PEDESTRIAN LIGHTING
WHY LIGHTING

- Safety Project and also Green project
- Haxton Way
  - Had highest rate of fatalities on reservation and Whatcom County
- Partners
  - Lummi Nation Tribe, Whatcom County, WSDOT, BIA, FHWA Federal Lands

http://www.youtube.com/watch?v=ltR2oiQ3R9Q

Before Conditions
38% CRF for all nighttime crashes

42% CRF for veh/ped nighttime crashes

Rural Area Illumination

- 71% CRF for all nighttime crashes

Install single light at intersection

<table>
<thead>
<tr>
<th>CMF</th>
<th>CRF(%)</th>
<th>Quality</th>
<th>Crash Type</th>
<th>Crash Severity</th>
<th>Area Type</th>
<th>Reference</th>
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<tr>
<td>0.29</td>
<td>71</td>
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<td>0.79</td>
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<tr>
<td>0</td>
<td>100</td>
<td>★★★★★</td>
<td></td>
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</tbody>
</table>

TORBIC ET AL., 2015
CMF (CRF)

Rural Intersection Illumination

- 44% CRF for veh/ped nighttime crashes

Guidance Document: supplement AASHTO, IES & CIE guides

- Policy and guidance
- Basic terms and concepts
- Warranting criteria
- Lighting impacts
- Application considerations
- Other systems and issues
Driving or walking on, or across, a roadway is less safe in darkness than in a lighted area.

Fatal crash numbers in daylight are about the same as in darkness, but only 25 percent of vehicle-miles traveled occur at night.

- Nighttime fatality rate is three times the daytime rate.

Lighting for pedestrian safety can also benefit vehicle safety.
Amount of light that falls onto a surface

- Measured as the amount of lumens per unit area either in foot-candles (lumens/ft²) or in lux (lumens/m²)
- Variable by the square of the distance from the source
- Illuminance is simple to calculate and measure - Do not need to take reflective properties of the roadway surface into account & can use a fairly inexpensive illuminance meter for field verification
  - Drawback to this metric is that the amount of luminous flux reaching a surface is often not indicative of how bright a surface will be or how well a person can see
Contrast is the difference between the visual appearance of an object and the visual background against which that object is observed.

Crosswalk lighting should maximize the contrast between pedestrians on or near the crosswalk and the visual background behind those pedestrians from the perspective of approaching drivers.

Figure 7. Photograph. Contrast of dark-clothed and light-clothed pedestrians.
Several factors affect the luminance contrast between pedestrians and their visual backgrounds:
- Fixed roadway lighting
- Headlamp lighting
- Pedestrian clothing
- Characteristics of visual background

Designers can only control roadway lighting.

Lighting designers must react to but cannot change the other factors.
Effectiveness of overhead lighting in increasing visibility distance—by increasing luminance contrast—is a function of:

- Location and orientation of luminaire(s)
- Intensity of emitted light
- Color of light source
- $E_{vert}$ defined as the illuminance on a vertical surface
- $E_{vert}$ on pedestrian is luminous intensity emitted by a luminaire in the direction of the pedestrian times the cosine of the angle between the direction of propagation and a horizontal line parallel to the road surface divided by the distance between the luminaire and the pedestrian.

$$E_{vert} = \frac{I \cos \phi}{D^2} = \frac{(I \cos \phi) \sin^2 \phi}{(h-1.5)^2} = \frac{I \cos \phi \sin^2 \phi}{(h-1.5)^2}$$

Figure 1. Drawing. Vertical illuminance components.

Figure 2. Equation. Vertical illuminance ($E_{vert}$) at a height of 1.5 m (5 ft).
PEDESTRIAN LEVEL LIGHTING
PEDESTRIAN-LEVEL LIGHTING

Purposes:

- Help pedestrians safely navigate sidewalks & pathways
- Provide for visibility & security at all hours
- Extend hours a business district is active
- Encourage walking as part of an active lifestyle
- Improve access to transit & other services at night/early morning
ROADWAY VS. PEDESTRIANWAY

- Roadway lighting typically 25 ft or higher
  - Overhead streetlights
  - Light source over roadway

- Road lighting may be sufficient for motorists to navigate & avoid obstacles
  - Often insufficient for specialized pedestrian needs

- Pedestrian-level lighting typically needs 20 ft or less (18 ft on non-arterials) from surface
ALONG THE ROAD
LIGHTING
Standard pole spacing layout designations:
- one-sided lighting
- opposite lighting
- staggered lighting
- median lighting
POLE SPACING

Diagram showing pole spacing for cross streets with set points and equal spacing for luminaire poles.
Consider:

• Land use
• Road width

Other Factors:

• Pole spacing and system layout
• Luminaire photometrics
• Wattage
• Road geometrics
• Power line conflicts
• Lighting levels and uniformity
• Aesthetics
• Obtrusive lighting issues
LIGHTING

