Advanced Roadway Delineation and Lighting Systems

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Driving Transportation With Technology

Subject Area Strategic Goal

- Improving nighttime roadway visual environment through the assessment of behavior, establishment of visibility needs, and control of adverse lighting effects.
  - Night driving has been described as a situation for which humans have not evolved, leaving our visual system inadequate and inefficient for certain tasks (Rumar, 1990).
- Our focus:
  - Provide the understanding and systems necessary to "evolve" the nighttime driving task for the driver.

STSCE ARDLS Projects

Tool Development

Luminance Camera
Color Camera
Roadway Lighting Mobile Measurement System

Metric Development

Glare Metrics
Luminance Metrics

Application Development

Object Color Contrast
Visibility Modeling
Roadway Lighting and Safety
Luminance Metrics

Luminance Camera

- The traditional methods for the photometric evaluation of Roadway Lighting and Delineation Research have proven to be inadequate
  - We have developed a dynamic method to evaluate the luminance of the visual environment from a moving vehicle

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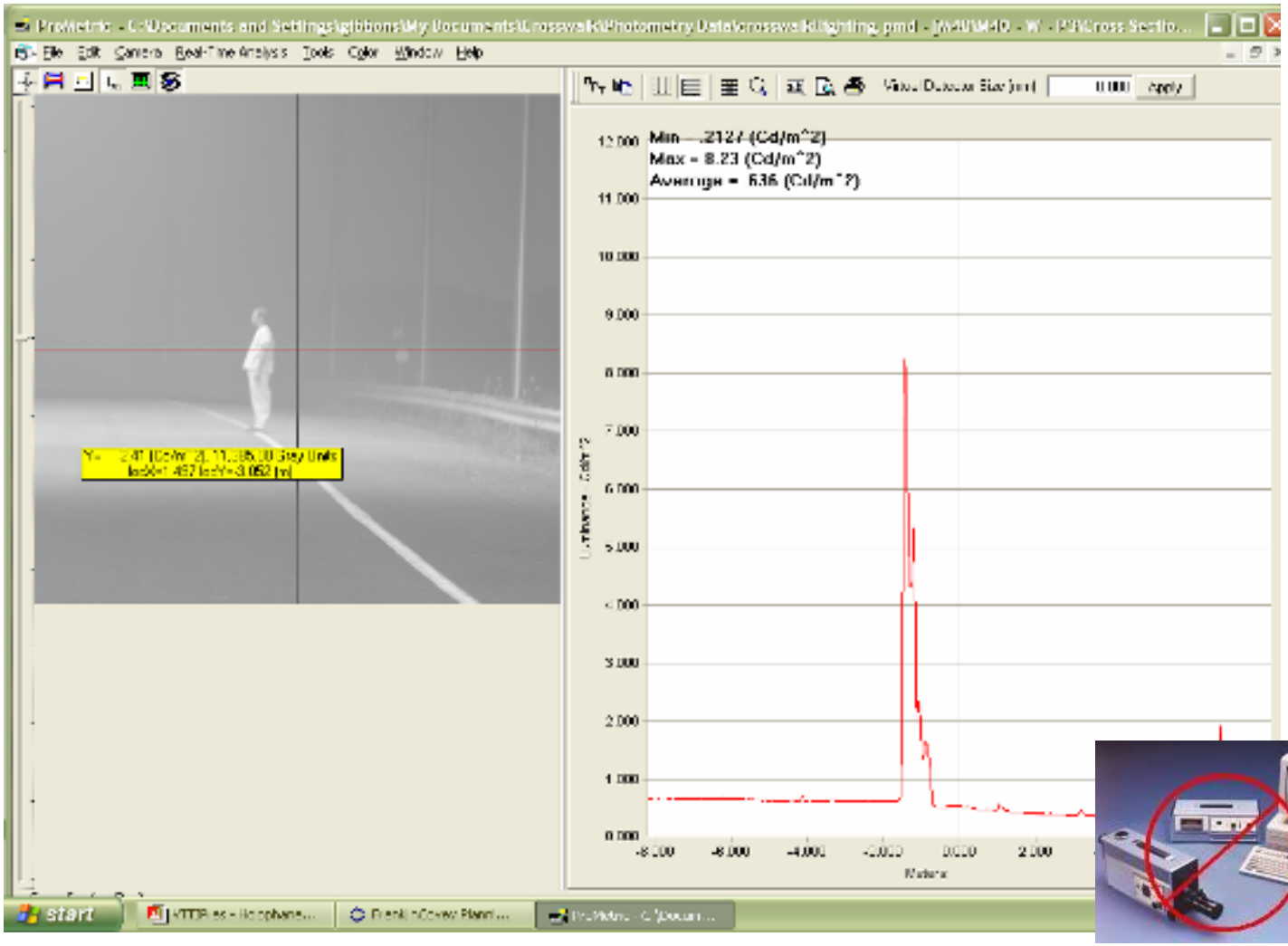
CCD Photometry



