PBIC Webinar Series

Lighting for Pedestrian Safety and Walkability

Frank Markowitz and Adam Smith
San Francisco Municipal Transportation Agency

James Le
Seattle Department of Transportation

Ronald Gibbons
Virginia Tech Transportation Institute

Wednesday, October 17, 2018

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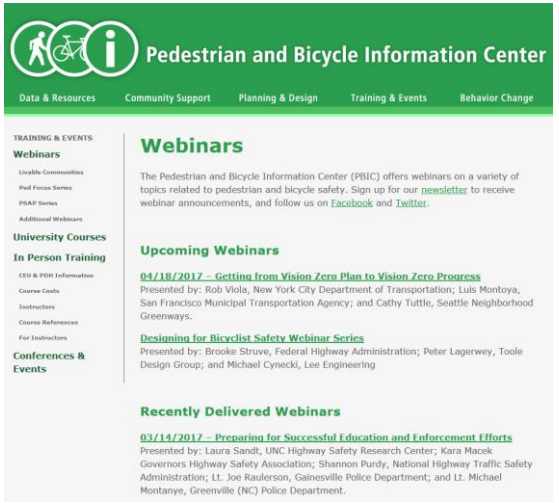

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Preventing Left-Turn Crashes Involving Pedestrians

Libby Thomas
UNC HSRC

David Hurwitz
Oregon State University

Chris Monsere
Portland State University

Bradley Topol
Seattle DOT

10/25, 2:00 – 3:30 PM Eastern

Rectangular Rapid Flashing Beacons

Megan McCarty Graham
Toole Design

Duane Thomas
FHWA

10/30, 1:00 – 2:30 PM Eastern

Strategies for Accelerating Multimodal Project Delivery

Wesley Blount
FHWA

Oana Leahu-Aluas
Cadmus

Mary Raulerson
Kittelson and Associates

Dan Gelinne
UNC HSRC

10/31, 1:00 – 2:30 PM Eastern

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Lighting for Pedestrian Safety and Walkability

Photo credit: NACTO website

PBIC Webinar, October 2018

Frank Markowitz, Principal Transportation Planner, San Francisco Municipal Transportation Agency (SFMTA)

Adam Smith, Transportation Planner, SFMTA

Presentation Outline

- **Background**
  - Benefits of lighting enhancements
  - Cost/adverse impacts of lighting enhancements
  - Lighting options

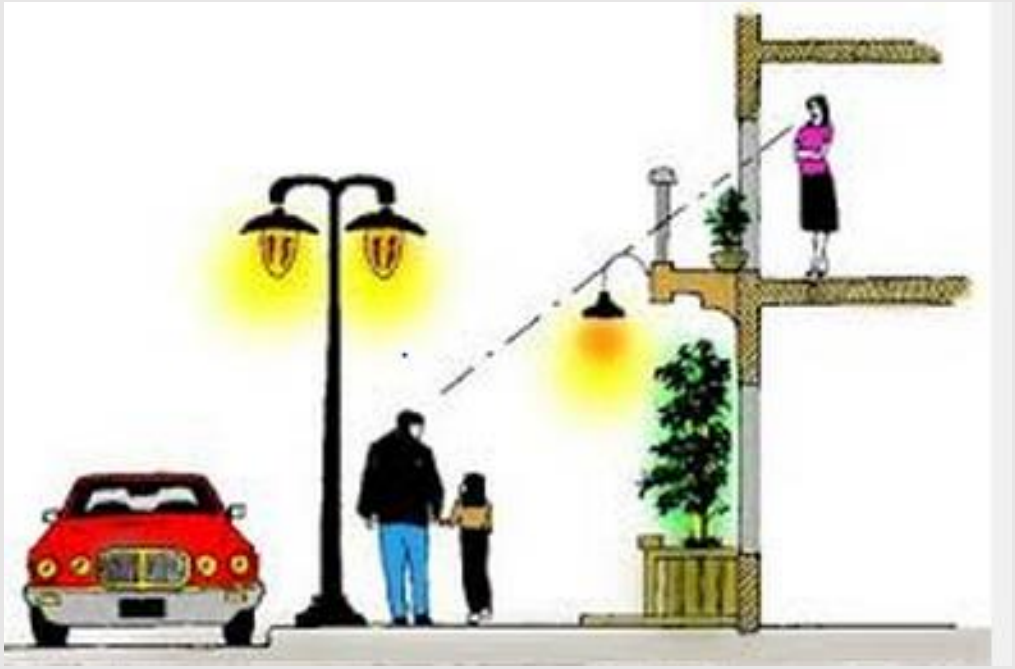
- **Case Studies**
  - Las Vegas “Smart Lighting” Project
  - San Francisco pedestrian lighting experience

Benefits of Lighting for Pedestrians: Safety

- **Pedestrian fatalities 3X + more likely at night**
- **Reduces pedestrian injuries**
  - -42-59% (national meta-analysis)
  - -12% (in Minnesota)

Photo credit: Aaron Bialick, Streetsblog

Benefits of Lighting for Pedestrians: Security & Comfort



- **Reduces crime**
  - 38% in UK and 7% in US
- **Improves comfort of walking**
  - Seattle: “low lighting” cited by citizens as barrier to walking after dark
- **Improves perceptions of security**
  - San Francisco: residents ask for enhanced lighting near bus stop

Image Credit: Santa Monica Office of Sustainability & the Environment

Benefits of Lighting:
Sense of Place

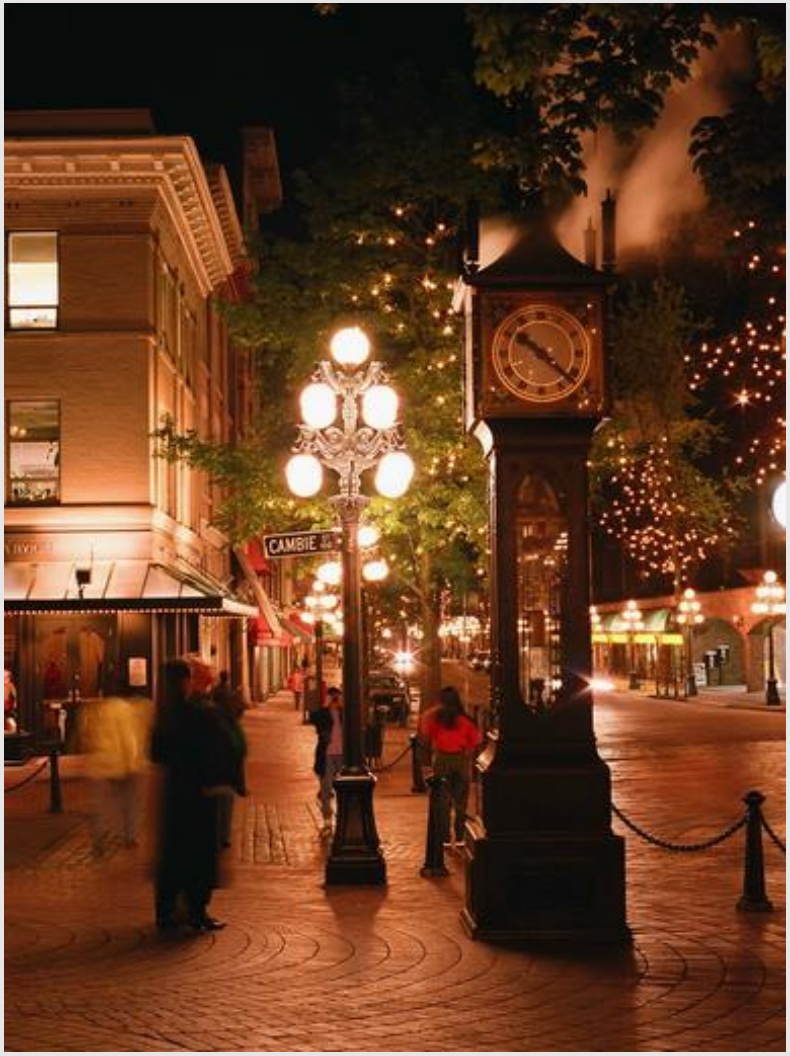


Photo credit: Dave Burdett, Map the Novel.com

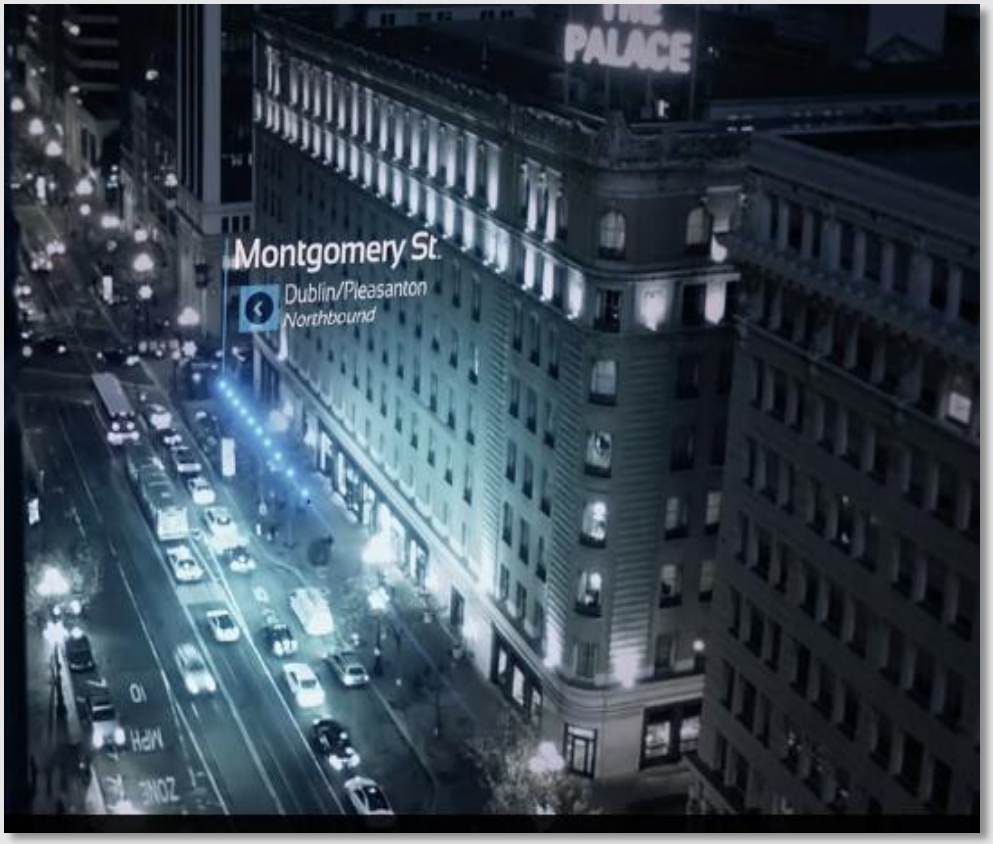
Benefits of Lighting:
Aesthetics and Entertainment

Vancouver

San Jose Underpass

Photo credit:https://www.artplaceamerica.org/funded-projects/illuminating-downtown

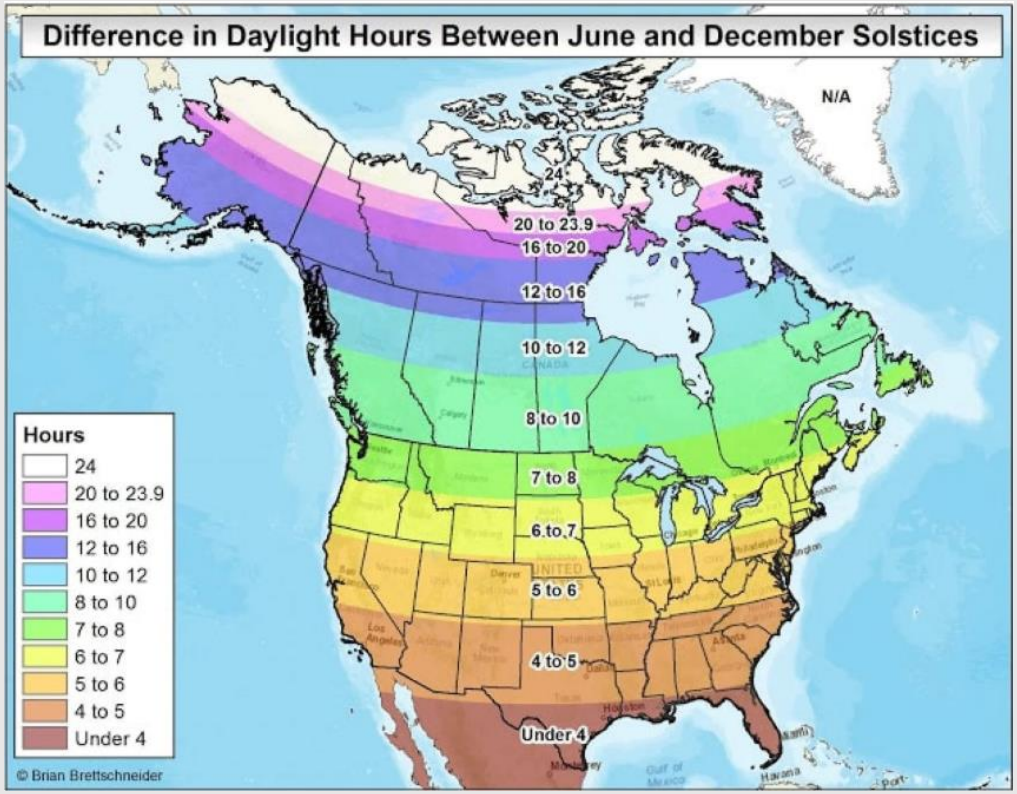
Benefits of Lighting: Aesthetics and Information



