆ monitor
- ◆ Video Signal Management and Control Equipment

Each of these areas has been discussed in Book 3 in this PACE series on Security Basics, and in this book, we will build on the information presented there.

To review, the scene is the area of surveillance — the area which is to be observed and its environment. This includes lighting, weather, security of the CCTV equipment and the detail desired of the picture displayed by the monitors.

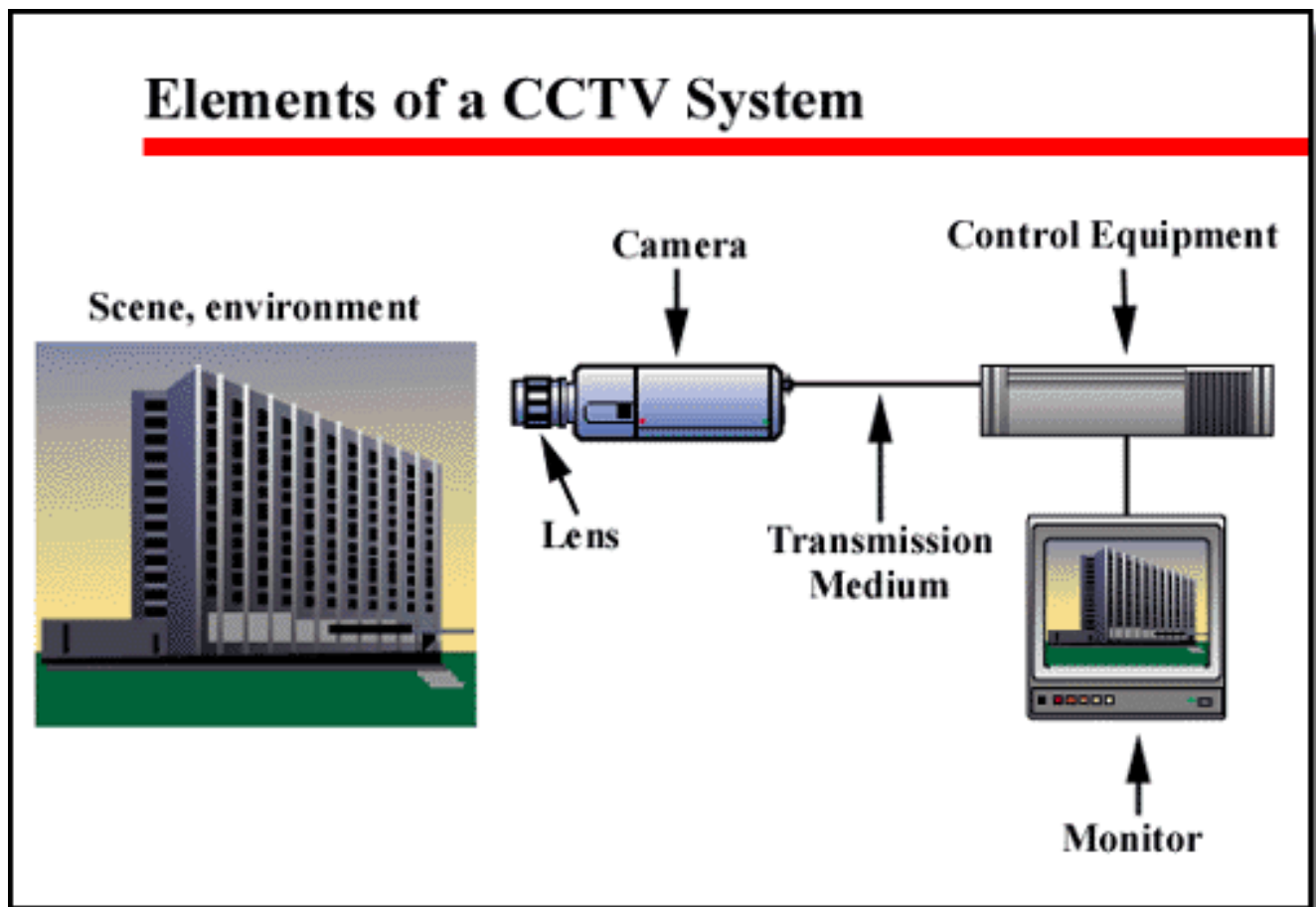
The lens is the optical component of the system which "defines" the image of the screen — its size, shape and focus.

The camera converts the optical image passed by the lens into the electronic signal transmitted to the monitor.

The transmission medium (optical fiber, coaxial cable, microwave, twisted-pair cable, etc.) carries the electronic signal generated by the camera to the monitor.

The monitor receives and displays the transmitted image.

The control equipment includes switchers, multiplexers, signal compressors and processors, and remote positioning devices (pan/tilt/zoom controllers).



Lighting Requirements

The scene is the place where all design decisions start, and no aspect of the scene is more important than light — quality and quantity. Without proper lighting, cameras cannot perform adequately, that is, provide usable images. A key issue in designing a CCTV security application is evaluating current lighting conditions in the area of interest, determining what, if any, additional light sources may be required, and asking "what does the customer want to see?"

Select the first topic below to begin this lesson:

- [Usable and Full Video](#)
- [Light Quality](#)
- [Light Quantity](#)
- [Measuring the Quantity of Light](#)
- [Calculating Light Levels](#)

[TOP](#)

Usable and Full Video

Usable is a term often applied to video. Another common term is *full video*. Both usable and full are somewhat subjective: what is "usable" to one person, may not be to another. The terms (Figure 4-3) describe for video what fidelity describes for audio recordings. A child's tape recorder and a recording studio Digital Audio Tape (DAT) recorder may be able to record the same sounds, but the child's toy will be noisy, with a limited frequency range. Much of the sound (the lows and highs, for example) will be missing; on the other hand, the DAT recording will sound "like you're there." A similar qualitative difference exists, between usable and full video.

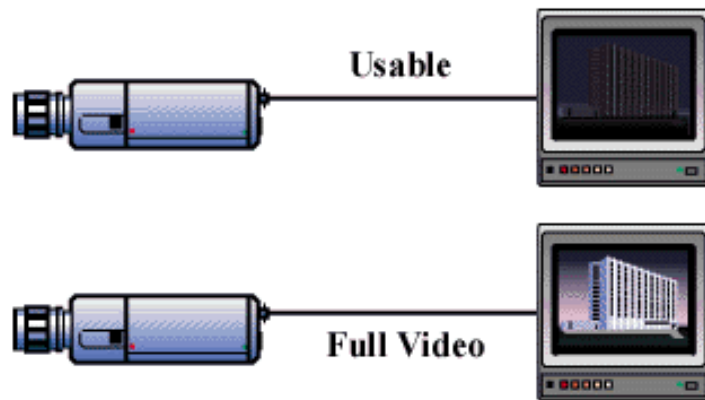
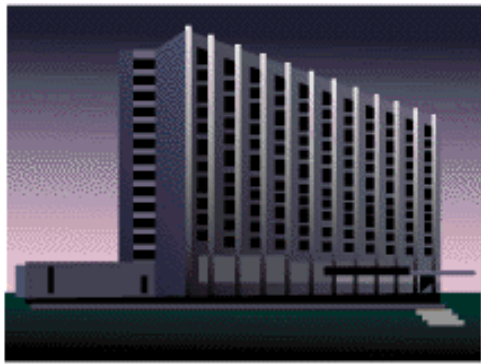
In general, usable video (or usable image) refers to video images which supply the minimum level of information required by an application. Full video is perhaps the less subjective of the two terms. It refers to images which reproduce the scene with a high level of "fidelity" — it appears on screen substantially as it does in actuality.

Usable or full video is only possible with proper illumination. Clearly, light levels in a scene must be high enough to produce usable video at a minimum. In situations with minimal light levels, ideally, additional light would be added to permit full video from the camera. If lighting levels are inadequate for a given camera, designers have two options:

- ◆ add light
- ◆ select a camera with greater sensitivity

Which option is chosen may depend on several factors including the cost of changing the camera vs. the cost of supplementing existing lighting.

Usable and Full Video



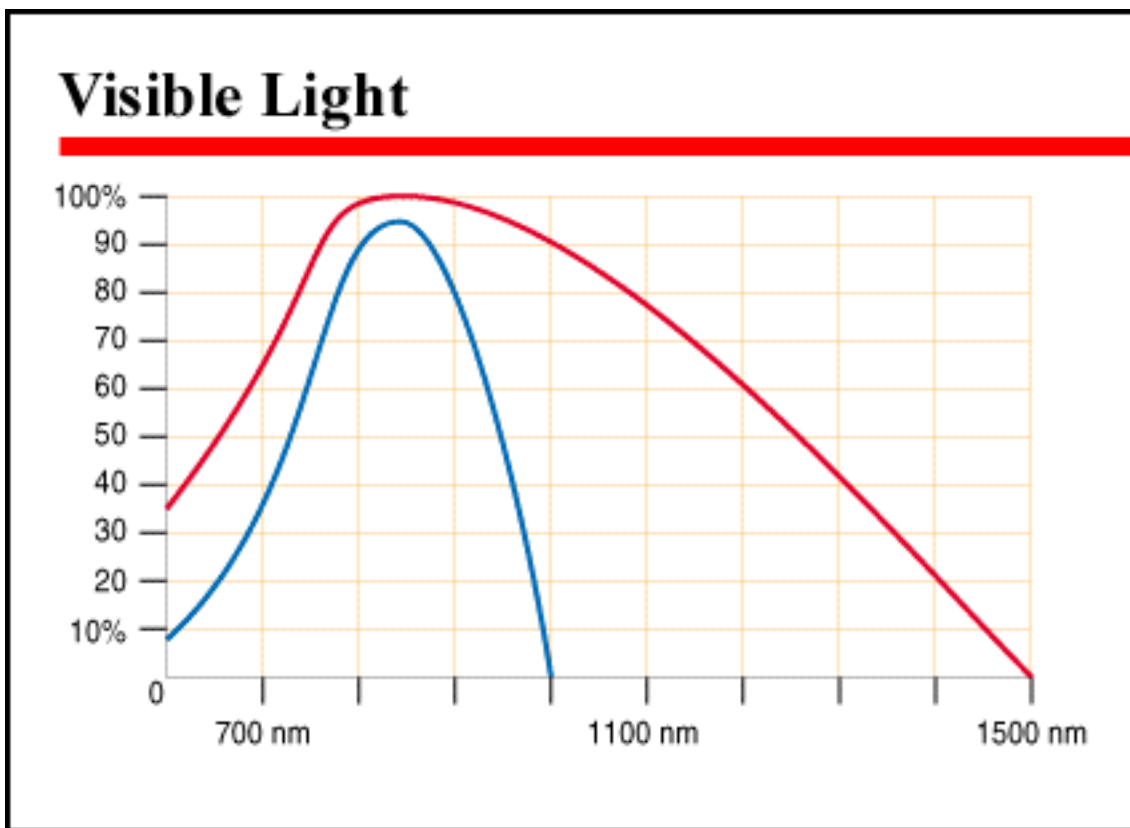
Light Quality

Cameras are often compared to the human eye, and in many respects, this is accurate. One significant difference, however, is that many cameras are able to "see" light which is invisible to humans. Visible light is actually made up of a spectrum of colors — red, orange, yellow, green, blue, indigo, and violet. Each color has its own wavelength, ranging from 400 nanometers (nm) for violet to 700 nm for red.

