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# ENERGY SAVINGS FROM LIGHTING APPLICATION EFFICIENCY IN ROADWAY LIGHTING


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# LIGHT APPLICATION EFFICIENCY IN ROADWAY LIGHTING

## 4 ELEMENTS

- Light Source Efficiency – Major Focus of DOE until now
- Optical Delivery Efficiency
- Spectral Efficiency
- Intensity Effectiveness

Areas to Focus on Further

# OPTICAL DELIVERY EFFICIENCY

## DELIVER LIGHT IN THE RIGHT AREAS

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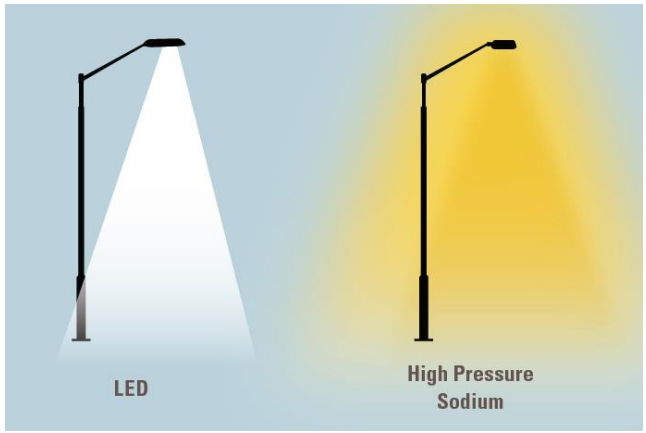
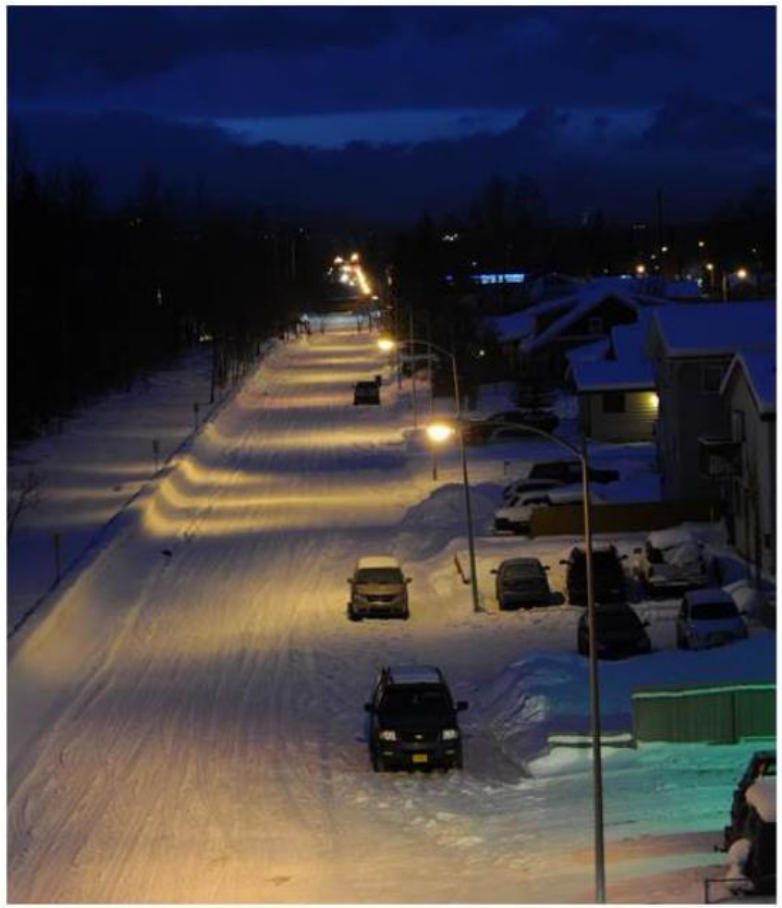
# WHAT AREAS SHOULD BE ILLUMINATED BY STREET LIGHTS?

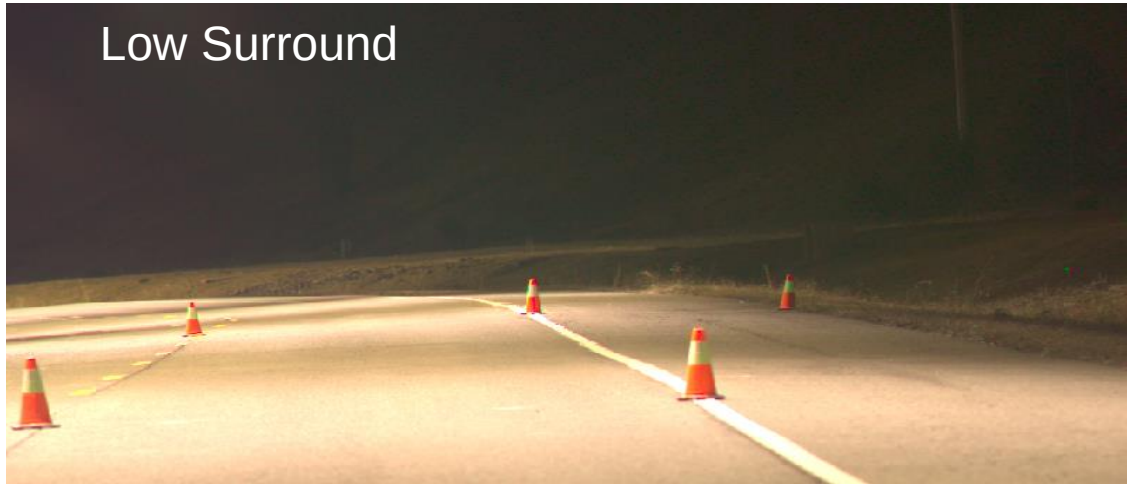


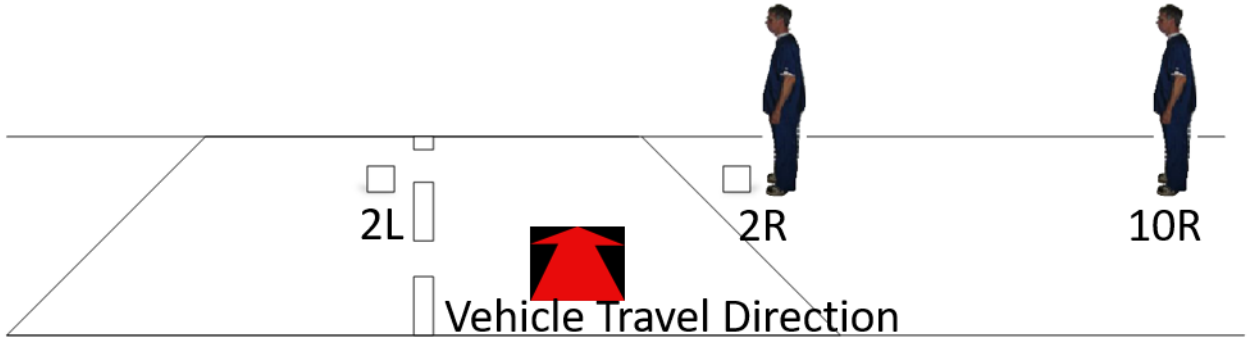



Anchorage. Photo by Wayne Johnson, ML&P

# Any Benefit to Lighting the Area Beyond the Travel Lanes?

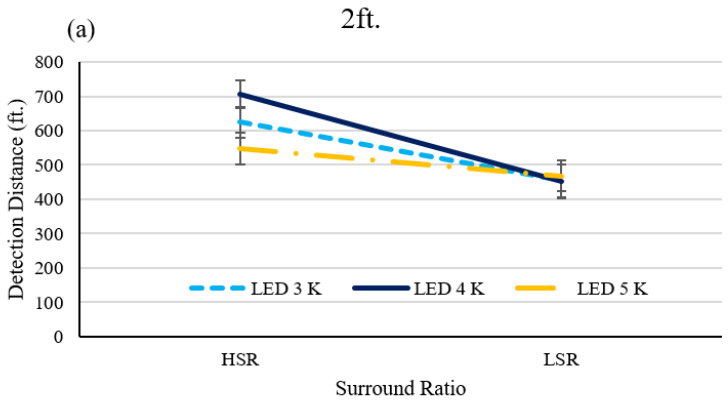
Surround Ratio: Ratio of Luminance of Shoulder to Travel Lanes

