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RECOMMENDED PRACTICE
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Transit Infrastructure Security Working Group

Security Lighting for Transit Passenger Facilities

Abstract: This document establishes recommended practices for security lighting systems for transit passenger facilities to enhance the security of people, operations, assets and infrastructure.

Keywords: security lighting, design

Summary: Security lighting may be one of the most cost-effective and universally accepted security measures any organization can use to improve its security posture. Effective security lighting both deters criminal behavior and enhance safety, thereby reducing overall risk. Properly designed and planned security lighting can create a sense of openness and security for passengers. Security lighting aids the ability to observe and monitor movements through the facilities and supports the fundamental principles of Crime Prevention through Environmental Design (CPTED). Throughout this *Recommended Practice*, Occupational Safety and Health Administration (OSHA) safety lighting standards and security industry lighting best practices were applied. Where OSHA foot-candle measurements for safety lighting were higher than security industry lighting measurements, the OSHA measurements were used. Where security industry lighting measurements were higher than OSHA safety lighting standards, the security industry lighting measurements were used.

Scope and purpose: This *Recommended Practice* contains minimum industry best practices, but can be exceeded. It should be used as a guide for security design reviews, capital improvement projects, retrofit projects, new designs and grant submissions that enhance security of the property. This *Recommended Practice* provides guidance for the application of security lighting systems to reduce risk to people, operations, assets and infrastructure. However, it does not address life and safety emergency lighting, which is described in the References section.

This Recommended Practice represents a common viewpoint of those parties concerned with its provisions, namely, transit operating/planning agencies, manufacturers, consultants, engineers and general interest groups. The application of any standards, practices or guidelines contained herein is voluntary. In some cases, federal and/or state regulations govern portions of a rail transit system's operations. In those cases, the government regulations take precedence over this standard. APTA recognizes that for certain applications, the standards or practices, as implemented by individual rail transit agencies, may be either more or less restrictive than those given in this document.

Participants

The American Public Transportation Association greatly appreciates the contributions of **Infrastructure Security WG**, who provided the primary effort in the drafting of this *Recommended Practice*.

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1. Stakeholder considerations

Lighting should be designed to meet the specific needs of users of transit passenger centers, stations, transit facilities and other transit areas (i.e., parking, walkways, internal or underground areas, bus stops and shelters). These stakeholders include passengers, law enforcement, security operations personnel, and facility operations and maintenance staff.

1.1 Passengers

Lighting should provide a sense of personal security for passengers. Waiting passengers should be able to observe approaches to the transit area, as well as other passengers within the facility.

1.2 Law enforcement and security operations personnel

Sufficient light should permit law enforcement and security personnel the ability to recognize activities and faces of individuals within the transit facility. The lighting should permit visibility of the interior and exterior of the facility.

1.3 Facility operations and maintenance staff

Lighting systems should permit ease of observation of revenue and nonrevenue critical infrastructure and equipment, ongoing operations and facilitate maintenance.

2. Risk assessment considerations

Transit agencies should evaluate risks and use systemwide and asset-specific risk assessments as a guide in determining effective placement of lighting systems to maximize transit security.

2.1 Systemwide assessment

Transit agencies should refer to their security risk assessments to determine the risks to their systems' assets and the surrounding environment. Transit agencies that do not have existing security risk assessments should develop them using current government guidelines.

2.2 Revenue and nonrevenue transit facility risk assessment

To determine specific passenger facility risks, refer to the agency asset's criticality ranking and the security and risk management issues for each specific location being considered. Transit agencies should use a risk-based assessment approach to identify security threats to their transit system. The approach may also evaluate system vulnerabilities to those threats, and determine the consequences to people, operations, assets and infrastructure. The results should be used to determine appropriate lighting system requirements for the protection of people, operations, assets and infrastructure.

3. Types of lighting

There are three basic types of security lighting that may be installed at transit facilities. They are continuous, standby and mobile. **Table 1** lists recommended applications for different types of security lighting.

3.1 Continuous lighting

Continuous lighting is the most common type of security lighting system installed. The application of continuous lighting consists of a series of fixed lights arranged to continuously light interior or exterior areas during hours of darkness. Use continuous lighting around a building perimeter, along pedestrian pathways or vehicle approaches, or along property boundaries.

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3.2 Standby lighting

This type of lighting is similar in layout and design to continuous lighting, except that the luminaries are not continuously lit. Instead, they are either turned on automatically when activity is detected in the area, or manually, as necessary to investigate the area. Standby lighting should use instant "on" lighting lamps (e.g. incandescent, halogen, fluorescent, inductively coupled, or LED).

3.3 Mobile lighting

This type of lighting is manually operated and moveable. Mobile lighting may supplement continuous or standby lighting. Use mobile lighting at special events and in emergencies during hours of darkness.