CONSIDER TREE EFFECTS

TRR 2120 - Trees, Lighting, and Safety in Context-Sensitive Solutions
STREETSCAPE LIGHTING LAYOUTS

2 LANE URBAN ROAD - PEDESTRIAN LIGHT OPTION
STREETSCAPE LIGHTING LAYOUTS

4 LANE URBAN ROAD - PEDESTRIAN AND OVERHEAD LIGHT
STREETSCAPE LIGHTING LAYOUTS

4 LANE URBAN ROAD - PEDESTRIAN AND OVERHEAD LIGHTS, BOTH SIDES
High Pressure Sodium (HPS) and metal halide (MH) lamps most common sources for roadway lighting
- HPS produces amber light
- HPS used most because of its high efficiency and long life
- Same lighting level is recommended for MH and HPS
- A color difference between continuous roadway lighting and crosswalk lighting may highlight the presence of the crosswalk

- MH produces white or bluish-white light
- White light provides higher level of facial recognition & comfort
- There are claims that MH may provide a safety benefit because it improves driver peripheral vision
- Research did not show large differences in detection of a black-clothed pedestrian under HPS and MH lighting
- Pedestrians in denim detected at longer distances under MH lighting
LED STREET LIGHTS

Advantages
- Lower energy use
- Longer lamp life
- No warm-up time
- Good light quality
- Directional (less light pollution)
- Environmentally friendly

Disadvantages
- High initial cost
- Sensitive to heat
- Long-term performance issues
NIGHT-SKY LIGHT POLLUTION
LIGHTING CROSSWALKS
LUMINAIRE PLACEMENT

- Luminaire should be located 10 ft in front of crosswalk
- 20 vertical lux at crosswalk

Figure 11. Drawing. Traditional midblock crosswalk lighting layout.

Figure 12. Drawing. New design for midblock crosswalk lighting layout.
LUMINAIRE SELECTION

- Luminaire type/level and height are critical.
- If all light is directed downward, the vertical profile of pedestrians will not be adequately illuminated.
- The luminous intensity distribution from the luminaire must be able to provide the required luminous intensity in the geometry required.
- If the luminaire cannot produce the required intensity, it is not suitable for use in a crosswalk installation.
Suitability of a luminaire – use lighting design program.

- 250-W HPS mounted at height of 28 ft
- Two vertical lines indicate that the desired vertical illuminance of 20 lx may be found for a crosswalk located at a distance of 14–20 ft from the luminaire position.

Figure 9. Plot. Vertical illuminance plot for a 250-W HPS flat lens cobra-head-style luminaire mounted at 8.5 m (28 ft).
- Same luminaire at different height may not be suitable.
- 250-W HPS luminaire mounted at 33 ft from the road surface.
- Vertical illuminance levels do not reach desired level of 20 lx.

Figure 10. Plot. Vertical illuminance plot for a 250-W HPS flat lens cobra-head-style luminaire mounted at 10 m (33 ft).
CROSSWALKS AT INTERSECTIONS

- No specific research done to address higher background luminance typically found at intersections
- 30 vertical lux considered conservative estimate

Figure 13. Drawing. Traditional intersection lighting layout.

Figure 14. Drawing. New design for intersection lighting layout for crosswalks.
OTHER SITUATIONS
The Design Guide for Roundabout Lighting, published by the Illuminating Engineering Society (IES), is the primary resource to consult for a roundabout lighting plan.

Lighting serves two main purposes:

1. Provide visibility from a distance for users approaching the roundabout
2. Provide visibility of the key conflict areas
## Roundabout Illuminance

<table>
<thead>
<tr>
<th>Functional Classification</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>(E_{avg}/E_{min})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major/Major</td>
<td>3.4 fc (34.0 lux)</td>
<td>2.6 fc (26.0 lux)</td>
<td>1.8 fc (18.0 lux)</td>
<td>3:1</td>
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<tr>
<td>Major/Collector</td>
<td>2.9 fc (29.0 lux)</td>
<td>2.2 fc (22.0 lux)</td>
<td>1.5 fc (15.0 lux)</td>
<td>3:1</td>
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<tr>
<td>Major/Local</td>
<td>2.6 fc (26.0 lux)</td>
<td>2.0 fc (20.0 lux)</td>
<td>1.3 fc (13.0 lux)</td>
<td>3:1</td>
</tr>
<tr>
<td>Collector/Collector</td>
<td>2.4 fc (24.0 lux)</td>
<td>1.8 fc (18.0 lux)</td>
<td>1.2 fc (12.0 lux)</td>
<td>4:1</td>
</tr>
<tr>
<td>Collector/Local</td>
<td>2.1 fc (21.0 lux)</td>
<td>1.6 fc (16.0 lux)</td>
<td>1.0 fc (10.0 lux)</td>
<td>4:1</td>
</tr>
<tr>
<td>Local/Local*</td>
<td>1.8 fc (18.0 lux)</td>
<td>1.4 fc (14.0 lux)</td>
<td>0.8 fc (8.0 lux)</td>
<td>6:1</td>
</tr>
</tbody>
</table>

**Major** = Roadway system that serves as the principal network for through traffic flow.

**Collector** = Roadway servicing traffic between major and local streets.

**Local** = Streets primarily for direct access to residential, commercial, industrial, and other abutting property.

**High** = Areas with significant numbers of pedestrians expected to be on the sidewalks or crossing the streets during the hours of darkness. Over 100 pedestrians during the average annual peak hour of darkness, typically 18:00 to 19:00 hours.