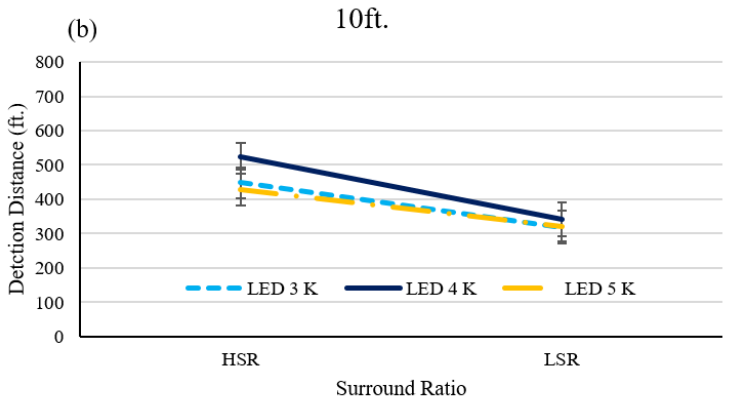



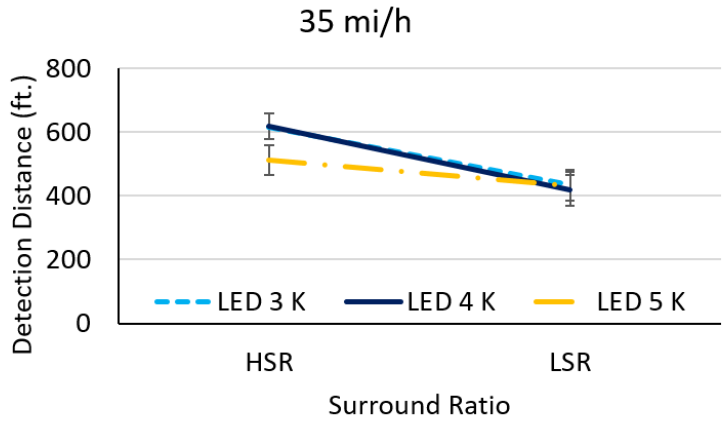
# Light in the Shoulder Helps increase Visibility

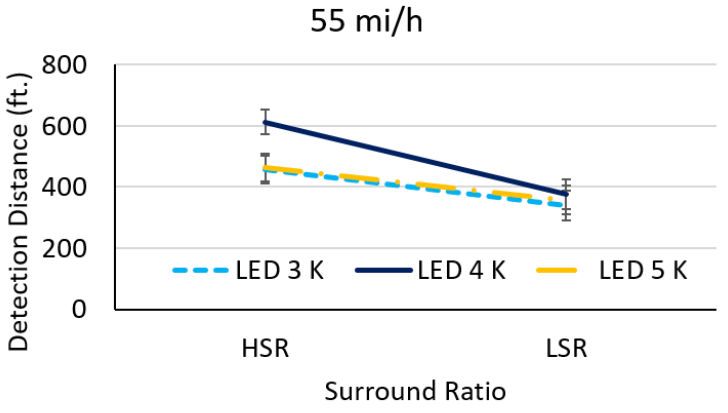
## Offset Distance from Roadway




## Speed

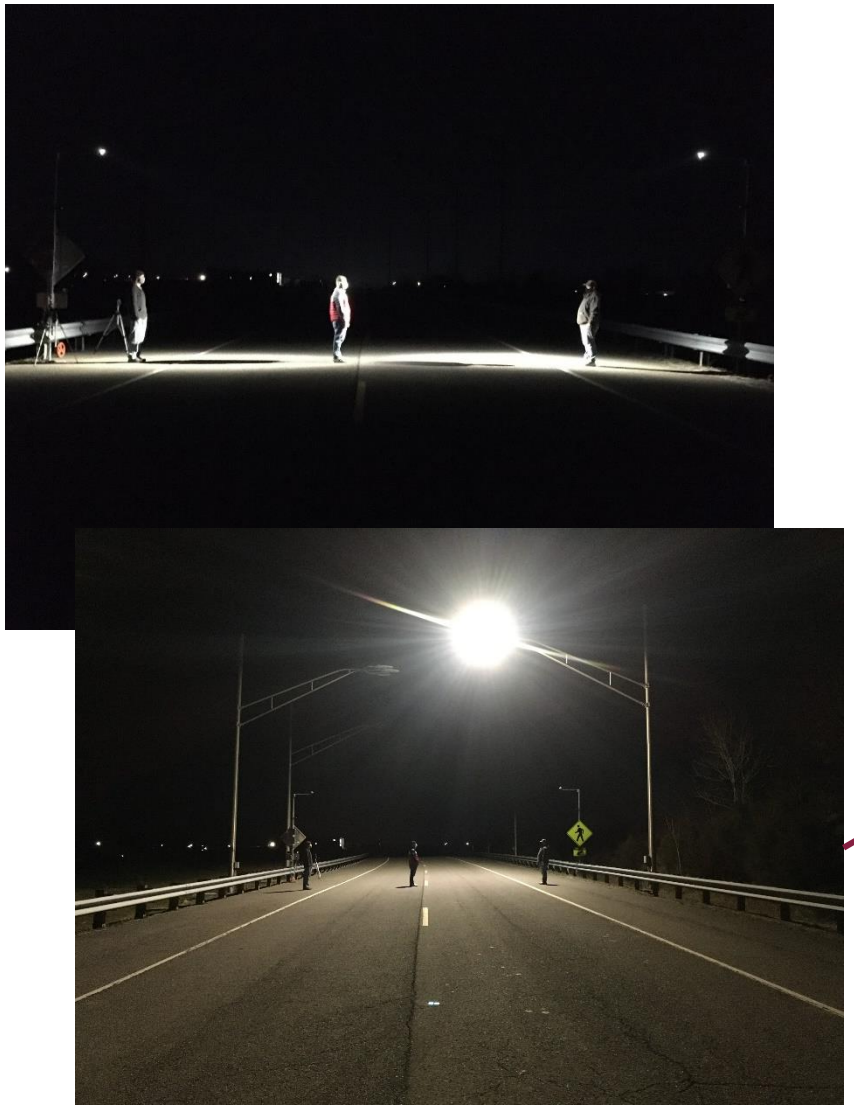


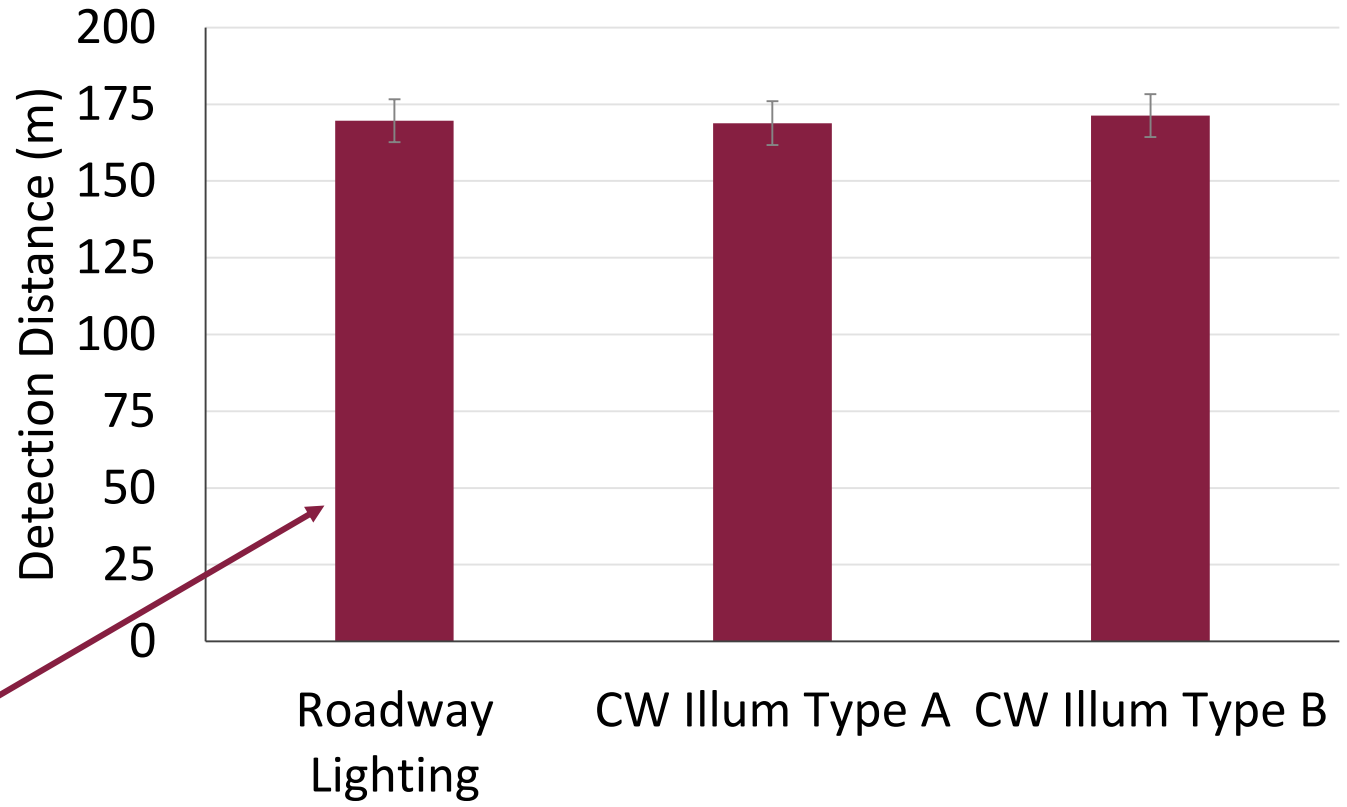




National Academies of Sciences, Engineering, and Medicine 2020. *Solid-State Roadway Lighting Design Guide: Volume 2: Research Overview*. Washington, DC:The National Academies Press. https://doi.org/10.17226/25679.

