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White Paper

Shining a Light on Security Lighting for Safety and Video Surveillance

It's time to think about lighting. From inside to outdoors, lighting can impact the perception employees and visitors have of their safety but it also can improve the effectiveness of security video.

Lighting is an essential element of a security program. To light the way through a parking garage, to illuminate doorways or a dock, to make hallway or stairway corners more visible, lighting plays a key role. With any type of solution, details make a difference. There are different types of lights. Their positioning can make a difference. And, when it comes to lighting to augment security video, lighting is part of the decision making process along with camera technical specifications.

To better understand security lighting applications, it is useful to first look at basic lighting terminology and technology. That's the job of Terry Jones, chief security officer (CSO), and Helena Smith, his second-in-command, who work for a mid-sized enterprise. Jones and Smith, part of this series of white papers, have faced diverse technologies and risk management issues.

Related White Papers from Infinova

Infinova has a series of white papers aimed at helping CSOs and senior security management to make the technical and business decisions needed to manage security and surveillance installations. The previous five cover:

- Coexistence strategy at the heart of a cost-effective move from analog to digital security video.
- Selecting cameras – analog to IP-based as well as megapixel and high definition.
- Fiber optics enhances the operation and business bottom line of surveillance solutions.
- Storage options and ways to determine which are the best for the needs of the enterprise.
- How to conduct a security site survey leading to a risk and vulnerability matrix.

These previous white papers are available for download at www.infinova.com

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Terry and Helena both agreed that lighting is a feature not as easy for them to understand as some of the other security technologies related to cameras, storage and compression. So they both took some time to research the topic and become acquainted with issues and terminology.

On the meeting room board, Terry wrote down six objectives of security lighting as part of a well-balanced security plan.

1. Provide a clear view of an area from a distance and enable anyone moving in or immediately around it to be easily seen.
2. Deny potential hiding spaces adjacent to frequently traveled foot and vehicle routes.
3. Permit facial identification and create the perception of being identifiable.
4. Facilitate the proper use of other security devices available on the property.
5. Deter crime against persons or property.
6. Enhance employees' and the public's feeling of comfort and safety when accessing spaces.

Of course, there is natural light which works with patrolling security officers and viewing cameras and, at times, can cause challenges to both.

Natural and Visual Light Levels

Light Level (footcandles)	Natural Light Source	Visual Experience
50,000		Upper Limit of Visual Tolerance
10,000	Direct Sunlight	Fresh Snow on a Clear Day
1,000	Full Daylight	Average Earth on a Clear Day
100	Overcast Day	Average Earth on a Cloudy Day
1	Twilight	1 foot from Standard Candle
0.1	Deep Twilight	
0.05		Snow in Full Moon
0.01	Full Moon	
0.005		Average Earth in Full Moon
0.001	Quarter Moon	
0.0001	Starlight	Snow in Starlight
0.00005		Grass in Starlight
0.00001	Overcast Night	
0.000001		Absolute Limit of Seeing

Beyond sun and moon light, to get an appreciation of lighting levels in different circumstances the Security Lighting Committee, previously known as The Protective Lighting Committee of the Illuminating Engineering Society of North America (IESNA), generates and develops criteria for lighting to enhance the security of people and property as well as integration and interaction of lighting as part of a total security system.

Centering on deterrence and the perception of safety through use of lighting, in an IESNA report Helena has in hand, she discovered that, way back in 1988, a before and after relighting study of a street in the outer city area of London, England, by K. Painter demonstrated a marked reduction in the incidence of crime and the fear of crime on the re-lighted street. While there are no guarantees that improved lighting will cause a decrease in crime, there are circumstances in which lighting can be an effective crime countermeasure, either alone or in combination with other measures.