In addition to the colors of the visible spectrum, cameras can see light in the near infrared range (750 nm to 1150 nm) and infrared (over 1150 nm). These wavelengths transition from color to heat. Special infrared cameras create an image using heat instead of reflected visible

light. Because many better quality cameras "see" these higher wavelengths, in lighting conditions with poor levels of visible light, cameras may actually see images more effectively than the human eye.

The human eye and brain can view a scene and average the conflicting light sources or reflectance. The highlights and lowlights are averaged by the brain to produce an acceptable image. Most cameras can not perform this averaging, trying to compensate for the highlights and lowlights. However, some of the viewed scene will be visible and fluttering of the picture can occur.



Light Quantity

In CCTV applications, the quantity of light is generally more important than the quality of light. The foot candle is the most common measure of light quantities. Originally, a foot candle had a rather literal meaning: the amount of illumination on a surface one foot away from a common candle. Foot candles are now defined more scientifically: one (1) lumen of illumination per square foot. (Lumen is a measure of illumination utilizing mathematical constructs from physics.)

The metric world's equivalent of a foot candle is a lux. One (1) lux equals one (1) lumen of illumination per square meter.

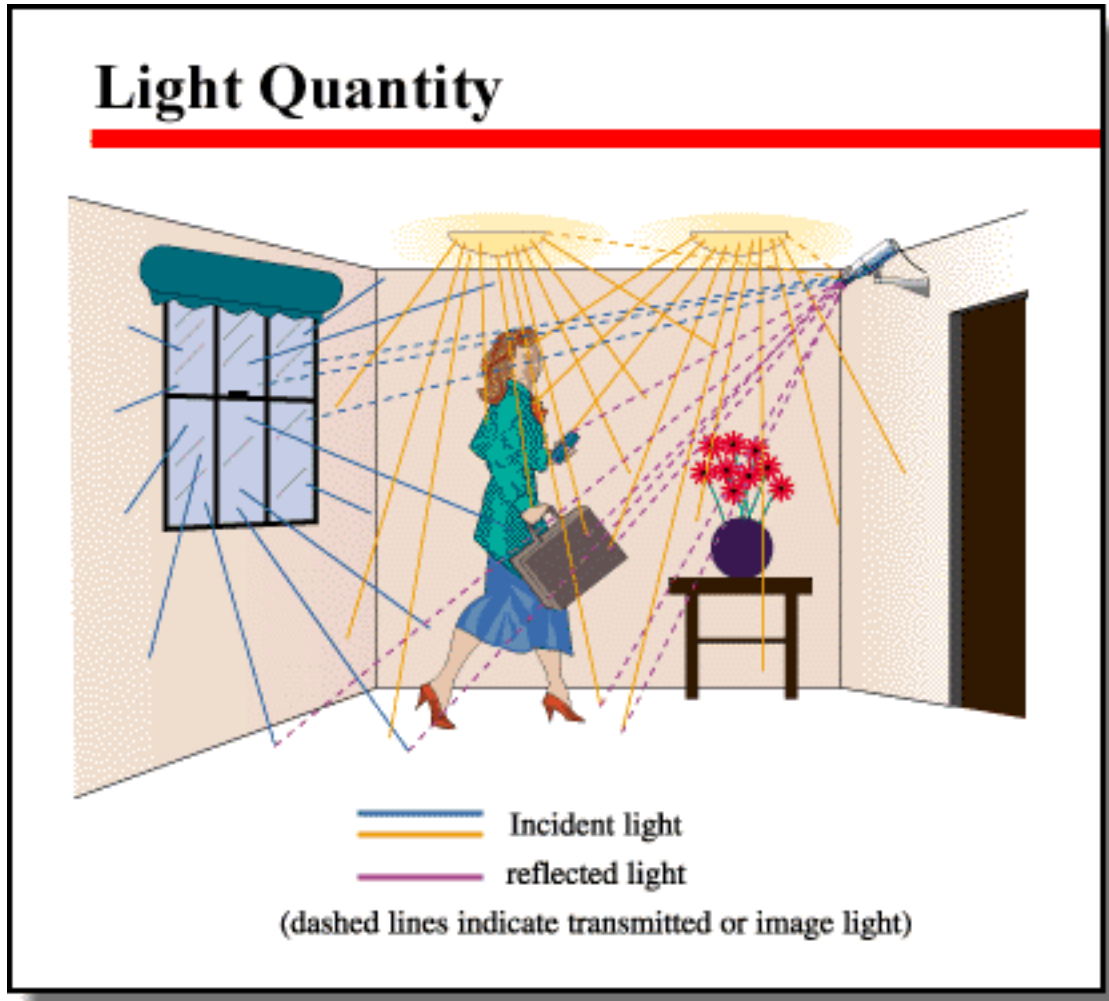
For comparison, a modern sports stadium or arena may have light levels reaching 200 foot candles or more. On the other hand, many areas — access roads with poor lighting, for example, may have light levels of one foot candle or less. Even with these extremely low levels of light, cameras can still acquire usable images.

It is important to recognize that CCTV system designers must consider three related quantities when considering light levels:

- ◆ incident (light coming directly from all sources)
- ◆ reflected (light bouncing off of the scene to the camera)
- ◆ image (amount of light reaching the image sensor).

As demonstrated in the figure, sufficient light must strike the image sensor to produce an electronic signal. This is a sort of "bottom line" with respect to lighting issues ... but the amount of light striking the image sensor is directly

related to the amount of reflected light ... and the amount of reflected light is directly related to the amount of incident light (coupled with the reflectance of the objects in the scene). There are specific tools and methods for evaluating light levels and we will consider these next.



Measuring the Quantity of Light

Measuring light — either incident or reflected — requires a photometer (light meter). A meter may be able to read only incident light, or reflected light, or — with conversion attachments — both. In CCTV applications, designers most commonly measure reflected light.

The photometer is placed exactly where the camera will be positioned). The photometer's sensor is turned toward the area of interest, and the resulting reading is noted. Several readings should be taken if the scene, the light levels, or the camera angle is going to change. Suppose the area of interest is the press room of a large offset printing operation. The reflected light levels may be higher when wide rolls of white paper are running through the press (during the day) than when the press is off-line at night (and when CCTV coverage may be more important). Another example: if the area of interest is an exterior location, measurements at night are crucial if the camera will be used at night. Or consider a dome-mounted camera: here readings all around the area should be acquired, if the camera is going to turn 360 degrees.

Besides the actual reflected light levels, two (2) other factors — both related to the lens — effect the amount of light reaching the image sensor:

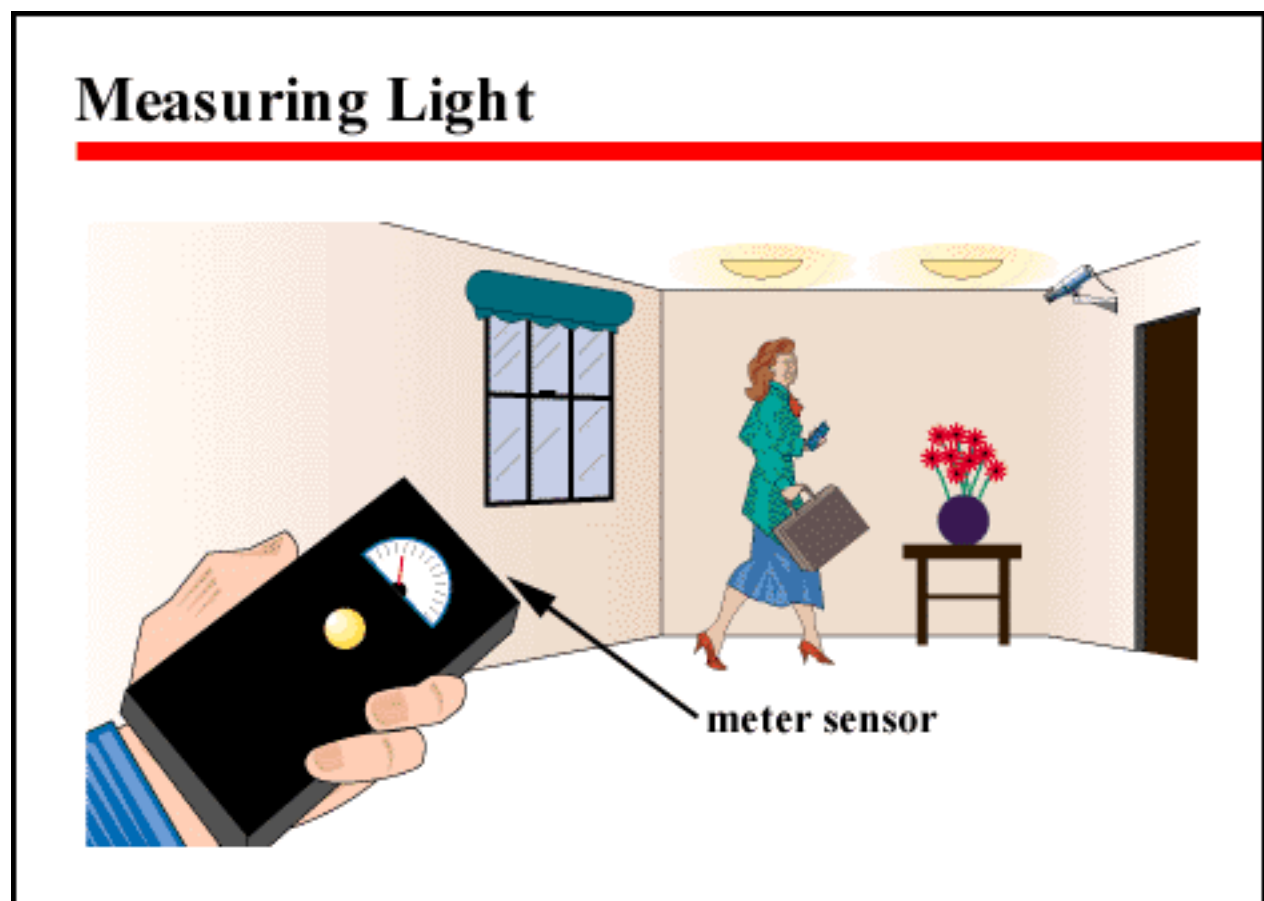
- ◆ lens transmissibility
- ◆ lowest f-stop (and widest opening) of the lens' iris

