Visibility Research
Linking Lighting and Safety

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Motor Vehicle Crashes – Magnitude of the Problem – US Statistics

NHTSA People Saving People http://www.nhtsa.dot.gov

Top 10 Leading Causes of Death in the United States for 2001, by Age Group[1]

NCSA National Center for Statistics and Analysis

RANK	Cause and Number of Deaths											Years of Life Lost[2]
	Infants Under 1	Toddlers 1-3	Young Children 4-7	Children 8-15	Youth 16-20	Young Adults 21-24	Other Adults 25-34	Other Adults 35-44	Other Adults 45-64	Elderly 65+	All Ages	
1	Perinatal Period 13,734	Congenital Anomalies 496	MV Traffic Crashes 533	MV Traffic Crashes 1,546	MV Traffic Crashes 5,979	MV Traffic Crashes 4,136	MV Traffic Crashes 6,759	Malignant Neoplasms 16,569	Malignant Neoplasms 139,785	Heart Disease 582,730	Heart Disease 700,142	Malignant Neoplasms 23%(8,614,131)
2	Congenital Anomalies 5,513	MV Traffic Crashes 421	Malignant Neoplasms 400	Malignant Neoplasms 829	Homicide 2,414	Homicide 2,738	Homicide 5,204	Heart Disease 13,326	Heart Disease 98,885	Malignant Neoplasms 390,214	Malignant Neoplasms 553,768	Heart Disease 22%(8,110,571)
3	Heart Disease 479	Accidental Drowning 393	Exposure to Smoke/Fire 178	Suicide 447	Suicide 1,879	Suicide 1,924	Suicide 5,070	MV Traffic Crashes 6,891	Stroke 15,518	Stroke 144,486	Stroke 163,538	MV Traffic Crashes 5%(1,700,952)
4	Homicide 332	Homicide 362	Congenital Anomalies 168	Homicide 391	Malignant Neoplasms 814	Accidental Poisoning 771	Malignant Neoplasms 3,994	Suicide 6,635	Diabetes 14,913	Chronic Lwr. Resp. Dis. 106,904	Chronic Lwr. Resp. Dis. 123,013	Stroke 5%(1,687,683)
5	Septicemia 312	Malignant Neoplasms 321	Accidental Drowning 164	Congenital Anomalies 324	Accidental Poisoning 566	Malignant Neoplasms 768	Heart Disease 3,160	HIV 5,867	Chronic Lwr. Resp. Dis. 14,490	Influenza/ Pneumonia 55,518	Diabetes 71,372	Chronic Lwr. Resp. Dis. 4%(1,444,745)
6	Influenza/ Pneumonia 299	Heart Disease 200	Homicide 133	Accidental Drowning 293	Heart Disease 398	Heart Disease 543	Accidental Poisoning 2,507	Accidental Poisoning 5,036	Chronic Liver Disease 13,009	Diabetes 53,707	Influenza/ Pneumonia 62,034	Suicide 3%(1,079,822)
7	MV Traffic Crashes 139	Exposure to Smoke/Fire 170	Heart Disease 82	Heart Disease 273	Accidental Drowning 326	Accidental Drowning 211	HIV 2,101	Homicide 4,268	Suicide 9,259	Alzheimer's 53,245	Alzheimer's 53,852	Perinatal Period 3%(1,070,154)
8	Nephritis/ Nephrosis 133	Septicemia 96	MV NonTraffic Crashes 51	Exposure to Smoke/Fire 140	Congenital Anomalies 244	Congenital Anomalies 206	Stroke 601	Chronic Liver Disease 3,336	MV Traffic Crashes 8,750	Nephritis/ Nephrosis 33,121	MV Traffic Crashes 42,443	Diabetes 3%(1,014,201)
9	Stroke 108	Influenza/ Pneumonia 92	Benign Neoplasms 46	MV NonTraffic Crashes 125	Accidental Falls 114	HIV 167	Diabetes 595	Stroke 2,491	HIV 5,437	Septicemia 25,418	Nephritis/ Nephrosis 39,480	Homicide 3%(924,263)
10	Meningitis 78	Perinatal Period 63	Septicemia 33	Chr. Lwr. Resp. Dis. 102	Acc. Dischg. Of Firearms 114	Accidental Falls 134	Congenital Anomalies 458	Diabetes 1,958	Nephritis/ Nephrosis 5,106	Hypertension Renal Dis. 16,397	Septicemia 32,238	Chronic Liver Disease 2%(623,998)
ALL[3]	27,568	4,288	2,703	6,672	15,851	14,940	41,683	91,674	412,204	1,798,420	2,416,425	All Causes 100%(36,866,317)

[1] When ranked by specific ages, motor vehicle crashes are the leading cause of death for age 2 and every age 4 through 33.

[2] Number of years calculated based on remaining life expectancy at time of death; percents calculated as a proportion of total years of life lost due to all causes of death.

[3] Not a total of top 10 causes of death.

Source: National Center for Health Statistics (NCHS) CDC, Mortality Data 2001

Note: The cause of death classification is based on the National Center for Statistics and Analysis (NCSA) Revised 68 Cause of Death Listing. This listing differs from the one used by the NCHS for its reports on leading causes of death by separating out unintentional injuries into separate causes of death, i.e., motor vehicle traffic crashes, accidental falls, motor vehicle nontraffic crashes, etc. Accordingly, the rank of some causes of death will differ from those reported by the NCHS. This difference will mostly be observed for minor causes of death in smaller age groupings.

What are Drivers doing in their vehicles?

- Can we assume that we all alert and capable drivers?

- Several research projects were undertaken to establish what the distractors to a driver are.
  - 100 Automobiles
  - 34 Trucks
  - Young, Older

The Naturalistic “100 Car” Driving Study: Database Statistics

- 42,300 hours of driving data collected
- 82 Crashes and collisions
  - Defined as any contact between the subject vehicle and another vehicle, fixed object, pedestrian pedacyclist, animal.
- 761 Near crashes
  - Defined as a conflict situation requiring a rapid, severe evasive maneuver to avoid a crash.
- 8295 Critical incidents
  - Conflict requiring an evasive maneuver, but of less
  - magnitude than a near crash.

Driver Behavior - Spinny

External Distraction

Impact of Lighting –Past Research

- Box [1972] showed that the night/day accident ratio was 66% higher on unlighted freeways than on lit ones.
  - 0.5 lux appeared to be the illuminance level which provided the lowest accident rate
- Osner [1973] and Nishimori[1973] both showed a 56% reduction in accidents when lighting was added to a roadway.
- CIE Pub. No 93 “Road Lighting as an Accident Countermeasure” rigorously analyzed 62 lighting and accident studies from 15 countries.
  - “(S)tatistically significant results show reductions (in nighttime accidents) of between 13 and 75 percent.”

What about Lighting Quality?

- The impact of lighting depends on:
  - Quantity
    - How much Light is needed?
  - Quality
    - What color of Light is needed?
    - What type of Light is needed?