# OPTIMIZING LIGHT BEAM DISTRIBUTION

## CROSSWALK LIGHTING






Same Vertical Illuminance on Pedestrians – 10 lux

Bhagavathula, Rajaram, Ronald Gibbons, and Andrew Kassing. *Roadway Lighting's Effect on Pedestrian Safety at Intersection and Midblock Crosswalks*. Illinois Center for Transportation/Illinois Department of Transportation, 2021.

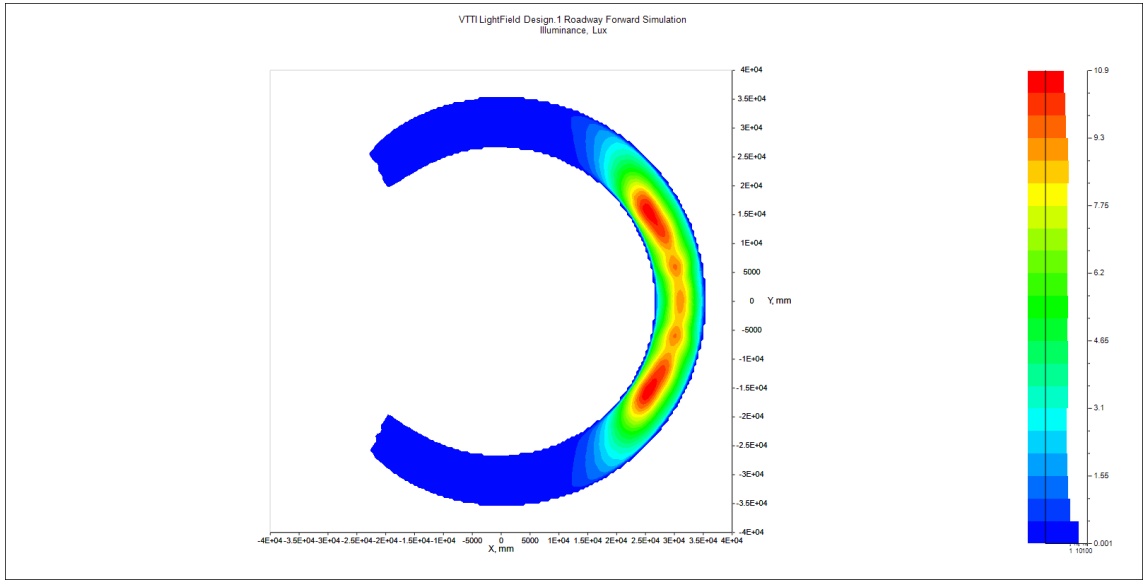
# OPTIMIZING LIGHT BEAM DISTRIBUTION

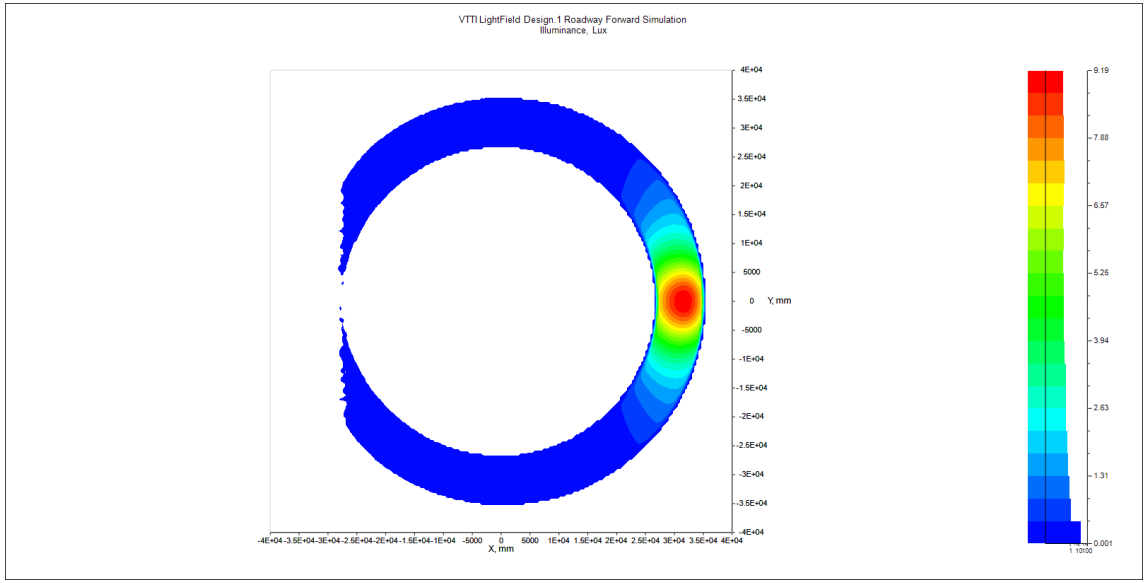
- Illuminating Curved Roadways has been a Challenge
- High Mast Lighting or Too many light poles
  - Illuminate surrounding areas – Bug not a feature
- Wastage of Luminous Flux

# FUTURE DIRECTIONS

## FLEXIBLE BEAM LEDS

- More Luminous Flux on Road Surface
- Fewer Poles
- Research in progress
  - Collaboration with Glint Photonics
  - Photometric and Human Factors Evaluations

# SPECTRAL EFFICIENCY

## DELIVER THE RIGHT SPECTRUM

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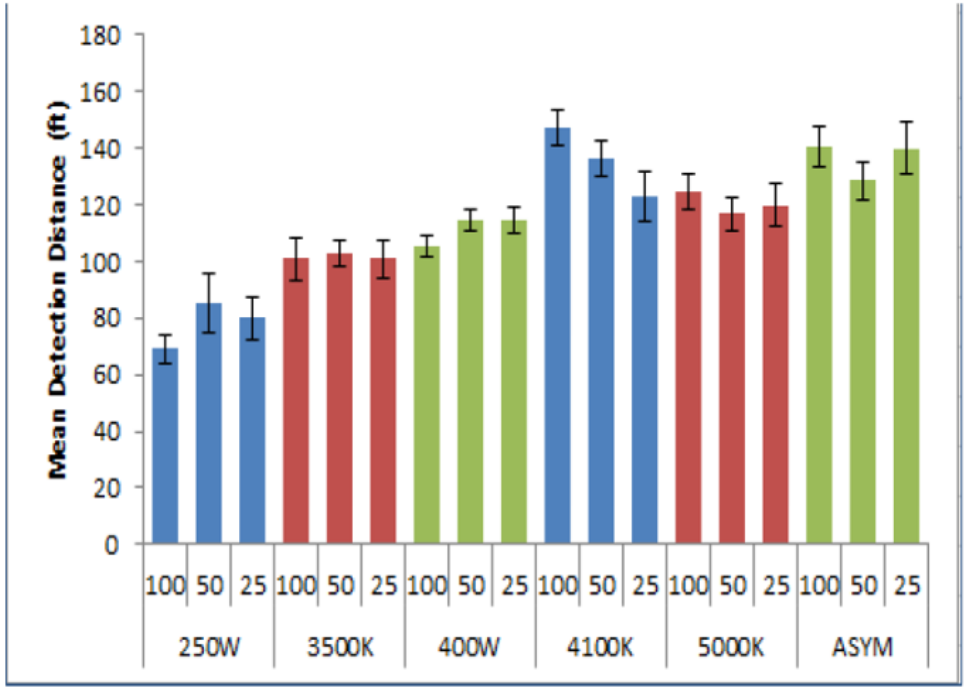
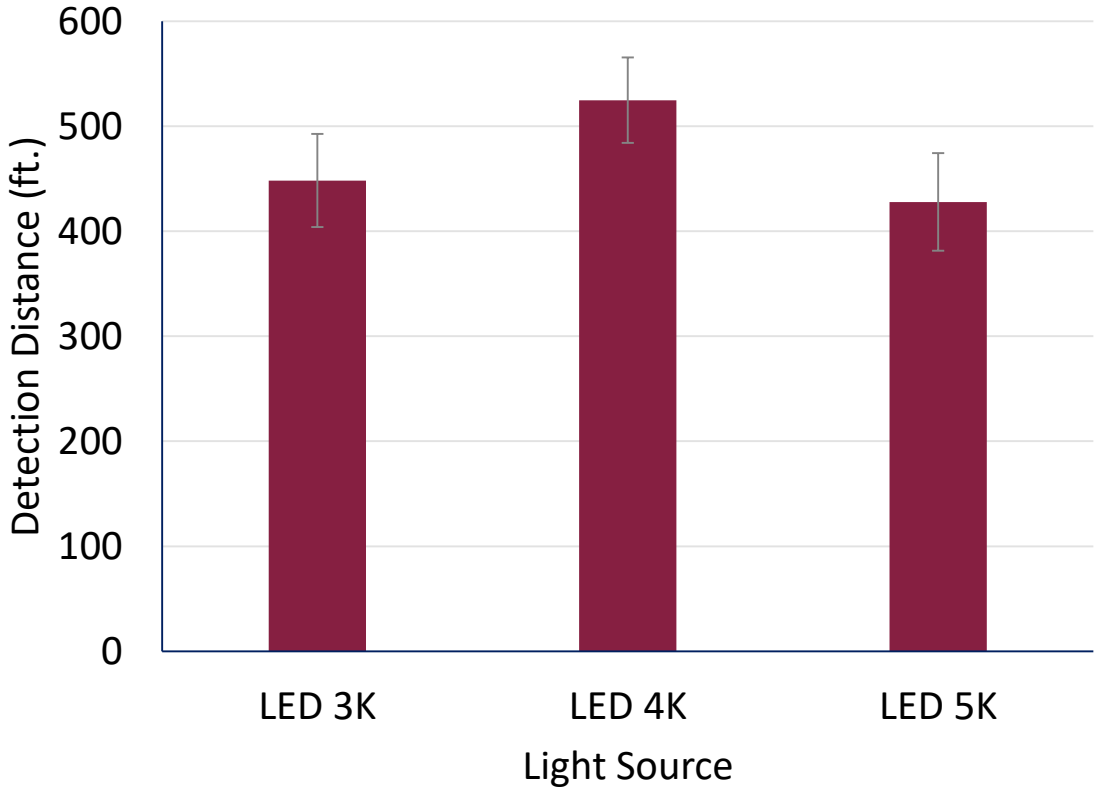
# DRIVER VISUAL PERFORMANCE UNDER LIGHT SOURCES