Lighting Can Make it Harder for Crime to Occur

Lighting can also affect crime by two indirect mechanisms. The first is the obvious one of facilitating surveillance by people and security video systems. If such increased surveillance is perceived by criminals as increasing their own effort and risk and decreasing the reward for a criminal activity, then the level of crime is likely to be reduced. Where increased surveillance is perceived by the criminally-inclined not to matter, then better lighting will not be effective. The second mechanism by which an investment in better lighting might affect the level of crime is by enhancing community or employee confidence and hence increasing the degree of informal social control. This mechanism can be effective both day and night but is subject to many influences other than lighting. So it is obvious that security practitioners can gain from an understanding of the properties of lighting and the components of a lighting system. There are different types of man-made light.

White Light — a mixture of light from 400-700 nanometer (nm) wavelength.

Practical Uses:

- Illuminate an area for the security video system
- Improve the overall level of illumination for key personnel
- Provide a welcoming environment for authorized personnel or visitors
- Deter crime by illuminating a secure area on intrusion
- Can be used with monochrome, color and day/night cameras

Infrared — 715-730nm wavelength overt IR, produces a red glow like a red traffic light.

815-850nm semi-covert IR with a faintly red glow is only just visible.

940-950nm covert IR is invisible to the human eye

Practical Uses:

- Provide discrete or covert illumination for security video
- Minimize light pollution
- Provide very long distance illumination when the output is focused
- Can be used with monochrome and day/night cameras

Making Sense of Lumens

In her research, Helena found that the quantity of light emitted by a light source is measured in lumens. For example, a typical 100 watt household bulb may output about 1,700 lumens. And illuminance, measured in lux (lumens per square meter) or footcandles (lumens per square foot), is the concentration of light over a particular area. For example, a spotlight and a floodlight may output the same quantity of light, but the spot concentrates its output in a small area. And the floodlight disperses the light over a larger area.

Light spreads from its source, so the farther away an object is, the less the illuminance. The bottom line: When evaluating the amount of light necessary to perceive a scene, it is the amount of light shining over the area of the eye or the camera lens – that illuminance – which is critical.

Outside, things reflect light, too. On average, the reflectance of most objects is approximately 50 percent. Helena tells Terry that, when a person or camera sees an object, eyes or lenses are sensing the light reflected from that object. The color of the surface also has an impact. A concrete parking lot, for example, has a higher reflectance than a dark surface such as an asphalt or blacktop lot. There are also man-made objects that reflect at different percentages.

In a back issue of Security Management Magazine (ASIS International, 1990), there was a handy reflectance chart that showed:

Asphalt	5 percent
New Concrete	40 percent
Old Concrete	25 percent
Red Brick	25 percent
Grass	40 percent
Snow	95 percent

Concerning security video, various camera makers assume reflectance of 75 percent or even 90 percent in their technical specifications so adjustments need to be made when figuring camera performance.

Types of Light Source Differ

At this point, Terry and Helena decide to evaluate the lighting systems they have or should have. A lighting system consists of a number of components, all important to the effectiveness of each lighting application.

A lamp (also known as a light bulb) is the manufactured light source that includes the filament or an arc tube, its glass casing, and its electrical connectors. Lamp names (incandescent, halogen, fluorescent, metal halide, mercury vapor, and sodium) describe the technologies used to create the light.

Light Emitting Diodes (LEDs) are one of the newest lighting technologies for security video applications. LEDs offer the lowest possible running costs (less than 100 watts for highest power units) with the longest operating life (up to 10 years). LEDs are semiconductors that naturally emit a narrow band of light. They are a relatively new development in lighting but their use is expanding rapidly on the back of clear technical advantages.

Lighting is a System

The luminaire (also known as fixture) is the complete lighting unit consisting of the lamp, its holder, and the reflectors and diffusers used to distribute and focus the light. Some lamps, like spots and floods, are designed with integral, shaped reflectors for the focus and distribution of the light. The luminaire will also contain the way to connect to the power source and, depending on the lamp technology, will include ballasts (to generate the correct starting and operating voltage, current and waveform) and photo sensors to control switching of lights based on ambient lighting conditions. The design of luminaires depends on aesthetics as well as performance characteristics. Various organizations have a culture or building look and lighting as well as the type of camera housing must match. Mounting hardware such as a wall bracket or a light pole fixes the luminaire at the correct height and location.