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Contrast Assessment

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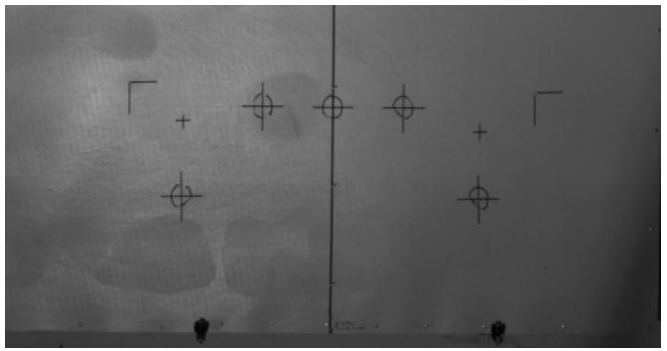
Luminance Camera

- 12 bit Point Grey Digital Firewire camera.
  - Calibrated against a Prometric Still Luminance Camera
- Varying shutter and gain values determine the range of luminance measured
  - 2 cameras can be coupled to increase dynamic response
- Individual images are stored for later analysis

Calibration - Procedure

- Controlled environment
- Simultaneous image capture with ProMetric photometer and Luminance Cameras
  - Software automatically adjusts Luminance Camera variables

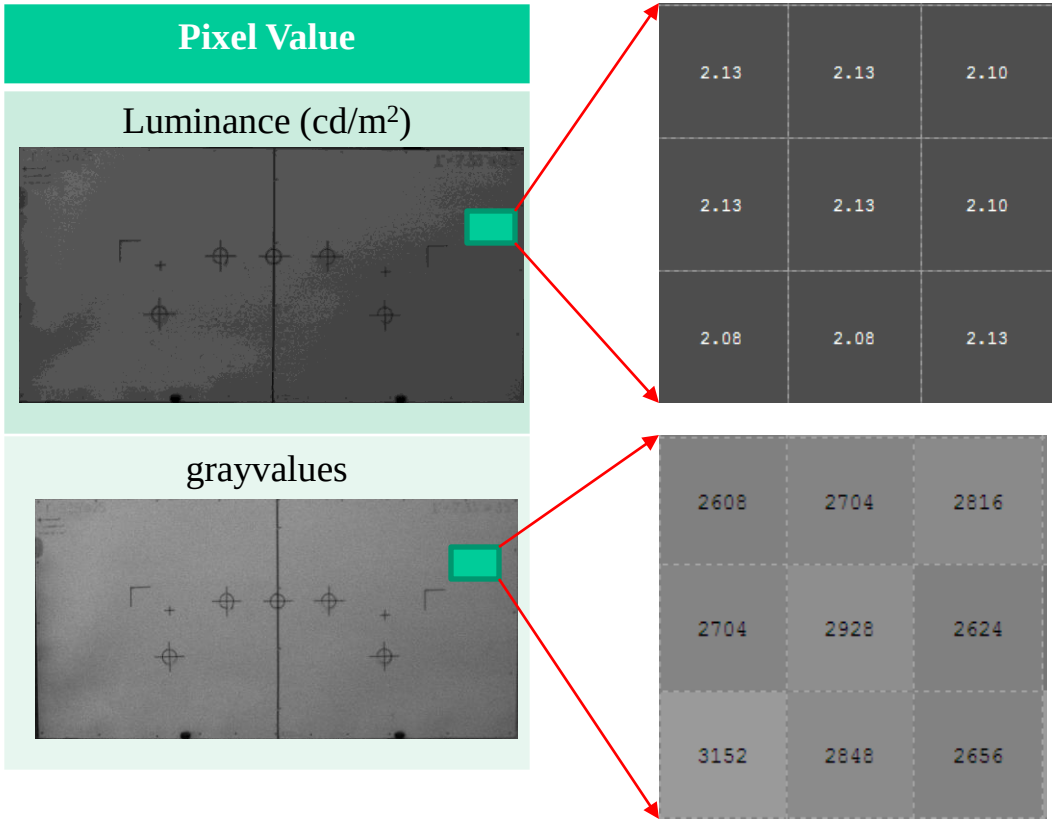


Light Level (cd/m2)	24.1, 15.6, 7.99, 1.87
Camera Gain (dB)	24, 21, 18, 15, 12, 9, 6, 3, 0, -2.25
Camera Shutter (ms)	267, 213, 159, 105, 51, 41, 36, 31, 26, 21, 16, 11, 6, 1