## BENEFITS OF 4000 K LED IN TRAFFIC SAFETY



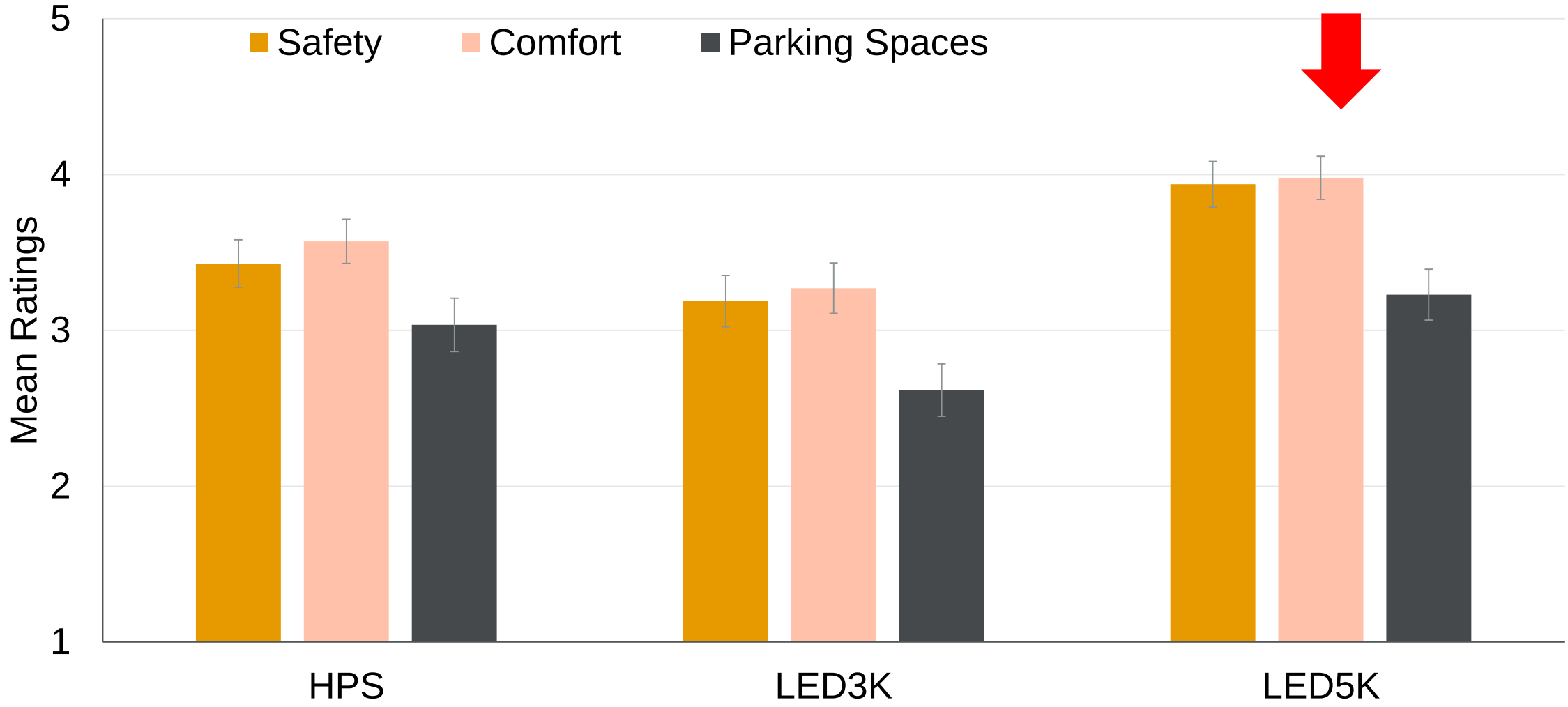

Clanton, N., Gibbons, R., Garcia, J., & Terry, T. (2014). Evaluation of Adaptive Lighting in the City of Seattle.




National Academies of Sciences, Engineering, and Medicine 2020. *Solid-State Roadway Lighting Design Guide: Volume 2: Research Overview*. Washington, DC: The National Academies Press. https://doi.org/10.17226/25679.

# LIGHT SOURCE SPECTRUM PREFERENCE DEPENDS ON USE-CASE

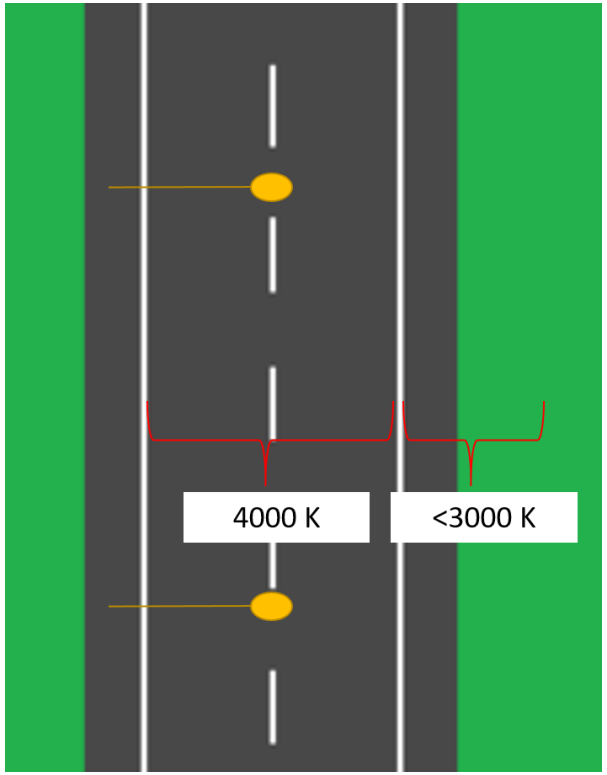
## PARKING GARAGES




Bhagavathula, R., & Gibbons, R. B. (2020). Light levels for parking facilities based on empirical evaluation of visual performance and user perceptions. *Leukos*, *16*(2), 115-136.

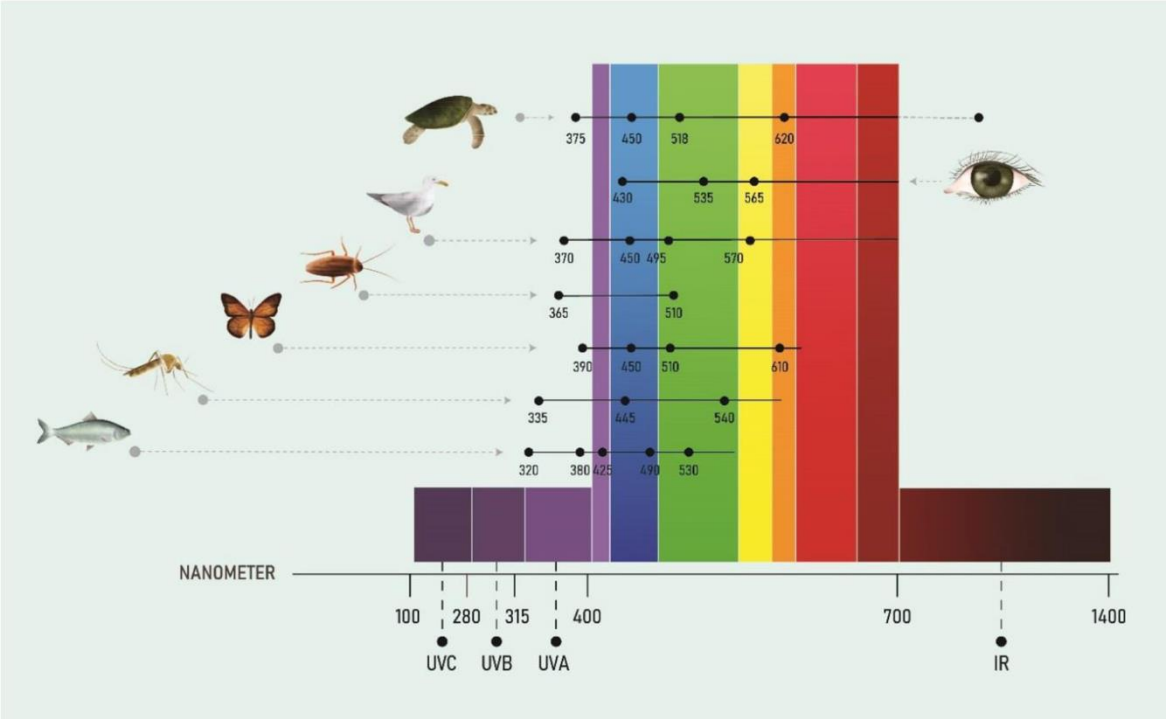
# FLEXIBLE BEAM LEDS

- Travel Lane to one SPD (or CCT) – 4000 K
- Adjacent Areas to another SPD – 3000 K or lower
  - Especially in environmentally/ecologically sensitive areas
- Research in progress