Electrical power operates the lamp, ballasts and photocells. Some lamp technologies are sensitive to reduced voltages, in particular the high-intensity discharge family of lamps (metal halide, mercury vapor and high-pressure sodium). These lamps require relatively stable voltage levels since they produce light from an arc discharge under high pressure. If the supplied voltage is sufficiently reduced, the arc will be extinguished. Back-up batteries, generators, solar panels and uninterruptable power supply systems need to be considered for the lighting of areas such as vaults, cash registers and paths of emergency exit and assembly.

There is another consideration when picking or adjusting lighting, in which the decision can impact safety and use with video cameras.

Some lamps require time to re-light (Strike Time) if they are switched off, or lose power in the event of a black-out or brown-out. Extended re-lighting time is typical of high-intensity discharge (HID) lamps, since they rely on an arc

to produce light. The lamp tube must cool sufficiently before the arc can re-strike. Also, when starting from cold, HID lamps and, to lesser extent fluorescent lamps, take time to reach their designed light output levels.

Lamp Starting and Re-strike Times

	Incandescent	Halogen	Fluorescent	Metal Halide	Mercury Vapor	High Pressure Sodium	Low Pressure Sodium
Cold Start Time Min.	Instant	Instant	Instant*	5–8	5–8	2–5	5–8
Re-strike Min.	Instant	Instant	Instant	10–20	10–20	1–20	0–8

* Fluorescent lamps require time (especially in cold weather) to reach full output.

Terry thinks that such functional limitations are a concern. Lamp strike times can be scheduled to allow for their start-up time; however, a full or partial power failure, however brief, can mean a loss of lighting for a considerable period. New technology and manufacturing methods are making positive impact. For example, some HID lamps are available with two tubes, one tube is powered-on while the other remains cool for a quick re-strike.

When considering lighting for safety as well as security video, other factors include color temperature and color rendition.

Color Temperature (Adapted from Philips Lighting)

Color Temp.	Warm 3000°K	Neutral 3500°K	Cool 4100°K	Daylight 5000°K
Associated effects and moods	Friendly, Intimate, Inviting, Personal, Exclusive	Friendly, Inviting, Non-threatening	Neat, Clean, Efficient	Bright, Alert, Exacting coloration
Applications	Restaurants Hotel lobbies Boutiques Libraries Office areas Retail stores	Public reception Showrooms Bookstores Office areas	Conf rooms Classrooms Hospitals Office areas Mass retail	Galleries Museums Jewelry stores Medical Printing companies
Lamp Types	Fluorescent Incandescent Halogen	Fluorescent Mercury vapor	Fluorescent Mercury vapor Metal halide	Fluorescent Mercury vapor Metal halide

Note: Color Temperature for low- & high-pressure sodium: 1750°K & 2000°K

During a planning meeting, Terry brings up color image concerns since his security cameras – except for day/night gear at night – capture color images with the end game of identification such as a red car or a green jacket. Overall, color temperature is a measure of the warmth or coolness of a light. Security monitoring staff members need to accurately identify and describe color. The ability of a light source to help accurately reproduce the colors seen in an object is known as color rendition and is measured as a color rendition index or CRI on a scale of 0 to 100. A CRI of 70 to 80 is considered good, above 80 is considered excellent, and 100 is considered daylight.

High- and low-pressure sodium and mercury vapor light sources have very low CRI values and are not usually used in conjunction with color camera applications or where color identification is critical. Helena tells Terry that, under low-pressure sodium light, a green shirt will have a blue hue. Concerning the ability of lighting to provide the perception of security, which is as important as the reality of deterrence, a high CRI value in outdoor locations at night make employees and visitors feel safer -- they can recognize and evaluate others at a greater distance and have better depth perception.