- How do we link these to Traffic Safety?
- How do we provide Energy Savings and continue to provide traffic safety?
  - New lighting technologies provide us with these opportunities
    - Adaptive Lighting
    - Controls
    - White Light Solutions (Solid State)

Research Efforts and Applications

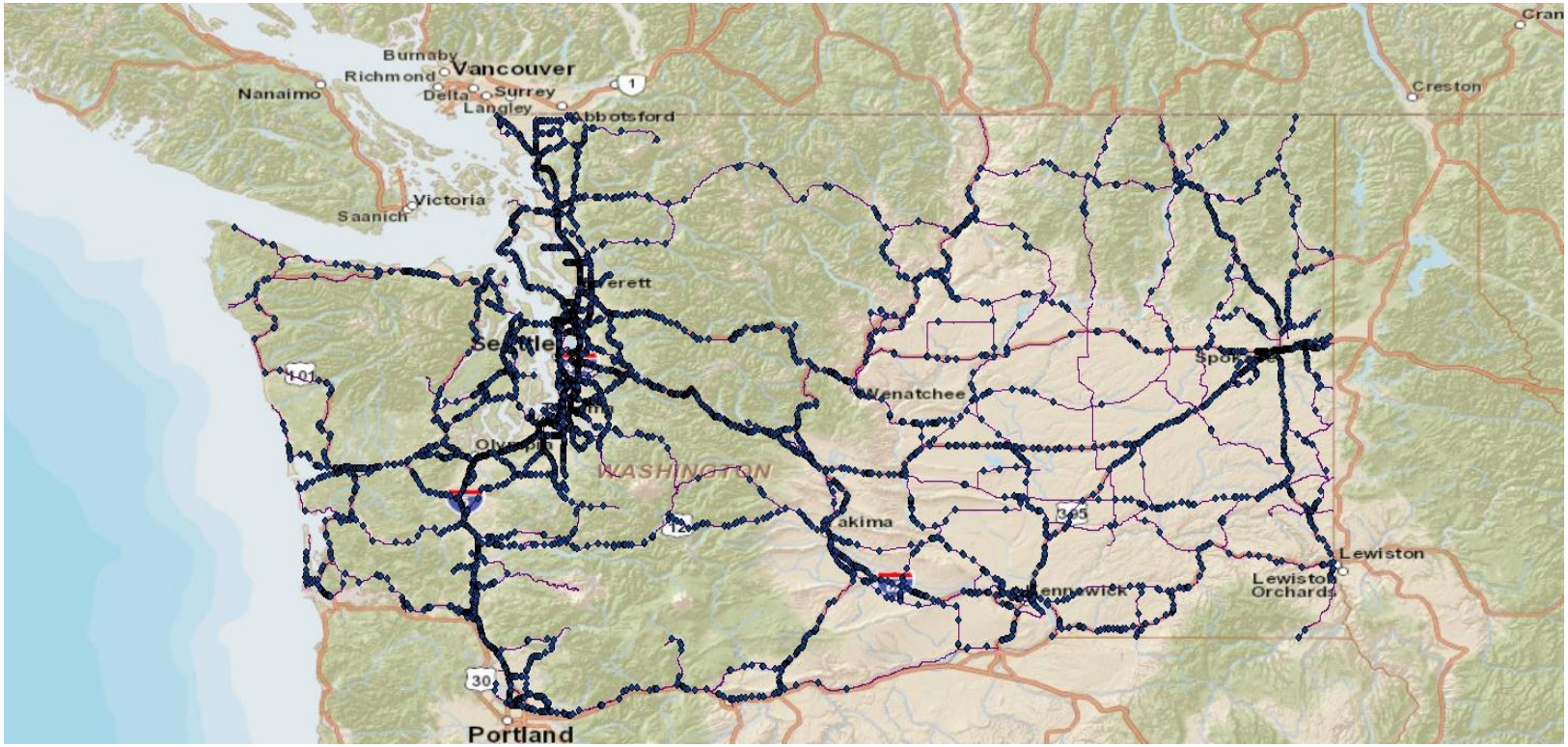
- Several Projects are underway to evaluate how all of these factors and opportunities can be applied.
  - Adaptive Lighting Evaluations
    - Federal
    - City Evaluations
      - Anchorage
      - San Diego
      - San Jose
      - Seattle
  - Color Impacts
    - Color Contrast
    - Mesopic Considerations

Adaptive Lighting

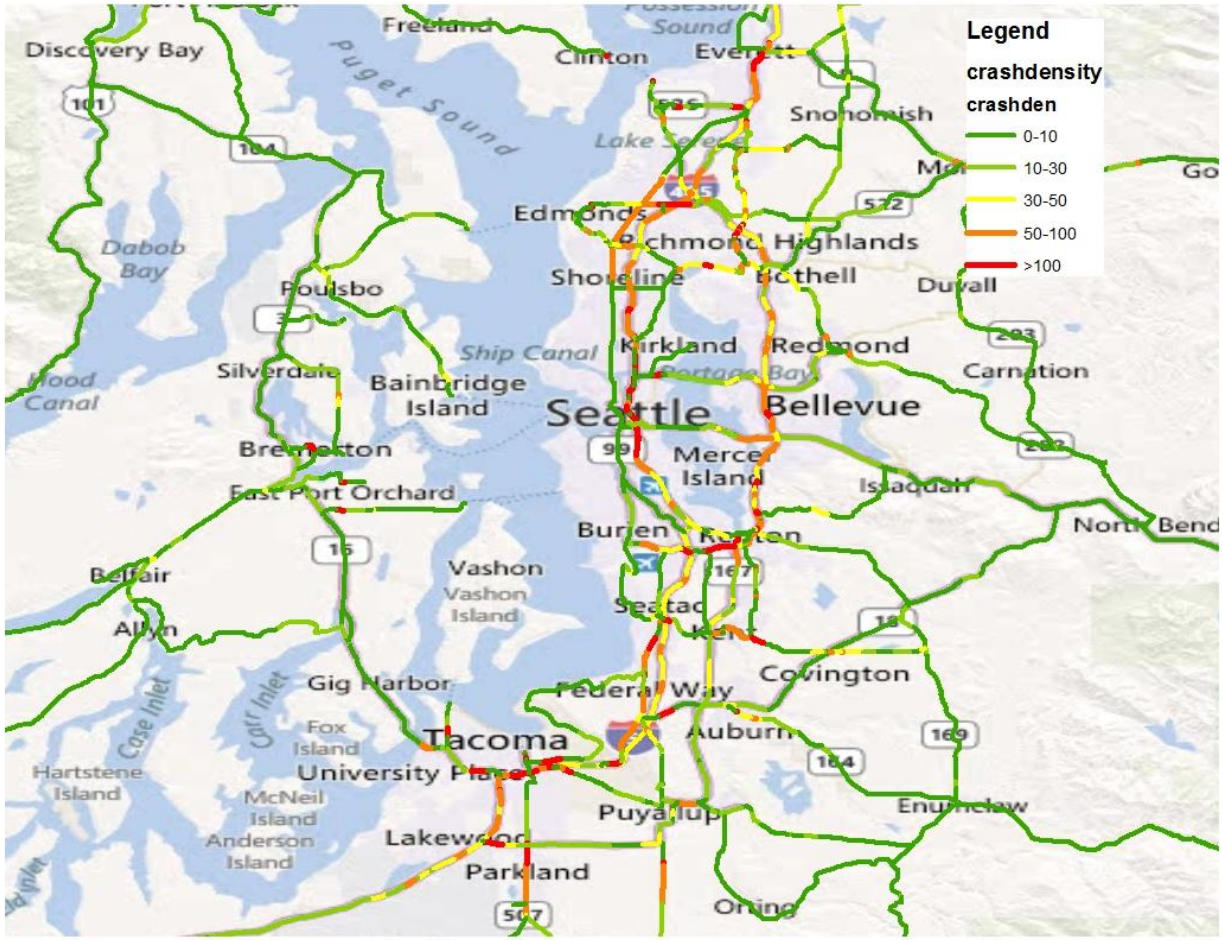
- We are linking the lighting level to crash rate for a variety of roadway designs and conditions
  - We will have a statistically accurate link between lighting design and crash safety
  - At least 3200 km of lighting data collected
  - Crash data collected
  - Stratify by Road Type and Traffic Volumes