TABLE 1
Application of Security Lighting in a Transit Environment

Location of Use	Type of Security Lighting		
	Continuous	**Standby**	**Mobile**
Critical infrastructure access point		X	
Fare gate	X		
Kiosk	X		
Mezzanine	X		
Parking lot (open area)	X		X
Passenger station waiting area	X		
Passenger emergency communications device	X		
Parking structure (covered deck)	X		X
Parking structure (roof decks)	X		X
Platform (outside canopy)	X		
Platform (under canopy)	X		
Pedestrian pathway	X		X
Restricted area entry/exit		X	
Station entrance/exit	X		X
Ticket vending machines	X		
Vehicle approach (kiss & ride)	X		
Vehicle staging area (waterborne transit operations)	X		X

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4. Lighting application and selection

4.1 Application and selection

Lighting lamp application and selection is an important function of security lighting. Each type of lamp has a different color characterization that affects human perceptions of color. **Table 2** lists commonly selected lamp types, recommended applications for their use, as well as their advantages and disadvantages. Disposal should be in accordance with industry prescribed methods and local ordinances.

TABLE 2
Lamp Comparisons

Lamp Type	Applications	Advantages	Disadvantages
Incandescent[1]	• Ambient, task or accent lighting • Flood or spot lighting	• Instant "on" • High CRI[2]	• Not energy efficient
Halogen (incandescent)[1]	• Ambient, task or accent lighting • Flood or spot lighting	• Instant "on" • High CRI	• Not energy efficient
Fluorescent	• Interior use • Area lighting	• Quick "on" • Energy efficient • Moderate/high CRI • Long life	• Lamp lumen output depreciates with ambient temperature change
Compact fluores-cent	• Interior use • Area lighting	• Quick "on" • Energy efficient • Moderate/high CRI	• Lamp lumen output depreciates with ambient temperature change
Metal halide	• Areas or displays where color identification is critical • Parking areas	• Long life • Energy efficient • Moderate/high CRI	• Slow "on" and restrike time • High initial cost
High-pressure so-dium	• Roadways, walkways and parking areas	• Long life • Energy efficient	• Slow "on" and restrike time • High initial cost • Low CRI
Low-pressure so-dium	• Roadways, walkways and parking areas • Area lighting where color identification is not critical	• Long life • Energy efficient • Excellent acuity	• Slow "on" and restrike time • Monochromatic • Low CRI • High initial cost
Mercury vapor[1]	• Area lighting where color identification is not critical	• Long life	• Slow "on" and restrike time • Low CRI • Not energy efficient
Inductively coupled electrodeless	• All interior and exterior areas	• Long life • Energy efficient • High CRI	• Size of lamp • Component heat control • High initial cost
Light-emitting di-ode (LED)	• All interior and exterior areas	• Long life • Energy efficient • Moderate/high CRI	• Component heat control • High initial cost

1. Lamps are being phased out due to federally regulated energy efficiency requirements.
2. Color Rendering Index (CRI)

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4.2 Lamp properties

The capacities, efficiencies, restrike times and CRI are important factors in considering the type of lamp that best fulfills the unique requirements of a transit environment. They should be reviewed and considered along with other security lighting survey information and calculations to determine the best values for an agency. **Table 3** lists factors to consider for each of the commonly used lighting lamps. The values given are approximate and can vary significantly depending on lamp type, wattage, manufacturer, ballasting and operating conditions.

TABLE 3
Lamp Properties

Lamp Type	**Lamp Life** (hours)	**Efficacy** (output lumens to input watts)	**Restrike Time** (minutes to full output)[1]	**CRI** (Color Rendering Index)
Incandescent[2]	750	17	instant	100
Halogen (incandescent)[2]	2,500	14	instant	100
Fluorescent	20,000-50,000	80-110	quick-on	75-90
Compact fluorescent	10,000	80-90	quick-on	72-90
Metal halide	12,000-20,000	70-90	up to 15	65-90
High-pressure sodium	24,000-40,000	80-110	1-2	22
Low-pressure sodium	18,000	126	7-15	monochromatic
Mercury vapor[2]	24,000	45	3-7	45
Inductively coupled electrodeless	100,000	75-80	instant	80
Light-emitting diodes (LED)	50,000	60-80	instant	80

1. "Instant" means that the lamp will immediately be at full output. "Quick-on" means that the lamp will immediately start and very quickly reach full rated output. The other listing times are the amount of time the lamp takes to restrike after being extinguished, which includes some lamp cooldown time. If already cool, these lamps will strike immediately but take a minute or several minutes to reach full rated output.

2. Lamps are being phased out due to federally regulated energy efficiency requirements.

5. Lighting design and planning

5.1 Design basis

Effective security lighting design and planning includes performing a design basis to benchmark the lighting system requirements. The elements of a design basis should include the following steps:

- Define the purpose of the lighting system.
- Identify areas requiring installation of or increased illumination.
- Determine the type(s) of security lighting to install in an area.
- Consider system expansion and value engineering options during any design and planning phases.

Other influencing factors to an effective design are light source color, illuminance, uniformity, glare and shadow of the light source. Also, the presence of CCTV systems that will use the light source and the effects of lighting on the surrounding community and area should be considered.