All lenses absorb and reflect a certain amount of the light entering them. Lens transmissibility is simply a percentage indicating the amount of light which is actually transmitted through a lens. Transmissibility for quality lenses is typically

in the .70 to .90 range.

f-stops are a measure of the iris (aperture) opening. The best lenses (and generally most expensive) have the lowest f-stop ratings. Low values for f-stops may range from 1.2 (for "fast" wide angle and normal lenses) to 4.5 (for telephoto lenses). Remember, lower f-stops mean the iris is open wider, and conversely, higher f-stops means the iris is closed more. (Note: most lenses have variable irises; therefore, there will be a range of f-stops possible, but for our purposes here — finding minimum levels of light required to make usable images — we're only interested in the lowest f-stops.)

Both the transmissibility of the lens and the f-stop ratings are available from the lens manufacturer's specifications.



Calculating Light Levels

The amount reflected light in foot candles, the lens transmissibility, and the lowest f-stop must be determined. Once these three pieces of information are known, a simple calculation yields the amount of light striking the image sensor:

$$I_f = I_l \times T \\ 4 (f^2)$$

where:

- ◆ I_f = foot candles illumination on the image sensor
- ◆ I_l = foot candles illumination on the lens
- ◆ T = transmissibility of the lens
- ◆ (f^2) = f-stop of the lens squared

Suppose a designer is considering a particular camera for a security system. According to the manufacturer's specs, one (1) foot candle on the image sensor for this camera will produce full video. The designer is also planning to use a lens with a transmission rating of .90 and a f-stop of 1.4.

The designer has used a photometer at the scene and found it has a reflected light reading of 5 foot candles. Assume the scene to be viewed produces five (5) foot candles on the camera lens (acquired by using a light meter). Assume the camera has a lens with light transmissibility of .90 and an f-stop of 1.4. The calculations are as follows:

- ◆ $l_i \times T \times 5 \times .90 = 4.5$
- ◆ $4 \times (f^2) \times 4 \times (1.4 \times 1.4) = 7.84$
- ◆ $l_f = 4.5 / 7.84$
- ◆ $l_f = 0.57$

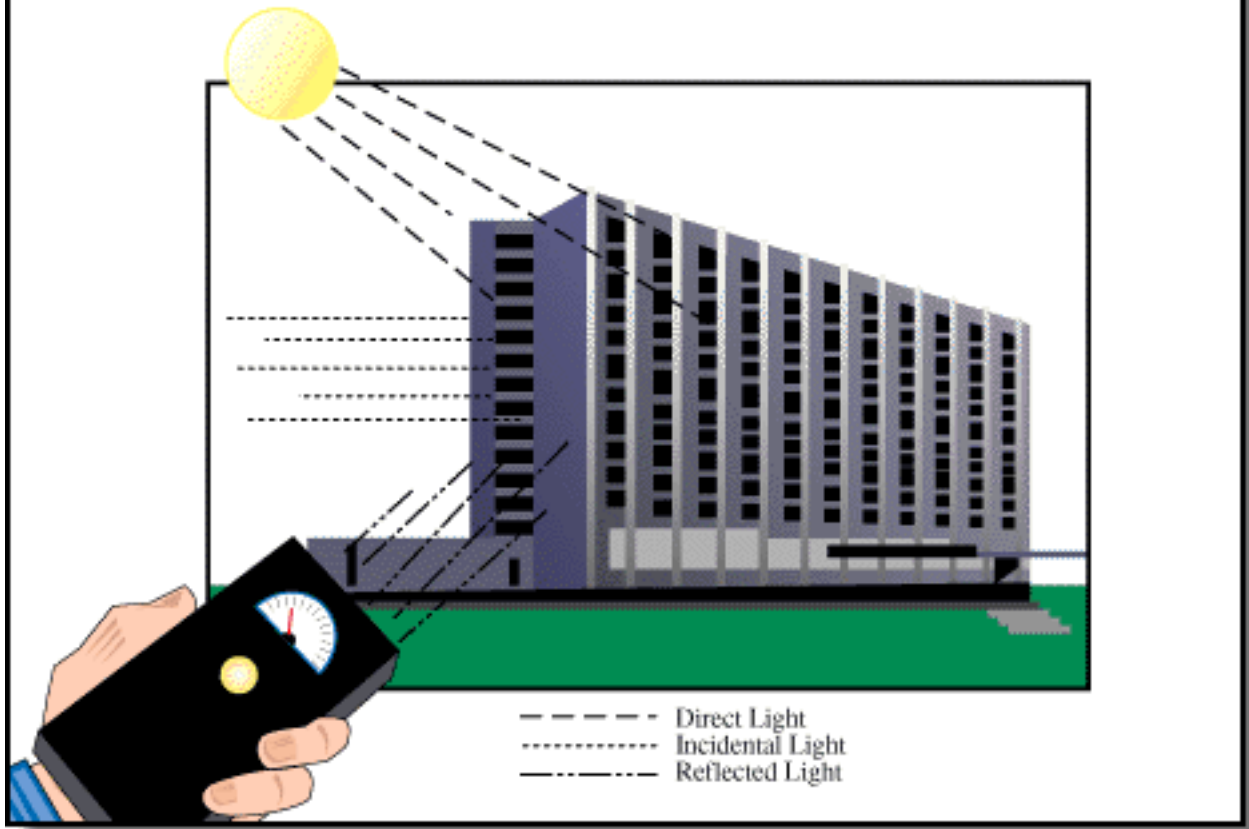
Since the result is less than the 1 foot candle requirement for light at the image sensor (as stated in the specifications), the designer must now decide to add lighting or use a more sensitive camera. If a "faster" lens were available that might be another option. Finding a lens with an f-stop lower than 1.4 is now possible from many manufacturers.

Incidentally, by changing the formula around, it is possible to identify how much reflected light is required for a given camera:

$$l_i = 1/f \times 4(f^2) = 1 \times 4(1.4^2) = 9 \text{ footcandles}$$

T .90

Calculating Light Levels



Cameras

Another key factor in designing CCTV systems is the camera. Today, except for the most extraordinary applications, CCD cameras are the preferred product. Therefore, our discussion will focus on CCD technology.

Select the first topic below to begin this lesson:

- [CCD Image Sensors](#)
- [Resolution](#)
- [Camera Compensation for Extremes in Light Levels](#)
- [Synchronization](#)
- [Genlock](#)
- [Environmental Factors](#)
- [Size and Weight](#)

[TOP](#)

CCD Image Sensors

A CCD — Charge-Coupled Device — image sensor offers several advantages:

- ◆ ease of operations
- ◆ improved life cycle
- ◆ small, compact camera packages
- ◆ excellent sensitivity
- ◆ less vulnerable to EMI (Electromagnetic Interference) and RFI (Radio Frequency Interference)
- ◆ cost effective

A CCD image sensor is actually an integrated circuit (IC). One surface of the integrated circuit — the sensor face plate — forms an array of light-sensitive devices (pixels). Light striking this array causes electrons to flow in proportion to the amount of light exciting a specific pixel. Note that this explanation has been simplified. In reality, the actual process is more complicated, with several variations depending on the specific CCD technology in use. The most common CCD technologies in CCTV applications include:

- ◆ MOS
- ◆ Interline transfer
- ◆ Frame transfer

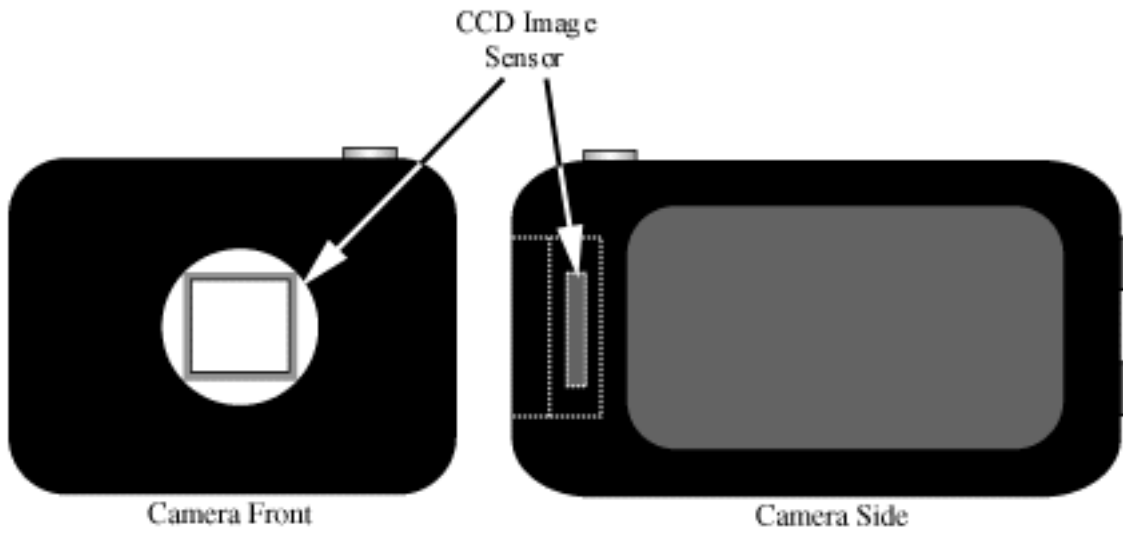
Cameras incorporating MOS — Metal Oxide Semiconductor — technology are currently at the low end of sensitivity and resolution for CCTV applications. These cameras function most satisfactorily in bright, even lighting. Shadows cause problems for MOS cameras, with significant loss of detail in the darker areas. In addition, MOS technology has a high resistance to infrared wavelengths, further limiting the

camera's ability to produce sharp, crisp images.