San Francisco: Proposed LightRail

Photo credit: ILLUMINATE (http://illuminatethearts.org/projects/)

Low Light Conditions Not Just at Night



Costs of Enhanced Lighting

- **Capital Costs**
  - Crosswalk: $11,000 - $42,000
  - Block: $600,000 for 1/3 mile of ped scale lighting in SF
- **Operating & Maintenance Costs/Energy**
  - $700+ per year per intersection (Minnesota)

Other Potential Issues with Enhanced Lighting

Glare

Light Trespass

https://solutions.borderstates.com/light-pollution-101-what-is-light-trespass/

Traditional Lighting Options

Street (Roadway) Lighting

- Over 20 feet high
- Spaced 100+ feet apart

Pedestrian-Scale Lighting

- 10-18 feet high
- Spaced about 50 feet apart

What's Possible?
Bollard Lighting

Image credit: https://www.aspentimes.com/news/aspen-mulls-pedestrian-lighting-system/

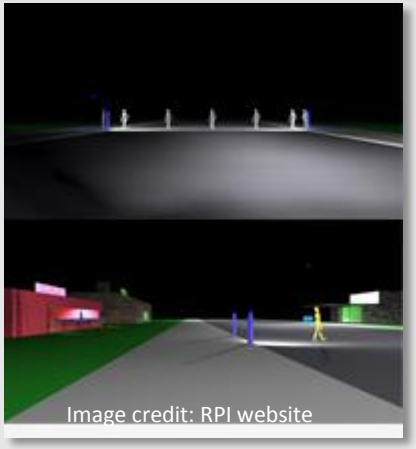
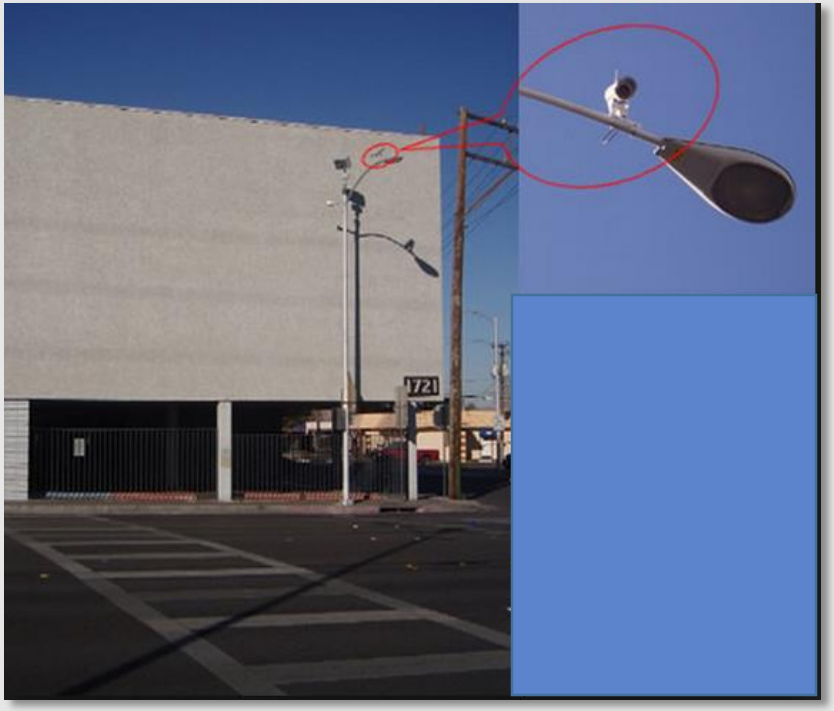


Image credit: RPI website

- **Illuminates pedestrians** in crosswalk but not background.
- **Field tested** in Aspen, CO; Schenectady and Slingerlands, NY; Old Bridge, NJ but rarely used.
- **Analysis**: significantly brighter and higher contrast, but also more glare-producing, than standard high pressure sodium overhead lighting (RPI, 2009 and 2015).
- Would have lower initial and operating **costs.**

What's Possible?
Smart Lighting Test in Las Vegas



- **Pedestrian activated lighting**
  - Federally funded test of supplemental midblock crosswalk lighting triggered by microwave/infrared detection of pedestrian crossing.
  - Part of a broad evaluation of generally low-cost physical measures to improve pedestrian safety.
- **Conclusion: significantly improved pedestrian safety**
  - Improved driver yielding
  - Reduced jaywalking
  - Reduced instances of pedestrian trapped mid-crossing

Image Credit: http://safety.fhwa.dot.gov/ped_bike/tools_solve/ped_scdproj/webinar052809/las_vegas/

San Jose – Smart Lighting

- **“Smart LED” Poles**
  - Replacing all street lights with “Smart LED” Poles
  - LEDs will save energy, with greener disposal
  - Control technology allowing remote control and monitoring, including dimming
- **Better Small Target Visibility (STV)**
  - Even at 50% of IES recommended levels, “white” LEDs better Small Target Visibility (STV) than full-power High Pressure Sodium
- **Automatic Dimming and Reduced Sky Glow**
  - Citizen perception tests of effects of dimming
  - Consulted local observatory about sky glow

San Francisco Better Streets Plan – Pedestrian-Scale Lighting

- **Better Streets Plan** Priorities:
  - Streets with high pedestrian volumes
  - Key civic, downtown, and commercial streets
  - Streets with concerns about pedestrian safety and security, such as at freeway underpasses
  - Small streets such as alleys and pedestrian pathways
- **City Catalog** of Approved Pedestrian-Scale Lights
- Policy to Provide **Operations & Maintenance Support**

San Francisco – Community Interest in Lighting

- **Frequently requested by citizens,** often concerned about crime
- **Tree canopies block street lighting** - Pedestrian-scale lighting often requested to counter
- **Pedestrians at crosswalk entrances often not as well illuminated as vehicles,** while intersection may meet IES illumination standards
- **More expensive** than most other pedestrian safety measures
  - Few “safety” funding sources
- **Coordination required** since SFMTA does not design, install or maintain street lighting

Balboa Park – Pedestrian-Scale Lighting at a Major Transit Hub

- **Balboa Park Station Capacity Study** :
  - **Assessed needs** at the largest public transit hub in SF outside of downtown
  - Identified lack of lighting as 3rd highest **barrier** to transfers (by intercept survey respondents)
  - **Concept plan** developed
  - Referred to potential for **artistic station lighting**

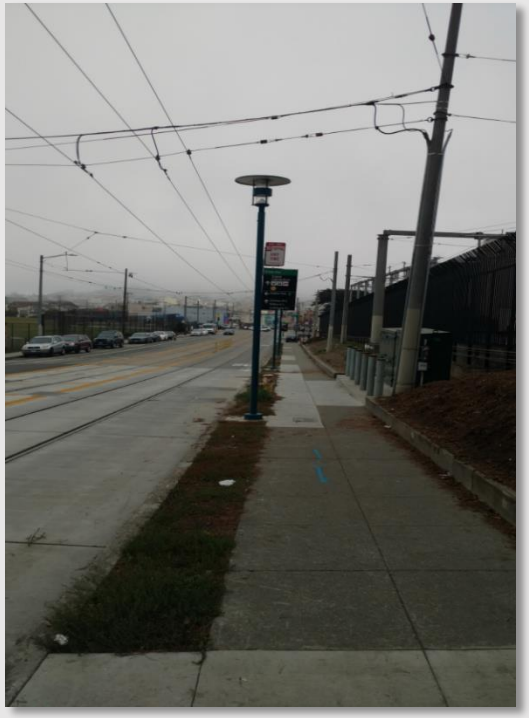
Balboa Park Lighting Concept

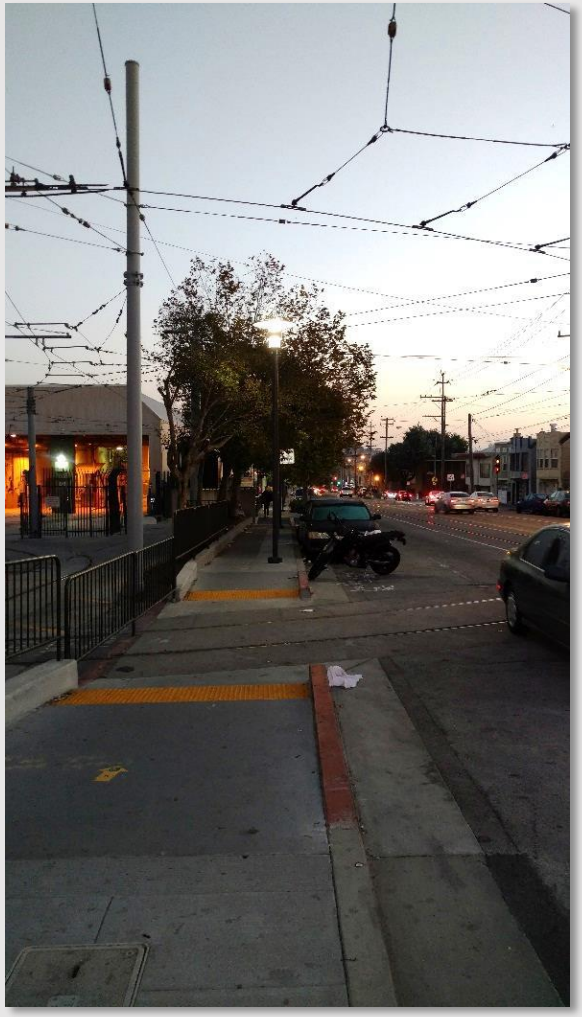
Spacing

- Concept plan recommended ped scale lights every 50 feet
- Existing street light spacing every 100 feet