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5.2 Light source color

The two factors that comprise light source are color temperature and color rendition, which affect mood and environmental surroundings. The higher the color temperature of a lamp, the more closely it replicates daylight. A basic guideline to estimate the perceived color of a source is that the higher the color temperature, the more "cool" the source will appear (more blue/green in tint). The lower the color temperature, the more "warm" the source will appear (more red/yellow in tint). In general, discharge sources, which are considered "white" light sources such as fluorescent and metal halide, will have a color temperature somewhere between 3000 ^{o}K and 4500 ^{o}K. Color temperature is an important factor in the selection of light sources.

FIGURE 1
Color Temperature Comparison

Metal Halide Installation
Correlated color temperature: 3700 ^{o}K
Color Rendering Index: -70

High-Pressure Sodium Installation
Correlated Color Temperature: 1900^{o}K
Color Rendering Index - 22

Color rendition is the ability of a lamp to accurately reproduce the colors seen in an object. It is referred to as the Color Rendition Index (CRI) and measured from 0 to 100. The closer to 100 the index number, the closer the lamp is to natural daylight. The qualities of color rendition characteristics can be influenced by CRI and the spectral distribution of the lamp.

5.3 Illuminance

Illuminance is the concentration of light that falls on a surface. It is measured in foot-candles or lux with a light meter on the horizontal and vertical planes. Horizontal illuminance does little to aid the visibility of vertical objects, such as signs and keyholes, whereas vertical illuminance in the appropriate lighting levels provides observers the ability to identify people and activities at a distance, especially in enclosed facilities, such as parking garages.

5.4 Uniformity ratio

Uniformity is the even distribution of light on a surface. It is measured as a ratio in determining uniformity of the minimum, average and maximum illuminance to an area. The ratios compare average-to-minimum or maximum-to-minimum illuminance. The differences in uniformity ratios aid the eye to view depth when scanning or viewing an area. Uniformity ratios may vary depending upon their application and built environment. Unbalanced uniformity ratios may present shadowing effects. In this *Recommended Practice,* the criteria are given in average values and minimum values. The uniformity ratio for E_{avg}/E_{min} can, therefore, be found as the ratio of those two values.

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Lighting uniformity can provide balanced lighting of an area and reduce shadowing. For example, a very uniform lighting environment can lack contrast, making the visibility of objects difficult by allowing the foreground and background to blend with little to no contrast. A more non-uniform scene provides greater opportunity that an object will be visible due to its contrast, either against a bright or dark background. For security lighting, however, a non-uniform scene can provide dark areas and shadows, which would allow for concealment. Therefore, the values listed attempt walk the fine line between too much or too little non-uniformity and should be used for security applications in the transit environment.

5.5 Lighting distribution

Lighting distribution is the direct area that the light covers. There are five types of lighting distribution patterns, shown in **Table 4**. Each application may depend on various factors determined during the design and planning phases of a project. The selection of the distribution types should be determined by lighting professionals based on size, shape, and location to be illuminated.

TABLE 4
Lighting Distribution Types

Type	Distribution	Application
I	Very narrow	Walkway, roadways
II	Increasing width	Walkways, roadways
III	Increasing width	Walkways, parking areas
IV	Increasing width	Walkways, roadway
V	Round	Parking areas, perimeter areas near structures, entryways

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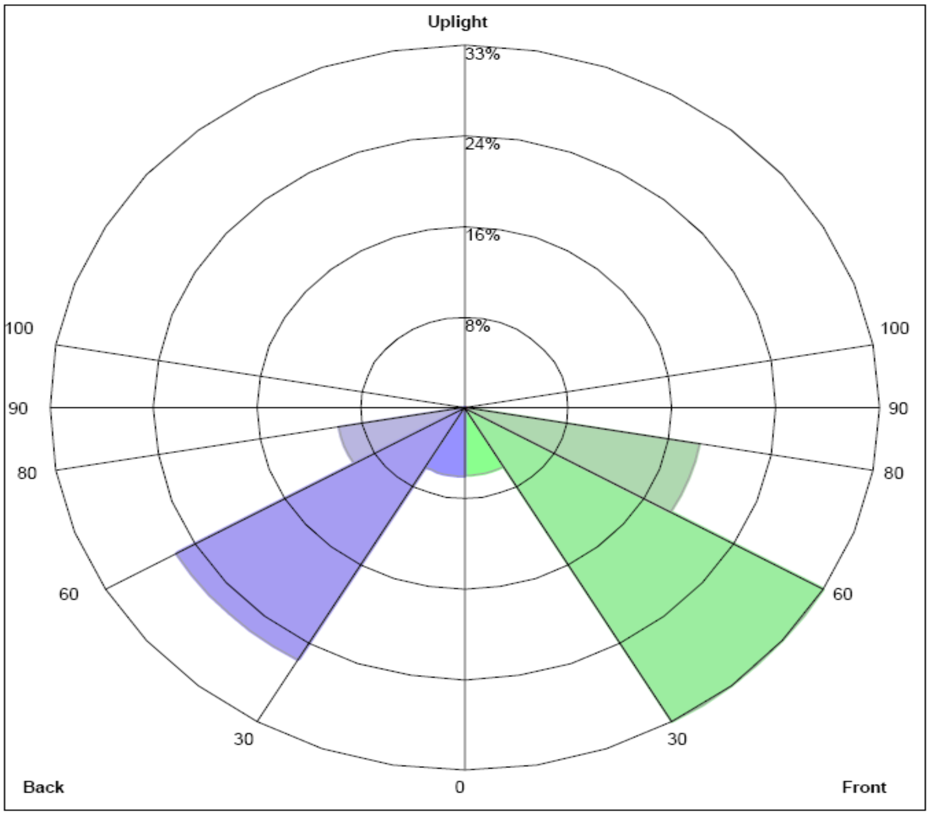
FIGURE 2
Example of LCS Classification Report