Interline transfer CCD cameras utilize Improved Metal Oxide Semiconductors. The pixels on the image are arranged in rows and columns, each separated by small spaces. The CCD uses this space to transfer the charge from the actual sensing pixel to a storage area. Unlike the low end MOS cameras, interline transfer cameras have some infrared sensitivity which can be increased by adding filters. The characteristics of an interline transfer CCD camera allow a particular camera to be set up for use either in daylight or at night, but the same camera cannot be used for both.

Frame transfer CCD's — unlike interline transfer CCD's — have no spaces between the pixels on the image sensor. Therefore, the actual surface area of each pixel is larger, resulting in a larger overall image area. The charges created as light strikes the pixels are moved to a storage area in the CCD one complete "frame" at a time. Frame Transfer CCD's produce high-quality images. They are good in low light and have better IR sensitivity than either MOS or interline transfer CCD's. Color rendition, particularly in daylight, is excellent. Not surprisingly, of the three CCD types discussed here, cameras utilizing Frame Transfer technology generally have a higher cost.

CCD Image Sensors



Resolution

Resolution



Low Resolution



High Resolution

General Camera Specifications for CCTV Applications When selecting a camera, system designers must consider a number of factors that affect the quality of the image and system reliability. These factors fall into seven general categories:

- ◆ image sensor resolution
- ◆ signal-to-noise ratio
- ◆ automatic light compensation
- ◆ synchronization
- ◆ signal output
- ◆ environmental conditions and camera reliability
- ◆ dimensions and weight

We will look briefly at each of these issues. As we do so, keep in mind that better cameras (with higher resolution, sensitivity, and signal-to-noise ratios) typically cost more, and cost is also a factor to consider in systems design.

Resolution Resolution is expressed as the number of lines scanned by the image sensor and output from the camera. As suggested in the figure, resolution varies from camera to camera. In general, for CCTV applications, image sensor resolution should be at least 600 lines. Cameras with lower resolution (home video cameras often report a resolution of

450 lines) may not provide the detail necessary for detection, recognition or identification. On the other hand, high resolution cameras (up to 800 lines or more) may not be necessary except in highly specialized applications.

Signal-to-Noise Ratio All camera specifications should list a signal-to-noise (S/N) ratio for the camera. Simply stated, signal-to-noise ratio is the amount "visual noise" present in a video signal in comparison to the "pure" image information in the same signal. Noise — in the form of "snow" — can often be seen on a monitor especially when a camera is transmitting black (because it is in total darkness, the iris is completely closed, or the lens cap is on). All cameras produce noise. Better cameras have higher signal-to-noise ratios. A S/N ratio is expressed in decibels. Mathematically, it is the ratio of the peak signal value compared to the peak value of electromagnetic interference (EMI). The greater the ratio (number of decibels) the "cleaner" and better defined the picture. Any value over 40 dB is acceptable.

Keep in mind that signal to noise ratios should be linked with camera sensitivity. A camera with high sensitivity and 40 dB signal-to-noise will produce a better image than a camera with low sensitivity and 40 dB S/N. In addition, some cameras have "gain" circuitry which allows the camera to produce pictures in lower light, but gain control can introduce significant levels of noise. Automatic Gain Control senses the signal dropping below full video levels. When this occurs the amplifier activates and compensates for the drop, maintaining the signal above full video levels at its designated range.

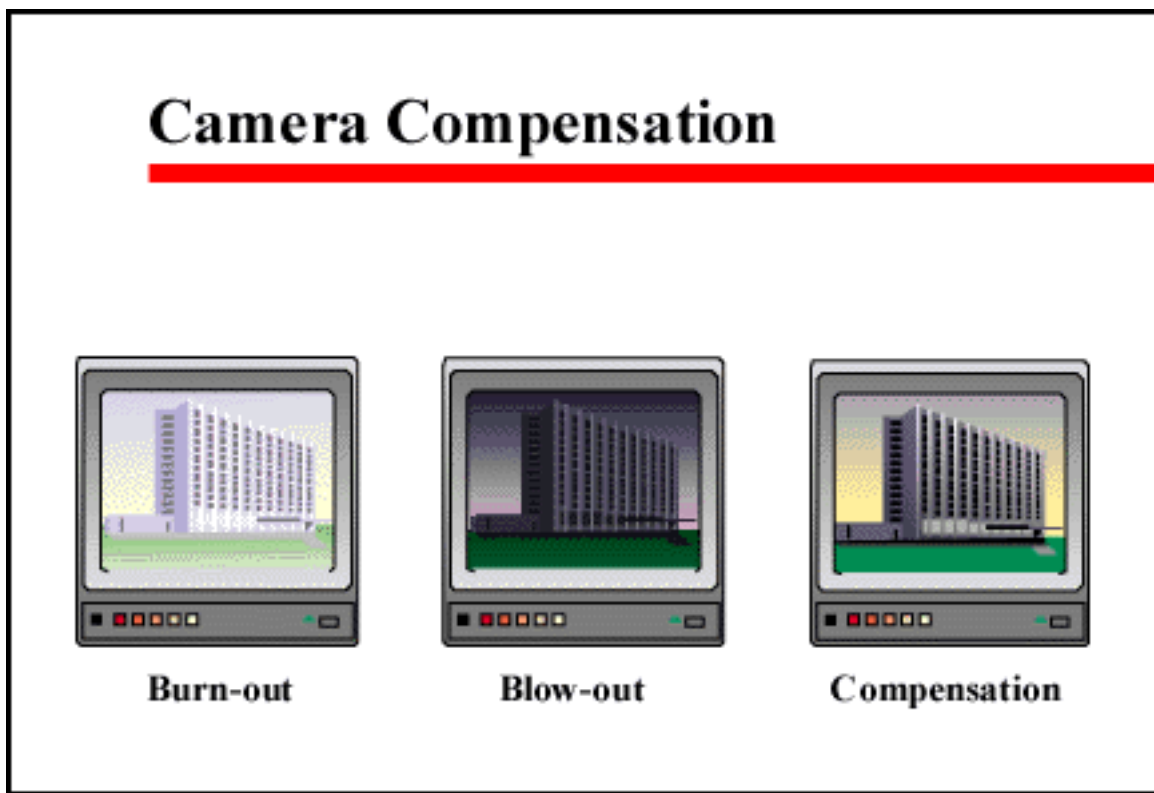
Camera Compensation for Extremes in Light Levels

A major concern, particularly in exterior applications, is the camera's ability to handle extreme variations in light levels. In daylight, more than 10,000 foot candles of light may illuminate a scene. At night, the same area could be lit by less than 1 foot candle. Cameras which cannot compensate for such lighting extremes present serious limitations for a system designer. In addition, cameras which cannot compensate for extreme levels of illumination with the same scene, may generate images

which either "burn-out" — a condition where the lightest portions of a scene turn all white — or conversely, "blow-out" — where all detail is lost in the darker areas of the image.

Fortunately, there are several features which help cameras adjust for these conditions. Automatic iris, remote iris and iris controlled circuits are compensating features. These affect the overall level of light striking the image sensor.

Backlight compensation and similar circuitry provide adjustments on portions of the image. This helps make objects objects by shade more visible on the image. Remember, this adjustment is for the depth of the view from the camera. Backlight compensation averages the lighting scene to either improve lowlights or highlights.

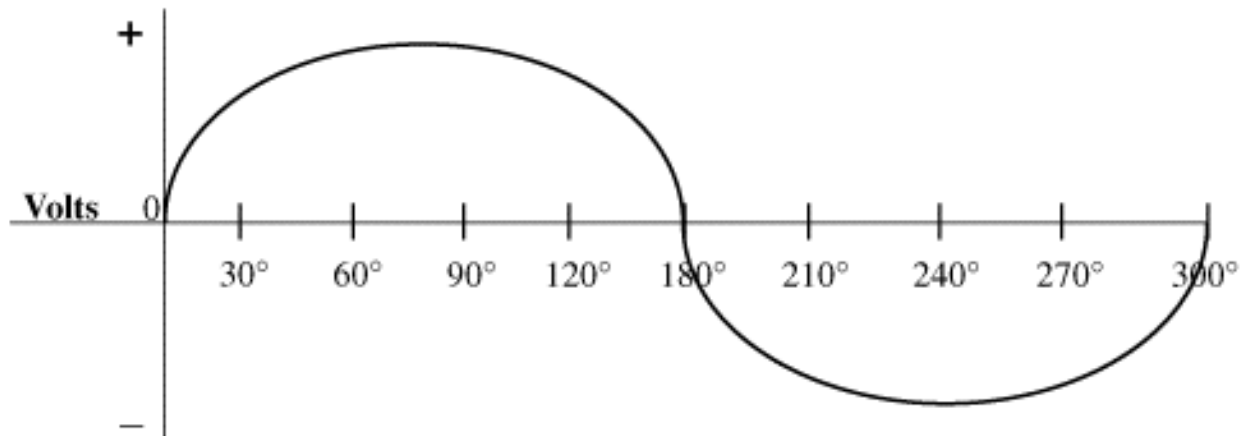


Synchronization

Some cameras can be "synchronized." This capability is important when a CCTV system involves several cameras and a switcher (to direct selected camera output to a monitor). Without the ability to synchronize the entire system, rolling images and other distortions will occur every time a signal is switched. In applications requiring time lapse recording of events (sending fewer than 30 frames per second), synchronization is also critical. Line lock is the most basic type of synchronization. It is internal to each camera. Line lock "sync" assumes that AC voltage provided to the camera has a constant waveform. That is, alternating current sends a plus charge then a negative charge. This plus-minus cycle is repeated 60 times a second (in North America). Given this cycling of plus-minus, there will be an instant in every cycle where there is neither a plus or minus electron flow. This is the zero point of the cycle.

