NCHRP 13-02
Development of Guidelines for Warning Lights on Maintenance Vehicles

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NCHRP Project13-02

- Purpose
  - Develop guidelines for the selection and application of warning lights to improve the conspicuity and recognizability of roadway-operations equipment used for construction, maintenance, utility work, and other similar activities

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Background

- There is a wide disparity in roadway maintenance vehicle warning lights
- This inconsistency raises problems of proper interpretation of their meaning
- No single study has tried to provide a comprehensive guideline for the marking of maintenance vehicles
- The impact of weather on the conspicuity and visibility of vehicles has also not been investigated

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Purpose of Warning Lights

- Warn motorists that a highway maintenance vehicle is on or near the roadway
- Allow drivers to take actions with enough warning time
- To define the shape and size of the vehicle
- To convey the intent of the vehicle

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Dynamic Performance Experiment

- Factors Tested:
  - Ambient Lighting Conditions
  - Weather
  - Visual Complexity
  - Light Position
  - Driver Expectancy
  - Distraction
- All of the experiments were conducted on the VTTI Smart Road
  - Rain, Clear and Fog weather conditions
  - Day and Night
  - 4 Sessions were required for the experiment
- An uniformed event was used at the beginning of the testing to test some of the characteristics
- 32 Participants (16 between 25 and 35 and 16 over 65)
  - Each saw 116 lighting and ambient conditions

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Vehicle Setup

- The same dump truck from the Screen Experiment was used
  - The four lighting conditions were mounted on the vehicle
- The system could be controlled by the driver
- All of the patterns were asynchronous with a 1 Hz frequency

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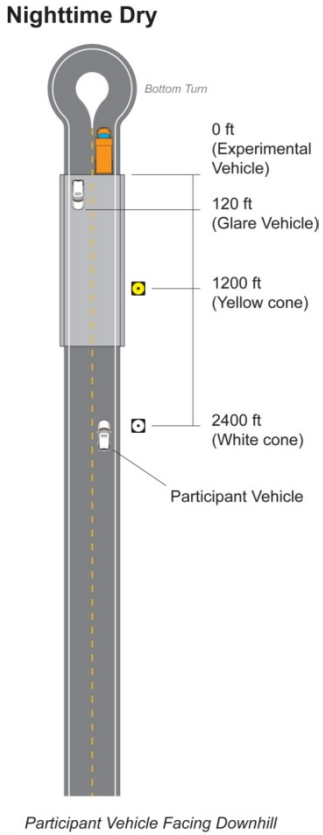
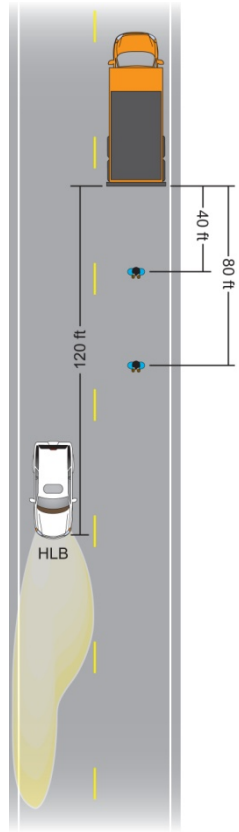
Nighttime Road Setup

Ratings



Pedestrian Testing



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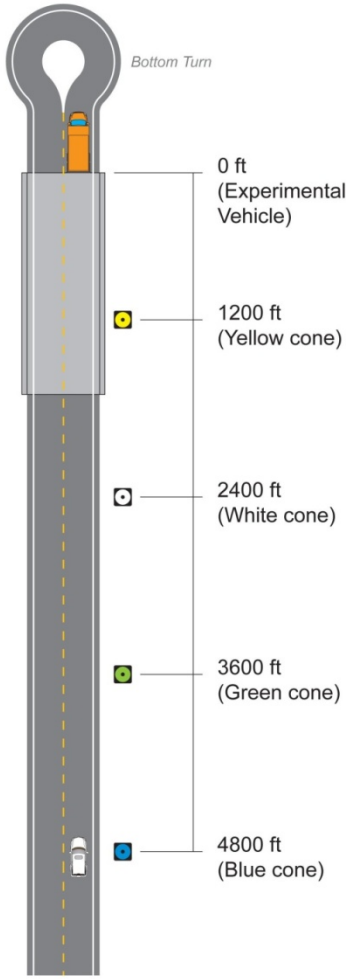
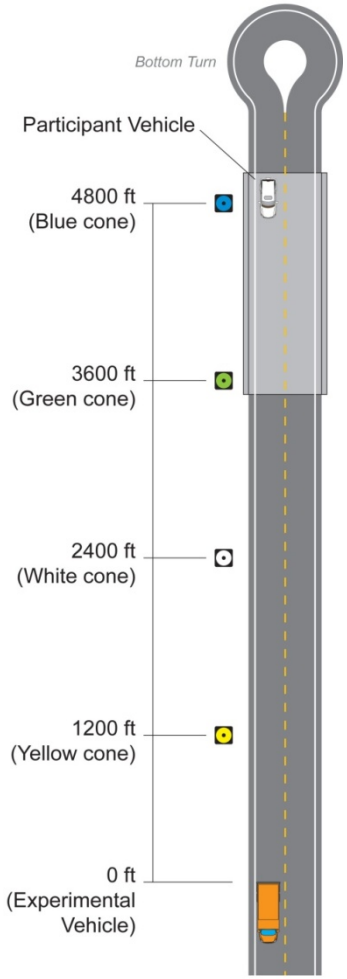
Daytime Road Setup