# FUTURE DIRECTIONS

- Right spectrum based on the location and need
- Challenging task




CamposSMC. (2017). The impact of artificial lighting on nature.

- Consider Intensity Control

# INTENSITY EFFECTIVENESS

## DELIVER THE RIGHT AMOUNT AT THE RIGHT TIME

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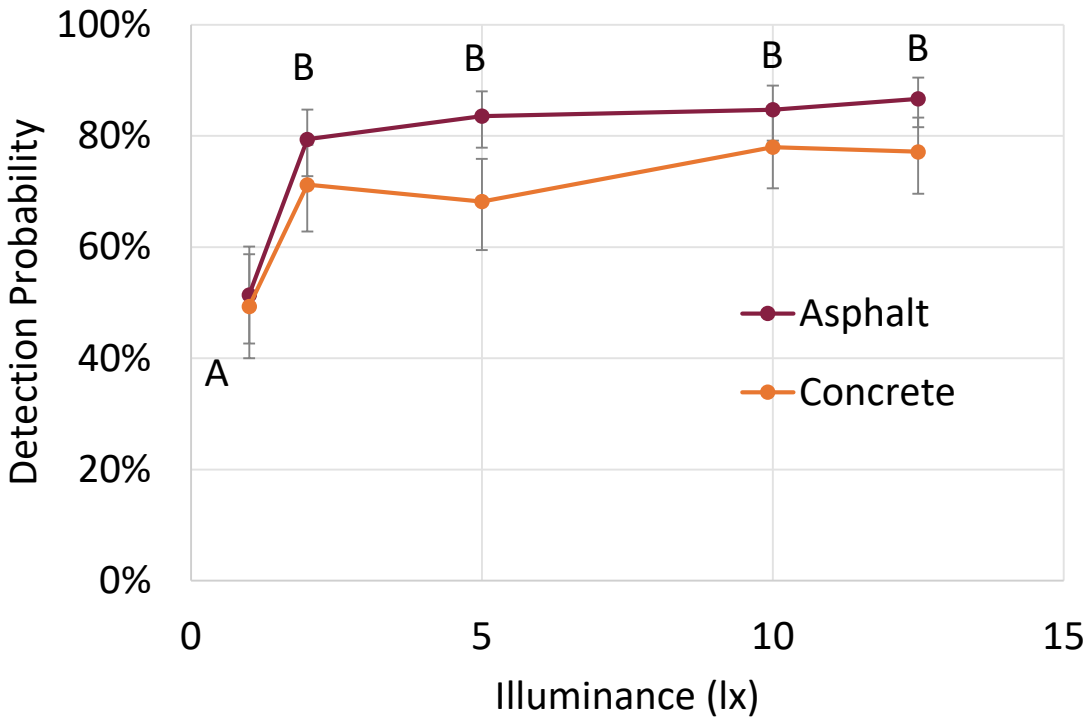
# EXISTING PROBLEMS IN ROADWAY LIGHTING

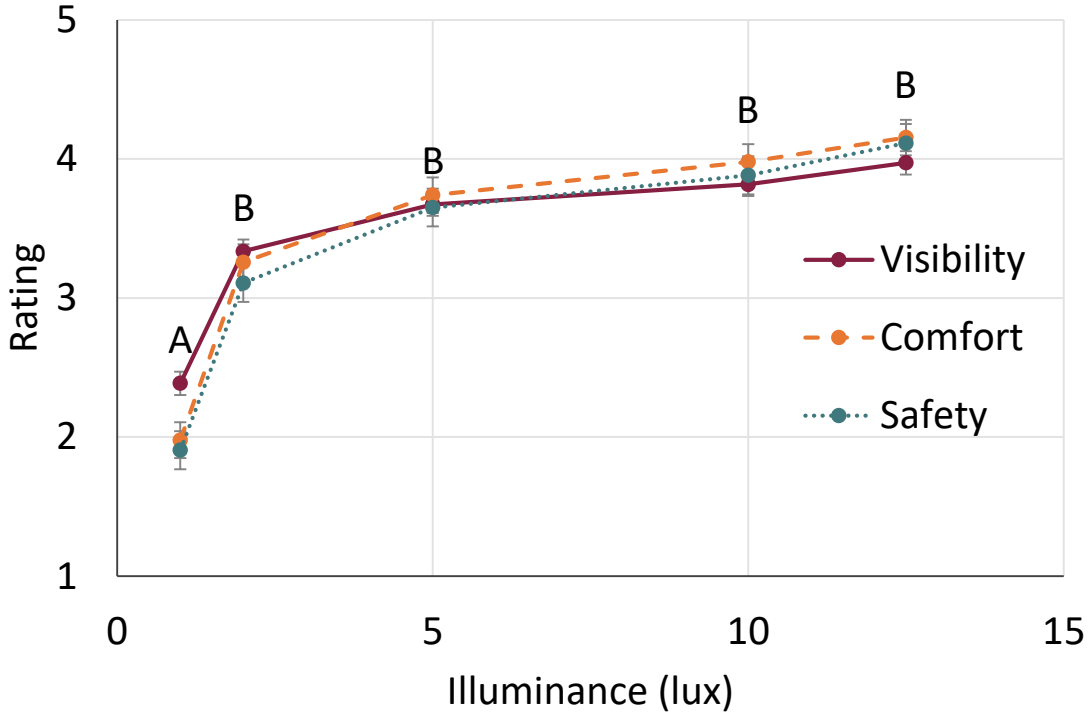
- Lighting Design Standards – Consensus
- Ignores visual performance and needs of the users
- Potential for over-lighting → glare & energy wastage
- Recent research is addressing these needs!