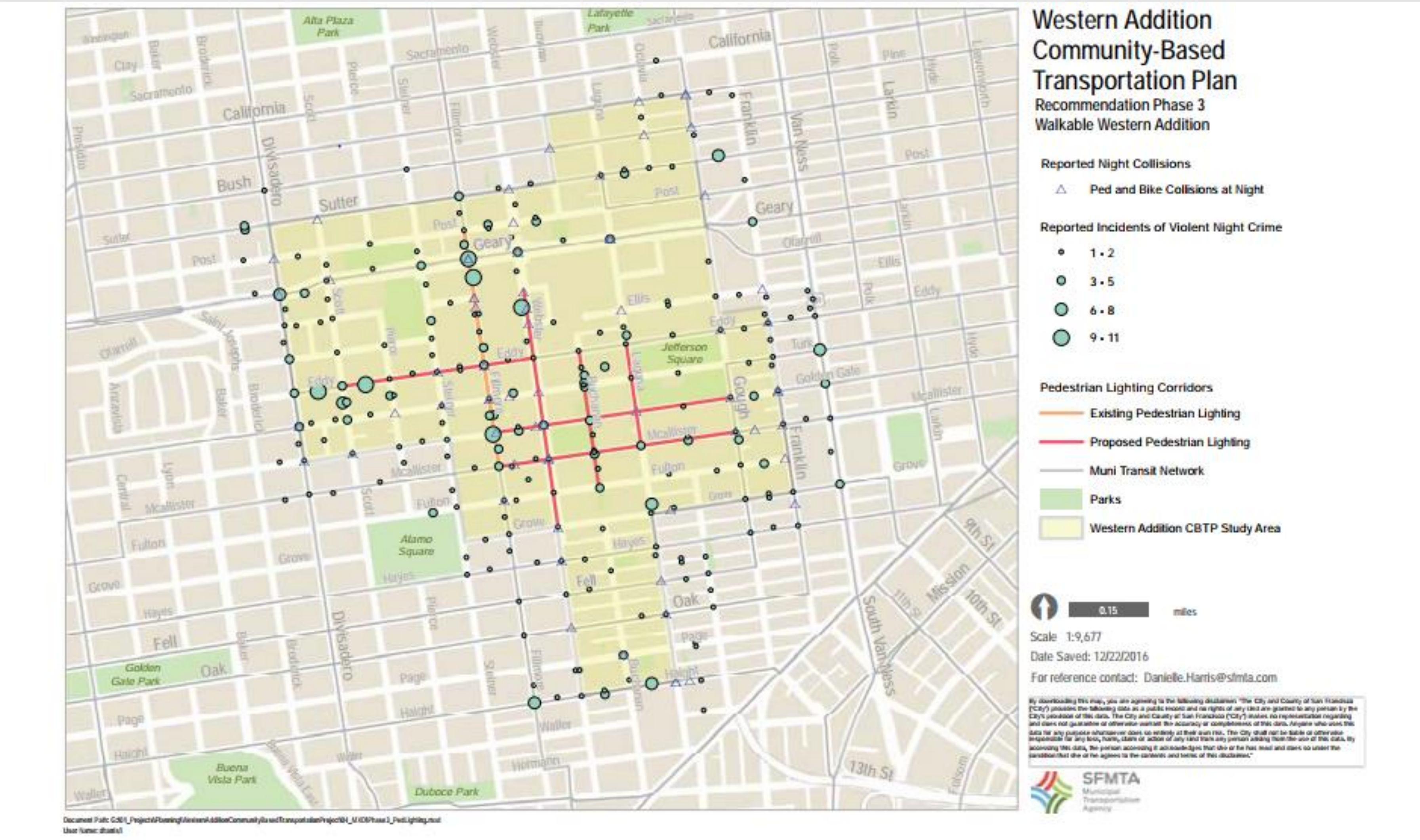
Fixture

- Louis Poulsen LP-170 with 12-foot Albertslund pole.
- LED
- 117 Watts
- 4000^{o} K





Mapping Pedestrian Lighting Corridors – SF Western Addition Neighborhood



Lighting for Pedestrians

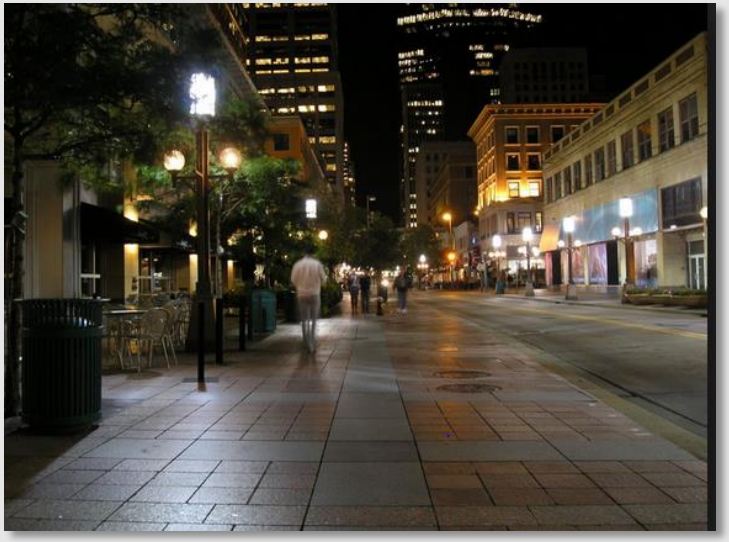


Photo credit: NACTO website

Credits

Danielle Harris, Senior Transportation Planner, SFMTA

Nick Carr, Senior Transportation Planner, SFMTA

Steven Lee, Lighting Engineer, SF Public Works

Fiat lux!

Contact: Frank Markowitz, Frank.Markowitz@sfmta.com

Lighting Projects in Seattle

Vision Zero

James Le
Pedestrian & Bicycle Information Center (PBIC) Webinar
October 17, 2018

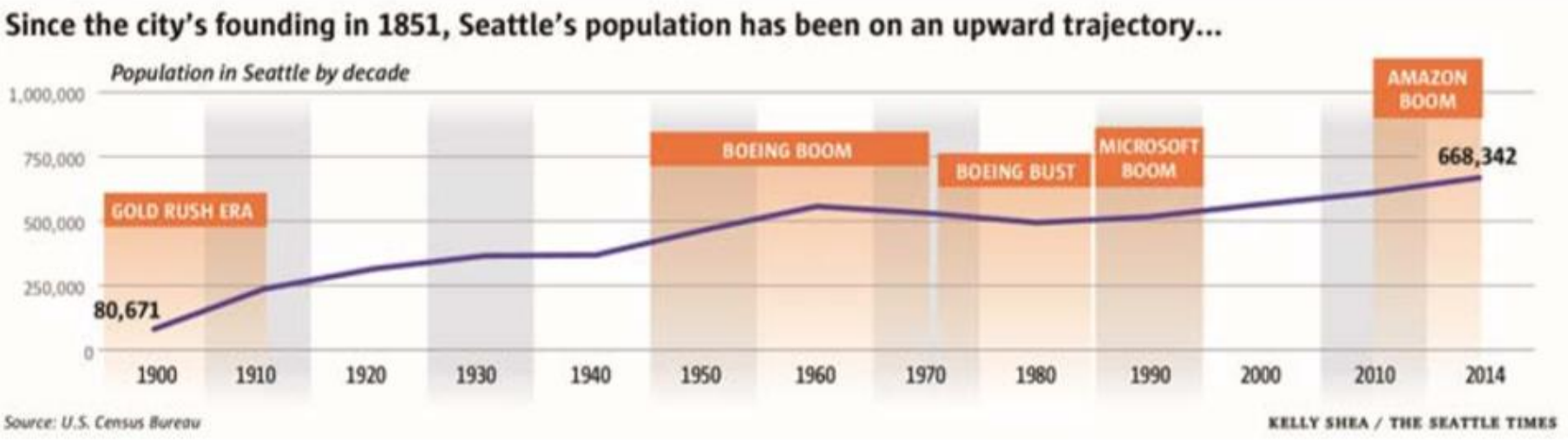
Seattle Department of Transportation

Presentation overview

- Background
- Lighting guidelines
- Projects
  - Arterial street lighting
  - Belltown adaptive lighting
  - Ballard Bridge lighting
- Q&A

Seattle is growing

- One of the fastest growing city in the US
- Population of +700,000



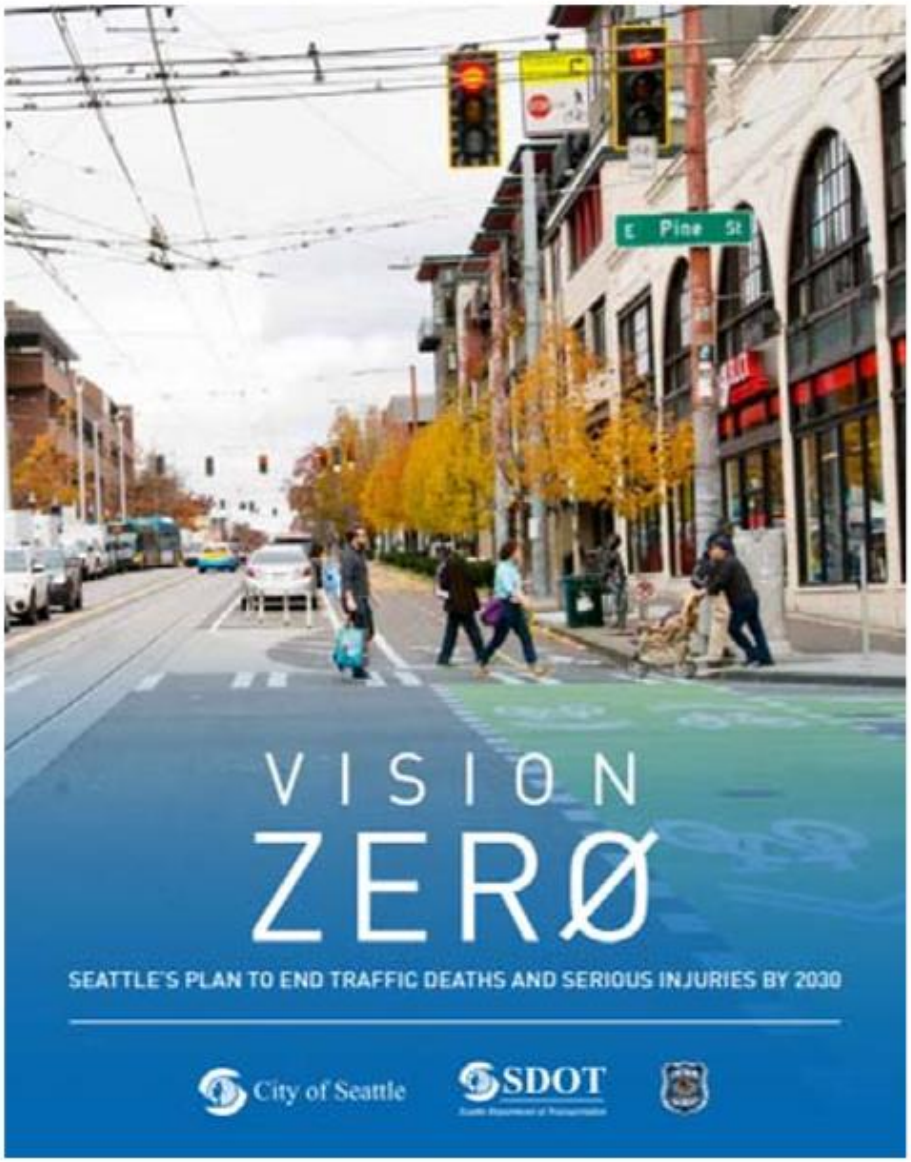
Trends


AVERAGE DAILY TRAFFIC IN SEATTLE
1,090,000
1,070,000
1,050,000
1,030,000
1,010,000
990,000
970,000
950,000
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
1,019,044
1,009,764
986,174
976,625


TRANSIT RIDERSHIP
160,000,000
150,000,000
140,000,000
130,000,000
120,000,000
110,000,000
100,000,000
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
158,069,578

Vision Zero

- End traffic deaths and serious injuries by 2030
- Multi-faceted approach through data driven action and the E's of safety:
  - Engineering
  - Education
  - Enforcement
  - Evaluation
  - Equity

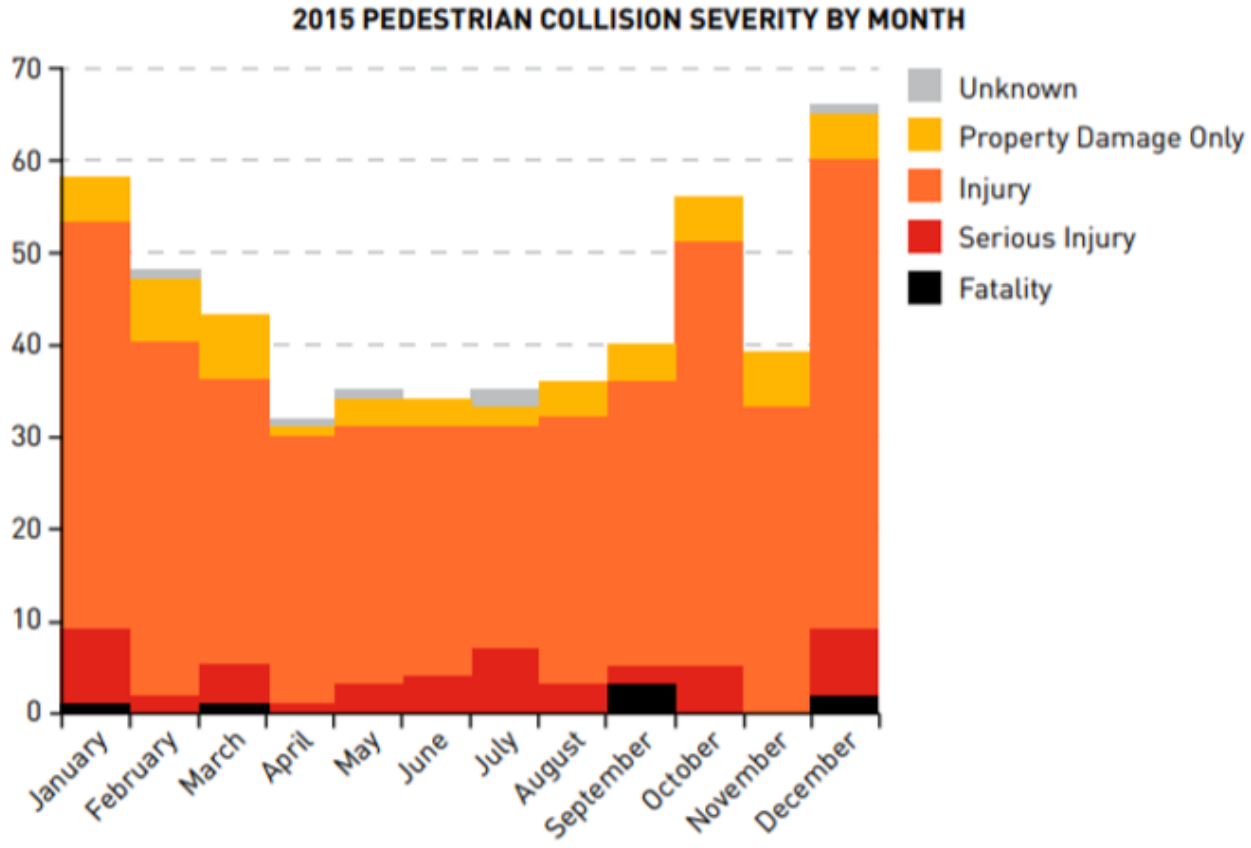


Progress

2017 Vision Zero Progress Report

Pedestrian crashes

Most pedestrian fatal crashes occur in the Fall/Winter months.