LUMINAIRE CLASSIFICATION SYSTEM (LCS) GRAPH



LCS Rating: F:6-33-19-1,B:6-26-10-1,U:0-0

Front: Low=6.1%, Medium=32.6%, High=18.7%, Very High=0.1%
Back: Low=6.1%, Medium=26.2%, High=10.0%, Very High=0.2%
Uplight: Low=0.0%, High=0.0%

In addition to the lighting distribution classification, there is also a luminaire classification system that describes how light is emitted from a luminaire. The older luminaire classification system, which described luminaires as either full cutoff, cutoff, semi-cutoff, or non-cutoff has been replaced by the IESNA, which now uses an LCS system rating noting the amount of light distributed from the front, back and upward from the luminaire. These areas are also further subdivided. This new classification system is outlined in IESNA TM-15-07.

5.6 Shadows

Shadows reduce the effectiveness of lighting because they reduce lighting uniformity and the contrasts from darkness to lightness. Shadows often impart a feeling of being unsafe, probably because they offer areas of concealment for persons or animals.

The effect of shadows is also a concern from a visibility and safety standpoint within stations. The locations of luminaires and their optical design should be based on the need to eliminate shadows on critical surfaces, such as platform edges and stair treads (see **Figure 3**).

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FIGURE 3
Platform Edge Lighting

FIGURE 4
Impact of Glare on Visibility

5.7 Glare

Glare is produced when the intensity of light in a direction on a surface is sufficiently greater than the eye can adapt to. It can reduce the contrast of an object against its background, resulting in difficulty for the eye to perceive depth accurately and to see well. Glare is may be hazardous for senior citizens and people with weak or impaired vision.

5.8 Photosensors and time clocks

Transit agencies should consider using photosensors or time clocks to control the electrical power to the luminaire. These devices will initiate the power source to operate only when the ambient light falls below a certain threshold (for example, luminaires operating from dusk to dawn or during low-light conditions such as a storm). Photosensor receptacles are common in roadway, parking lot and area lighting applications where the electric utility provides the lighting system. Lighting controls (photo sensors, time clock, etc.) should be used in outdoor and indoor lighting to maximize lighting energy savings. Luminaries should have a photosensor receptacle for a plug-in photosensor unit.

Dusk-to-dawn lighting control, commonly incorporating a photocell or time clock, ensures that the lighting system is shut off during daylight hours. When luminaires use multiple mounting configurations, some lighting luminaires may be switched off by time clock or manual shut off switch instead of a photosensor during hours when the illumination is not expected to be used. This strategy can save energy while maintaining a minimal illuminance for security purposes.

5.9 Landscape impacts to lighting

Landscape selection should ensure that light distribution will not be obstructed by the foliage of trees, shrubs or other vegetation as it matures or as seasons change. An example of the impact that landscaping can have is shown in **Figure 5**. The images are of the same pedestrian location during the winter and summer months. The presence of the leaves on the tree reduces the average vertical illuminance by more than 60 percent. During hours of darkness, pole-mounted luminaires should be clearly seen from a distance away from the pole of 2.5 to 3 times their height to ensure area lighting coverage. If the line of sight to the luminaire cannot be clearly seen during the full blossom of the canopy, the tree or shrub branches obscuring the view should be removed by pruning. This action is also referred to as “limb up.” Further, at least annually, trees, shrubs and other vegetation should be pruned to prevent interference with light distribution patterns and to eliminate

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shadows. Designs that include decorative landscaping at transit facilities should be planned with the full understanding of density, height and breadth of the landscape as it grows to full maturity.

FIGURE 5
Impact of Vegetation on Lighting Systems

6. Energy and environmental considerations

6.1 Energy conservation

Energy consumption in parking lot or area lighting system depends on the lamp type, ballast, luminaire, number of luminaires required and control strategy. Where incandescent and mercury vapor lamps were used at a higher wattage and cost, high-pressure sodium, low-pressure sodium or metal halide lamps may be installed with lower wattages and little reduction in illuminance. Energy savings can also apply to internal applications. For example, compact fluorescent lamps (CFLs) can replace incandescent lamps with lower wattages and little reduction in illuminance at a cost savings. Therefore, older lighting installations replaced by highly efficient lighting systems can translate to greater cost savings.