# CAN WE LIGHT OUR WAY TO SEEING BETTER OR FEELING SAFER?

## NO!

No increase beyond 2 lux



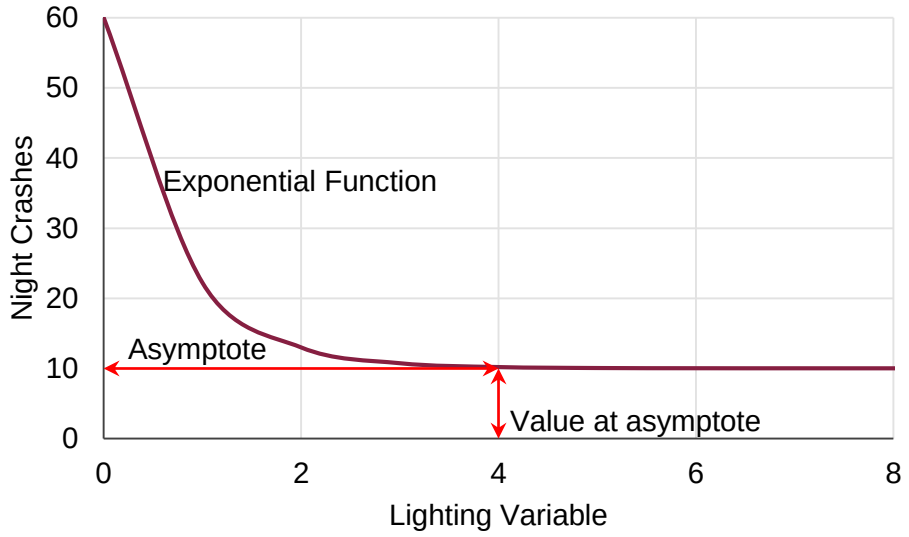



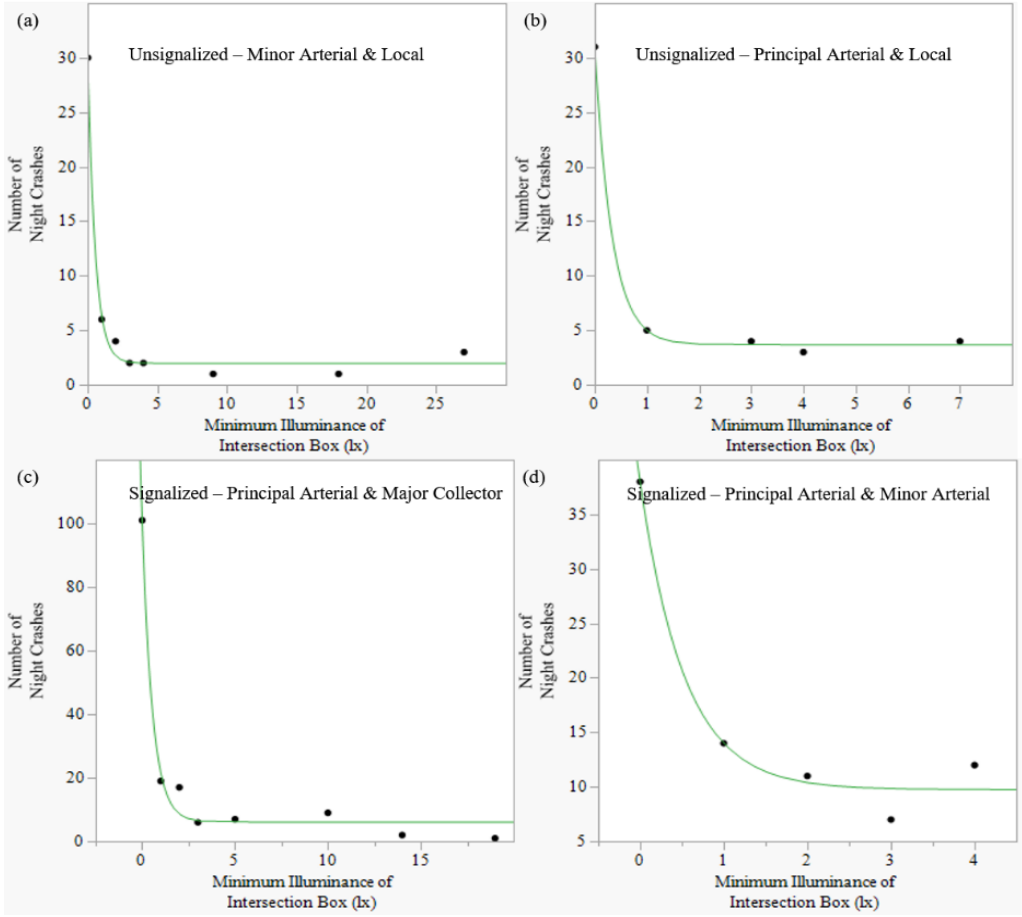

84% reduction in energy by dimming to 2 lux

Bhagavathula, R., & Gibbons, R. B. (2020). Light levels for parking facilities based on empirical evaluation of visual performance and user perceptions. *Leukos*, *16*(2), 115-136.

# RIGHT LIGHT LEVELS FOR APPLICATIONS

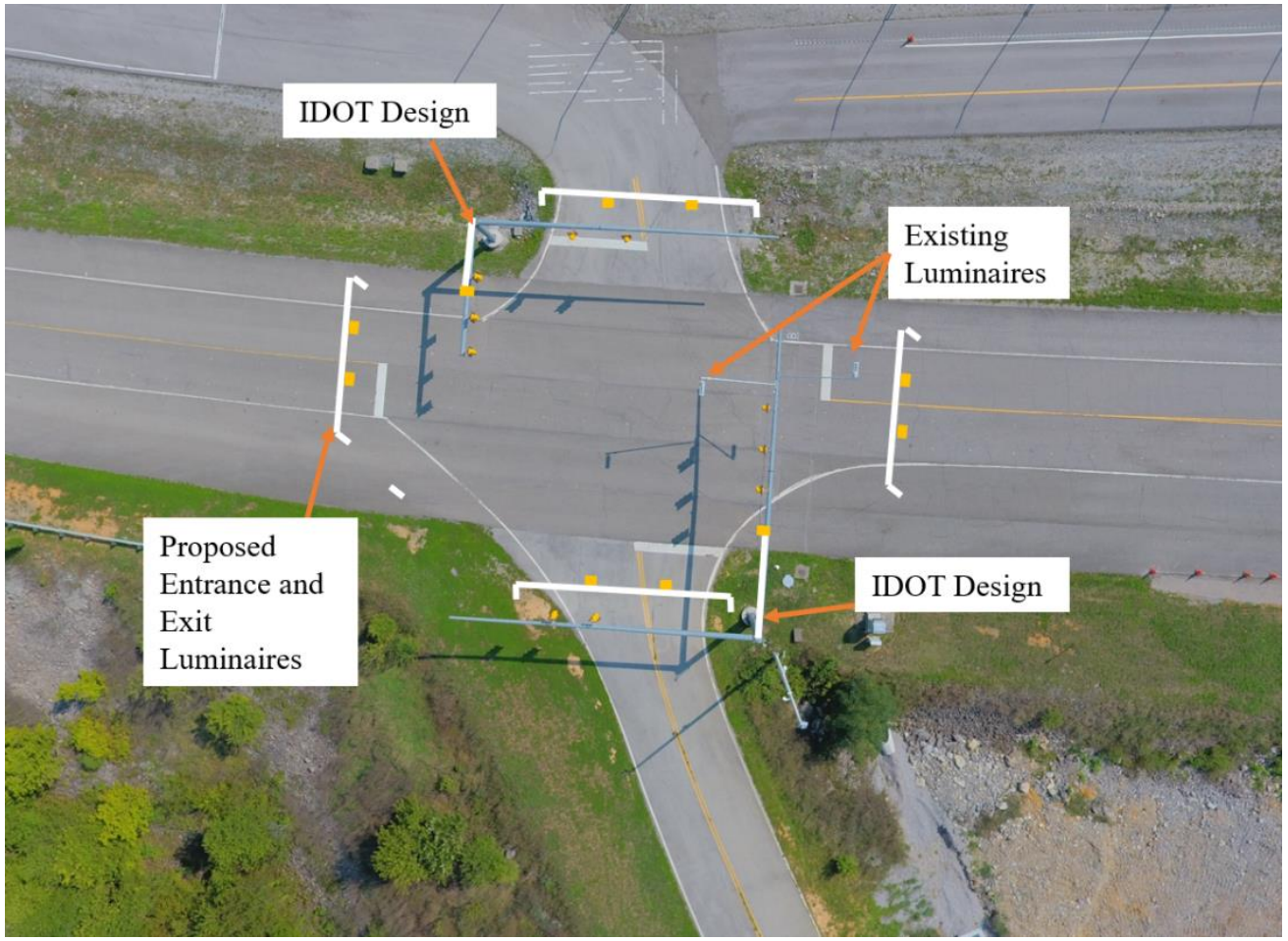
- 235 Intersection in Virginia
- Increase in light level by 1 Lux is associated with decrease in Night to Day Crash Ratio by 2.9 %

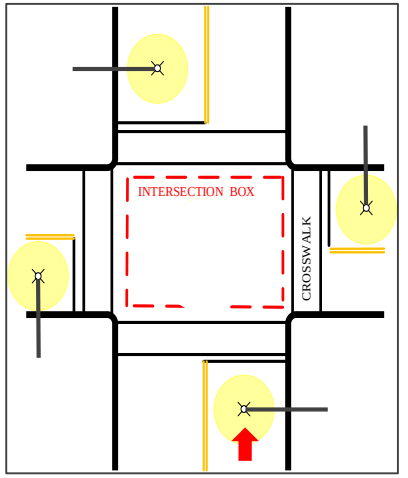


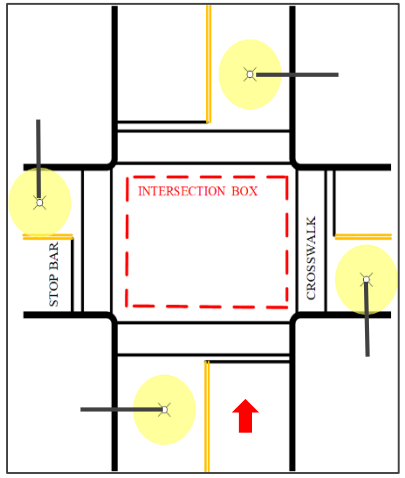

Li, Y. E., Bhagavathula, R., Terry, T. N., Medina, A., & Gibbons, R. B. (2020). *Safety benefits and best practices for intersection lighting* (No. FHWA/VTRC 20-R31). Virginia. Dept. of Highways.