**Medium** = Areas where lesser numbers of pedestrians use the streets at night. Between 11 and 100 pedestrians during the average annual peak hour of darkness, typically 18:00 to 19:00 hours.

**Low** = Areas with low volumes of nighttime pedestrian usage. Less than 11 pedestrians during the average annual peak hour of darkness, typically 18:00 to 19:00 hours.

*Note: Use values for local/local functional classification if roundabout is located on roadway without continuous lighting.

Source: Adapted from IES *Design Guide for Roundabout Lighting* (1)
### LIGHTING EQUIPMENT TYPE

<table>
<thead>
<tr>
<th>Type of Lighting Assembly</th>
<th>Typical Wattage</th>
<th>Typical Distribution</th>
<th>Common Mounting Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobra-style</td>
<td>75 W–400 W HPS</td>
<td>Type II or III (full or semi cutoff)</td>
<td>30 to 50 ft (9 to 15 m)</td>
</tr>
<tr>
<td>Ornamental</td>
<td>75 W–200 W HPS</td>
<td>Type V (360° spread)</td>
<td>14 to 20 ft (4 to 6 m)</td>
</tr>
<tr>
<td>High-Mast</td>
<td>400 W–1,000 W HPS</td>
<td>Type V (360° spread)</td>
<td>50 to 100 ft (15 to 30 m)</td>
</tr>
</tbody>
</table>

W = watts; HPS = High Pressure Sodium
Source: Kansas Roundabout Guide (9)
CENTRAL VS PERIMETER LIGHTS

Central Illumination Design

Perimeter Illumination Design
## Advantages & Disadvantages for Perimeter Lighting

<table>
<thead>
<tr>
<th>Illumination Type</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perimeter illumination</td>
<td>• Illumination can be strongest around critical bicycle and pedestrian areas.</td>
<td>• Illumination is weakest in central island, which may limit visibility of roundabout from a distance.</td>
</tr>
<tr>
<td></td>
<td>• Continuity of poles and luminaires is maintained for the illumination of the lanes, as well as good visual guidance on the circulatory roadway.</td>
<td>• More poles are required to achieve the same illumination level.</td>
</tr>
<tr>
<td></td>
<td>• Approach signs typically appear in positive contrast and thus are clearly visible.</td>
<td>• Poles may need to be located in critical conflict areas to achieve illumination levels and uniformity.</td>
</tr>
<tr>
<td></td>
<td>• Maintenance of luminaires is easier due to curbside location.</td>
<td></td>
</tr>
</tbody>
</table>
## ADVANTAGES & DISADVANTAGES FOR CENTRAL LIGHTING

<table>
<thead>
<tr>
<th>Illumination Type</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
</table>
| Central illumination | - Perception of the roundabout is assisted at a distance by illuminating the central island.  
- Fewer poles are required to achieve the same illumination.  
- Pole in central island is clear of critical conflict areas for all but the smallest of roundabouts.  
- Exit guide signs on the periphery appear in positive contrast (front lit) and thus are clearly visible. | - Cannot achieve adequate vertical lighting levels without additional approach lighting.  
- Illumination is weakest in critical pedestrian and bicycle areas.  
- Signs on the approach are in negative contrast (back lit).  
- A path is needed to the base of the central pole for maintenance.  
- There is a greater risk of glare.  
- The central pole affects central island landscaping plan.  
- High mast lighting may be inappropriate in urban areas, especially residential areas. |

Source: Adapted from Kansas Roundabout Guide (9)
MONITORING AND MAINTENANCE
- Periodic relamping
- Periodic nighttime inspections
- Citizen (Police) reports
  - Phone calls
  - Emails
  - Smart Phone Apps
- Internal system monitoring
  - Glendale, AZ
  - *(Had to discontinue due to cost)*
QUESTIONS / RESOURCES

- FHWA Lighting Handbook – 2012
- Informational Report lighting Design for Midblock Crosswalks
- Pedestrian Lighting Citywide plan City of Seattle
  - http://www.seattle.gov/transportation/pedestrian_masterplan/docs/PedLightingFINAL.pdf
- Accessing Transit Design Handbook for Florida Bus Passenger Facilities
- Public Lighting for Safe and Attractive Pedestrian Areas NZ Transport Agency Research Report 405
- Design and Evaluation of Effective Crosswalk Illumination Final Report NJDOT