6.2 Environmental considerations

Light pollution, uplight, sky glow, light trespass and glare are lighting issues caused when light penetrates areas unintended for lighting. This can affect the living environment of neighboring properties. However, careful planning and effective designs can reduce and control the effects of unintended lighting on the environment.

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The IESNA provides guidelines for the limitation of light trespass, which are included in IESNA TM-11-00, *Light Trespass: Research, Results, and Recommendations*. Depending on the type of area the facility is located, vertical illumination limits at the property line are recommended. The areas are classified into the following zones:

- **E1:** Areas with intrinsically dark landscapes.
- **E2:** Areas of low ambient brightness.
- **E3:** Areas of medium ambient brightness.
- **E4:** Areas of high ambient brightness.

Lighting levels from TM-11 are recommended in **Table 5**. For the purpose of this document, these levels are given as a goal. Security lighting levels should meet the recommendation contained in Section 6 of this *Recommended Practice*.

TABLE 5

Light Trespass Limits from IESNA TM-11-00

Environmental Zone	Pre-Curfew Limitations[1]	Post-Curfew Limitations[1]
E1	1.0 (0.10)	0.0 (0.00)[2]
E2	3.0 (0.30)	1.0 (0.10)
E3	8.0 (0.80)	3.0 (0.30)
E4	15.0 (1.50)	6.0 (0.60)

1. Lux (foot-candles) values on a plane perpendicular to the line of sight to the luminaire(s).

2. Where safety and security are issues, nighttime lighting is needed. Such lighting should meet IESNA recommendations for the particular property being lighted. Lighting should be designed, however, to minimize light trespass.

6.3 Other environmental hazardous material considerations

Agencies should use the accepted practices for the proper disposal of lighting lamps and fixtures that are considered hazardous material.

7. Recommended illumination levels for facility locations

The recommended illumination levels listed below are applicable for underground, elevated and exterior space lighting criterion. Most of the values given are the minimum required for typical operations and functional activities in which security is a primary element. In some areas such as pedestrian walkways and parking lots, the values are higher than typical functional values for these types of uses in order to provide adequate illumination for system and customer security.

For unoccupied building interiors with only security personnel present, 1.0 maintained foot-candles with an average-to-minimum uniformity of not greater than 6:1 are generally sufficient for patrol officers. In many cases, the part of the normal lighting system connected to emergency circuits meeting the levels prescribed in NFPA 101, *Life Safety Code*, is also used to provide nighttime security lighting.

The values given in **Tables 6 and 7** are initial and maintained values for exterior areas but are applicable for underground, elevated and exterior space lighting criterion. The maintained values are the lowest in-service value the lighting system will reach before it is serviced (relamped or cleaned). The initial values are given only as a guide for initial design consideration. The actual required initial values will depend on the expected maintenance of the lighting system as well as the lamp and luminaire used. For example, if a lighting system is designed with a lamp that has only a small amount of lumen depreciation throughout its life, the luminaire

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used is well constructed against dirt infiltration, group relamping will be performed, and cleaning is done on a regular basis, then the initial value (and therefore, the capital cost) of the lighting system may be lower. If, however, the lamp and luminaire are more prone to lumen and dirt depreciation, spot relamping will be used, and cleaning will be irregular or nonexistent, then a higher initial value may be required.

While average foot-candle illumination should always be the goal for area lighting listed below, the illumination criteria provided recommends minimum horizontal values and, for some areas, minimum vertical values. These values are the minimum point at any location in the defined area. For pedestrian areas, it is the minimum point in both directions along the path of travel. The uniformity for these areas is obtained from the table using the ratio of the average maintained fc to the minimum maintained fc.

TABLE 6

Lighting Levels (Foot-Candles) for Exterior Transit Facility Locations

Area	Average Foot-Candle Illumination Level		Minimum Foot-Candle Illumination Level	
	Maintained	Initial	Maintained	Initial
Open parking lots (employee parking)	3	4	1 horizontal 0.5 vertical	1.4 horizontal 0.7 vertical
Parking garage (employee parking)	6	9	1.5 horizontal 0.8 vertical	2.2 horizontal 1.2 vertical

TABLE 7

Lighting Levels (Lux) for Exterior Transit Facility Locations

Area	Average Lux Illumination Level		Minimum Lux Illumination Level	
	Maintained	Initial	Maintained	Initial
Open parking lots (employee parking)	32.29	46.28	10.76 horizontal 5.38 vertical	15.06 horizontal 7.53 vertical
Parking garage (employee parking)	64.58	96.87	16.15 horizontal 8.61 vertical	23.68 horizontal 12.91 vertical

Tables 8 and 9 provide initial and maintained values for maritime transit revenue facility locations.

