Roadway & Intersection Lighting
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“Driving Down Fatalities Through Knowledge Sharing”
Brief History of Lighting

First use of street lighting is believed to be in Ancient Greece around the 4th Century in the City of Antioch.

Next significant use was in Cordova in the Arab Empire around 9th and 10th Century, then London in about 1417.

It was introduced in the US by Benjamin Franklin in Philadelphia, using candles in lanterns which he fashioned to have 4 separate glass sides.

William Murdoch introduced gas lighting to London in 1792 and the US followed soon with gas lighting in Newport RI around 1803.
Brief History of Lighting

Electric Light bulbs for street lamps were developed soon after Edison’s invention of the incandescent bulb

The first City to use electric lights was Wabash Indiana in 1880.

Introduced in 1948 mercury vapor was the first major improvement to the incandescent street light.

In 1957 Westinghouse introduced the cobrahead, GE its followed later with its own version.

High Pressure Sodium (HPS) was invented in 1970 and in wide use since the 80’s.

Light Emitting Diode (LED) Roadway Luminaire not introduced until more recently, mid 2000’s, is FDOT preferred lighting on new systems.
Purpose

• Reduce nighttime vehicle crashes, injuries and fatalities

• Reduce nighttime pedestrian and bicycle crashes, injuries and fatalities

“Driving Down Fatalities Through Knowledge Sharing”
Numerous studies have shown nighttime fatal crashes have been reduced up to 60% with installation of roadway lighting.*

- Elvik and Vaa (2004) 64% reduction of fatal crashes, 28% reduction and 17% reduction in property damage only crashes after lighting installed.
- Per Ole Wanvik (2009) 28% reduction in injury crashes, 60% reduction in fatal crashes, a 45% reduction in injury crashes involving pedestrians.
- Minnesota Local Road Research Board (2006) before and after study found that 44% of the intersections showed reduction in number of nighttime crashes.

*FHWA Lighting Handbook Aug 2012
Highway Safety Improvements with the Highest Benefit-Cost Ratios (1974-1995)*

1. Illumination 26.8
2. Upgrade Median Barrier 22.6
3. Traffic Signs 22.4
4. Relocate/Breakaway Util. Poles 17.7
5. Remove Obstacles 10.7
7. Impact Attenuators 8.0
8. New Median Barrier 7.6
9. Upgrade Guardrail 7.5
10. Upgrade Traffic Signals 7.4

*Review of the Safety Benefits and Other Effects of Roadway Lighting for NCHRP/TRB June 2009
Positive Impacts

- Improve view of roadway geometry and adjacent environment.
- Increase sight distance to improve response to hazards and decision points.
- Eliminate dark spots and improve the mutual view of motorists and pedestrians.
- Provide clearer view during police, emergency, construction and maintenance activities or events.
Positive Impacts

- Well designed lighting helps with adjustment to avoid affects of glare
- Roadway lighting helps the eye adapt to increased levels of luminance
- Older drivers and pedestrians benefit from increased lighting levels
Negative Impacts

- **Light Trespass**
  - Glare - often referred to as Veiling Luminance
  - Spill light – light that falls outside the area intended to be lit
  - Sky Glow – Light that is reflected up into the atmosphere from source, road or other surfaces
• Light Trespass

Light pollution is often caused by the way light is emitted from lighting equipment. Choosing proper equipment and carefully mounting and aiming it can make a significant difference.
Light Trespass

SKY GLOW

GLARE
Warrant analysis is required for FDOT Projects

- Follow the guidance outlined in the Manual on Uniform Traffic Studies, chapter 15
- Requires a Letter of Acceptance or Memo of Understanding (MOU)
- Safety analysis or study showing that lighting would be a cost–effective alternative or countermeasure using the AASHTO or (HSM) predictive or other methodology
- Meeting the warrants does not guarantee that lighting must be installed
Lighting Justification

Step 1

AASHTO Warrants

- Traffic Volumes (ADT)
- Ratio of Night to Day Crashes (2.0 or greater)
- Local Government Participation in Cost- local government agreements
- 25 % (or greater) Nighttime crashes
Lighting Justification

Step 2

Determine if Project is justified based upon its Benefit Cost Ratio

- If Benefit Cost Ratio is 1.0 or greater then lighting is justified for high crash locations, but prefer to use 2.0 or greater for all locations

- If the benefit cost ratio is 2.0 greater then the location may qualify for federal safety funds
Lighting Justification

Map showing corridors with 25% or greater nighttime crashes

Available through District 7 Traffic Operations Safety Office

http://d7sharepoint.dot.state.fl.us/Operations/trafficSafety/Miscellaneous/Maps/Forms/AllItems.aspx
Lighting Justification