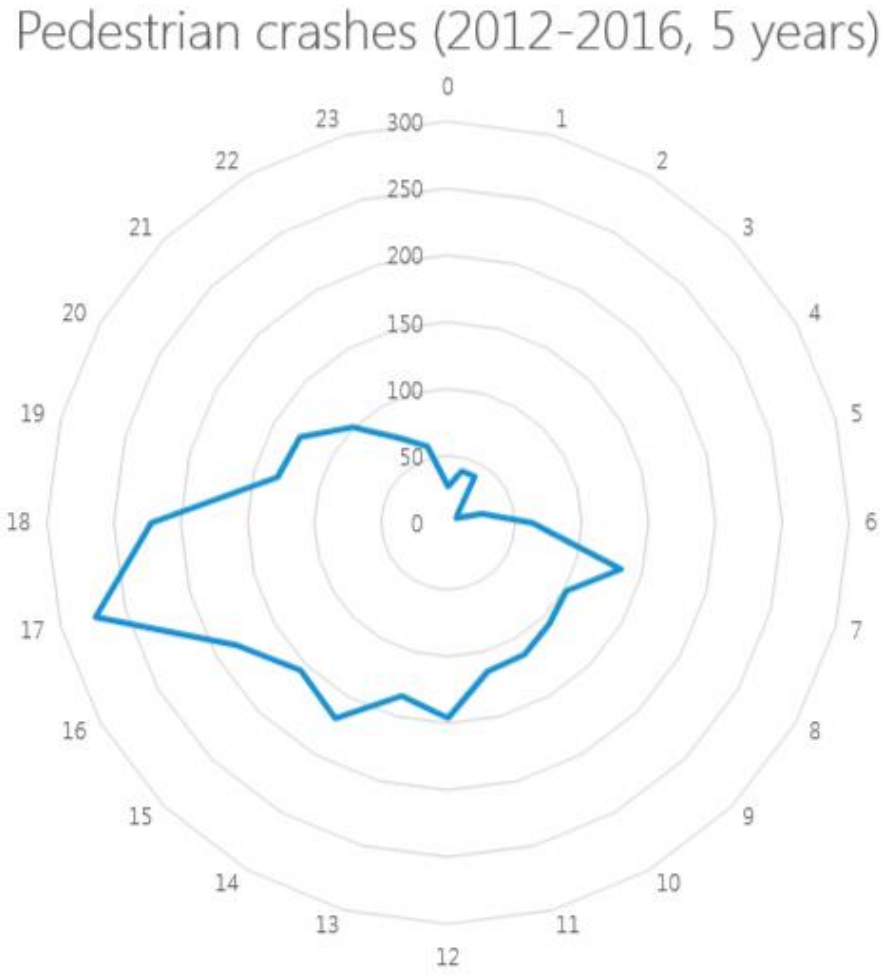


2016 Traffic Report

https://www.seattle.gov/transportation/reports.htm

Pedestrian crashes

Most pedestrian crashes happen between 5-6pm



Lighting guidelines

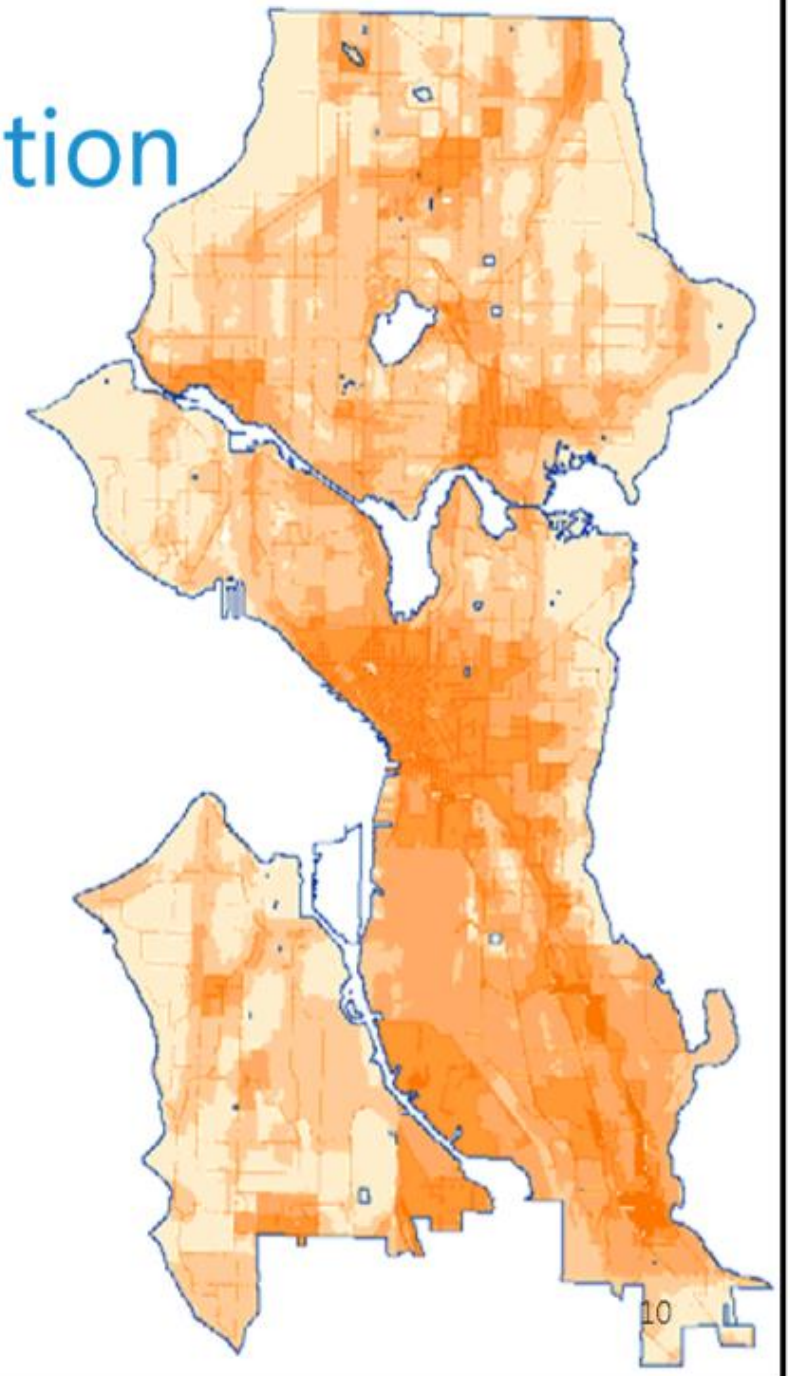
- Based on roadway characteristics (adapted from CIE 115:2010)
  - Speed limit
  - Presence of median or center turn lane
  - Bicycle facility type
  - Pedestrian Plan Priority Tier
  - Average block length
  - Traffic volume
  - Presence of curb parking

ILLUMINANCE CRITERIA						
Value determined in Step 2	≥ 5	4	3	2	1	≤ 0
Average Illuminance (fc)	2	1.7	1.2	1	0.7	0.5

Lighting criteria for LED light sources

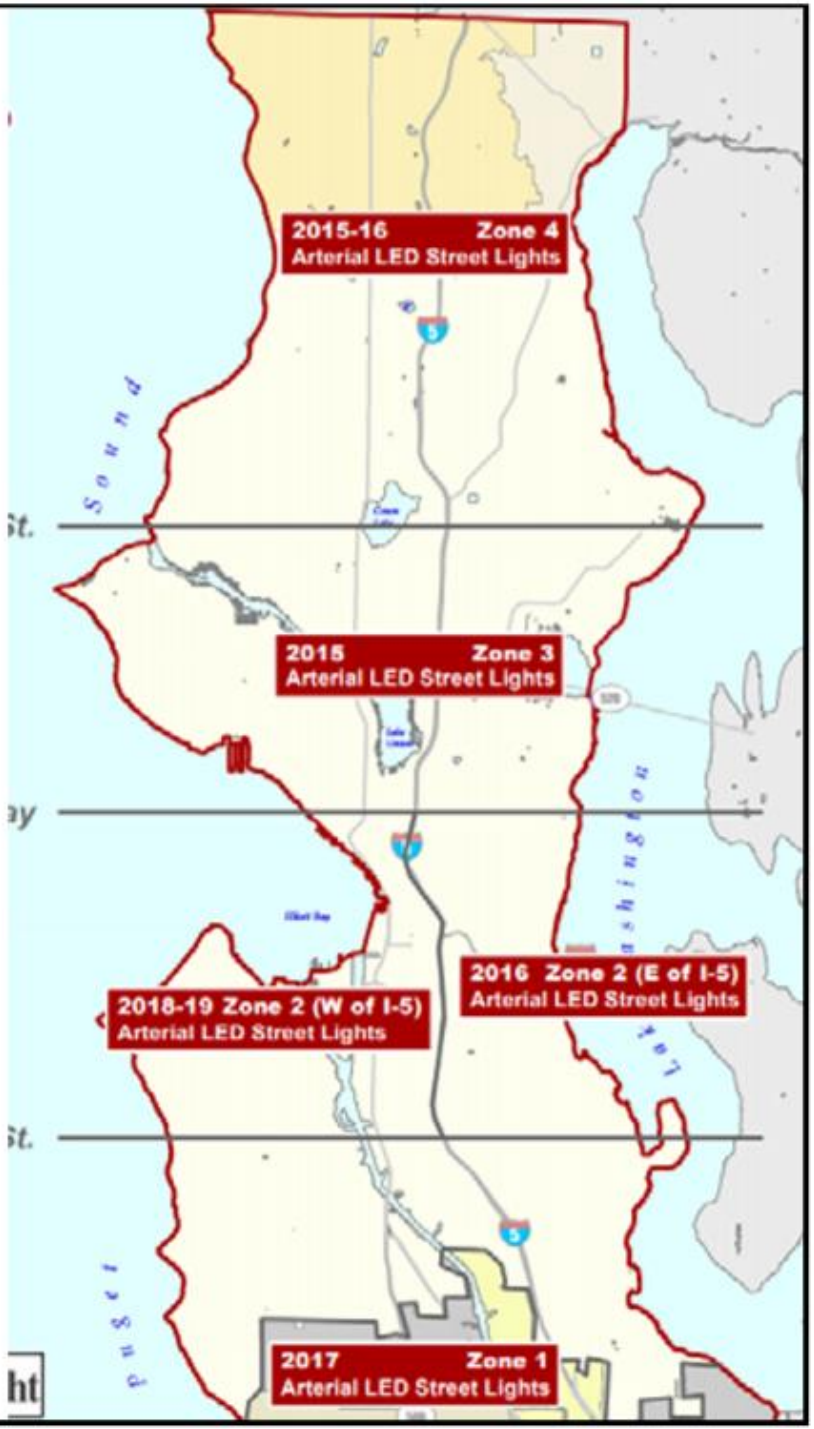
Ped lighting prioritization

- High priority areas
  - Pedestrian demand
  - Socioeconomic analysis
  - Street-type
  - Lighting gaps
- Crime deterrence
  - Illuminate areas visible to the public
  - Public can see and accurately report a crime