Daytime Dry



Participant Vehicle Facing Downhill

Daytime Dry



Participant Vehicle Facing Uphill

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Dependent Variables

- Uninformed Test
  - Lane Change Distance
  - Attention-Getting
- Smart Road Testing
  - Vehicle Identification Distance
    - Participants stated when they were sure that they were approaching a vehicle
  - Pedestrian Detection Distance
    - Distance at which a pedestrian beside the vehicle could be seen
    - Nighttime only
  - Attention-Getting
    - 7 Point Scale
  - Confidence
    - Rating from 0 to 100
    - Daytime only
  - Discomfort Glare
    - 9 Point Scale with 9 being the highest
    - Nighttime only
  - Urgency
    - Rating from 0 to 100

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Pedestrian Position

- The pedestrian was located at rear of the truck in the center of the approach lane
  - They were wearing Denim Scrubs and a retroreflective vest

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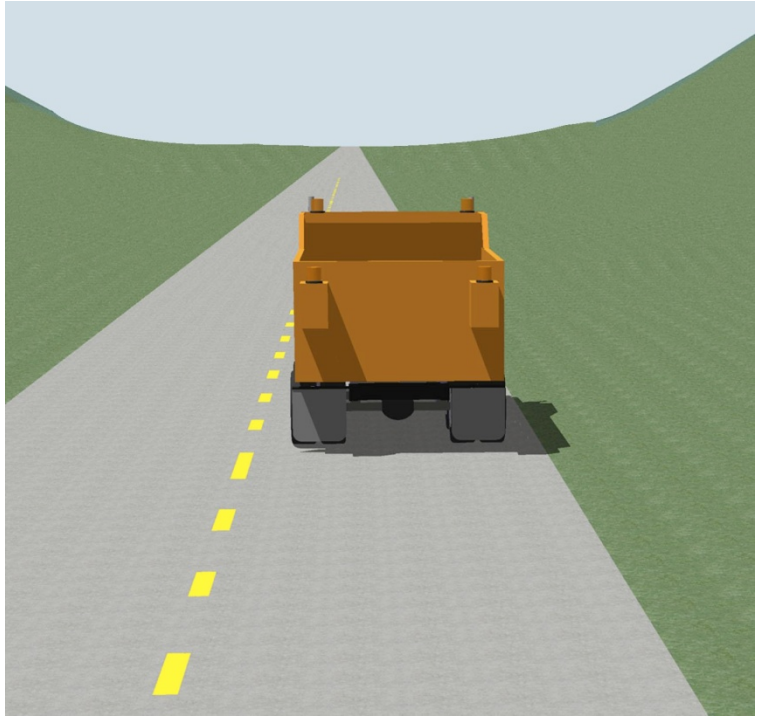
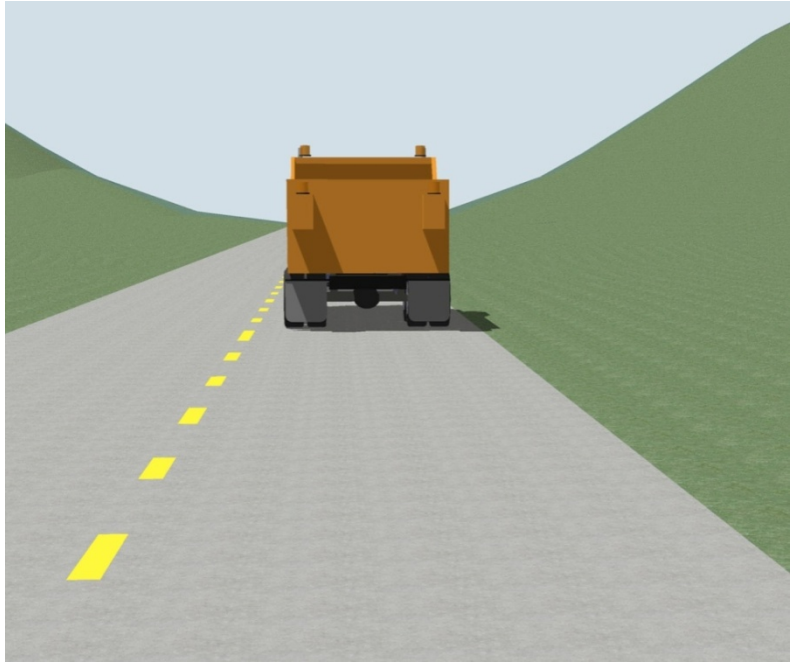
Daytime Truck Appearance