4 Light levels
10 Gain values chosen
x 14 Shutter values chosen
560 images captured by Luminance Camera

Calibration - Procedure

Overlay of images completed automatically through software



Dynamic Evaluation – Procedure Camera Setting Selection

Estimation of maximum luminance

Darkened image → High pixel saturation

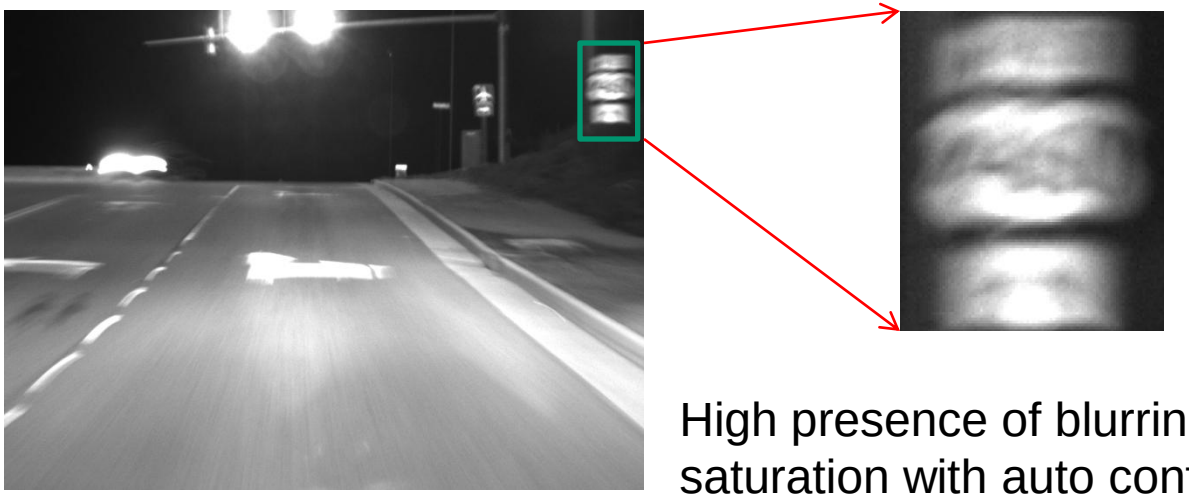
Increase in image noise ↓

GAIN (dB)	SHUTTER (ms) 1	6	11	16	21	26	31	36	41	51	105	159	213	267
-2.25	899.4	172.6	96.2	66.6	48.4	40.6	34.7	30.1	26.5	21.7	10.8	14.0	6.8	7.3
0	732.1	120.8	69.1	47.2	39.3	**32.2**	25.9	23.2	20.7	15.8	7.8	5.4	3.6	3.0
3	477.8	89.3	49.2	34.9	26.8	21.7	19.3	15.0	14.0	12.5	5.5	3.5	2.7	2.2
6	332.8	64.0	35.1	24.5	19.4	15.2	13.3	12.6	9.9	7.7	3.7	2.5	1.9	1.6
9	214.1	40.6	23.4	17.6	12.6	10.0	9.6	7.7	6.1	5.5	2.8	1.7		
12	165.4	33.6	18.6	12.0	9.7	7.5	6.1	5.6	5.2	3.9	2.0			
15	107.3	22.9	12.7	9.8	6.8	5.4	4.4	3.7	3.2	2.7	1.7			
18	81.2	14.8	8.2	6.2	3.9	3.2	2.5	2.4	2.0	1.8				
21	56.1	12.1	6.9	3.8	3.3	2.6	2.2	1.8	1.8					
24	41.8	7.0	5.2	2.4	2.0	1.8	1.8	1.7						