Predictive Method

- Highway Safety Manual Method
Lighting Justification

Other Important factors:

- FDOT policy to light all interchanges
- Lighting in adjacent areas
- Presence of crosswalks or medians
- Constructability, feasibility
- Engineering Judgement
Lighting Analysis

Software packages

1. AGI 32
2. Visual
3. Cala-holophane
4. Alladin-GE
Lighting Analysis Report

- Project overview or description (location)
- Purpose - specify lighting criteria, document methodology for selection
- Procedure - project designed to FDOT standards and PPM
- Analysis - software tool used
  - Alternatives - (parameters) describe luminaires (LED for new system), wattage, mounting height, cost comparisons, pole spacing
  - Design - criteria, photo metric analysis and lighting calculations
- Recommendations
- Lighting and Voltage Drop Calculations (Appendices)
LIGHTING ANALYSIS
Selection Factors

- Meets or exceeds, standards and specifications
- Photometric performance
- Durability, Aesthetics
- Availability
- Maintenance requirements
- Costs-initial and operation
Design Standards

- Florida Department of Transportation (FDOT)
  FDOT Design Standards
  Plans Preparation Manual (PPM)
- Federal Highway Administration (FHWA)
- American Association State Highway Transportation Officials (AASHTO)
- Illuminating Engineering Society of North America (IESNA)
- Local Agencies and Power Companies
FDOT lighting standards can be found in the Design Standard Indexes 17500 to 17515.

FDOT Design Standard Index 17515
Design Standards

Staggered

Median
Design Standards

One Side

Opposite
Design Standards

Typical Intersection Lighting on Mast Arm Signal Poles
Design Standards

FDOT lighting clear zone requirements for Conventional Lighting

• Urban curb and gutter < 45° – minimum 4’ from face of curb
• All other roadways - 20’ from travel lane or clear zone if less than 20’
• Breakaway supports unless median barrier mounted or shielded

PPM vol. 1 Chapter 2 Table 2.11.2
Design Standards

The Department uses the illuminance technique for all lighting design.

- **Illuminance** – It is a measure of how much light illuminates a surface.
- **Foot-candle** – The illuminance cast on a surface by a one-candela source one foot away.
## Design Standards

### Table 7.3.1: Conventional Lighting - Roadways

<table>
<thead>
<tr>
<th>Roadway Classifications</th>
<th>Illumination Level Average Initial Horizontal Foot Candle (H.F.C.)</th>
<th>Illumination Uniformity Ratios</th>
<th>Veiling Luminance Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interstate, Expressway, Freeway &amp; Major Arterials</strong></td>
<td>1.5</td>
<td>4:1 or Less</td>
<td>10:1 or Less</td>
</tr>
<tr>
<td><strong>All Other Roadways</strong></td>
<td>1.0</td>
<td>4:1 or Less</td>
<td>10:1 or Less</td>
</tr>
<tr>
<td><em>Sidewalks and Shared Used Paths</em></td>
<td>2.5</td>
<td>4:1 or Less</td>
<td>10:1 or Less</td>
</tr>
</tbody>
</table>

PPM vol. 1 Chapter 7 Table 7.3.1
Design Standards

Example of poor uniformity ratios
Where are we going?

Proposed changes to Chapter 7 include:

1. Methodology
   - Analysis Zones
   - Use Polygon Method for all Photometric Calculations
   - Lighting Criteria

2. Intersection Criteria
Proposed Design Standards

Urban and Rural FDOT Facilities

- Divided Roadway Segments
- Undivided Roadway Segments
- Signalized Intersection Segments
Proposed Design Standards

Photometric Calculations – Polygon Method

- Roadway Segments
  15 Feet Longitudinally
  5 Feet Transversely

- Signalized Intersection Segments
  5 Feet Longitudinally
  5 Feet Transversely
## Proposed Design Standards

### Table 7.3.3 Intersection Lighting With High Pedestrian Traffic

<table>
<thead>
<tr>
<th>ROADWAY CLASSIFICATIONS</th>
<th>ILLUMINATION LEVEL AVERAGE INITIAL FOOT CANDLE</th>
<th>ILLUMINATION UNIFORMITY RATIOS</th>
<th>VEILING LUMINANCE RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAJOR ARTERIALS</td>
<td></td>
<td>AVG./MIN. MAX./MIN. Ly(max)/Lavg.</td>
<td></td>
</tr>
<tr>
<td>Horizontal (H.F.C.)</td>
<td>3.0</td>
<td>4:1 or Less 10:1 or Less</td>
<td>0.3:1 or Less</td>
</tr>
<tr>
<td>Vertical (V.F.C.)</td>
<td>2.3*</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
</tbody>
</table>

**Note:** *Vertical illumination value is only valid for new projects or where the intersection is being reconstructed. The vertical illumination is a target value and may not be achievable for all traffic movements.*
Proposed Design Standards

Vertical Illuminance is the primary design value to be used to measure pedestrian visibility.
Proposed Design Standards

The vertical illuminance calculation method to be used at intersections will be the variable light meter aimed toward the driver’s location.