Washington

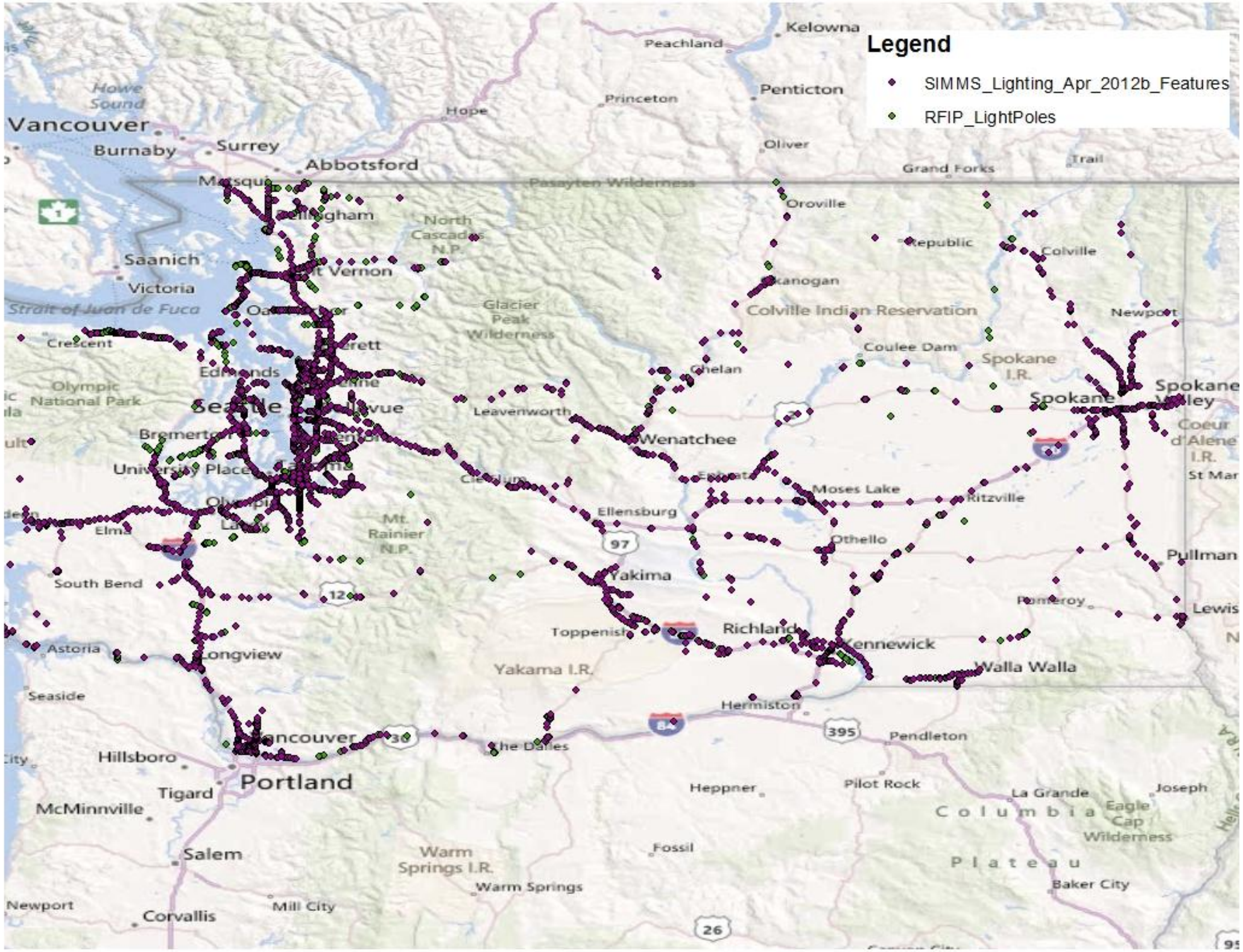
- Crashes 2008



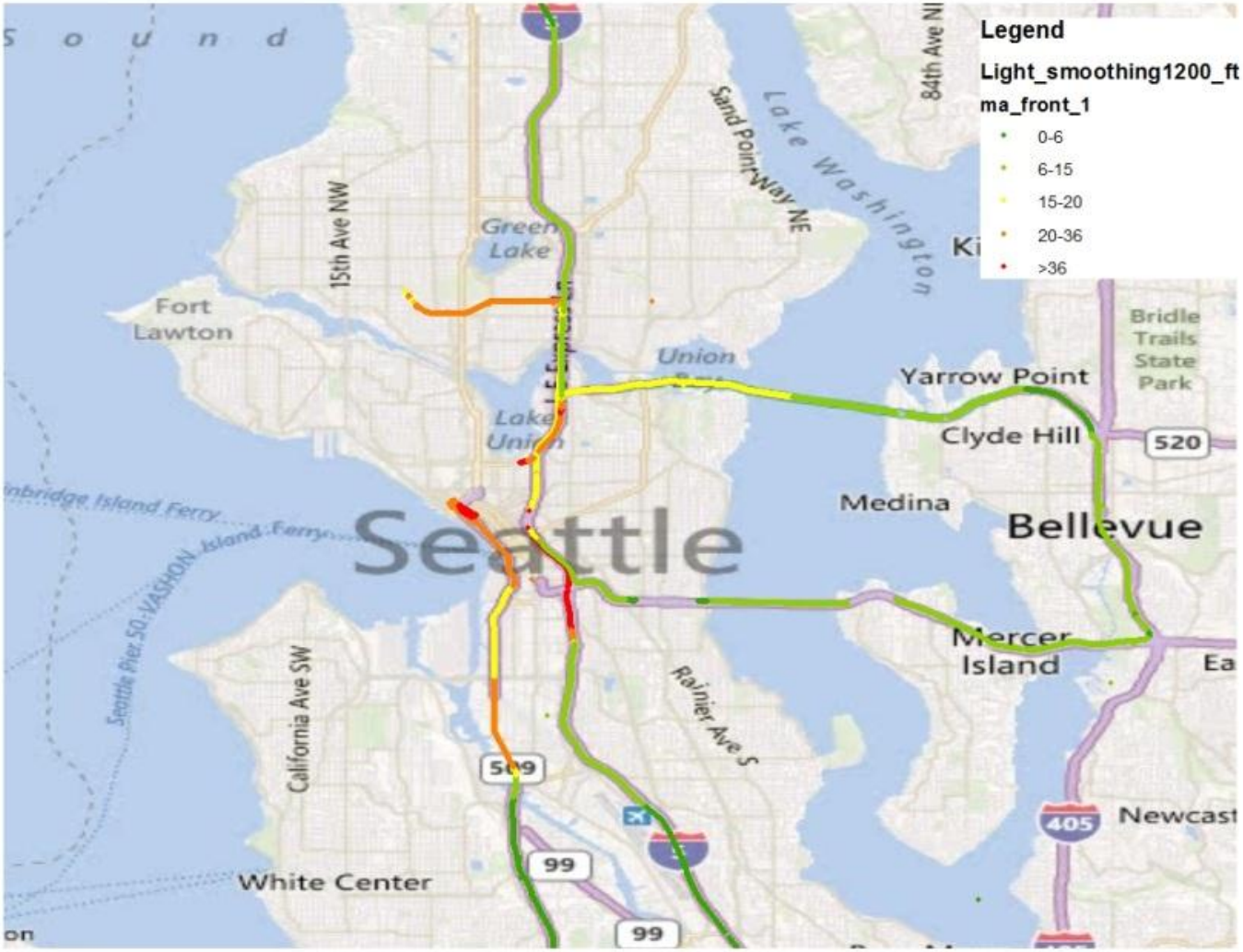
Crash Density per Mile



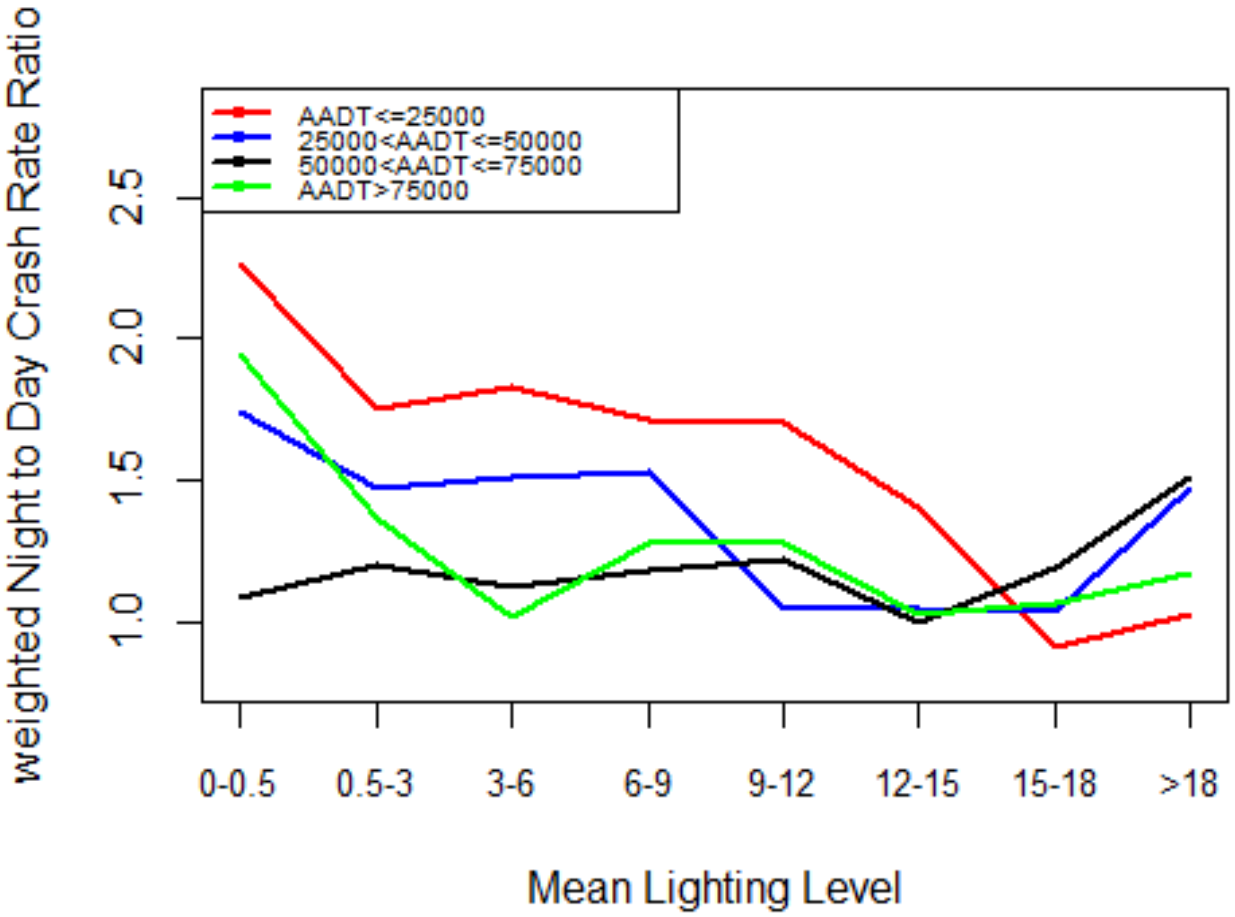
Washington Light Pole Locations



WA Lighting Data Collection



Composite Results



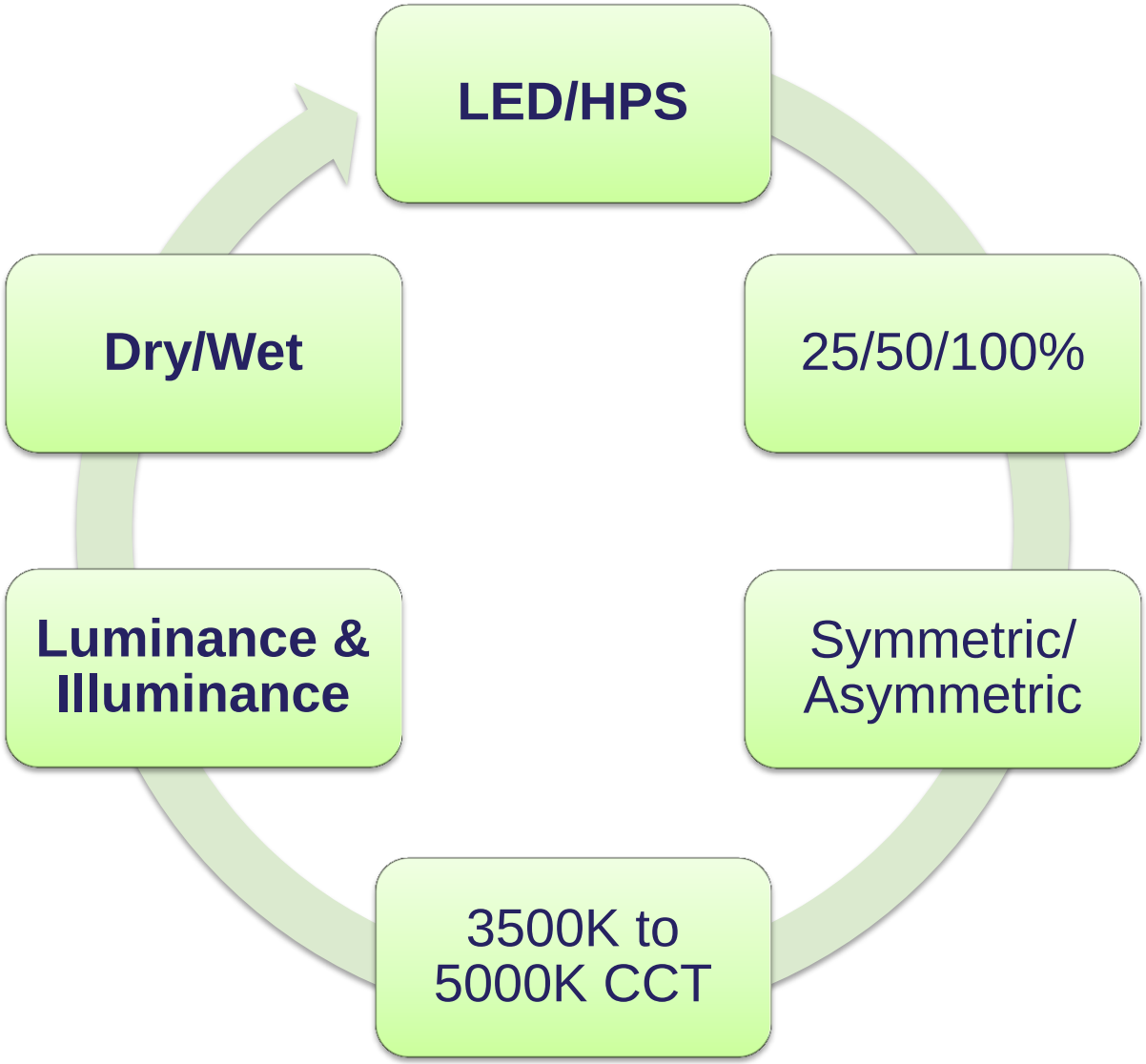
Energy Usage

- In 2001:
  - It was estimated that there are 72 929 000 outdoor lighting fixtures in the US
  - Consuming 57.35 Twh of Electricity
  - Costing $5.9 Billion in energy usage each year
- Potential to reduce energy usage by 25%
  - 50% diming, 50% of the time