Color Rendition Index

Incandescent	Halogen	Fluorescent	Metal Halide	Mercury Vapor	High Pressure Sodium	Low Pressure Sodium
100	100	75-100	70	50	20	5

Among other subjective elements are brightness and glare. Brightness is an individual's perception of the amount of light that reaches lenses or eyes. Glare is a term used to describe excessive brightness, and it must be considered in security applications. Both brightness and glare have implications beyond security video. Some situations may cause light trespass onto adjoining properties including sidewalks and roadways.

Helena mentions to Terry that there always is a cost involved.

The cost of lighting is a major factor in the decision about the level of lighting and to support security video. Some lighting is mandated by code. Sometimes security lighting is cost based on identifiable savings or quantifiable reduction in risk such as insurance premium savings.

For a typical lighting situation, operating cost consists of the initial cost of the hardware **and** the cost of the energy and maintenance. Since the proportion of these costs is approximately eight percent capital items, four percent maintenance and 88 percent energy, the energy efficiency, or efficacy, measured by the lamp's output in lumens divided by the lamp's power draw in watts, is very important.

$$\text{Energy Efficiency} = \frac{\text{Output (Lumens)}}{\text{Power (Watts)}}$$

The next highest cost is that of replacement lamps. This is a function of the lamp technology and the quality of the lamp.

Maintenance costs include the labor to replace lamps and to clean them. Helena was told by the facilities manager that cleaning is important, since lumen output will degrade if dirt accumulates on the fixture. In cleaner environments, such as a command and control center, computer room or office areas, the percentage output will reduce by approximately three to four percent per year and a cleaning routine over several years is recommended. In very dirty environments, a luminaire could be emitting only 80 percent of its design output after only one year. Since the power consumption remains the same regardless of the amount of dirt accumulated on the luminaire, it makes sense to implement regular cleaning to maintain the designed light output, both security executives concluded.

Performance of most lamps also reduces with age. By the end of a lamp's rated life it may produce only 80 percent of its designed output even when clean.

Lamp Efficacy and Life

	Incandescent	Halogen	Fluorescent	Metal Halide	Mercury Vapor	High Pressure Sodium	Low Pressure Sodium
Efficacy – Lumens Per Watt	20	25	60-80	125	65	125	200
Life – In Thousands of Hours	1-4	10-20	10-20	10-25	16-24	16-24	15-25

As a ready guide for white paper readers, it is good to realize that there are 8,760 hours in a year. A lamp that is on for eight hours per day will burn for 2,920 hours per year.

When complementing the kind, coverage and placement of security video cameras, the number of luminaires required is a function of the area to be covered, the light levels required, the height of the luminaires and their design, and the type of lighting technology used. It is expensive to achieve a uniform distribution of light, particularly outdoors. Some variation in light levels is considered acceptable and is measured as uniformity, the ratio between the average light level and the minimum light level.

$$\text{Uniformity} = \frac{\text{Average Light Level}}{\text{Minimum Light Level}}$$

Typical uniformity ratios would be 1:0.7 for working environments, 4:1 on a pedestrian walkway and 10:1 on a roadway. Higher uniformity gives better depth perception and a greater perception of security to individuals in the area.

When providing security video illumination, also think of the beam. The beam angle should always cover the full field of view of a surveillance camera. The correct angle of illumination must be used to light the full scene. Modern adaptive illumination units allow the angle of illumination to be adjusted on site to suit the specific scene requirements.