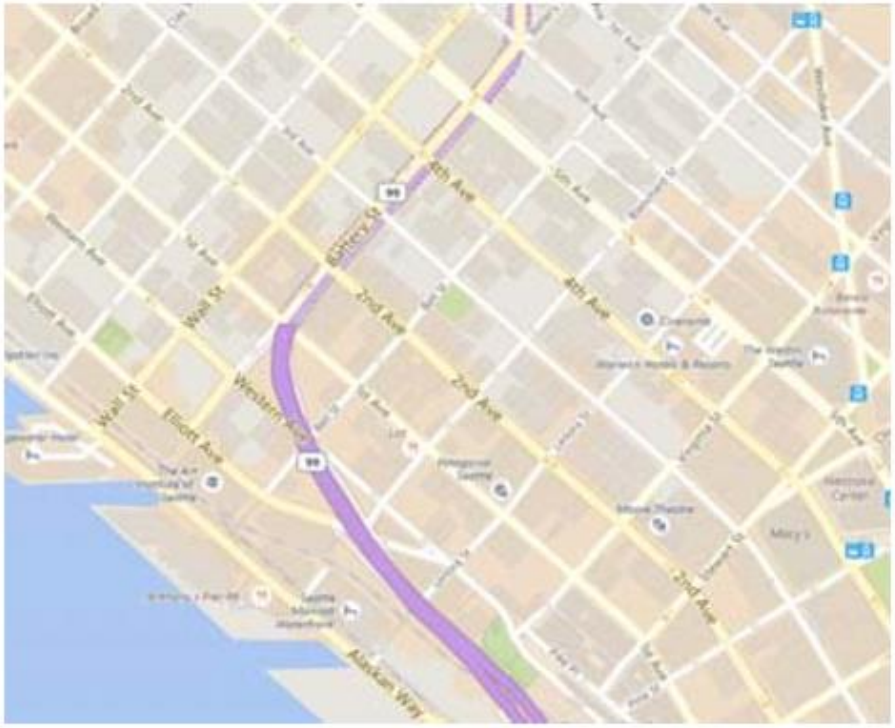
LED conversion

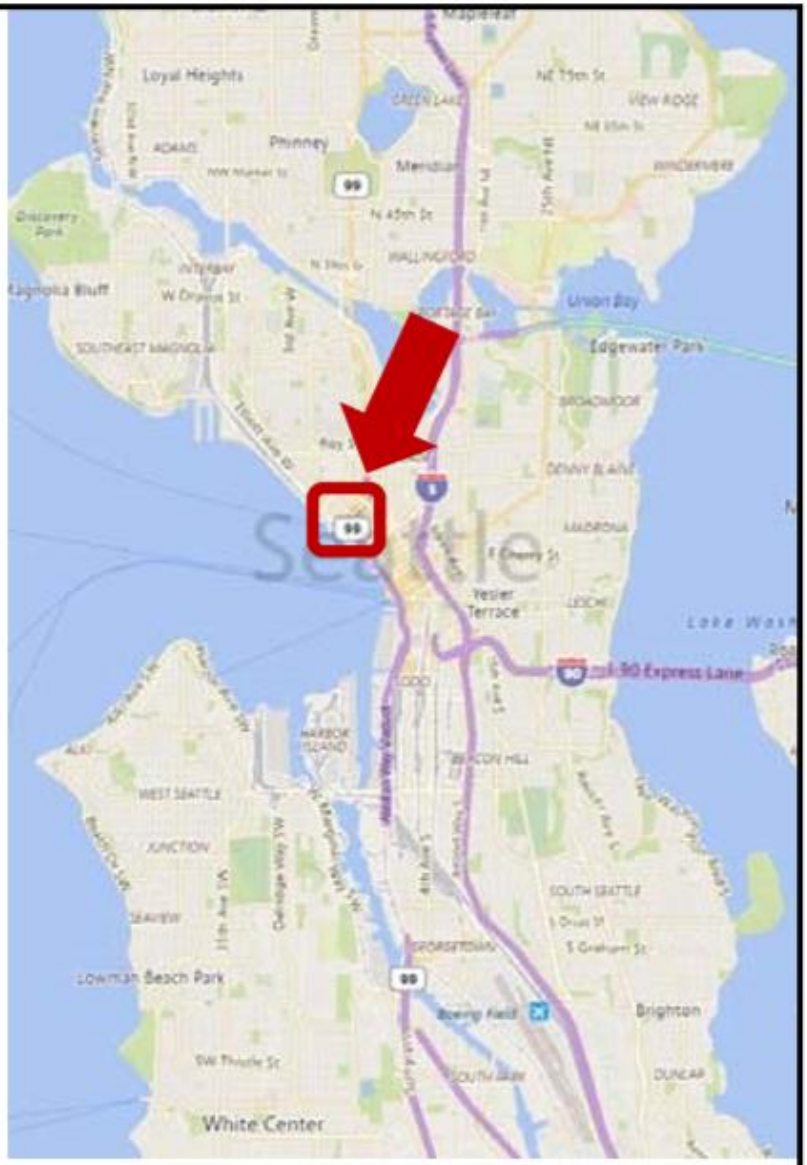
- Seattle has converted streetlights from HPS to LED
  - Residential streetlight conversion (2010-2014)
  - Arterial streetlight conversion (2015-current)
- SCL has LED standards for almost every fixture now
- Community feedback



Adaptive lighting

- Currently operating in Belltown
- Lighting level needs based on traffic and security.



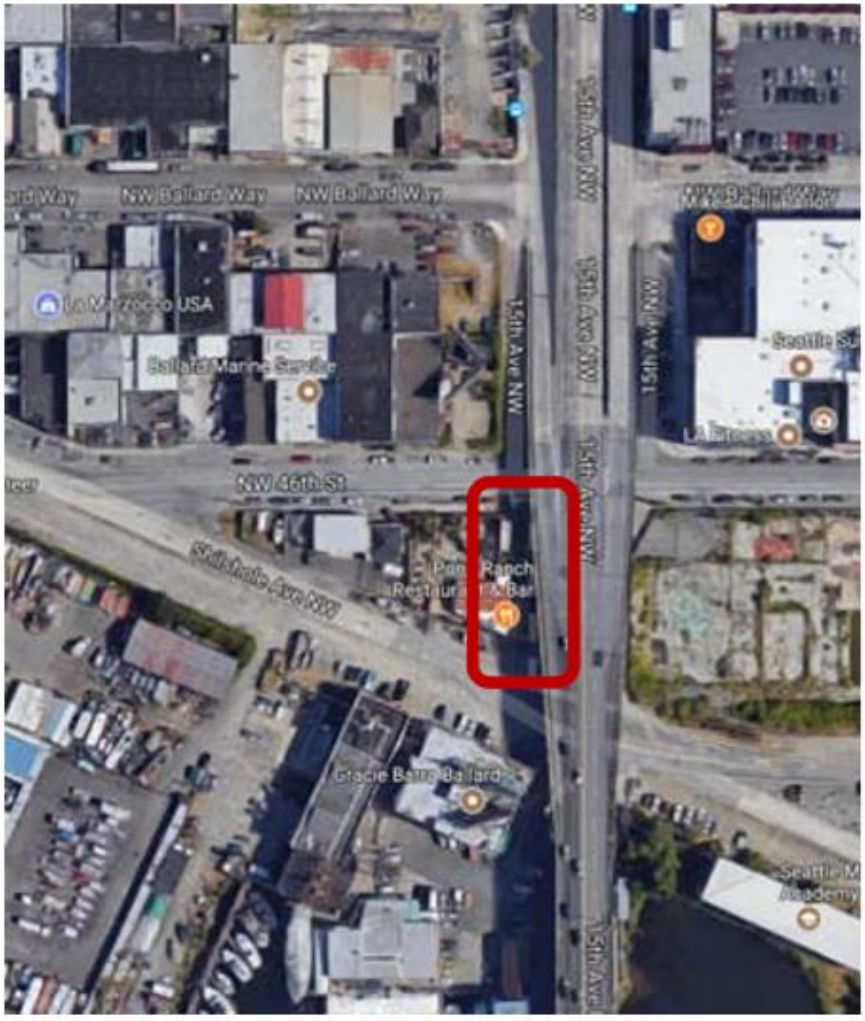


Adaptive lighting

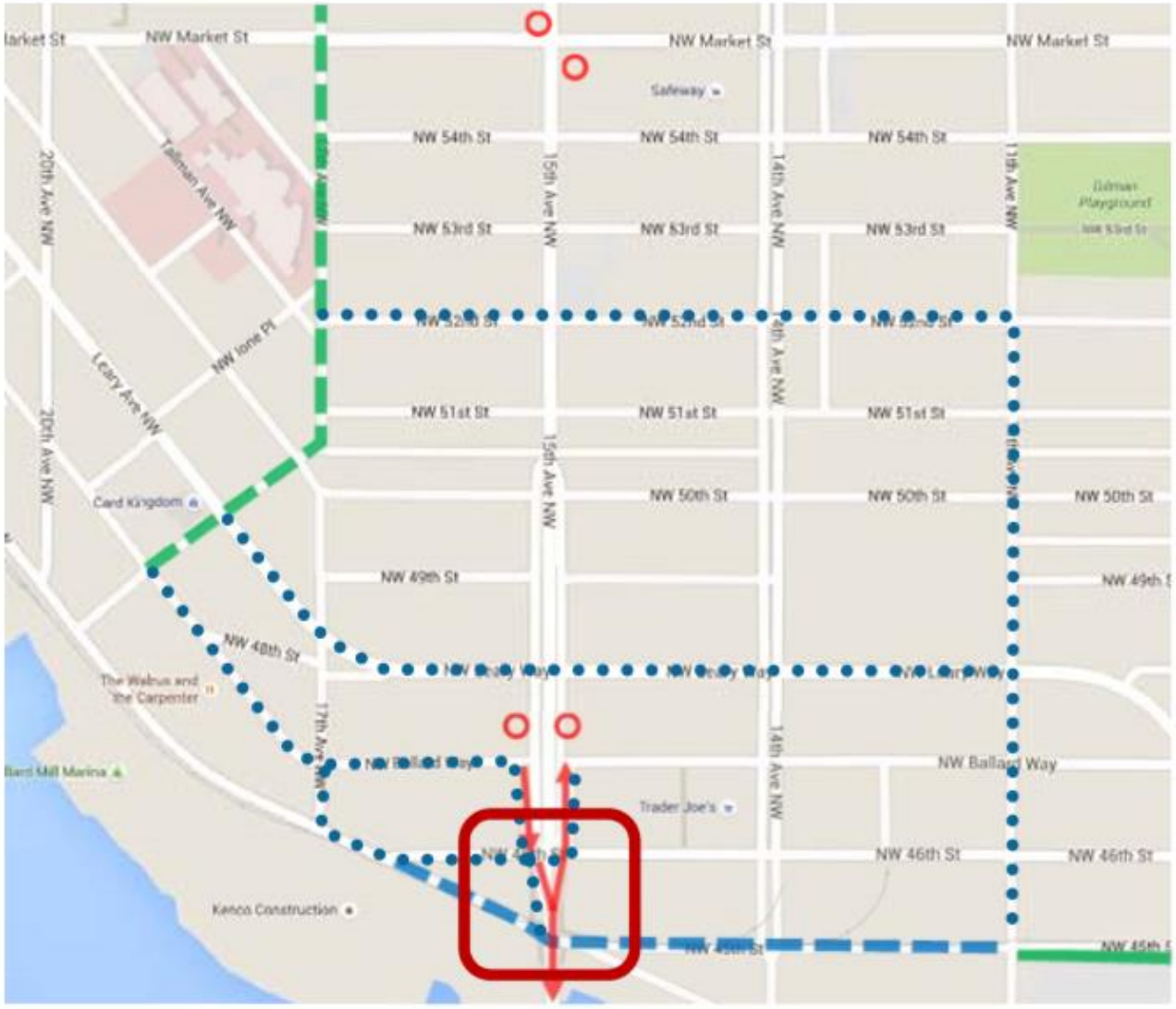
- Lighting levels:
  - 80% of lumen output from dusk to 1 AM (for traffic)
  - 100% of lumen output from 1 AM to 5 AM (to increase security when bars and clubs are closing)
- Future considerations:
  - Traffic volumes
  - Pedestrian activation