  - $1.49 Billion Savings = $20 per luminaire per year

City Investigations

- We have performed a significant number of investigations looking at cities and the best possible application of new light technologies.
  - Important to determine how citizens relate to the lighting system as well as how those systems perform
    - Subjective Analysis
    - Objective Analysis
  - Seattle is the most recent city we considered

Seattle Experiment Variables

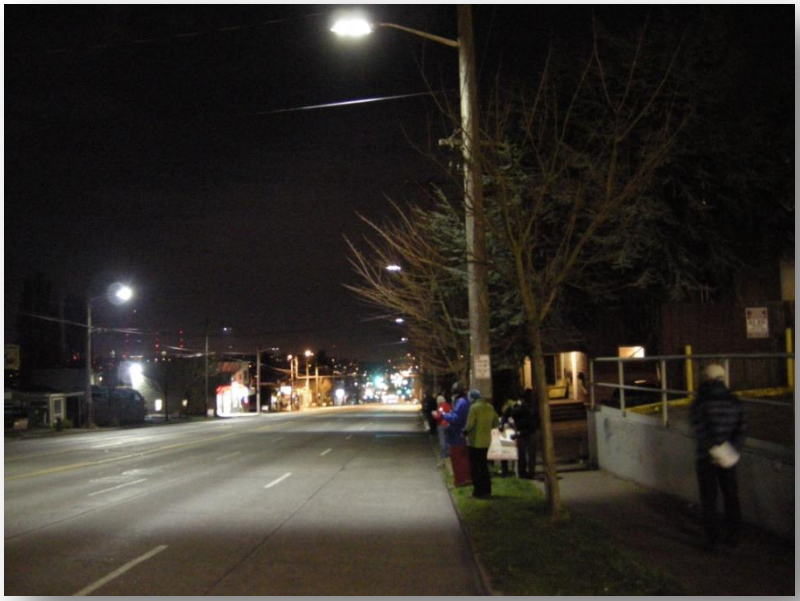


Research Questions in Seattle

1. Which light source is preferred?