Check on the Beam

As standard, beam patterns from an illuminator are provided at a fixed angle, either narrow or wide. Historically spot and flood lenses have dominated but more recently there are more precise angles such as 10, 30 or 60 degrees. However, these are still fixed angle output, meaning they are inflexible on site. If the lighting requirements change, or if the camera's field of view is changed, the lighting may become less acceptable. Also, it means that all lighting decisions must be made prior to installation, which is difficult. Often final lens decisions and viewing areas are made during the installation process. Match the angle of illumination to the camera's field of view, suggests Helena, as a rule of thumb.

Lighting which is too wide means wasted light and reduced viewing distance. Many installations use camera vari-focal lenses and ideally require the same level of flexibility with lighting to maximize system performance. With adaptive illumination, which does not provide light at a fixed output angle, it provides a range of output angles allowing the end user to select the angle that covers the exact field of view and gives the highest quality images.

Helena adds that bright spotlights create dark areas on the fringe of their beams. Areas just outside the spot will create difficulty for security cameras and give an intruder a chance to literally "hide in the shadows" in an area that would otherwise have them in clear sight. In some locations, lower wattage outdoor security lighting, often used in landscaping, can be a good alternative to overly bright and costly spotlighting. Not only will lighting of this type cut energy costs, it will also cut out the video "blind spots." Another strategy is to light building walls so that unlit moving persons and quickly seen against the light background.

Lighting and Security's Mission by Footcandles

When it comes to the three goals of the combination of lighting and officers or security video, there is a base as measured by footcandles.

Detection	0.5 fc
Recognition	1.0 fc
Identification	2.0 fc

With both security executives better educated to lighting for deterrence and identification, it was time to move to a more specifics.

Camera placement depends on the application, availability of ambient light, proximity to infrared illuminators and practical installation limitations because of structural design. One example: cameras monitoring parking lot entrances and exits must not only perform well in low light but also effectively compensate for severe highlight and backlight conditions. Camera position – mounted higher and facing down – would be out of the direct headlight beams of oncoming vehicles.

Advancements in camera backlight compensation now permit indoor cameras looking at objects or people against a window to be more clearly identified by eliminating much of the excess light from the image.

If an indoor security camera is pointed towards a window or an entrance area, you will see the background washed out during daytime. This is a very common situation in office building lobbies, restaurants and stores which have large glass windows.

Cameras will always produce a better image when the majority of the lighting is from behind the camera or directed in the same direction as the camera. The best place for an indoor camera with relation to light, though rarely achievable, is a position where the light source will not hit the camera lens directly.

Lighting for Video Cameras

Color Rendition – Accurate Reproduction

Reflectance – Camera Specs use ~75%

Min. Light Levels – Faceplate Illumination/Lens

Vertical v. Horizontal – Coverage of the Scene

Color Temp. – Auto Adjusted by White Balance

Glare – Wide Dynamic Range

Wavelength of Light – Spectral Sensitivity

The same principles hold true for outdoor cameras, although this can be even more difficult because the light source during the day – the sun – is always changing. Although natural light is well diffused, care needs to be taken to point the camera so that it does not look straight at the sun at sunrise or sunset during any season of the year. One challenging example is security in parking lots and garages. The combination of lighting and security video in these areas needs careful planning in advance. Terry pointed out that about 80 percent of incidents occur in a parking lot or garage. Most open parking lot lighting points down vertically onto the horizontal ground so that tripping hazards are easily seen; this is the opposite of what would be preferred for people or cameras being able to identify faces.

Security lighting can increase effectiveness of security officers and video by increasing the visual range during periods of darkness or by increased illumination of an area where natural light does not reach or is insufficient. Each parking lot presents its own particular problems based on physical layout, terrain, atmospheric conditions, and security requirements. The most challenging is illuminating the small narrow "corridors" formed by adjacent parked vehicles. Some communities, e.g., Minneapolis and St. Paul, Minnesota, have developed their own security

ordinances for parking structures. Special requirements may include painting a white band on vertical surfaces (to permit people to be more easily seen) and regular patrols.