Cameras with line lock synchronization use this zero point in the AC cycle to sync image scanning and other electronic processing. Link locked cameras may be switched from one to another without rolling images. Notice that cameras utilizing battery power (DC) cannot use line lock synchronization since no AC is supplied to the camera.

AC Cycle



Genlock

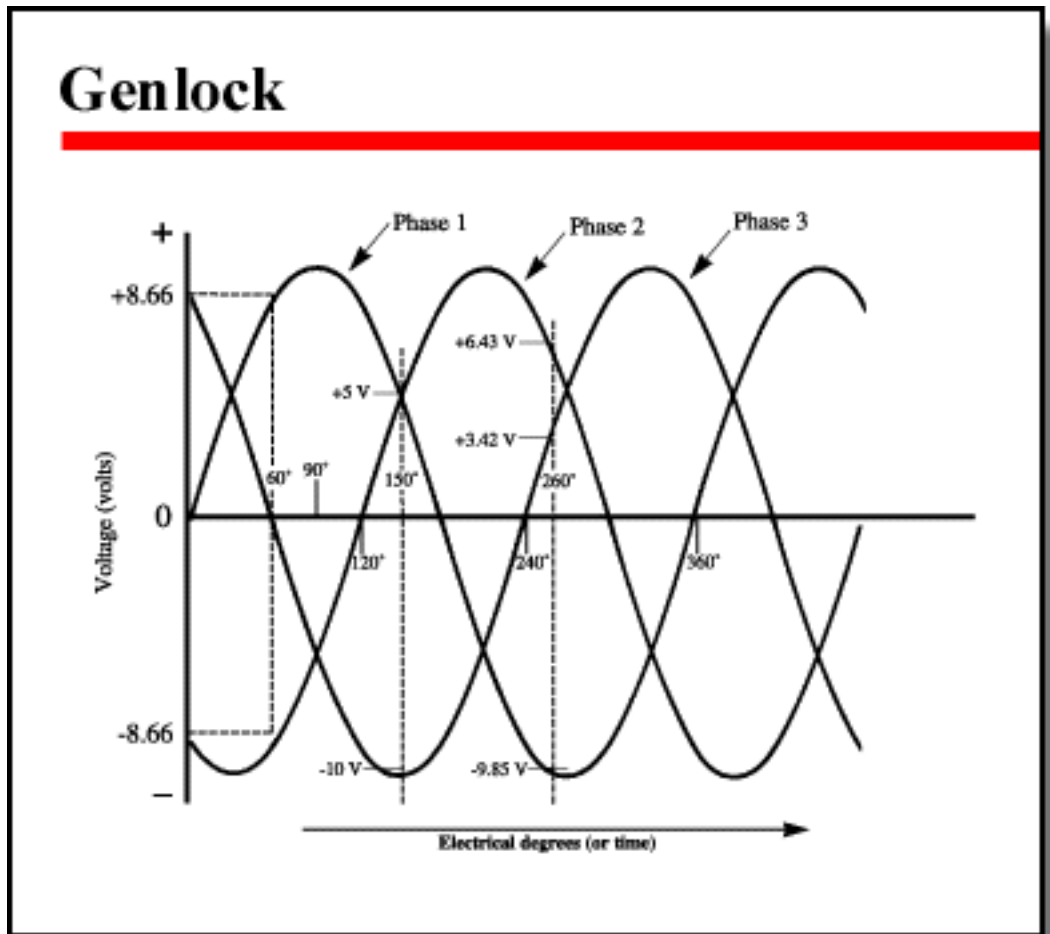
The signal sent from a video camera contains more information than simply the video image.

A more sophisticated method of synchronization is "Genlocking." Here the CCTV system includes a "synch generator." This component, which may be built into a switcher, generates a series of pulses. These pulses are simultaneously sent to each camera, signaling when to begin the scanning process and how fast to do it.

"Synching" the system also establishes a constant transmission rate from each camera to the switching

device. The result is that an extremely stable image is delivered to the monitor with no distortion as images are switched from source to source.

The signal also contains synchronization information and "blanking" information. Some cameras may also send coded identifying information along with this other information.



Environmental Factors

Video cameras, like all electronic systems, are vulnerable to a variety of environmental hazards. Camera specifications should include information about the temperature range and humidity levels within which a camera can function. Additional environmental information should report the severity of vibration and shock which the camera can tolerate without degradation in performance. These factors may be important as systems designers assess the environmental characteristics of a specific location.

Environmental Factors



Size and Weight

Finally, the dimensions and weight of the camera may be factors when selecting mounts and enclosures.

Lenses

Select the first topic below to begin this lesson:

- [Lenses](#)
- [Covering the Scene](#)
- [Focal Length and Field of View](#)
- [Image Size and Focal Length](#)

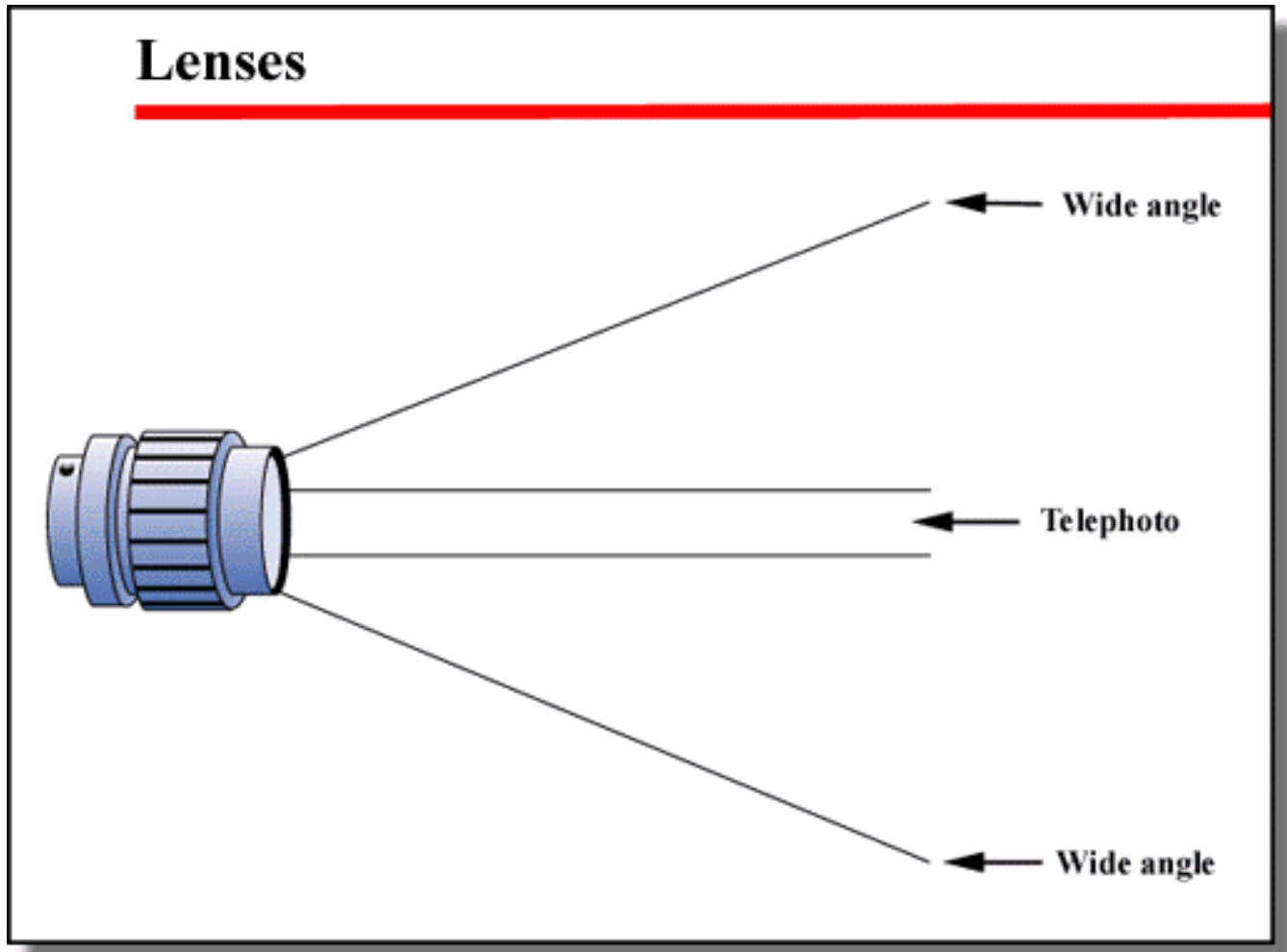
[TOP](#)

Lenses

Technically speaking, lenses define the geometry of the image striking the image sensor. A lens is directly related to image size, shape and sharpness. The characteristics of the lens determine how much of a scene is captured in an image, the degree of magnification, and which objects will be in focus.

A lens is an optical element of one or more layers (glass lenses). In its simplest form, it is a piece of distorted glass, similar to fun-house mirrors. The distortion actually bends light waves, but unlike those wavy mirrors, the distortions in lenses are carefully engineered to bend the light in an exact and predictable manner. This controlled bending of light is what shapes and focuses an image on a surface. In a video camera, this surface is the face plate of the image sensor.

The distance from the image sensor to the optical center of the lens is the focal length. As shown in the figure, the longer the focal length, the smaller the field of view, but the greater the magnification of the objects in the field of view. Shortening the focal length widens the field of view and decreases the amount of magnification.