# Intersection Lighting Designs




Approach

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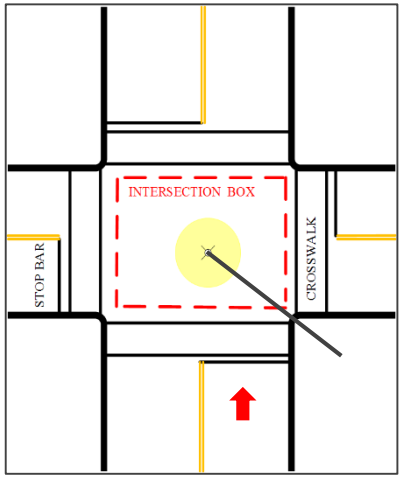
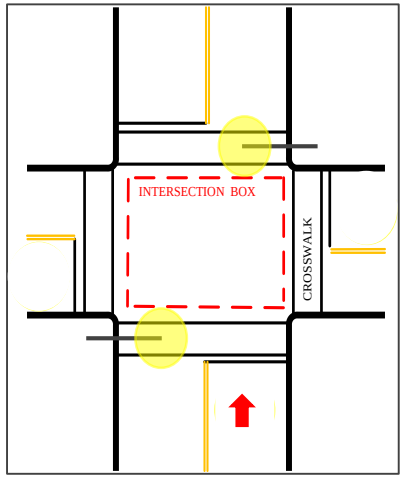



Box

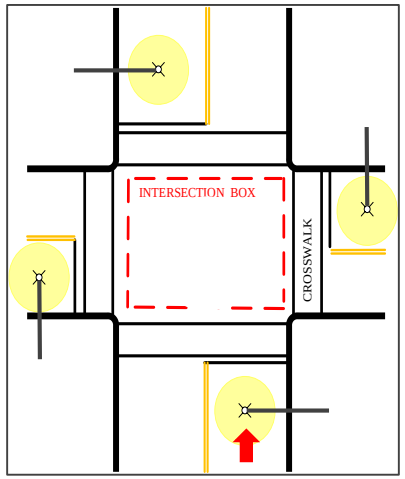



IDOT

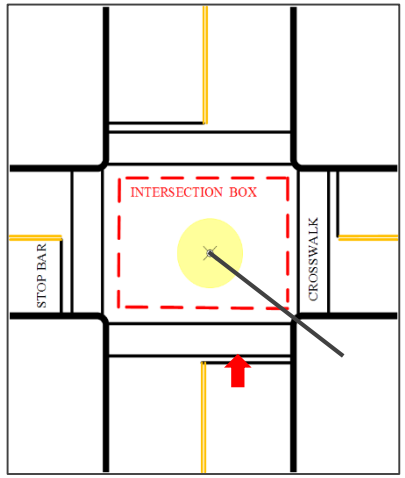
# Evidence Based Research

- Visual performance plateaued at 14 lux (avg. horizontal)
- Light Levels lower than existing standard practice (IES RP-8-18) → Energy Savings

Approach




Box

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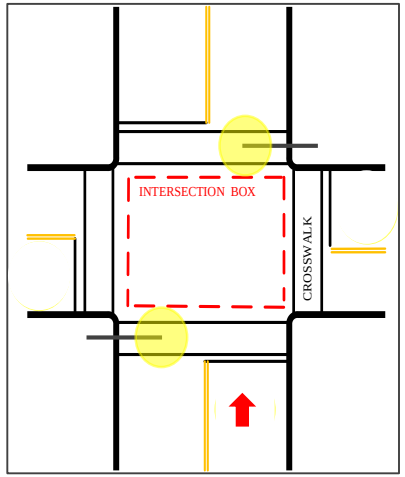


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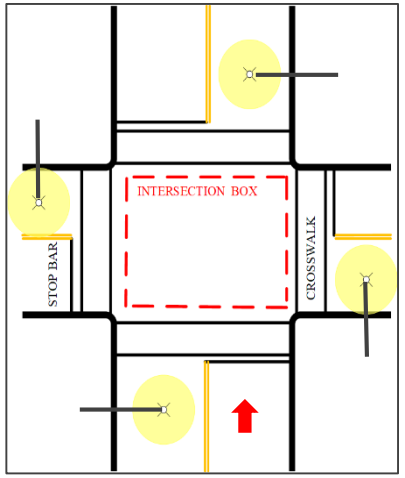



| | | |
|---|---|---|
| **No Glare** | 14 lux | |
| **Glare** | 14 lux | 24 lux |

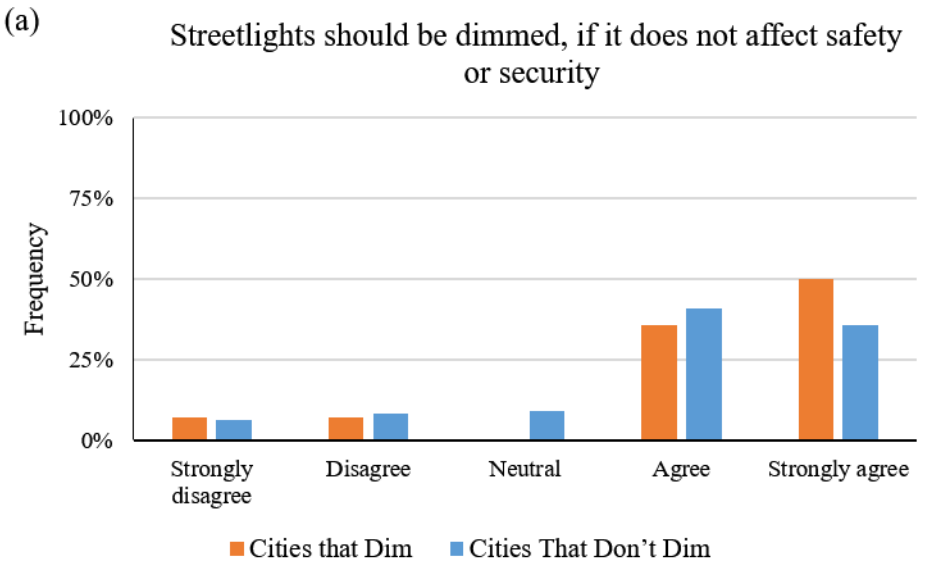
Bhagavathula, Rajaram, Ronald Gibbons, and Andrew Kassing. *Roadway Lighting's Effect on Pedestrian Safety at Intersection and Midblock Crosswalks*. Illinois Center for Transportation/Illinois Department of Transportation, 2021.

# ADAPTIVE LIGHTING

- 2 Projects considering the utilization of the Adaptive (Controlled) Lighting Systems
  - Cambridge MA (DOE Sponsored)
  - Interstate 64 (FHWA Sponsored)
- Current Barriers
  - Public Perception
  - Financial Impact – Cost of Equipment versus energy reductions
  - Impact on:
    - Crashes
    - Crime
    - User Health
    - Environment
    - Energy Usage
    - Light Trespass
- These investigation are a holistic consideration of these factors

# PUBLIC'S PERCEPTIONS TOWARDS ADAPTIVE DIMMING

(a)