Parking Facilities Deserve Carefully Thought-out Lighting

To get some light into these areas, it is recommended that any point in the entire parking lot be provided with illumination from at least two and preferably four lighting (pole) locations and with the lights mounted at a minimum height of 20 foot. The lowest value on the pavement should not be less than 25 percent of the recommended average. The minimum recommended illumination level for the barest sight essentials on the parking lot proper is:

- One footcandle (average maintained horizontal to the surface) for self-parking areas.
- Two footcandles for attendant parking areas because of liability and potential damage to vehicles.
- Five footcandles or higher is often used where additional lighting for business or employee and visitor convenience is a consideration.

Technology advances inside cameras have helped aid lighting needs. In day/night cameras, for example, there is a mechanism built into the camera module that will remove the IR-cut filter from in front of the image sensor allowing an increased spectrum of light to be received. At the same time, the camera will remove the color information from the image creating a monochrome picture. This can make a camera 15 to 20 times more sensitive in low light conditions while allowing increased picture information – color image – during periods of good light availability. So day/night operation is one approach that has helped resolve the imaging problem caused by changing lighting conditions.

Infrared illuminators are used in areas where light is not sufficient for surveillance. They are generally used with black and white cameras since these cameras have greater sensitivity to infrared light. Color cameras that switch to black and white at night can couple with IR illuminators for night time surveillance, making them suitable for both day and night viewing.

For certain applications, thermal imaging cameras eliminate most of the need for any lighting. Objects that emit heat are emitting energy. This energy can be classified as infrared energy. With thermal imaging technology, cameras can be used to capture this energy. Once captured, the computer and software parts of the cameras read the infrared signals coming in and translate them into an image.

Content for this white paper includes input from writings and presentations by David G. Aggleton, CPP, CSC, president and principal consultant of Aggleton & Associates Inc., a security consulting firm based in New York State. Dave is also a past president of the International Association of Professional Security Consultants and has served as chair and member of the ASIS Standing Council on Security Architecture & Engineering. He has been specifying security systems and coordinating applications with architects for more than 30 years. Email him at dave.aggleton@aggleton.com

More resources:

- National Lighting Bureau – www.nlb.org
- Protection of Assets Manual, ASIS International — <http://www.protectionofassets.com>
- Illuminating Engineers Society of North America – www.iesna.org
- National Council on Qualifications for the Lighting Professional – www.ncqlp.org
- National Association of Lighting Designers – www.iald.org
- Philips Lighting Company – www.lighting.philips.com

- GE Lighting – www.gestpectrum.com
- Sylvania Lighting – www.sylvania.com



By helping channel partners provide their customers with complete, affordable, best-in-class, large and small video surveillance solutions, Infinova helps integrators generate more business more profitably. Leveraging a manufacturing process certified to ISO 9001:2000 standards and over 250 engineers with a list of video industry firsts, Infinova channel partners provide their end-users with industry-acknowledged product reliability and technical leadership.

So that Infinova channel partners can create complete solutions, Infinova provides IP surveillance cameras and components, CCTV analog cameras, DVRs and components, camera accessories, monitors, power supplies and fiber optics communications devices. Infinova also has the technical ability and manufacturing flexibility to let integrators propose customized solutions. In addition, Infinova will partner with other manufacturers making other surveillance equipment and software to help its channel partners create turnkey solutions. Contrary to most other companies, Infinova will back-up their partners' products as well as its own to assure both the integrator and its customers that one call – to Infinova only – takes care of everything.

Infinova works diligently to assure its channel partners can provide cost-conscious solutions. With Infinova's hybrid systems, channel partners can propose systems that protect a customer's investment in its already-installed analog surveillance system but that also put them on a dynamic migration pathway to IP systems.

Infinova is lauded for its exceptional maintenance programs. A major highlight is the company's 24-hour advanced replacement policy in which a substitute product is shipped immediately upon notice of a problem.

With such customer focus, Infinova is often referred to as "the integrators' manufacturer."

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