Dynamic Evaluation - Results

Manual

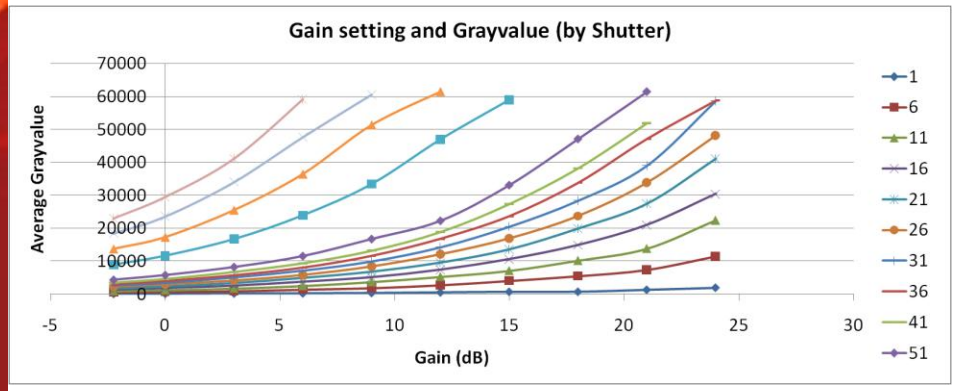
Automatic



High presence of blurring and saturation with auto configuration

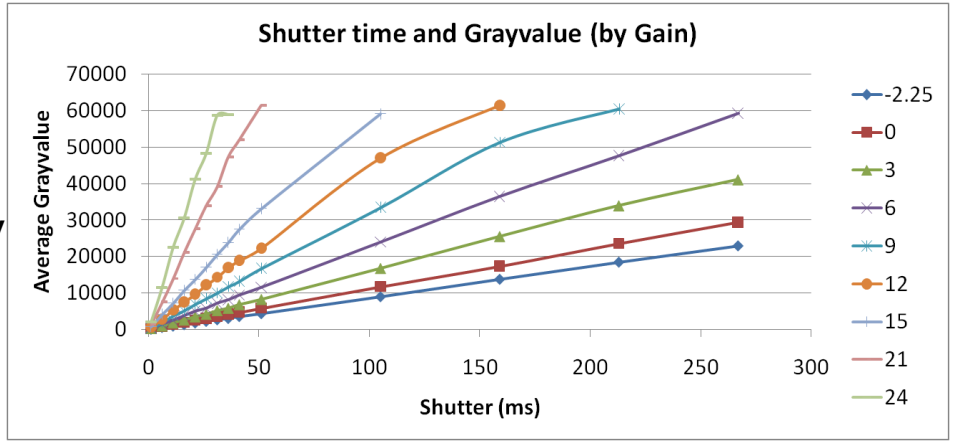
Calibration - Results

- Pixel analysis



Positive relationship of Luminance Camera gray value and gain

Positive relationship of Luminance Camera gray value and shutter

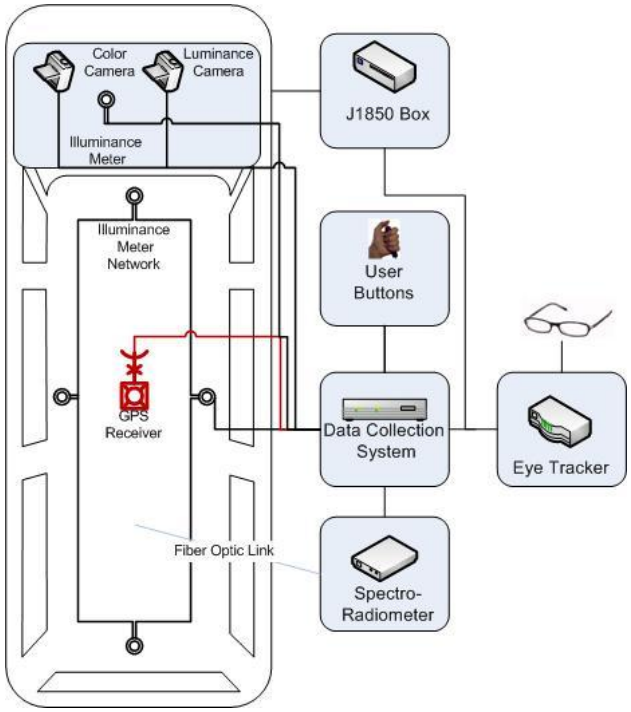


RLMMS

- We have developed the Roadway Lighting Mobile Measurement System to allow us to assess performance in-situ