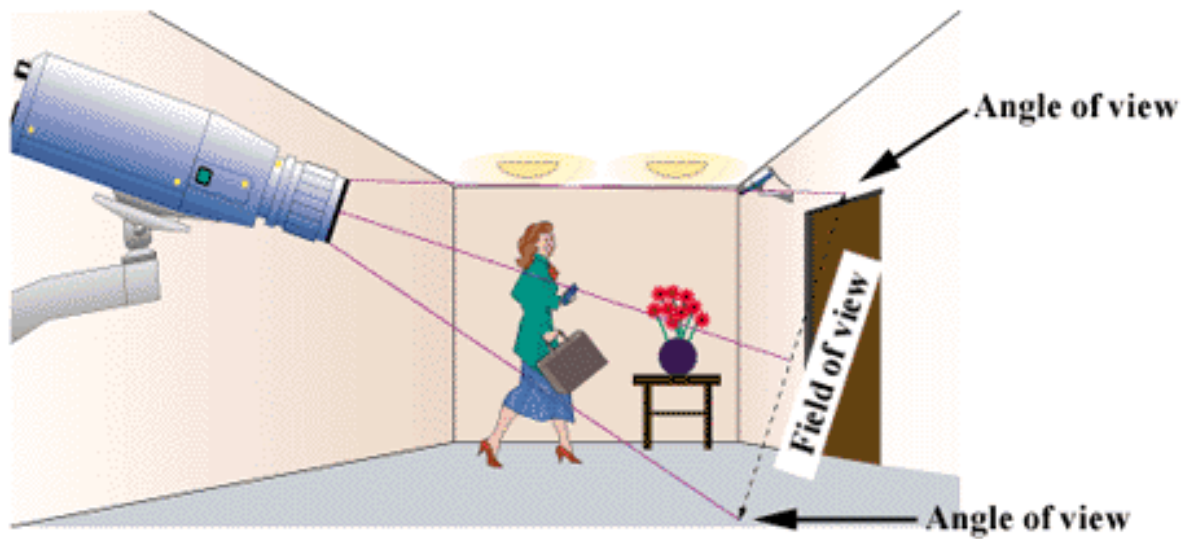
Covering the Scene

A measure used to express what a camera sees if field of view. Field of view is related to the angle of view. Consider the situation presented in the figure: a camera is aimed at a scene. Imagine a line drawn from the center of the lens to the center of the scene. The camera will see not just the point at the end of this imaginary line, but the image will actually extend a number of degrees from the center line to the left of the scene, and the same number of degrees from the center line to the right of the same, and the same number of degrees to the right. This is the "angle of view". The area (width and height) defined by the angle of view is the "field of view." Angle of view and field of view are solely functions of the focal length of the lens. It is for this reason that short focal length lenses are called "wide angle" lenses; simply stated, they "see" a wider angle than longer focal length lenses.

Selecting lenses of different focal lengths (or using zoom lenses with a variable focal length) allow system designers to place a camera at a fixed distance from a scene, yet adjust the field of view and the transmitted. The following three factors determine image size:

- ◆ camera format size (1", 2/3", 1/2", 1/3")
- ◆ lens focal length
- ◆ distance from scene to camera

Lenses

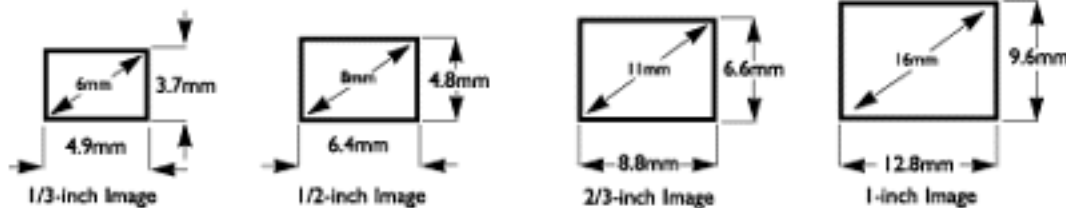


Focal Length and Field of View

Charts, such as the one in the figure, and calculators are available to assist designers in determining an image's size using a particular lens and camera at a given distance. Usually, a designer will start with a known area of interest. For example, a customer might say, "I need a camera to cover this doorway and fifteen feet on either side." The designer will likely also select a position for the camera, perhaps mounted on the wall outside the doorway which, in this example, is some 40 feet away. Assuming the camera selected for use in this applications has a 1" format, the designer can use a chart similar to

the one in the figure to determine the focal length of the appropriate lens — in this case, a 16mm lens. (Actually this lens will capture a little greater field of view — 32.4 feet at 40 feet distance. To cover precisely 30 feet, the designer would have to either move the camera forward somewhat or resort to a zoom lens.)

Focal Length and Field of View



**Viewed Scene at Distance (Horizontal)
Distance = 100 (feet)**

Lens Focal Length (mm)	1/3 Inch Horizontal F-O-V (feet)	1/2 inch Horizontal F-O-V (feet)	2/3 inch Horizontal F-O-V (feet)
2.8	174.6		
3.7	132.2	173.0	
4.0	122.3	160.0	220.0
4.2	116.4	152.4	209.5
6.0	81.5	106.7	146.7
12.0	61.1	80.0	110.0
12	40.8	53.3	73.3
16	30.6	40.0	55.0
25	19.6	25.6	35.2
35	14.0	18.3	25.1
50	9.8	12.8	17.6
75	6.5	8.5	11.7
100	4.9	6.4	8.8
180	2.7	3.6	4.9

Image Size and Focal Length

The width (or height) of the field of view for a particular camera and lens at a particular distance from a scene can also be calculated using a simple formula. Before presenting this, however, it will be helpful to discuss another optical term, aspect ratio. This is a number representing the ratio of the width to the height of the image. In video this is a standard 4 by 3 ratio, that is, the height is 75 percent of the width. In the previous example, where the client wanted to cover an area 30 feet wide, the height can be easily determined by multiplying 30 by .75 — 22.5 feet. Conversely, when the height is known — 12 feet, for example — the width of the area covered can be calculated by dividing by .75 — 16 feet, in this case.

Now, to the formula. Knowing the focal length of the lens, the camera format size and the distance to the scene, it is possible to calculate the image width and height.

The formulas for this are as follows:

$$W = \frac{\text{Horizontal Format (in mm)} \times \text{Distance}}{\text{Focal Length}}$$

$$H = \frac{\text{Vertical Format (in mm)} \times \text{Distance}}{\text{Focal Length}}$$

where:

- ◆ W = Width of the viewed scene in feet
- ◆ H = Height of the viewed scene in feet

- ◆ Focal Length, expressed in mm
- ◆ Distance from the camera to the scene in feet

Horizontal Format:

- ◆ 1/3 inch = 4.8mm
- ◆ 1/2 inch = 6.4mm
- ◆ 2/3 inch = 8.8mm
- ◆ 1 inch = 12.7mm

Distance from the camera to the scene in feet Vertical Format:

- ◆ 1/3 inch = 3.6mm
- ◆ 1/2 inch = 4.8mm
- ◆ 2/3 inch = 6.6mm
- ◆ 1 inch = 9.6mm

Suppose a designer needs to determine the width of the coverage area using a 1/2 inch format camera with a 25mm focal lens which is 35 feet from the area of interest. Placing the values in the formula yields the following:

$$W = \frac{6.4 \times 35}{25} \quad W = \frac{224}{25} \quad W = 8.96$$

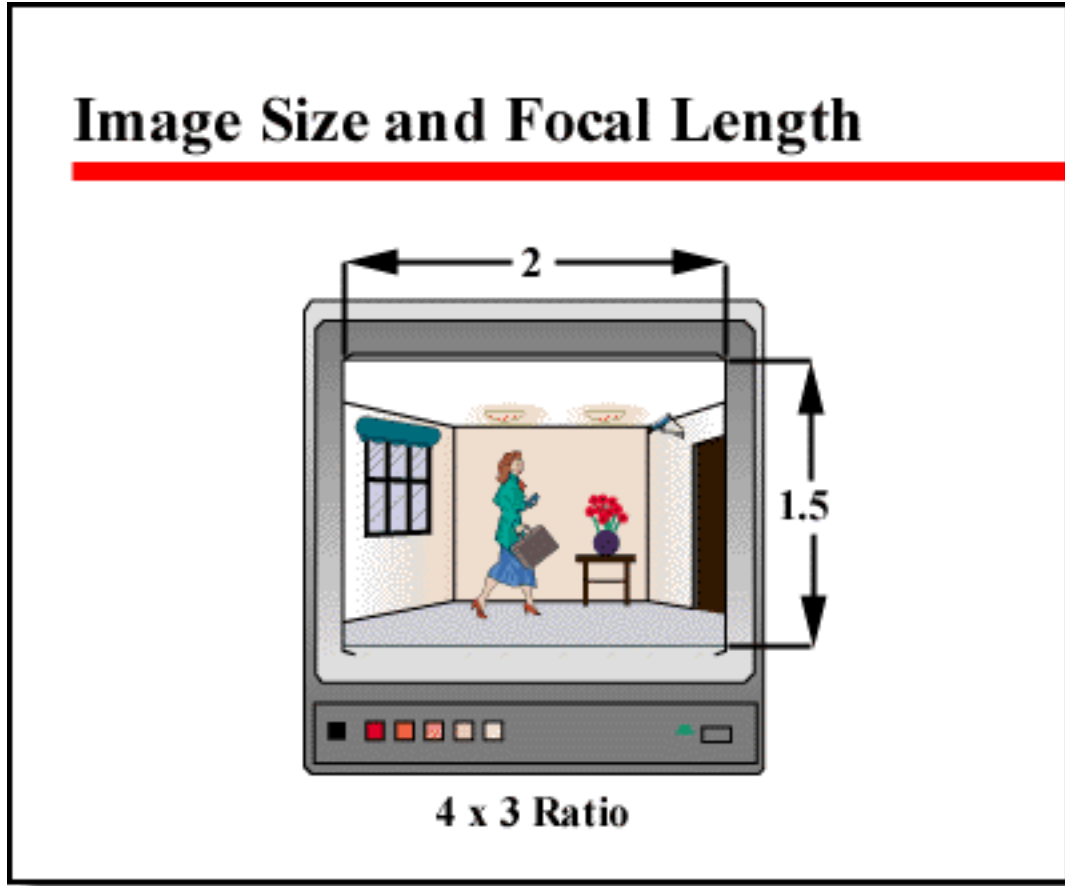
The width of the area of coverage is 8.96 feet.

By changing the formula around, other values can be determined. Consider a situation where the width of the desired coverage is known (along with the camera format size and the distance from the scene to the camera), but the appropriate focal length lens is unknown. The following formula yields the desired information:

$$\text{Focal Length} = \frac{\text{Horizontal Format} \times \text{Distance}}$$

W

Focal Length = 6.4×35 Focal Length = 224 Focal Length
= 25mm
8.96 8.96



CCTV Monitors

A number of criteria exists for monitors which fall into two major categories:

- ◆ electronic factors
- ◆ human interface factors

As with other components of a CCTV system, the exact monitor selected will vary from application to application, depending on the specific requirements, e.g., the purpose of the monitor and its placement in the operations center.