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TABLE 8

Lighting Levels (Foot-Candles) for Maritime Transit Revenue Facility Locations

Area	Average Foot-Candle Illumination Level		Minimum Foot-Candle Illumination Level	
	Maintained	Initial	Maintained	Initial
Berth	5	8	1.5	0.9
Customer service area	20	26	6	4.6
Dock	5	8	1.5	0.9
Facility entrances/exits	3	5	1	0.6
Gangways	10	16	3	1.9
Pier	5	8	1.5	0.9
Vehicle lanes	2	3.5	0.6	0.4
Vehicle loading/unloading	3	5	1	0.6
Waiting area	10	13	3	2.3
Wharf	5	8	1.5	0.9

TABLE 9

Lighting Levels (Lux) for Maritime Transit Revenue Facility Locations

Area	Average Lux Illumination Level		Minimum Lux Illumination Level	
	Maintained	Initial	Maintained	Initial
Berth	53.81	86.11	16.14	1.9
Customer service area	215.27	279.86	64.58	49.51
Dock	53.81	86.11	16.14	9.68
Facility entrances/exits	32.29	53.81	10.76	6.45
Gangways	107.63	172.22	32.29	20.45
Storage yard, low activity	5.38	8.61	1.61	1.07
Storage yard, high activity	53.81	86.11	1.61	9.68
Pier	53.81	86.11	1.61	9.68
Vehicle lanes	23.68	37.67	6.45	4.30
Vehicle loading/unloading	32.29	53.81	10.76	6.45
Waiting area	107.63	139.93	32.29	24.75
Wharf	53.87	86.11	1.61	9.68

8. Security lighting survey

8.1 Approach

To ensure that the basic principles of security lighting are understood and applied, a security lighting survey should be performed on an annual basis, or when there are changes to the built environment. First, transit agencies should review their current security assessment results to analyze identified threats and determine

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the potential hazards against people, operations and assets. Then, transit agencies should complete a design basis in order to do the following:

- Establish the purpose of the lighting system.
- Identify areas requiring installation of or increased illumination.
- Determine the type(s) of security lighting to install in a specific area.
- Consider value engineering options during any design and planning phases.

Finally, the transit agency should perform a comprehensive security lighting system survey that includes lighting measurements and a review of operational procedures.

8.2 Lighting measurements and system maintenance/repairs

As a function of the security lighting survey, lighting measurements should be taken and analyzed, using Underwriters Laboratories certified equipment and proper manufacturers' calibration, to determine the current lighting levels throughout the different transit property areas. The status of scheduled maintenance and necessary repair of identified damages should be noted as part of the survey. The measurements may be completed in foot-candles (fc) or lux (lx), but should be recorded.

8.3 Security lighting survey procedures

Table 10 provides recommended procedures for completing a security lighting survey. To record the results of a security lighting survey, an example of a lighting survey field report form is listed in Appendix B.

TABLE 10

Lighting Survey Procedures[1]

Procedures	Purpose
Review lighting plans and drawings	To verify lighting designs and any system modifications.
Review lamp/light maintenance	To verify schedule of luminaries and lamp maintenance.
Identify power source	To identify primary and secondary power sources.
Inspect luminaries and connections	To identify frayed or worn wiring or damaged connections.
Select equipment (light meter and compass)	To capture lighting calculations with a light meter measuring device. To ensure light meter is functioning and calibrated. To identify the cardinal directions (north, south, east and west).
Select a typical test time at night	To avoid full or no moon conditions, snow on the ground, overcast, stormy, or rainy nights. Survey should be performed during hours of darkness.
Orient the property	To identify the cardinal directions (north, south, east and west) and mark them on a plan or sketch.
Lay out the area	To identify test points and determine spacing of measurements between test points.
Determine height	To identify primary and secondary measurement heights.
Take reading at ground (primary)	Capture and analyze lighting level at (ground) primary height level (horizontal plane).
Take reading at height (secondary)	Capture and analyze lighting level at secondary height level (1.5 meter – 5 ft.) (vertical plane).
Look for trouble	To note other site problems that may influence additional threats to property.

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Note off-site conditions	Make notation of off-site conditions. Adjacent properties may have installed high light levels or glare-intensive sources, which may impact the visibility on the surveyed site.
Note other security systems	Make notation of type and location of security system elements such as CCTV cameras, emergency telephones, “blue light” stations, etc. and their general configuration as it relates to the lighting system.

1. Lamp “burn-in” of a minimum of 100 hours per lamp should be performed before lighting measurements are taken to ensure the most stable lumen output.

9. Inspection, maintenance and repairs

The optimum operational effectiveness of a lighting system can be limited by the performance or nonperformance of inspections, maintenance and repairs. Maintenance for parking lot, pole-mounted lighting and area lighting systems can be high because the mounting heights often require special equipment to access the luminaires. Easily replaced bulbs, ballasts and other optical components can reduce labor costs. Ease of maintenance is also a safety issue, because the less time a person works on maintaining a lighting system, the less risk there is for an accident to occur. Group relamping rather than spot relamping may also help to control maintenance costs.

A clean luminaire is essential for best performance. Poorly aligned, poorly fitted or damaged luminaire components such as gaskets, housing covers, lenses, etc. can allow dirt or water to penetrate, which can reduce illuminance and increase maintenance or operating costs over the life of the system.