- This system allows us to travel and perform assessments of installed lighting systems
  - The system has been used in:
    - VTTI
    - Anchorage
    - San Diego
    - Hawaii
    - San Jose
    - Rural Intersections
      - Iowa
      - Virginia

Equipment

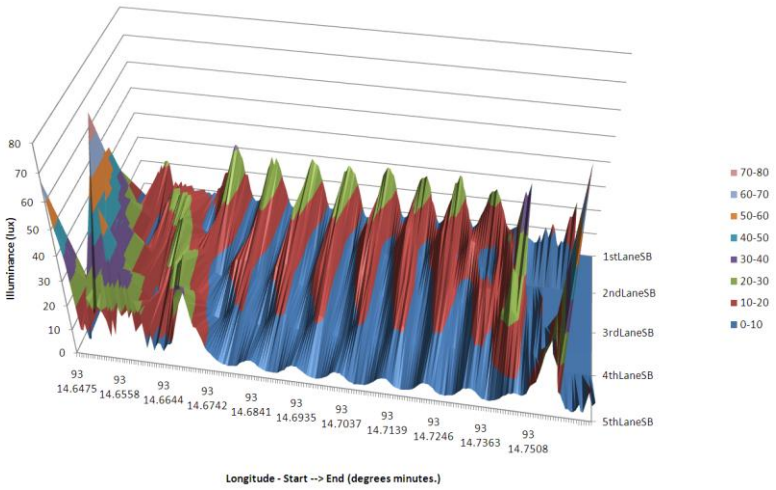
- External
  - Novatel GPS device mounted at the center of the vehicle
  - Illuminance Meter Grid
    - Four weatherproof heads mounted horizontally on the roof of the vehicle in the center of the wheel path