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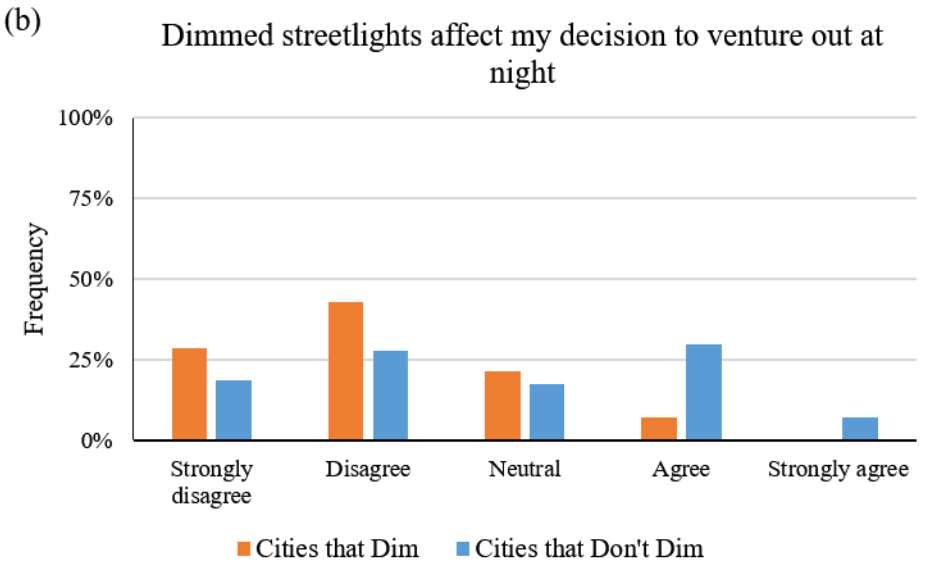
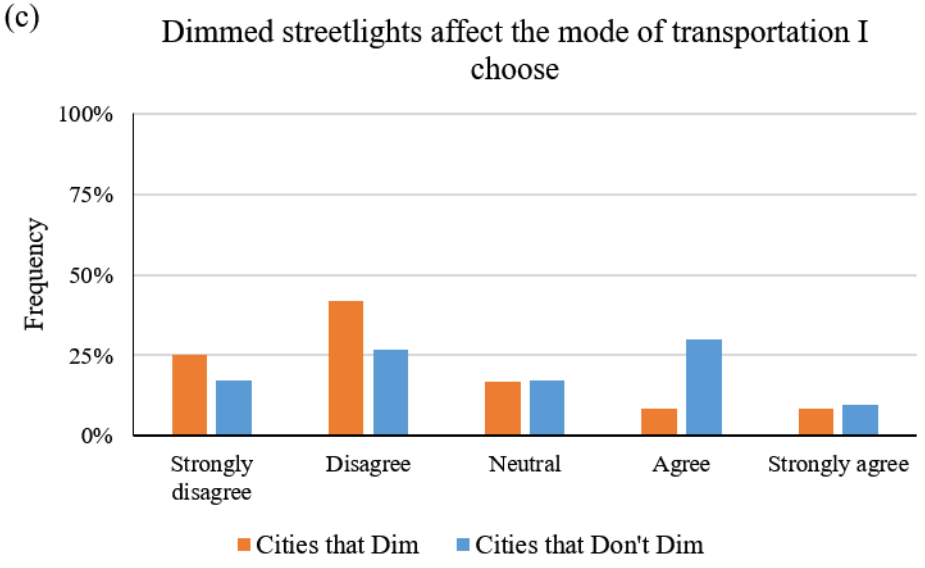
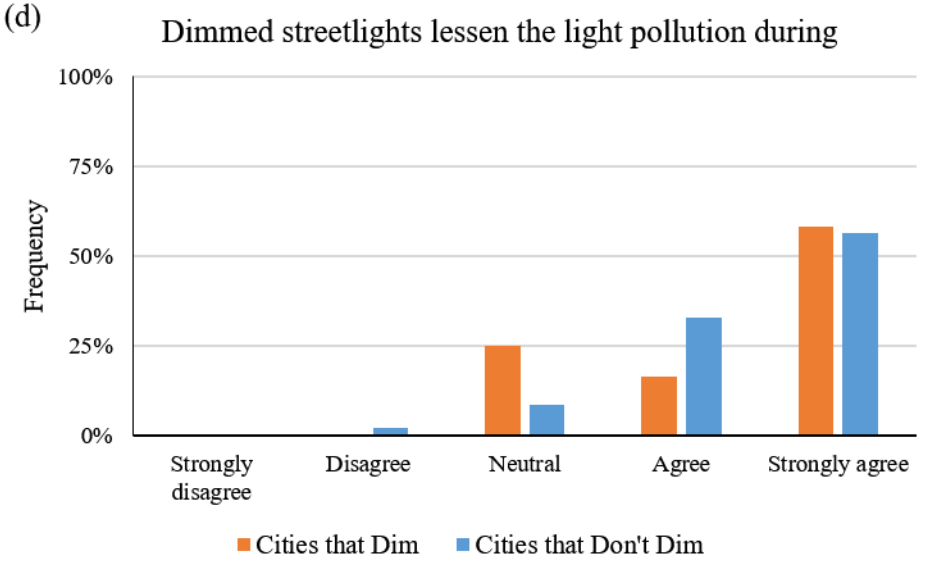


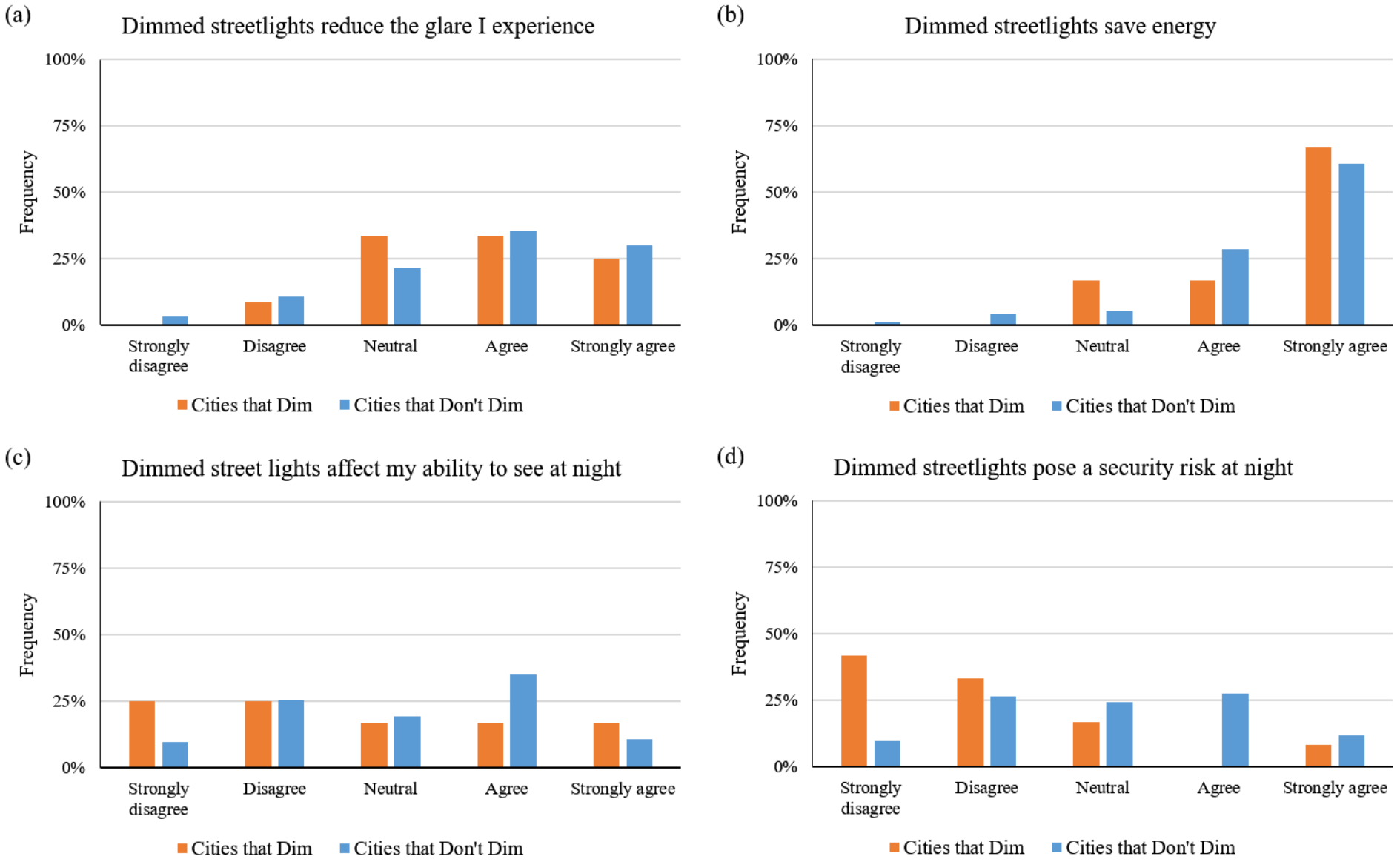

(c)




(d)

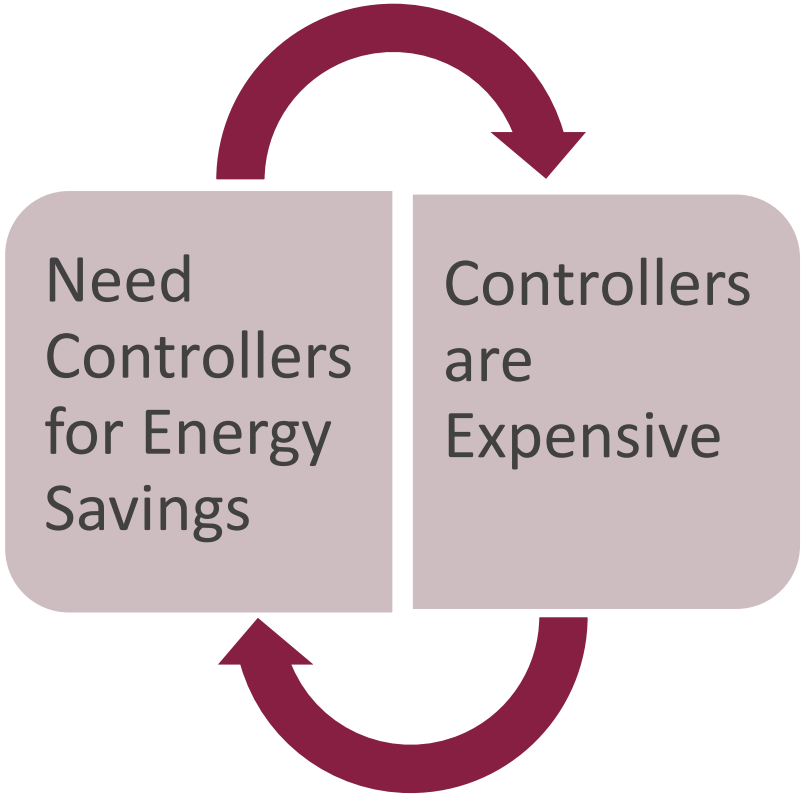


# PUBLIC'S PERCEPTIONS TOWARDS ADAPTIVE DIMMING



# FUTURE DIRECTIONS

- Evaluate visual performance and perceptions of pedestrians
  - Right Light Level to Dim
- When to dim?
  - Interactions with stakeholders is critical
- Biggest Challenge – Price of Controller
- Need to drive down controller cost



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# Questions?

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