Lighting system issues, maintenance and inspection of the systems should be performed at least monthly (for instance, routine maintenance and cleaning of pole and or luminaries, lamp or ballast replacement, etc.). However, if there is a history of vandalism or efforts to defeat the lighting system, then maintenance and inspections should be performed more often. Security lighting systems repairs should be performed without delay. For optimum security lighting system performance, follow manufacturers’ recommended best practices for inspection, maintenance, and repair.

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Appendix A: General security lighting considerations

1. Lighting patterns should overlap so that no area is dependent on a single luminaire and to eliminate dark spaces, corners and shadows.

2. Security lighting layout and the maintenance, inspection and repair protocols should be incorporated into the facility's security plan.

3. Illuminate objects, people and spaces to allow observation and identification.

4. Protect lighting by installing protective covers over lamps, and place lamps on poles out of the reach of passengers.

5. Use photosensors or time clocks to automatically control lighting operations.

6. Turn lights off when not in use.

7. Provide primary, auxiliary or redundant power sources to lighting.

8. Landscape design, fences and other facility features should not obstruct lighting. Trees and other landscaping should be coordinated with the lighting system and pruned to permit illumination below the canopy.

9. Illuminate all vehicle and pedestrian entrances in parking facilities.

10. Building doorways should be individually illuminated to reduce or eliminate shadows that may be cast by other light sources.

11. Use the minimum light levels required.

12. Choose efficient luminaires and lamps.

13. Reduce light pollution, sky glow, light trespass and glare as much as possible.

14. Lighting should be reliable, easy to maintain, able to withstand the elements and protected from vandalism.

15. Protective lighting should be installed to protect areas and critical infrastructures, such as communications and power systems.

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Appendix B: Lighting survey field report form

The following is an example of a lighting survey field report form, which can be used in present form or modified as necessary.

LIGHTING SURVEY FIELD REPORT

< Distance 1 >

< Distance 2 >

Cardinal Direction

<table>
<tr><td></td><td colspan="3"></td></tr>
<tr><td></td><td>Date:</td><td>Time:</td><td>Location:</td></tr>
<tr><td></td><td>Distance 1:</td><td colspan="2">Spacing 1:</td></tr>
<tr><td></td><td>Distance 2:</td><td colspan="2">Spacing 2:</td></tr>
<tr><td></td><td colspan="3">Pole Height:</td></tr>
<tr><td></td><td>Fixture Type:</td><td>Lamp Type:</td><td>Wattage:</td></tr>
<tr><td></td><td colspan="3"></td></tr>
<tr><td></td><td>Meter Type:</td><td colspan="2">Date Calibrated:</td></tr>
<tr><td></td><td colspan="3">Weather Conditions:</td></tr>
<tr><td></td><td colspan="3"></td></tr>
<tr><td></td><td colspan="3">Readings: Fc ( ) Lux ( )</td></tr>
<tr><td></td><td colspan="3"></td></tr>
</table>

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	Primary (Ground)	North	South	East	West	Secondary (Vertical)

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Lighting survey field report form explanations

Issue	Explanation
Area	use the blank area to draw or sketch the area being surveyed
Cardinal Direction	enter the direction of north with an arrow
Date	date of survey
Time	times of survey
Location	name or location of survey sight, e.g., parking lot, building, etc.
Distance 1 & 2	distances of the area being surveyed
Space 1 & 2	distances between poles or other objects
Pole Height	height of light poles
Fixture Type	luminaires type
Lamp Type	lamp type
Meter Type	lighting calibration meter type being used
Date Calibrated	date of recent calibration
Weather Conditions	condition at lighting survey sight during survey (temp, moonlight, overcast, clouds)
Readings	check fc or lux (for consistency, use only one type of reading throughout survey)
Primary Reading	at ground level (horizontal plane)
Cardinal Direction	check appropriate reading direction block
Secondary Reading	at approximately 5 ft. from ground (vertical plane)

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Appendix C: Lighting system checklist

LIGHTING SYSTEM CHECKLIST		
Lighting Issue	**Refer-ence**	**Re-viewed**
Stakeholder considerations	1	
Passengers	1.1	
Law enforcement and security operations personnel	1.2	
Facility operations and maintenance staff	1.3	
Risk assessment considerations	2	
Systemwide assessment	2.1	
Revenue and nonrevenue transit facility risk assessment	2.2	
Types of lighting	3	
Continuous lighting	3.1	
Standby lighting	3.2	
Mobile lighting	3.3	
Lighting application and selection	4	
Application and selection	4.1	
Lamp properties	4.2	
Lighting design and planning	5	
Design basis	5.1	
Light source color	5.2	
Illuminance	5.3	
Uniformity ratio	5.4	
Lighting distribution	5.5	
Shadows	5.6	
Glare	5.7	
Photosensors and time clocks	5.8	
Landscape and impacts to lighting	5.9	
Energy and environmental	6	
Energy conservation	6.1	
Environmental considerations	6.2	
Other environmental hazardous material considerations	6.3	
Recommended illumination levels for various facility locations	7	
Security lighting survey	8	

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LIGHTING SYSTEM CHECKLIST		
Lighting Issue	**Refer-ence**	**Re-viewed**
Approach	8.1	
Lighting measurements and system mainten-ance/repairs	8.2	
Security lighting survey procedures	8.3	
Inspection, maintenance and repair	9	
General security lighting considerations	App. A	
Lighting survey field report	App. B	
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Definitions

ballast: A magnetic or electronic device used to control the starting and operation of discharge lamps.

brightness: The intensity of the sensation from which light is seen by the human eye.

color rendition: The ability of a lamp to reproduce accurately the colors seen in an object.