2. What color temperature is preferred?
3. Is there a visibility enhancement with broad spectrum light sources?
4. How far can lighting levels be reduced and still achieve safety goals?
5. What lighting is better?
6. How do these compare under wet vs dry pavement?

Study Design

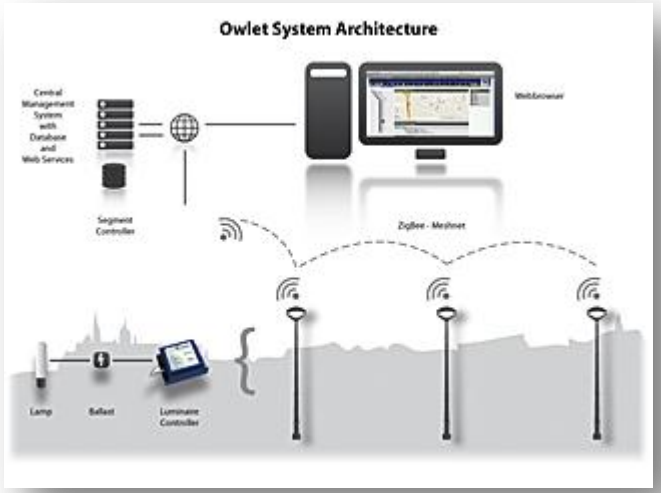
- Six test areas (different colors of lights)
  - LED 3500K, LED 4100K, HPS 400W, LED Asymmetric at 4100K, LED 5000K, HPS 250W
- Three light levels
  - 100%, 50%, 25%
- Two road conditions
  - Dry and wet
- Subjective evaluations
- Objective driving test