Ballard Bridge lighting project

Ballard Bridge



Connections



- Existing Greenway
- Existing On Street Bike Safety Improvements
- Existing Burke Gillman Trail
- Rapid Transit Connections
- Ballard Bridge Connections
- Connection Routes

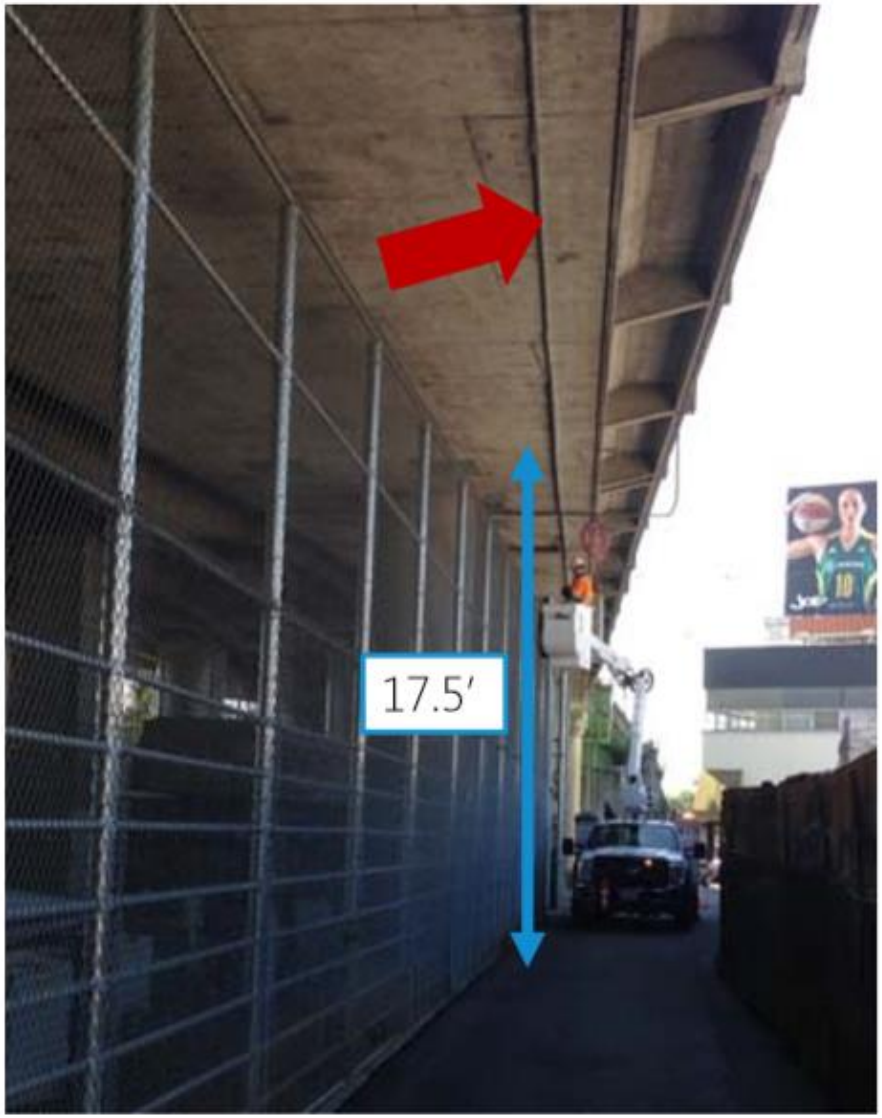
Project goals

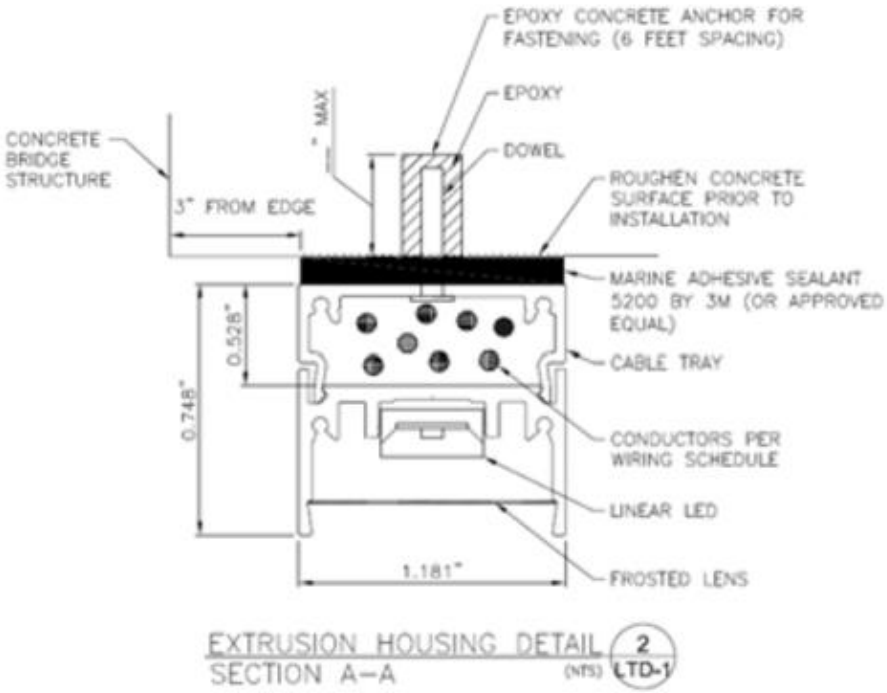
- Improve connection between the Burke-Gilman Trail and RapidRide
- Paved walkway
- Lighting

Challenges

- Roadway Structures access
- Utilities
- Drainage
- Non-standard lighting
- Power for lighting system
- FTA funding

Installation





After

Lighting criteria (for pedestrian/bike areas with LED lighting)	
Average	1.0 fc
Uniformity	4.0 or less

Calculated lighting levels	
Average	1.11 fc
Uniformity	2.78

After

Flex posts allows maintenance vehicles to go through.

Westlake bus shelter

We have used the same linear product for bus shelters.

Questions?

James.Le@seattle.gov
Project Development

www.seattle.gov/transportation

Seattle
Department of
Transportation

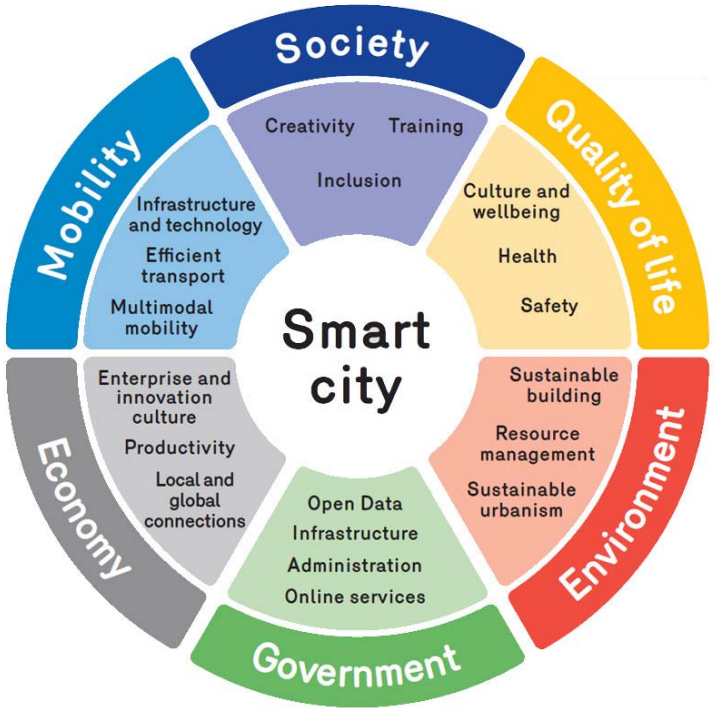
Connected Infrastructure Activities

Dr. Ronald Gibbons
Director
Center for Infrastructure Based Safety Systems

VirginiaTech
Transportation Institute

Connected Infrastructure and Smart Cities

- In our view a Smart City is an locality where data is used to increase the efficiency of the city operations for both the citizens and the government.



City of Brussels

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Connected Infrastructure

- Adaptive Lighting
  - Dimming of Lighting based on need
  - Data Collection based on Pedestrian and Vehicle Usage
  - Safety Improvements
  - Enabled by Solid State Lighting
- Lighting as an Enabler
  - Networking
  - Informational Gathering
  - Smart Poles

LED Acceptance

- LED lighting is the current direction
  - Very few new traditional projects
- Uncertainty on the Color of the light source
  - Detection issues
  - Color
- Lighting Level to use
- Acceptable of Led has been slowed
  - Negative effects
    - Health
    - Light Pollution
    - Electrical Issues
      - Fusing

Consider Light as a Drug

- Like every drug there are benefits and side effects.
- The question is:
  - How do we determine an appropriate dose and minimize the negatives?
- Also we need to establish a system to determine the dose as the needs of the infrastructure changes

Looking for “Just right” in Lighting

- So what is “Just Right”?
- We judge this by a variety of Dimensions
  - Roadway User Safety
    - Crash Reduction
      - Detection
      - Glare
  - Energy Consumption
  - Impact on User Health
  - Public Perception and Acceptance
  - Impact on Light Pollution
    - Trespass
    - Skyglow
  - Impact on Surrounding Areas
    - Flora
    - Fauna

- Our current approach is Adaptive Lighting

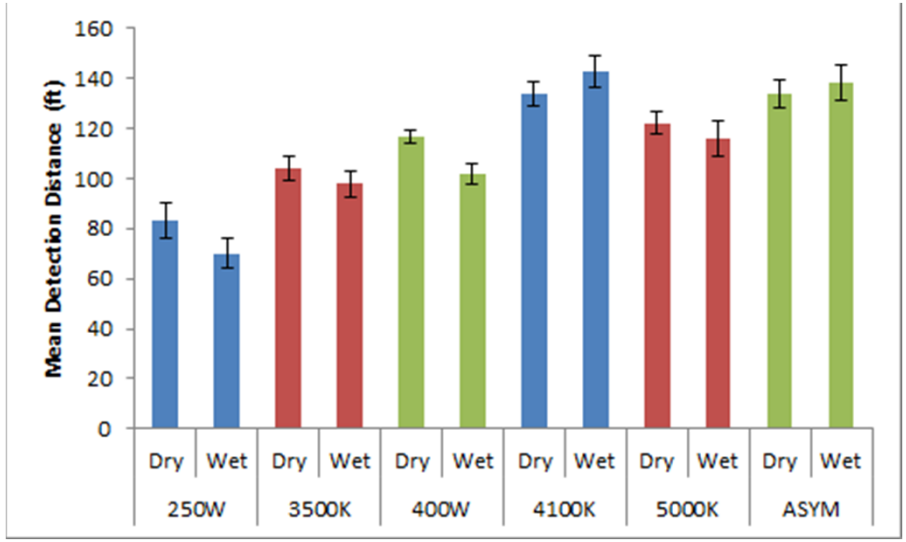
Positive Effects of Lighting

- Lighting is linked to safety
  - Some models exist
    - RVP
    - Cumulative Probability Functions
  - Correlative rather than Causative

- Lighting is generally a Secondary Effect
  - No police report says the crash was caused by the lighting