Select the first topic below to begin this lesson:

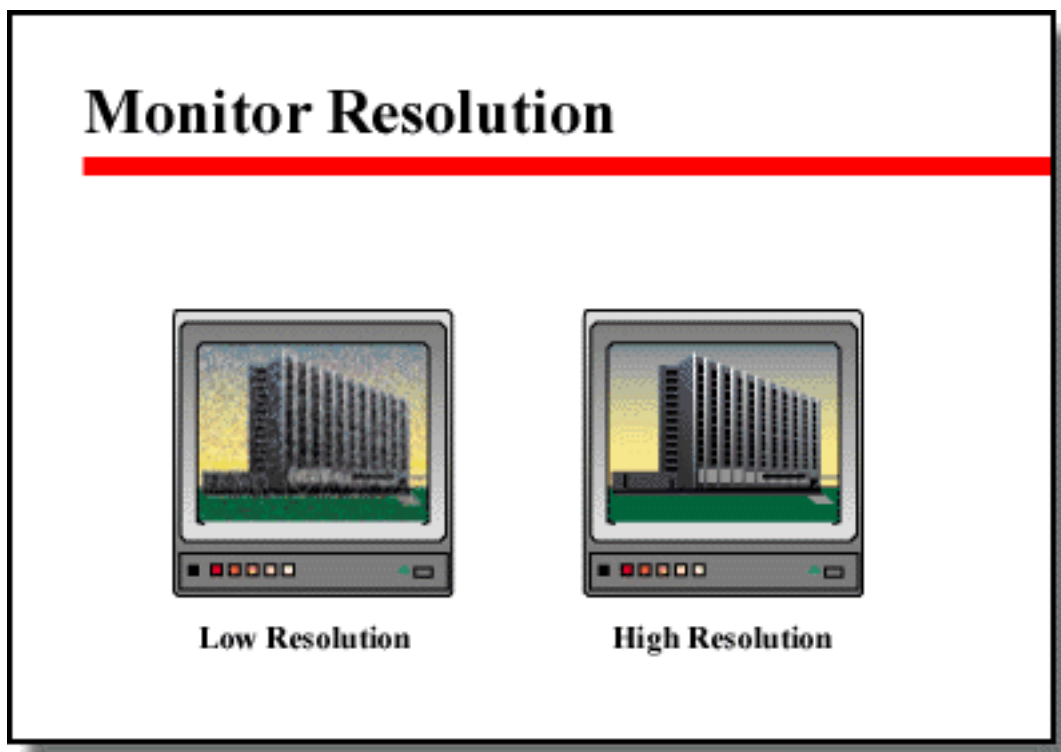
- [Monitors - Electronic Factors](#)
- [Monitors - Human Interface Factors](#)

Monitors - Electronic Factors

Monitors in a CCTV application are not like home TV receivers. CCTV monitors typically run 24 hours a day, seven days a week, 52 weeks a year. Given this heavy duty usage, reliability and durability are primary considerations. Monitor specifications include indications of life cycle and often mean time between failures (MTBF). A minimum life cycle for a CCTV monitor is 43,000 hours.

Monitor resolution ranges from 300 to 1200 lines. This is similar to camera resolution in that the more lines, the better the resolution and detail.

A final electronic "characteristic:" CCTV monitors utilize a composite video signal over a "balanced" (75 ohm) cable. Composite video means all elements of the video (image, color, brightness, etc.) are delivered in one continuous "stream," unlike component video which sends each element separately.



Monitors - Human Interface Factors

Physical Factors relate to ergonomics, the science which, simply stated, measures and optimizes human interactions with machinery and equipment. As shown in the figure, three parameters impact on the ability of an operator to interface efficiently with a monitor:

- ◆ screen size
- ◆ distance of operator to monitor
- ◆ angle of view.

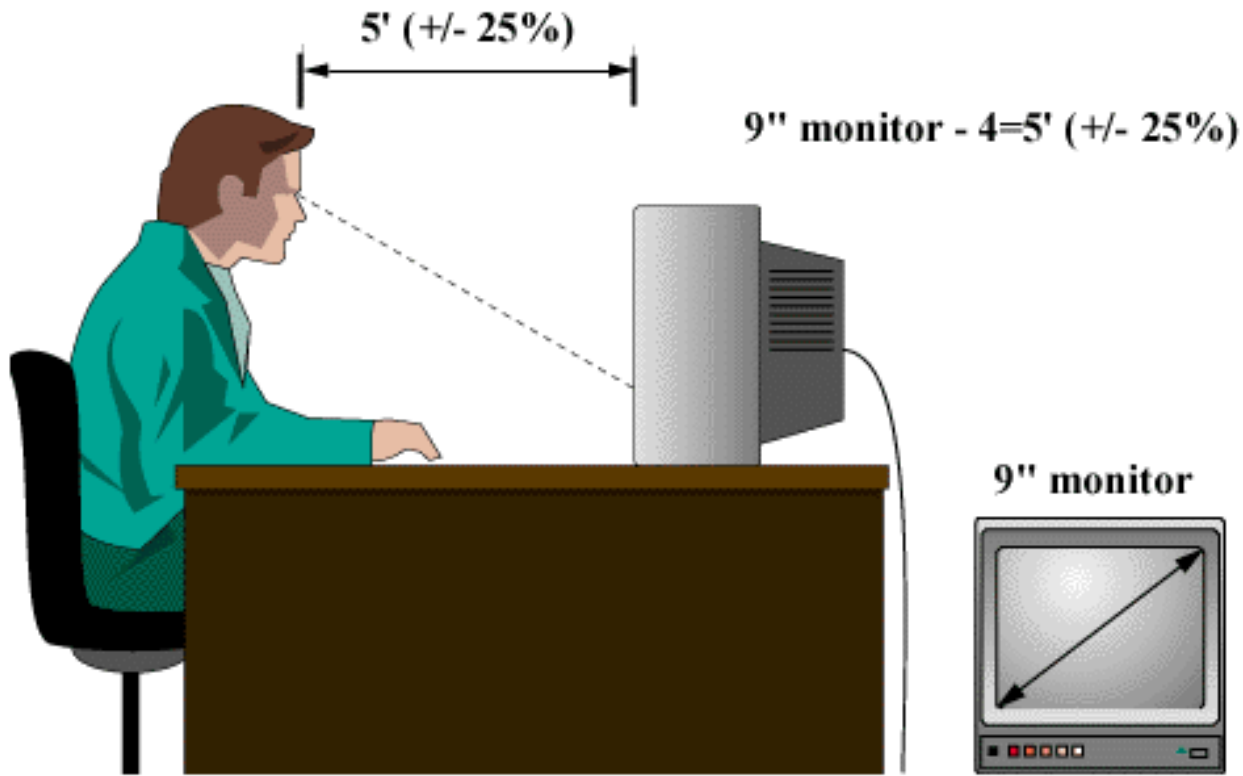
The key variables to consider in monitor size is what images and screen formats the monitor will display, and how far it will be from the operator. For example, if the monitor will be used in quad compression or other split screen configurations, then a larger monitor is essential. Distance from the operator also effects size. A simple formula aids in determining distance and size. (Remember, monitor size is expressed as diagonal measure — from lower corner to opposite upper corner.)

Monitor size (in inches) - 4 = Optimum viewing distance +/- 25% (in feet). For example, with a 9 inch monitor, the suggested viewing distance is 5 feet (9-4=5). Factoring in the 25% visibility, the viewing distance could range from 3.75 ft to 6.35 ft.

A final consideration for monitor placement is the optimum viewing angle. The monitor should be placed so that it is within 30 degrees (left or right, up or down) of the operator's line of

sight (determined when the operator is sitting comfortably and looking straight ahead.). Operators can perceive movement on monitors for a maximum of 40 minutes continuously, after that it diminishes significantly, so proper design is critical.

Image Size and Focal Length



Design Requirements

Before any camera, lens, cable or monitor is selected for a CCTV application, a designer must ask three basic questions:

- ◆ What is the system's function — what is it being designed to accomplish, and will the system be integrated into other systems, i.e., access control system?
- ◆ Who will manage the system and how?
- ◆ Is the system new, or is it an upgrade (retrofit) of an existing system?

We will address each of these below.

Select the first topic below to begin this lesson:

- [System Function](#)
- [System Management](#)
- [Designing a CCTV System](#)

[TOP](#)

System Function

Throughout this discussion, we have repeatedly said things like, "depending on the specific purpose of the CCTV system." Determining that purpose is a crucial component of the initial phase of designing any CCTV system. There's a familiar saying among designers: Form follows function — that is, the form something takes is shaped by its purpose and usage. This form of a CCTV system — the specific camera and lenses selected, the mounts and enclosures, the transmission mediums used, the monitors, switching devices and recorders — all depends on the system's function. In the world of CCTV security systems, there are three (3) basic functions, based upon what the customer wants to see:

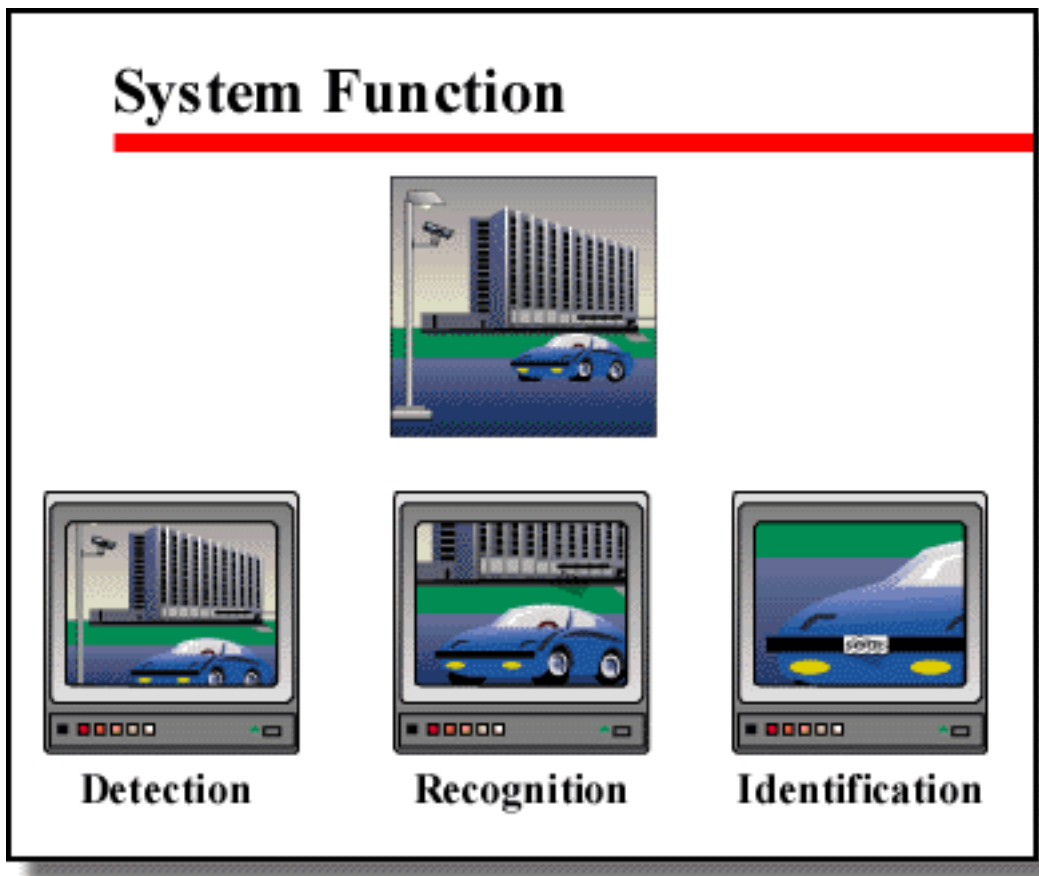
- ◆ detection (alert operator that something is happening)
- ◆ recognition (allow operator to determine what is happening)
- ◆ identification (show operator who is involved)

As you can see, there is a priority to these three functions. Detection is the least demanding, recognition is more demanding, and identification places the most demands on the system and the operators. It is not surprising, then, that the design criteria are similarly prioritized. In systems (or subsystems) with detection as the primary focus, there are low design criteria, that is, the demands on the equipment are not as great. Recognition is said to have medium design criteria. Identification — seeing someone "up close and personal" — requires high design criteria.

Suppose a designer is planning a CCTV installation at a bank. Security personnel must be able to observe several

areas, among them: the entrance, the lobby area, and the teller windows. At the entrance, operators simply want to know that someone is coming into the building (detection). For the purposes of this example, a camera with a fixed focal length lens viewable on a monitor is all that is needed (low design criteria). Once in the lobby area, the operators will want to determine where the subjects are, and what they are doing (recognition). A camera equipped with a remote positioning device and medium range zoom lens is required (medium designer criteria). Finally, at the teller's windows, it is essential for security personnel to positively identify the subjects (identification). Here the requirement is for an overt, in plain view subsystem which includes a lens with high magnification, attached to a camera with remote control, carefully positioned to afford a uninterrupted view of the subject in even, adequate lighting (high design criteria). (Note: the Federal Bank Security Act requires teller windows to have a fixed camera, in plain view, that captures the teller and person at the teller window.)

In addition to the items presented in the example, the design criteria will evolve to include specifications for monitors. A small monochrome monitor may be sufficient for detection, but a large color monitor with good resolution may be the ideal for identification



System Management

As a designer begins the task of planning a CCTV system, several policy and personnel issues come into play. Asking the right questions (and getting the right answers) as well as guiding the customer, will help identify the policies and personnel requirements for the system which, in turn, helps define system parameters. These questions include:

- ◆ Who will operate the system?
- ◆ What are the criteria for controlling the system?
- ◆ What are the recording criteria?
- ◆ Why are they recordings being made?
- ◆ How long will the recordings be archived?

- ◆ What do you want to see and for what purpose?
- ◆ What limitations do you have, legal and financial?

The answers to the above questions can ensure the recommended CCTV system meets important operating criteria for the customer.

Who will operate the system: Will the operators be direct company-hired personnel or contractor-supplied?

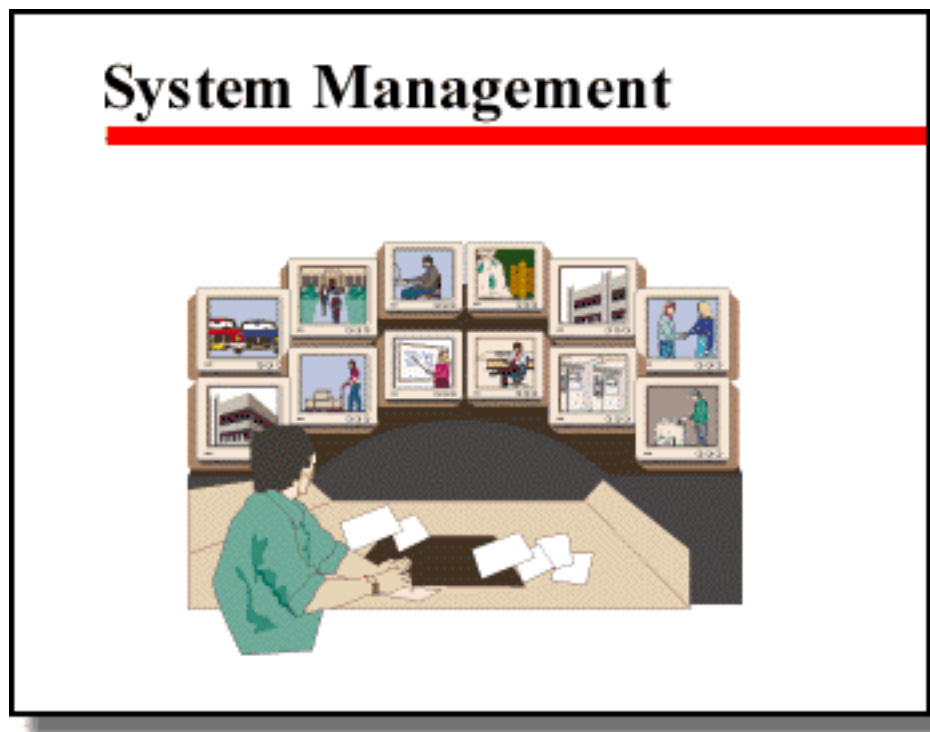
Historically, contractor personnel tend to change more often than company staff members. Experience suggests that company personnel — with greater longevity on the job — can generally handle more complexity in a system than contract workers.

The response to the first questions impacts on the answer to the second question: what are the criteria for controlling the system? CCTV system controls can be fully automatic (computer based operation with programmed sequencing of camera activity, etc.); completely operator-controlled (manual switching, directing outputs, etc.); or a combination of the two. The skill levels of operators may suggest the optimum level of automation for the system.

Now we shift to policy issues. What are the recording criteria? For example, is real time recording of event critical? How about time-lapse recording? Will video be multiplexed? Do you need a demultiplexer for individual camera viewing? If your signal is exposed to potential outside interception, do you want the signal to be recorded to be encoded and then decoded for playback control? Is there a requirement to store images on

computer disk as well as video tape?

Why are the recordings being made? Are images being stored simply for administrative purposes — for use by company personnel only? Or will the stored images possibly be used as evidence in possibly litigation? Finally, how long will the recordings be archived? Long-term archiving suggests the need for a storage area which has environmental controls to preserve the tape (as well as space enough to contain the volume of tapes accumulated over the years). Answers to these questions will impact on the type of equipment selected and even the basic design of the system infrastructure.



Designing a CCTV System

Designing a CCTV System



New Construction or Retrofit Designing a CCTV system can be a lot like house construction. It is often easier to design and proceed with all new construction instead of integrating new components into existing systems. Whether the project is new construction or upgrading (retrofitting) an existing system, several fundamental issues must be addressed prior to the installation process. Answers to the following questions will provide valuable information:

- ◆ Will other systems (e.g., access control) be integrated with the CCTV system?

- ◆ What transmission mediums will be used?
- ◆ What is the project budget? Has it been planned, committed and approved?
- ◆ What are future system requirements regarding upgrades?
- ◆ Will application requirements change in the future?

Each of these questions help the designer to define a system that meets the customers needs for the present and the future.

Will the CCTV system be integrated with other systems? Will the CCTV system need to supply information regarding access control or other systems? What level of integration is required? If there is an existing CCTV system, are there component compatibility issues that must be addressed? What is the most efficient and cost-effective transmission medium for the system? If an existing CCTV system is being upgraded or supplemented, what is the existing transmission medium, and should the upgrade include changes to the existing transmission medium?

What is the project budget? In a

sense, the answer to this question can define many of the design elements for a CCTV project. There are obviously many ways to proceed while satisfying any budgetary restrictions. The basic options are to reduce the number of components (and therefore coverage) or use components with fewer capabilities or lower quality, e.g., monochrome cameras instead of color, or a camera with generally lower specs (resolution, sensitivity, S/N) as long as the component will still provide the performance required for the application. Also, how was the budget determined? Is it based on sound preliminary research or a "guesstimate?" Have the decision makers committed to it and has it been approved? Does the option exist to review the budget or is the designer locked into the approved amount?

Designing a New System

What are the requirements for future upgrades? As newer technologies become available, is the customer's expectation that these will be incorporated into the system design. Is there a planned migration path to accomplish this?

Related to this last question is

another: will application requirements be changed in the future? Will enhanced functionality be required at a later date? That is, will the function of the CCTV system or the overall security system change in the future?

For example, is the company planning to expand its facilities locally or even remotely? Consider a commercial laboratory that is planning to move into new markets within the next five years. The new business will demand new levels of access control and CCTV coverage. Being aware of that future requirement can impact decisions regarding the current decision.

Answers to all of the above questions sets a baseline for CCTV system design. These are primary issues. Secondary issues are the "nuts and bolts" aspects of system design, and careful attention to these primary questions will automatically define many of the hardware issues.

A carefully designed CCTV system will ensure:

- ◆ adequate coverage

- ◆ extendibility for future additions and enhancements
- ◆ satisfied customers.