Equipment Selection

- LED luminaires
  - Philips Lumec RoadStar
  - 105W 79 LED

- Control system
  - Owlet Nightshift
  - 42 LuCos (2 repeaters), 1 SeCo

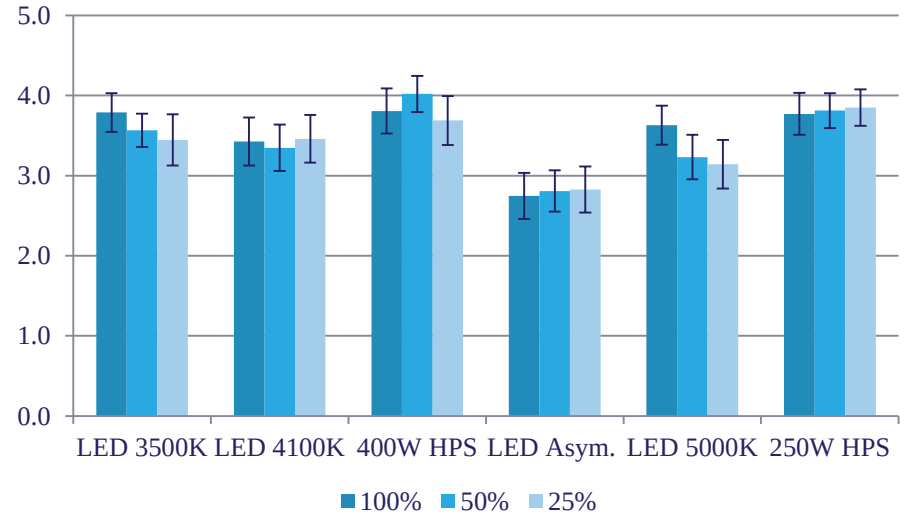


Road Wetting

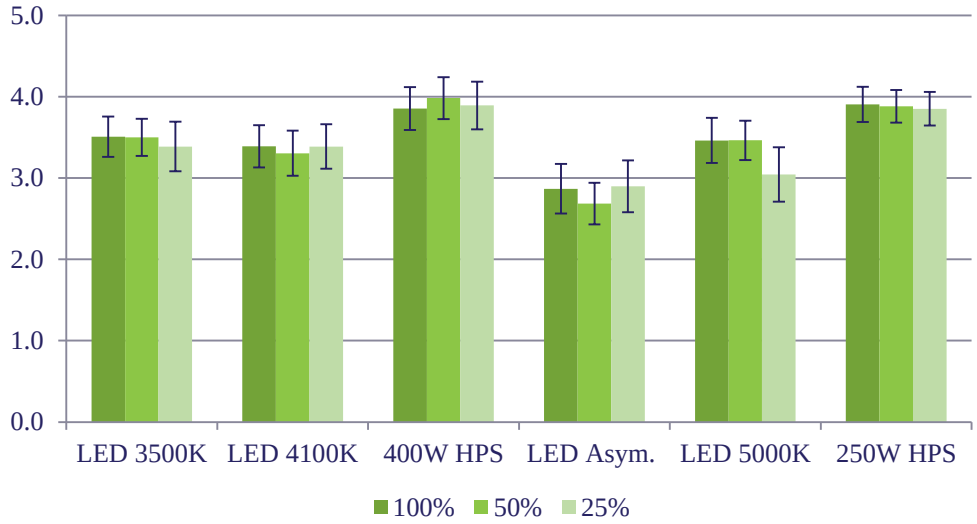
How did it go subjectively?

Lighting is Comfortable - Subjective

- **5 - Strongly agree**
- **1 - Strongly disagree**



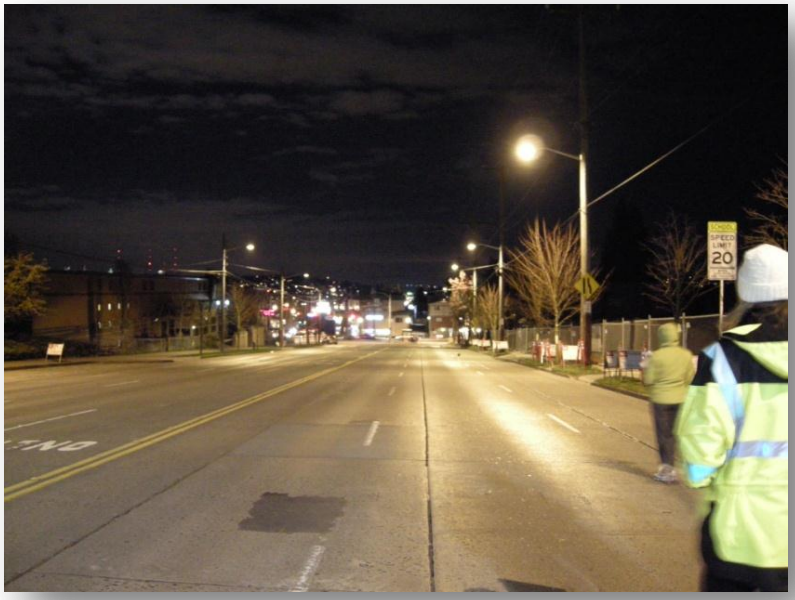
DRY



WET

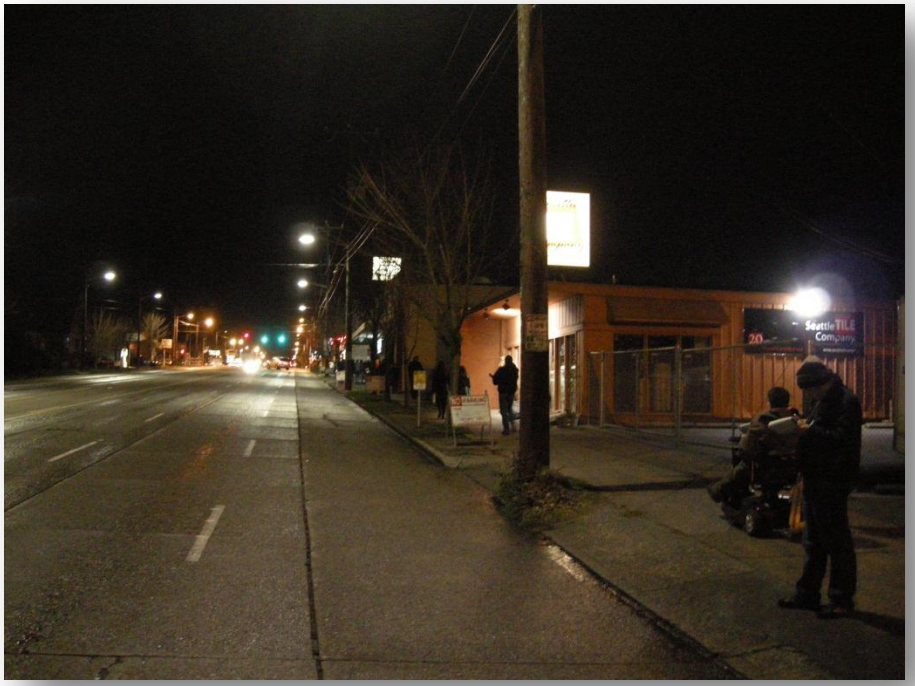
Color Temperature - Subjective

- *Previous studies in San Diego and San Jose, indicate that participants preferred the 3500K LED (neutral white)*