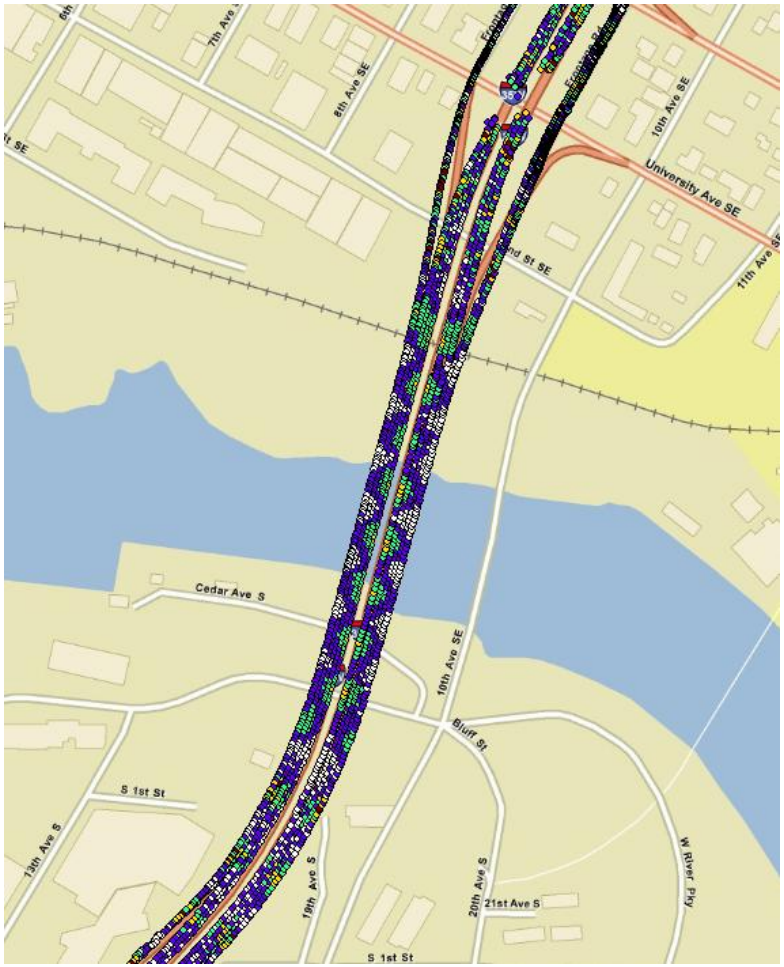


- Internal
  - Illuminance Meter
    - One mounted vertically inside the windshield
  - Luminance Camera
    - VTTI-developed luminance camera to monitor the entire scene
    - Luminance is derived from a calibration procedure performed on each camera
  - Color Camera
    - 1280x960 RGB FireWire camera
  - J1850 box
    - Returns vehicle information from internal vehicle CAN network
  - Spectroradiometer
    - Ocean Optics HR4000
    - Measures spectral information through a fiber optic link to a cosine or sphere collector on vehicle roof
  - Buttons
    - Small push buttons mounted in vehicle to capture human response events
  - Eye Tracker
    - Arrington Research Binocular Eye Tracking System

System Layout

RLMMS Integration





Alternative Light Sources

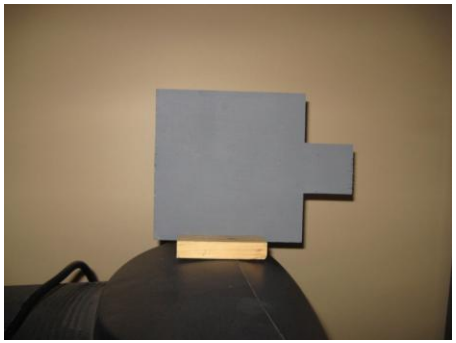
- Four on-site investigations have been undertaken to investigate the impact of Broad Spectrum Lighting on Driver Performance
  - Anchorage
  - San Diego
  - San Jose
  - Hawaii

- In each experiment, the RLMMS measurement system was used to measure light source and observer performance
- Small Targets were used along the side of the roadway to provide an observation target