The driver’s location from the approach to the crosswalk is established based on the stopping sight distance for the posted approach speed.
Proposed Design Standards

The vertical illuminance method will be calculated for three movements at the intersection.

1. Near Side Crosswalk Approach
2. Right Turn Movement
3. Left Turn Movement
Proposed Design Standards
Near Side Approach
Proposed Design Standards

Right Turn Movement
Proposed Design Standards

Left Turn Movement
Lighting Challenges

- Intersection Luminaire Photometrics
- High Overall Lighting Levels
- Transition Lighting Requirements
Lighting Challenges

- Turtle Nesting
  [http://ca.dep.state.fl.us/mapdirect](http://ca.dep.state.fl.us/mapdirect)
- Nocturnal Animals
- Development
- Pedestrian activity level (conflicts)
Lighting Challenges

- Roadside safety considerations
- Available power
- Presence of overhead and underground utilities
- Proximity to Railroads and Airports
- Maintenance agreements
- Existing lighting
## Lighting Challenges

<table>
<thead>
<tr>
<th>Voltage (kV)</th>
<th>X (Min. Clearance Dist. in ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 50</td>
<td>10</td>
</tr>
<tr>
<td>&gt;50 - 200</td>
<td>15</td>
</tr>
<tr>
<td>&gt;200 - 350</td>
<td>20</td>
</tr>
<tr>
<td>&gt;350 - 500</td>
<td>25</td>
</tr>
<tr>
<td>&gt;500 - 750</td>
<td>35</td>
</tr>
<tr>
<td>&gt;750 - 1000</td>
<td>45</td>
</tr>
<tr>
<td>&gt;1000</td>
<td>As per utility owner /reg. prof. engineer</td>
</tr>
</tbody>
</table>

[Diagram showing the relationship between different voltage classes and the respective minimum clearance distances.]
Lighting Challenges

LOCATION MATTERS

Stay out of the bottom of the ditch
Lighting Challenges

RETROFIT PROJECTS

Consider Lighting
Lighting Challenges

RETROFIT PROJECTS

Consider Lighting
Lighting Challenges

RETROFIT PROJECTS

Light pole relocated and pull box added
Lighting Challenges

RETROFIT PROJECTS

Adjust pole location, path location, ditch location or all of the above
HIGH MAST LIGHTING

Consider the needs of adjacent properties and add shades if needed
Lighting Challenges

INTERSECTION LIGHTING

Power Company lighting on utility pole
INTERSECTION LIGHTING

Power Company lighting attached to signal pole with overhead power service
INTERSECTION LIGHTING

LED Lighting installed to improve pedestrian visibility
INTERSECTION
LIGHTING

Power Company lighting on stand-alone pole
Lighting Challenges

DAY

NIGHT
Lighting Challenges

INTERSECTION LIGHTING

Stand-alone DOT pole
Lighting Challenges

INTERSECTION LIGHTING

DOT luminaire attached to a signal pole
Lighting Challenges

EXAMPLE OF LUMINAIRE ATTACHMENT

Add note requiring a Shop drawing submittal
INTERSECTION LIGHTING

Powered through the traffic signal source
Lighting Challenges

INTERSECTION LIGHTING

County owned stand-alone light poles

“Driving Down Fatalities Through Knowledge Sharing”
Lighting Challenges

NIGHT TIME

DAYLIGHT
Lighting Challenges

INTERSECTION LIGHTING
Design Standards

High Mast lighting

- 715-19-ABC High Mast Light Pole, Complete
- 715-500-2 Light Pole Cable Distribution System, High Mast

These pay items are both needed for high mast lighting plans
Sources, Resources and Credits

- FHWA- Lighting Handbook 2012
- FDOT- PPM, MUTS, Design Standards, “Greenbook”- Ch. 6
- ASSHTO- Roadway Lighting Design Guide
- IESNA (IES)- Illuminating Engineering Society of North America
- IMSA- International Municipal Signal Association
- ANSI- American National Standards Institute
- Chester Henson, State Traffic Standards Engineer
- History- Wikipedia
Questions?