Backlight - Subjective

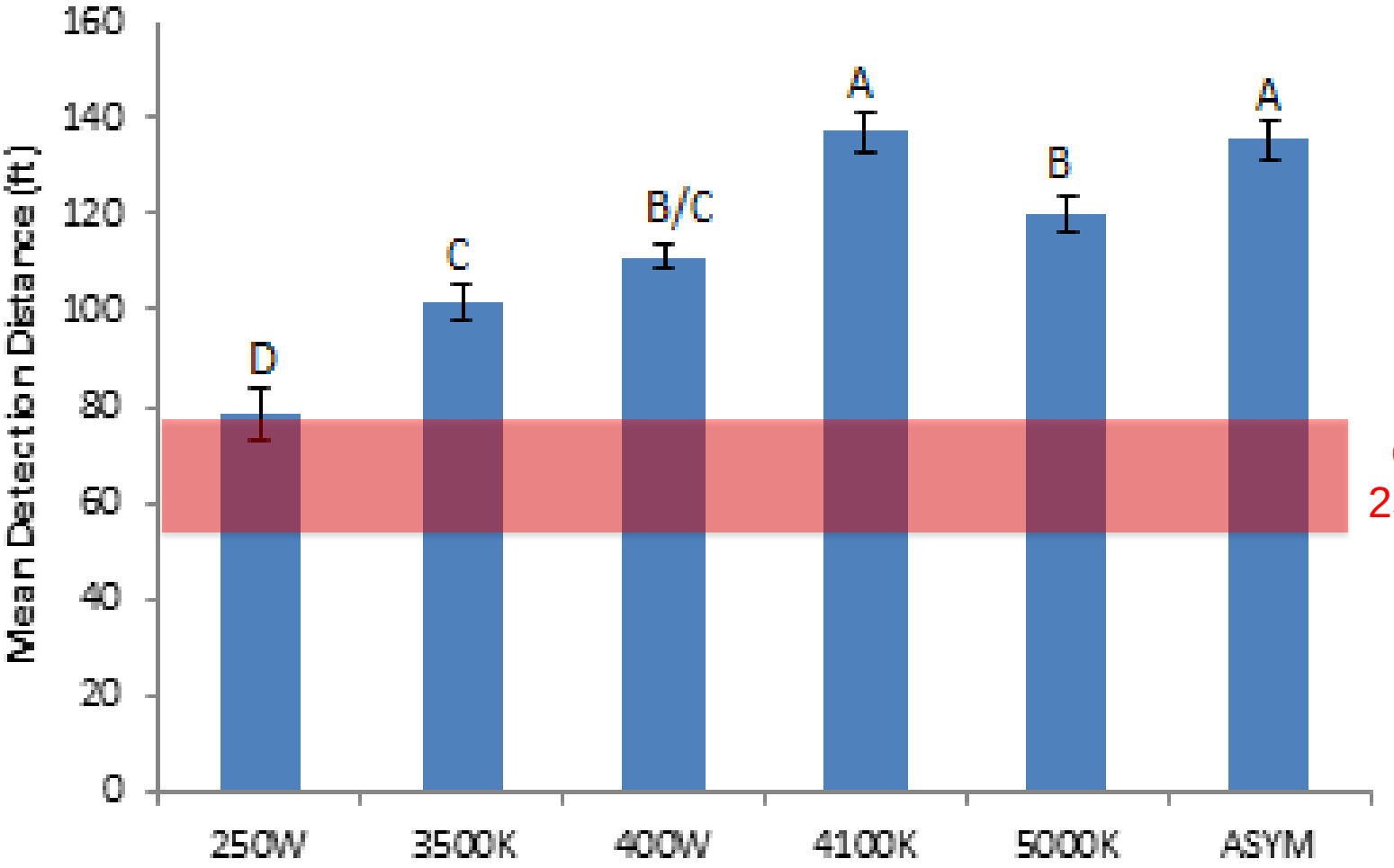
- At the lower light levels, some participants evaluated the lighting as being too dark on the sidewalks.



How did it go objectively?

Detection Distances

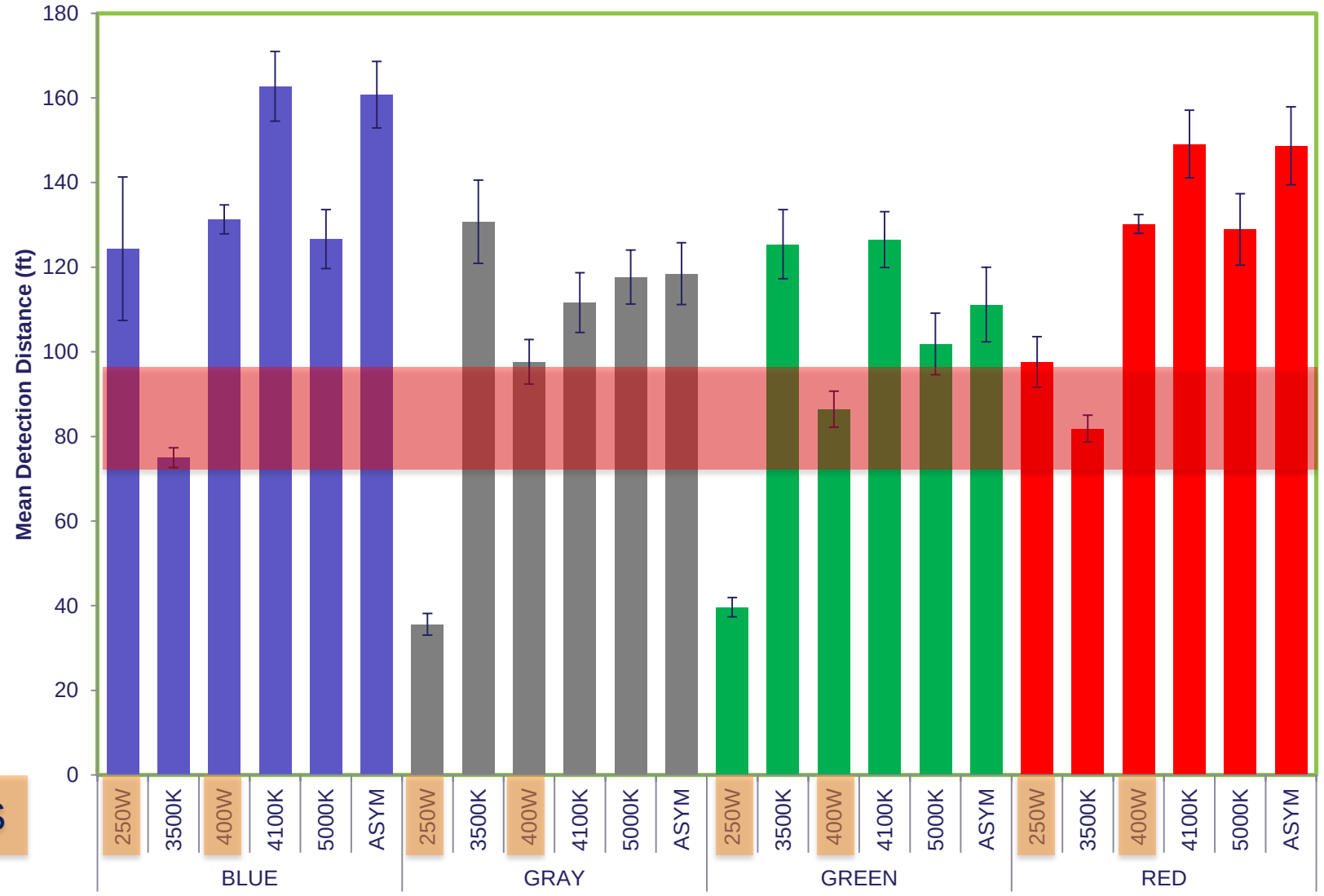
Average values for all light levels and pavement conditions