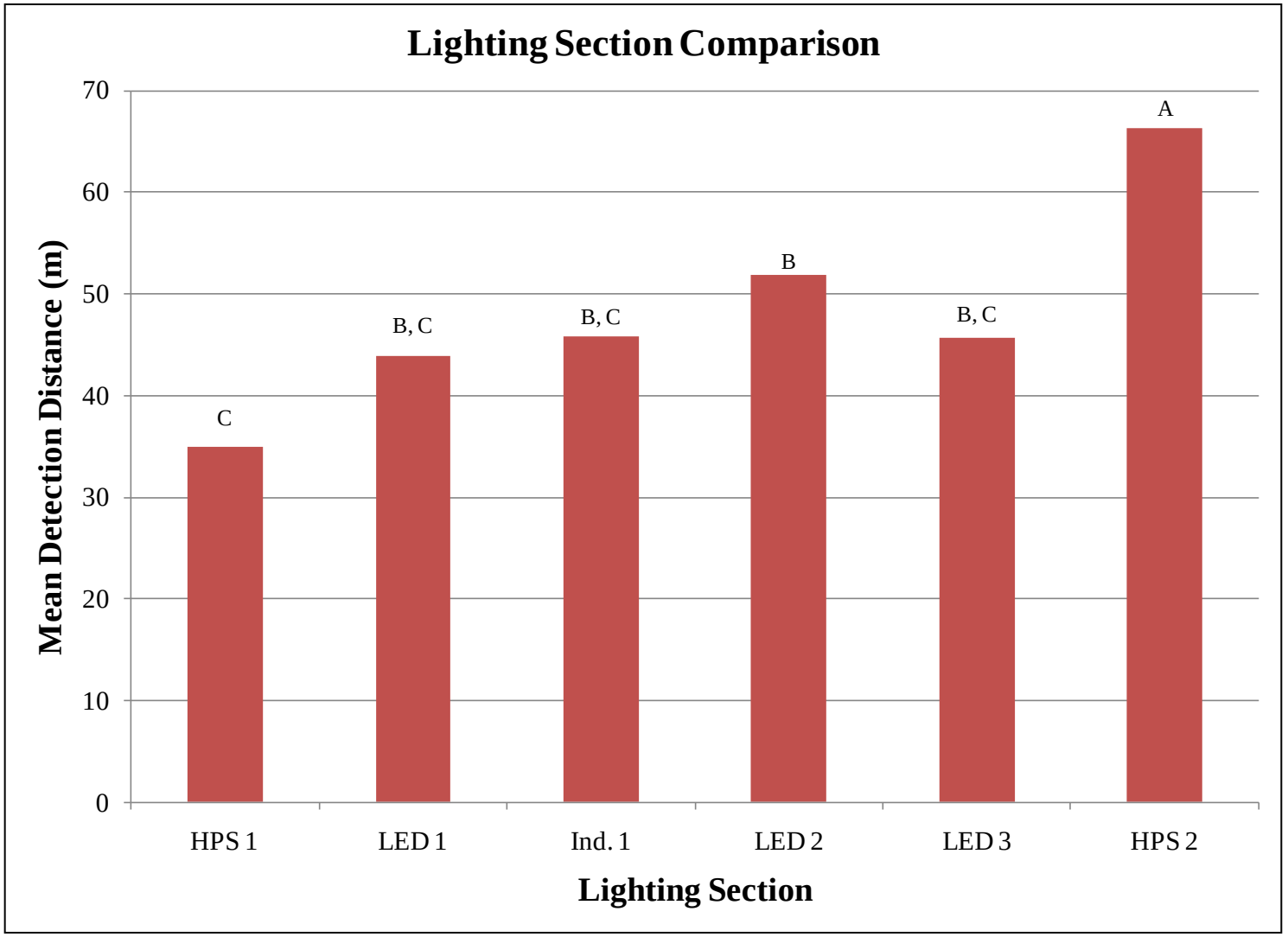
Anchorage

- 6 different lighting systems were tested along an urban street in Anchorage
  - HPS, LED, Induction
- 27 Participants from the public were tested for object detection and public opinion
  - Using the RLMMS

- Different Colored targets
  - Red
  - Green
  - Blue
  - Gray
- 2 Different Sizes
  - 7 inches
  - 18 inches



Initial Results



Energy Consumption

System	Description	Watts/ Lamp	Watts/Luminaire
1	Dimming HPS	250	257
2	BetaLED	234	234
3	Kim Induction	165	165
4	Lumecon	160	160
5	Kim LED	146	146
6	Existing HPS (non-dim)	400	460

Table 1: Lighting system power consumption