Color Rendering Index (CRI): A measure from 0 to 100 of how closely a lamp renders colors of objects compared to a standard source. Daylight is considered the standard source of light for the purpose of this *Recommended Practice*. The higher the Color Rendering Index, the more natural the appearance of the source and the richer colors appear.

contrast: The relationship between the brightness of an object and its immediate background.

correlated color temperature (CCT): The measure of the "warmth" or "coolness" of a light.

efficacy: The ratio of light output (in lumens) to input power (in watts), expressed as lumens per watt.

emergency communications device: Equipment and or technology installed at locations open to the traveling public or passengers and intended to communicate the need for assistance, help or another type of emergency or alarm to transportation staff or area first responders (telephone, alarm button or panel, intelligent video device or other GPS or non-GPS communications device).

flare: A situation created when a light source overwhelms a CCTV system sensor, making the image unusable.

foot-candle (fc): A unit of measure of illuminance. One foot-candle is equal to 1 lumen cast per square foot of surface. 1 fc is equal to 10.764 lux.

glare: A visual sensation caused by excessive and uncontrolled brightness.

high-intensity discharge (HID) lighting: An electric lamp that produces light directly from an arc discharge under high pressure. Metal halide, high-pressure sodium, low-pressure sodium and mercury vapor are examples of types of high-intensity discharge lamps.

horizontal illuminance (Eh): The measure of brightness from a light source, usually measured in foot-candles or lumens, through a horizontal position on a horizontal surface.

Illuminating Engineering Society of North America (IESNA): The recognized technical authority on illumination.

illuminance (E): The total amount of visible light landing on a surface from all directions above the surface.

lamp: Electrical light sources often referred to as bulbs.

light-emitting diodes (LED): Diodes (electronic components that let electricity pass in only one direction) that emit visible light when electricity is applied, much like a light bulb.

light meter: Electrical device that measures light in foot-candles or lux.

light trespass: Illumination cast to area where it is not wanted, such as an adjacent property.

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luminance: The luminous intensity of a surface in a given direction per unit area of that surface as viewed from that direction; often incorrectly referred to as brightness.

lumen: The quantity of luminous flux emitted within a unit solid angle by a point source with one candela intensity in all directions.

lux (lx): The metric standard unit of measure for illuminance, lumens per square meter (lm/m^2). 10.764 lx is equal to 1 foot-candle.

nonrevenue transit facility: A non-publicly accessible transit facility or the non-publicly accessible portion of a mixed revenue/nonrevenue facility, i.e. operations control centers, maintenance facilities, bus vehicle storage yards, rail vehicle storage yards, traction power substations, communication rooms, train control rooms, emergency fan plants, elevator rooms, passenger station ancillary rooms, and other similar facilities.

photosensor: An electronic device used to automatically turn lights on and off based on the amount of ambient light near the cell.

sky glow: The result of natural or artificial light sources increasing the night sky brightness. Sky glow varies greatly depending on weather conditions, the quantity of dust/particles in the air, and the amount of light directed skyward. It is considered light pollution.

time clock: An electronic device used to automatically turn lights on and off on a predetermined schedule.

revenue transit facility: A publicly accessible transit facility or the publicly accessible portion of a mixed revenue/nonrevenue facility, i.e. passenger stations and terminals.

transitional lighting: Illumination levels that gradually increase or decrease between brightly illuminated and dark areas.

uplight: Light directed upward from the source, whether from luminaries or reflected light from the ground or other surfaces. Uplight can increase sky glow.

uniformity ratio (UR): The maximum or average illuminance across an area. The uniformity ratio may be expressed as a ratio of average to minimum, or it may be expressed as a ratio of maximum to minimum level of illumination for a given area.

vertical illuminance (Ev): The total amount of visible light landing on a vertical surface from all directions.

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Abbreviations and acronyms

ANSI	American National Standards Institute
APTA	American Public Transportation Association
CCT	correlated color temperature
CCTV	closed-circuit television
CFL	compact fluorescent lamp
CPTED	crime prevention through environmental design
CRI	Color Rendering Index
E	illuminance
Eh	horizontal illuminance
Ev	vertical illuminance
fc	foot-candles
HID	high-intensity discharge
IESNA	Illuminating Engineering Society of North America
LCS	Luminaire Classification System
LED	light-emitting diode
LPW	lumens per watt
lx	lux
NEC	National Electric Code
NFPA	National Fire Protection Association
NLPIP	National Lighting Product Information Program
OSHA	Occupational Health and Safety Administration
TCRP	Transit Cooperative Research Program
UR	uniformity ratio

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