Impact on Visibility

- Critical to detecting pedestrians



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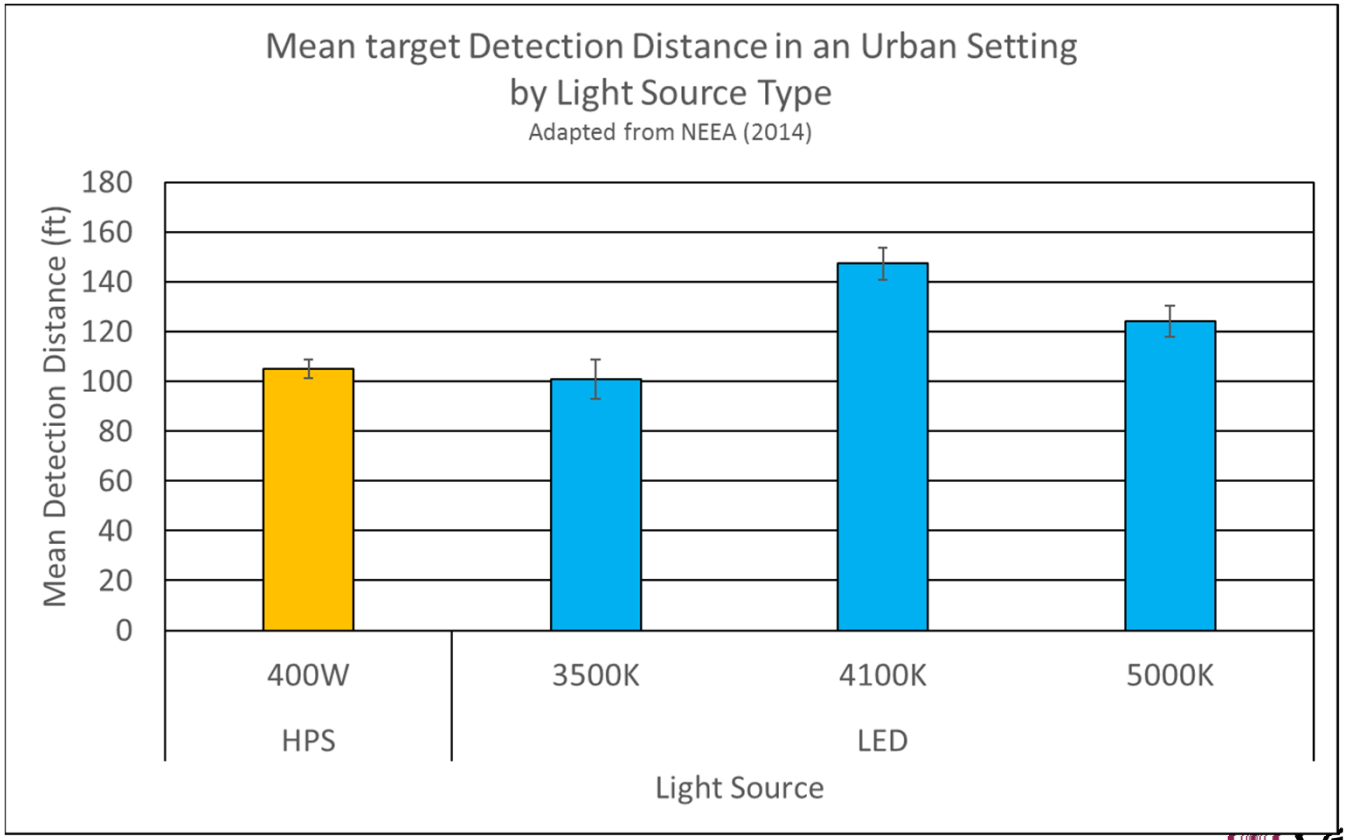
Light Source and Detection



https://neea.org/docs/default-source/reports/seattle-led-adaptive-lighting-study.pdf?sfvrsn=4

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Color Contrast

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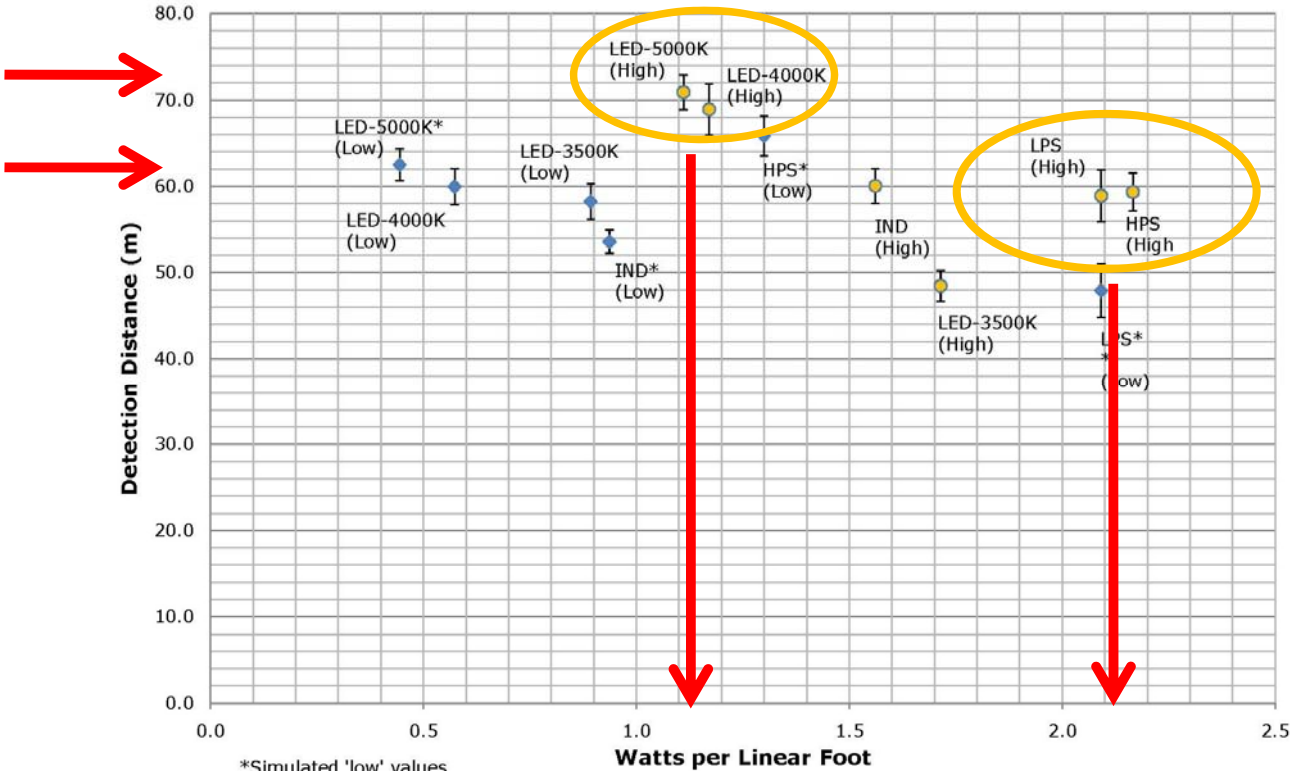
San Jose – Detection distance

vs watts per linear foot HIGH (100%)



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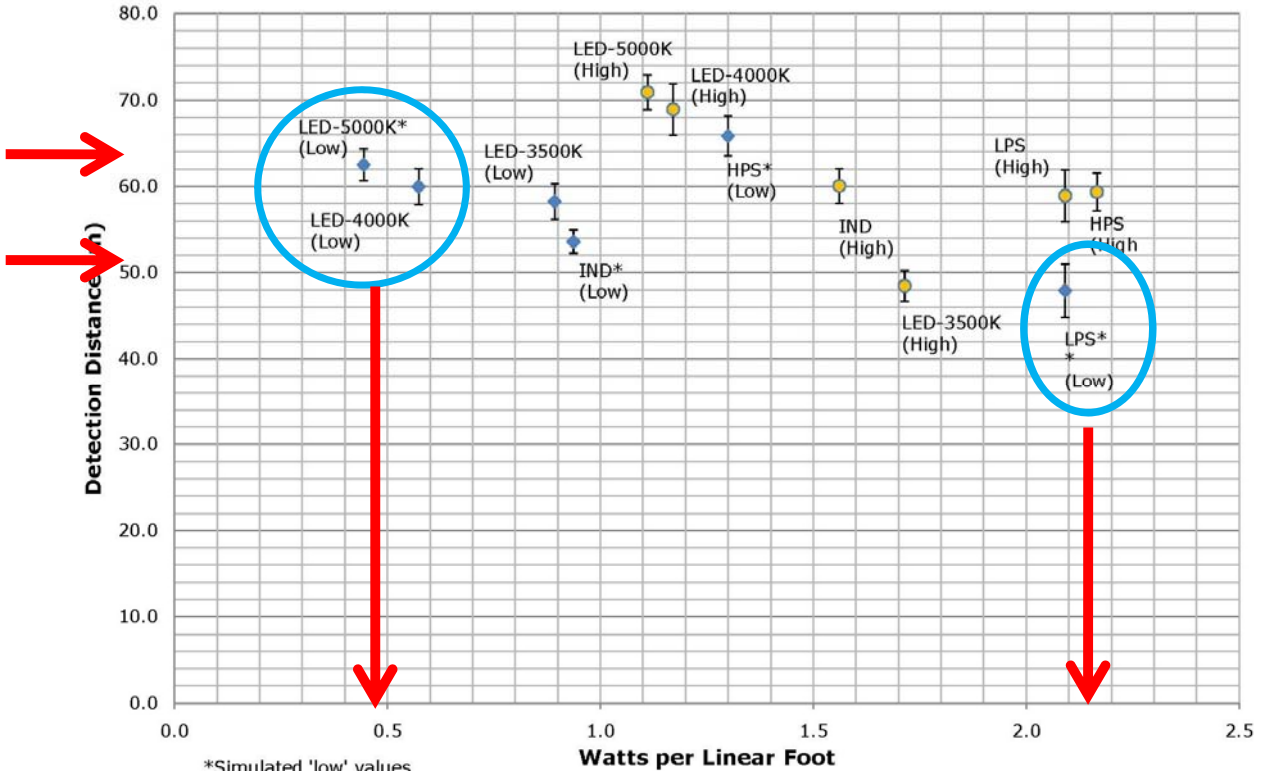
San Jose – Detection distance

vs watts per linear foot LOW (50%) setting



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Negative Impacts of Roadway Lighting

- Health Impacts
- Sky glow
- Impact on Flora and Fauna
  - Bugs, Buds, Bears and Bass

- Among others

AMA Report

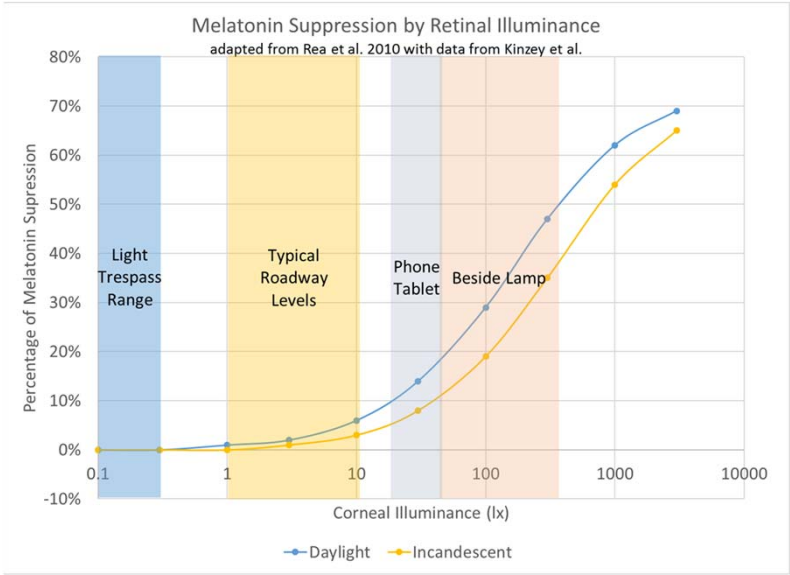
- AMA has stated –
  - Use 3000k
    - Reduces Sky Glow
    - Reduces impact in Humans
    - Reduces impact on Migratory Animals
    - Reduces impact on Sea Turtles

Investigating the Health Impacts of Outdoor Lighting

- There is a strong link between light and melatonin level
  - Impacting sleep, alertness, general health
- Highly Dependent on Dosage
  - Spectral
  - Quantity / Timing

Potential Impact on Human Health

- Preliminary there may be an impact
  - Correlation but no causation
- Roadway Lighting Levels are below thresholds
  - Research is on-going



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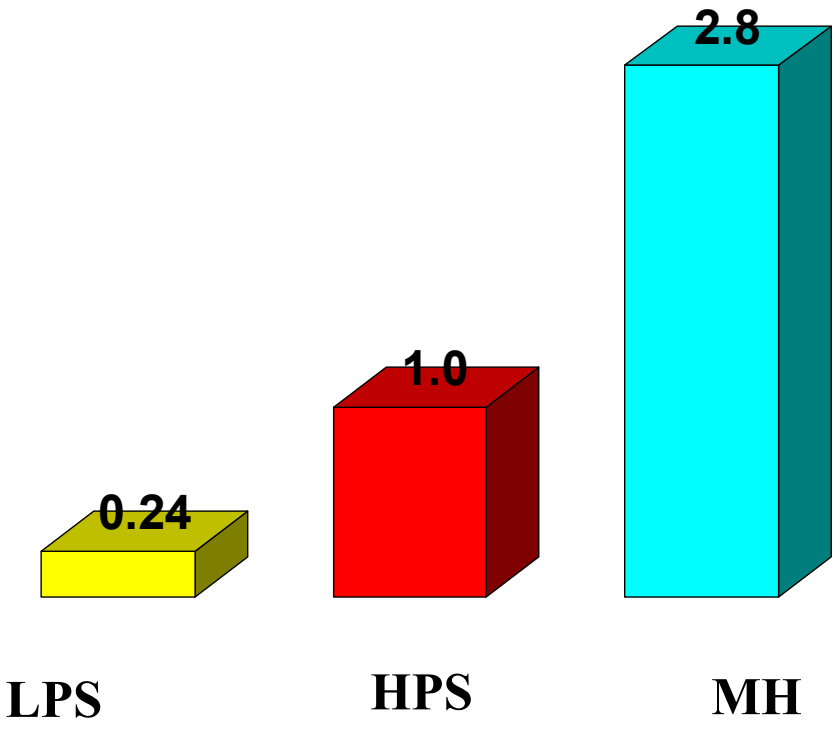
Sky Glow