*Traffic and Roadway Accident Analysis and ..., Issues 400-402; Issue 1467

Color Contrast Importance?

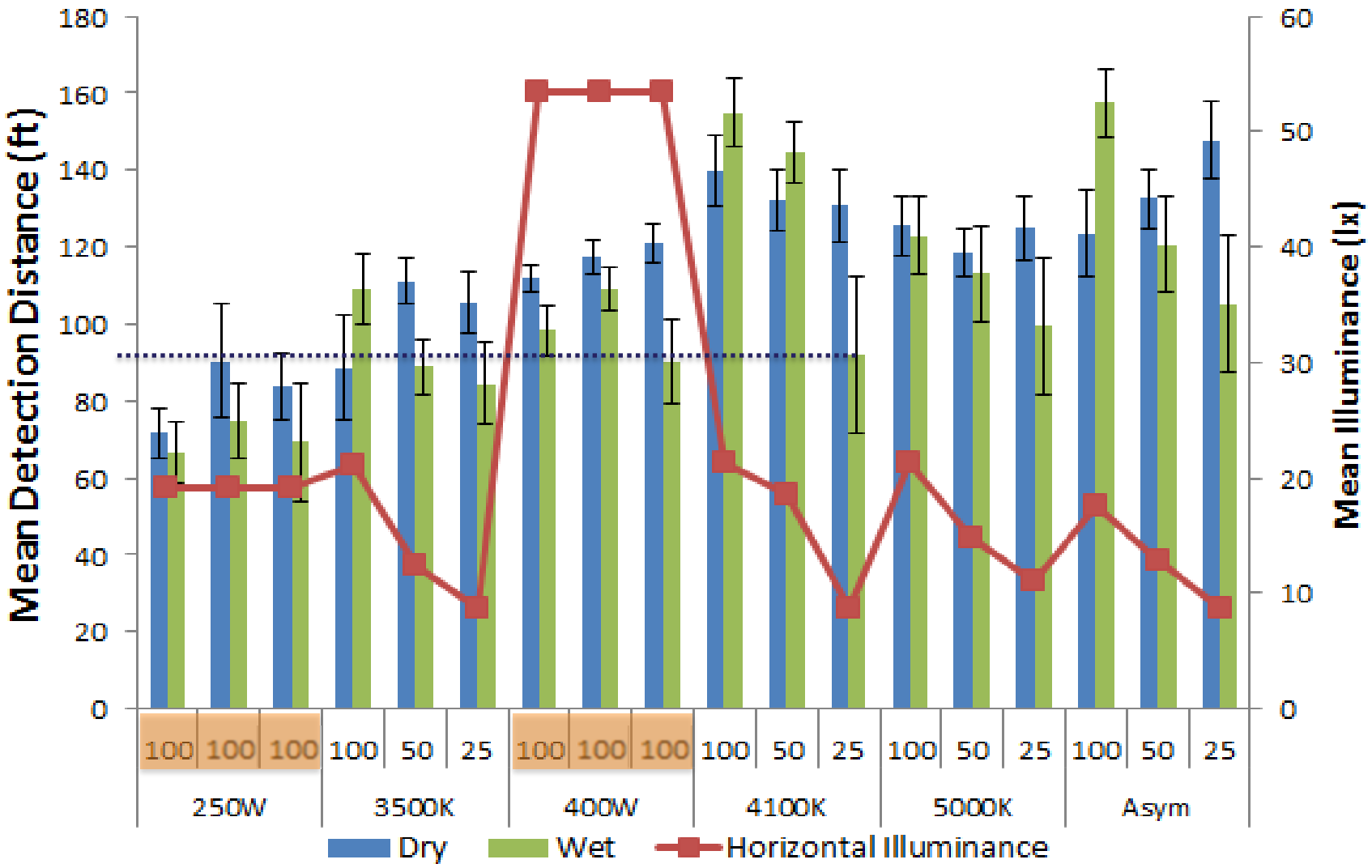
Specific Color Analysis



HPS

*Stopping distance at 25mph (wet) Traffic and Roadway Accident Analysis and ..., Issues 400-402; Issue 1467

Detection Distance vs Horizontal Illuminance



Adaptive Standards - Objective

- Objective results for dry pavement dimming did NOT significantly affect object detection distance.

Conclusions from the City Tests

1. Adaptive changes (dimming the lighting) do not appear to change contrast of the objects
2. Visibility is linked to contrast
3. 4100K came out on top in performance because it represents a middle between red and blue targets (color contrast)
4. Non uniformity has more to do with visibility (more uniform is not necessary better, probably the opposite)

The Future

- Connected Vehicles
  - Vehicles will transmit a “Safety” message in the a 300 meter range of the vehicle
  - This message will allow for collaborative safety
    - Vehicle to Vehicle (V to V)
      - Currently being standardized
    - Vehicle to Infrastructure (V to I)
      - In Development
    - Cell phone to Infrastructure (X to I)
      - 3 – 5 years out

V to I Applications

- Adaptive Lighting
  - Vehicle Counts
  - Vehicle Speed
  - Pedestrian Presence
- Just in Time Lighting
- To take advantage of these technologies
  - Install controls today

Lessons Learned

- Data shows that installing LED Luminaires will allow you to maintain or improve safety levels
  - Color Improvement
  - Mesopic Applications
    - Switch from Mercury Vapour is simple
      - White Light for White Light
- Adaptive Lighting will allow for further energy savings
  - You need a control system
    - Individual Luminaire with Dimming
  - Install Controls now even of you are not ready for adapting

Questions?