- Sky Glow
  - Blue Light Scatters more than amber light
- Rayleigh Scattering
  - Molecular Scattering – Molecule are about the same size as the wavelength for blue light
  - Blue Light Scatters more
  - Low angle blue content light is particularly bad
- Mie Scattering
  - Aerosol Scattering – Particles are much bigger than wavelength
  - Not Spectrally Selective

Relative Sky Glow



From CORM 2008, Luginbuhl, Keith & Knox

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Impact on Soybean Growth

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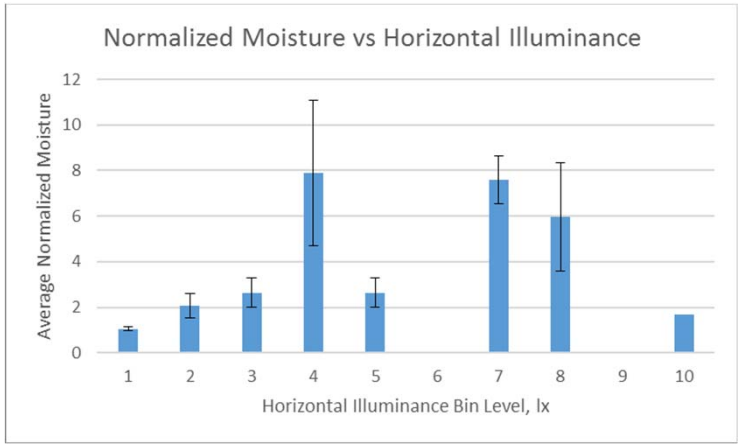
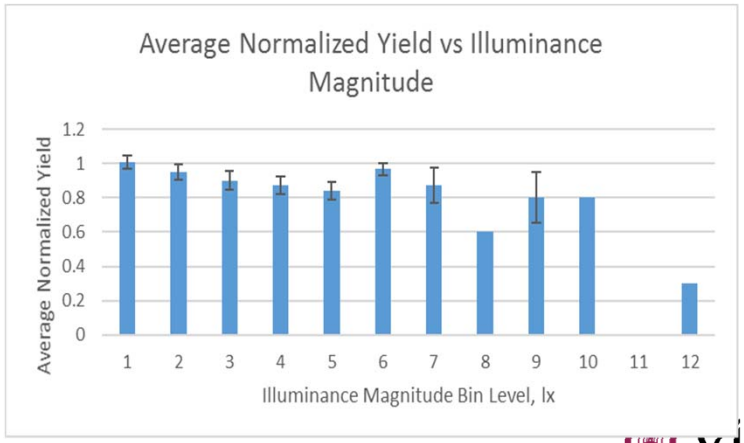
Yield and Moisture





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Adaptive Lighting

- Wwe have the ability to adapt a roadway lighting system to the needs of the environment.
  - Traffic Volume
  - Weather
  - Lighting Condition
  - Pedestrian Usage
- Adaptive Lighting basically represents the lowering or raising of the light level based on the needs of the roadway and the drivers
  - This requires dimming capabilities

Adaptive Benefits

- The obvious and primary benefit of adaptive lighting is the reduction of energy use
  - between 20 percent and 40 percent
- The other potential benefits of adaptive lighting are reductions in the following:
  - Maintenance costs.
  - Lamp and Driver replacement cost due to extended luminaire performance.
  - Traffic and travel interruptions due to maintenance operations.
  - Possibility of tort issues resulting from system maintenance issues.
  - Over-lighting.
  - Light trespass.
  - Sky-glow.
  - Glare from roadway lighting installations.

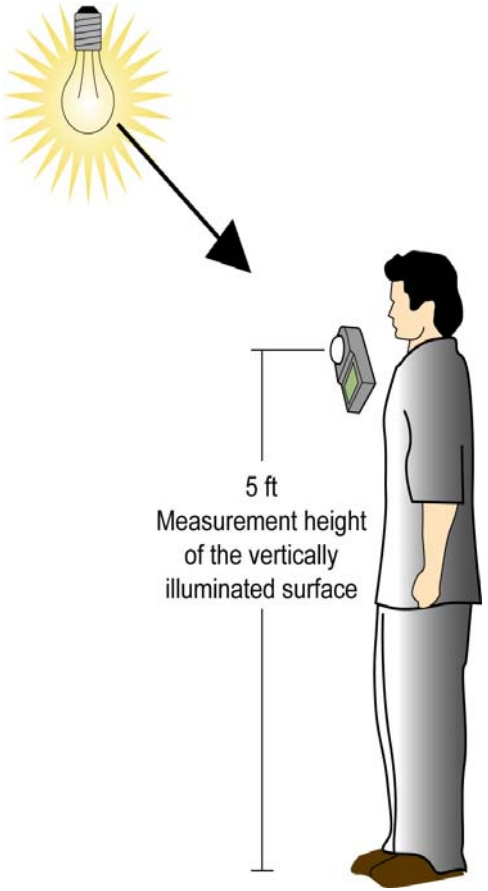
Criteria for Luminance Selection

- Speed
- Traffic Volume
- Median
- Intersection / Interchange Density
- Ambient Luminance
- Guidance
- Pedestrians and Bicycles
- Parked Vehicles
- Facial Recognition

Issues for Pedestrains

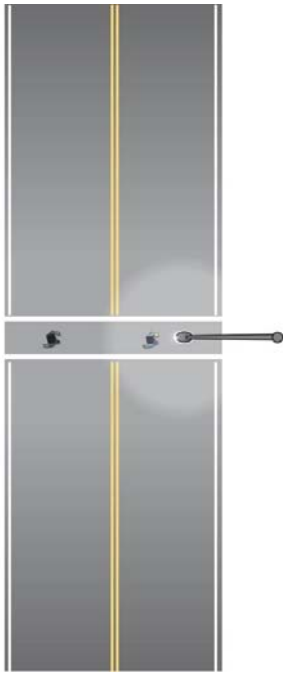
- Light outside of the roadway
  - Traditional sources have has lousy optical control
  - LEDs specifically limit light outside of the roadway
    - Problems for pedestrains
  - New research looking at Surround ratio which is a requirement for light outside of the roadway.
- Light source selection
  - Choosing to maximize visibility
- Illumination
  - Vertical Illuminance

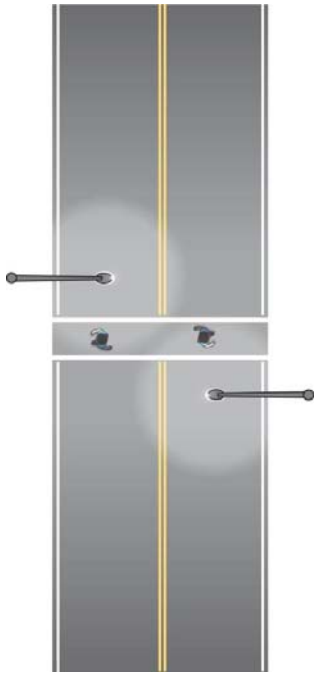
Vertical Illuminance



- Vertical Illuminance is the light that falls on the vertical face of the pedestrian
  - For this study the illuminance was measured at 5 ft
- Measured with a Minolta T-10 Illuminance Meter

Impact on Lighting Design





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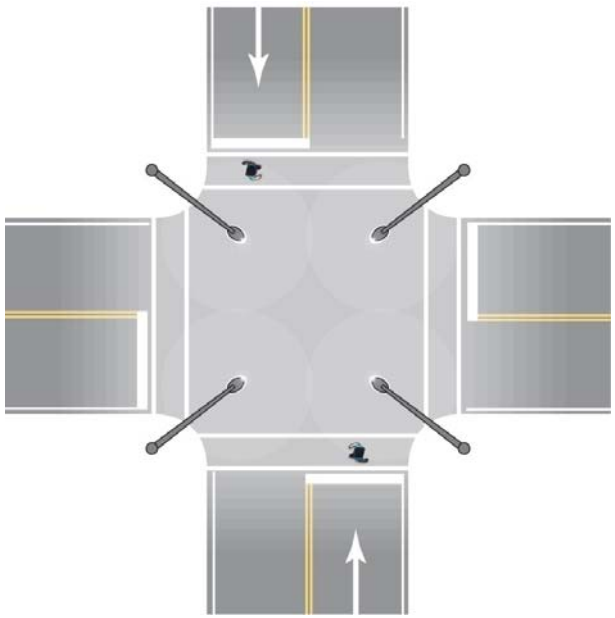
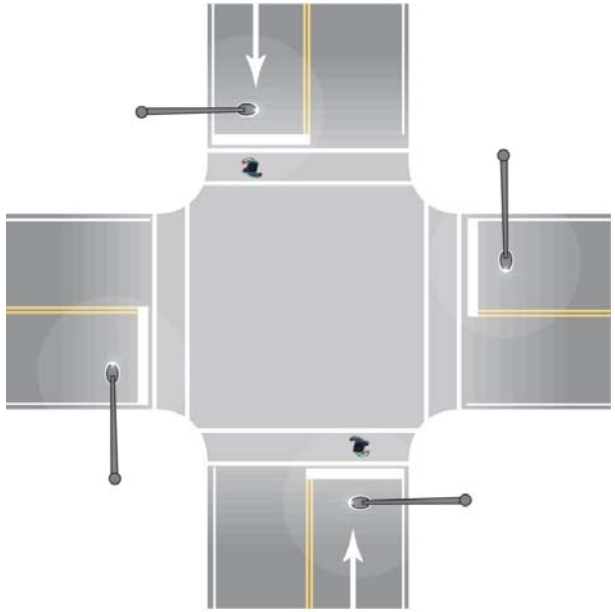
Potential Intersection Design





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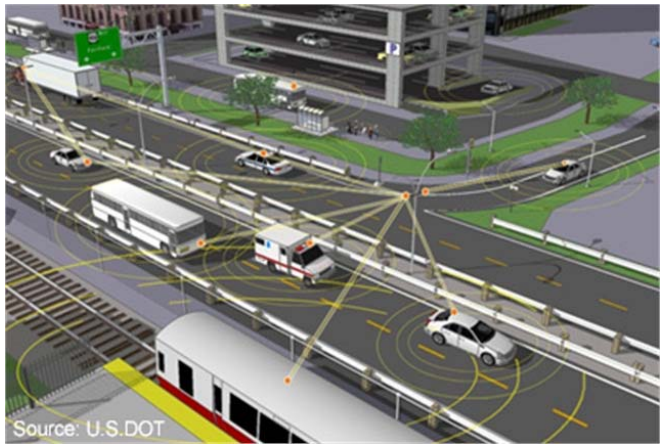
Intersection Issues

- Intersection are typically brighter than street and roadways
  - Can cause contrast problems
  - Research is on-going

The Immediate Future

- Connected Vehicles
  - V2V, V2I, V2X
- Lighting on Demand
  - DSRC and Cellular
    - Pedestrian Pickup
  - Issues
    - Comfort Level
      - » How many luminaires, how big a space
      - » Driver Glance Behaviour
      - » Object Detection / Safety



Lighting as the Backbone to the Smart City

- Breaking down the information silos in a city
  - Traffic Flow
  - Pedestrian usage
  - Environmental factors
  - Connected Vehicles
  - Light Status
  - Transit

- Information is linked on the lighting network backbone
  - Linking through the IoT endpoints on each luminaire

Will Street Lighting Become the City's Central Nervous System???

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The Long Range Future

- More and More Automation
  - Autonomous Vehicles
    - Do we need lighting?
    - Vision systems pickup pavement markings and Radar/Lidar detect other vehicles and obstacles
  - Pedestrians will always have legacy Vision Systems (eyeballs)

CIBSS

- Nighttime researchers during the day…..

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Discussion

- Send us your questions 
- Follow up with us:
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