Downhill against Background



Uphill against Sky



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Draft Guidelines

- Guidelines were developed based on the experimental results
- The document is currently being put into its final form by NCHRP

- Document includes guidelines and draft specifications

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Draft Guidelines

- Lighting Characteristics
  - Lighting Systems with a profiled Output provided better vehicle identification
  - 360º Sources should be avoided close to the line of sight
- Adverse Weather
  - LED systems had increased scatter and caused decreased detection distances
- Color
  - The lighting should be amber in color
- Lighting System Layout
  - The Lights should appear against a controlled background not the sky
- Other Factors
  - Other vehicles and roadway lighting will generally reduce the impression of glare from the lighting system

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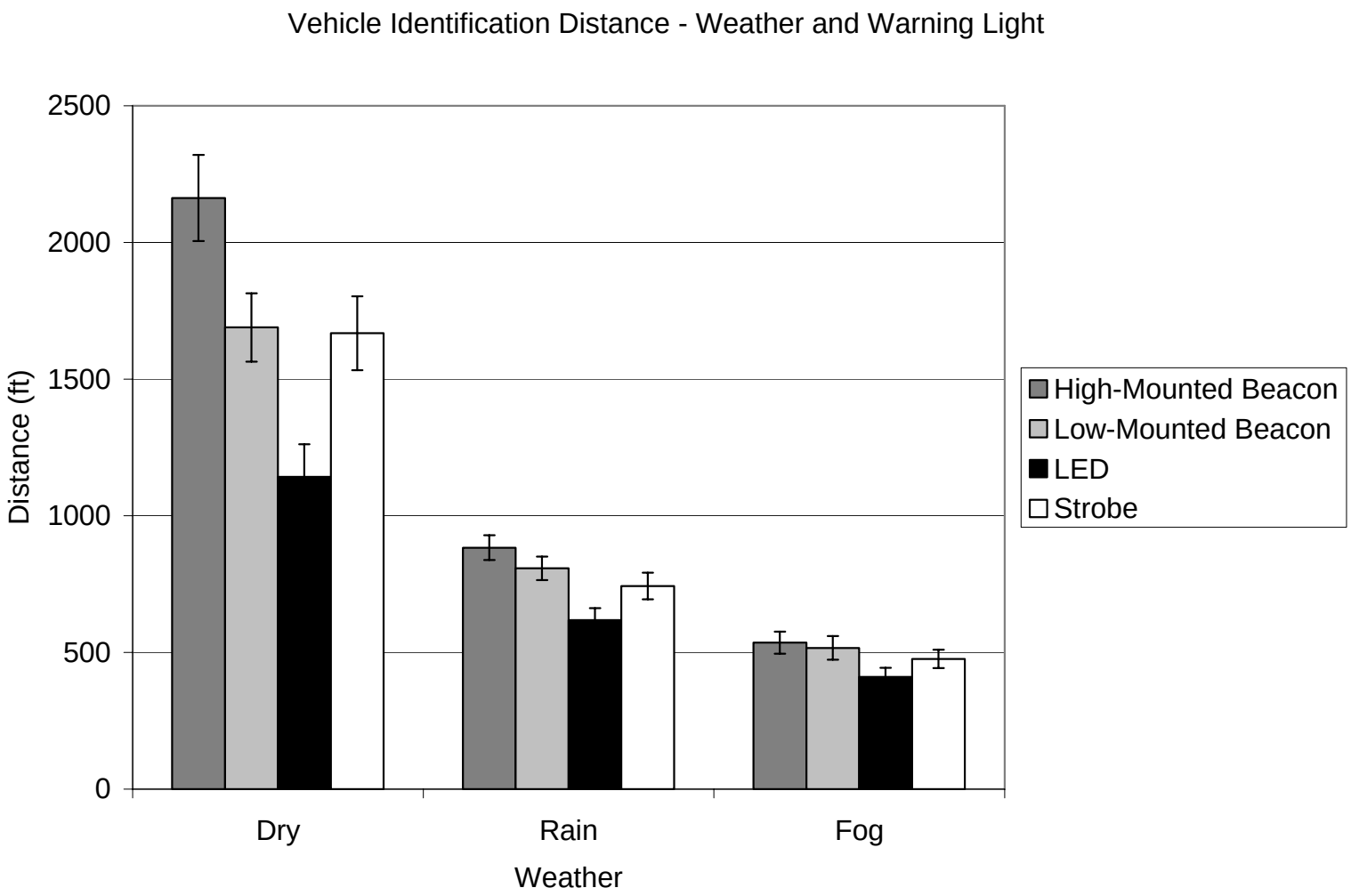
Impact of Weather on Vehicle Identification



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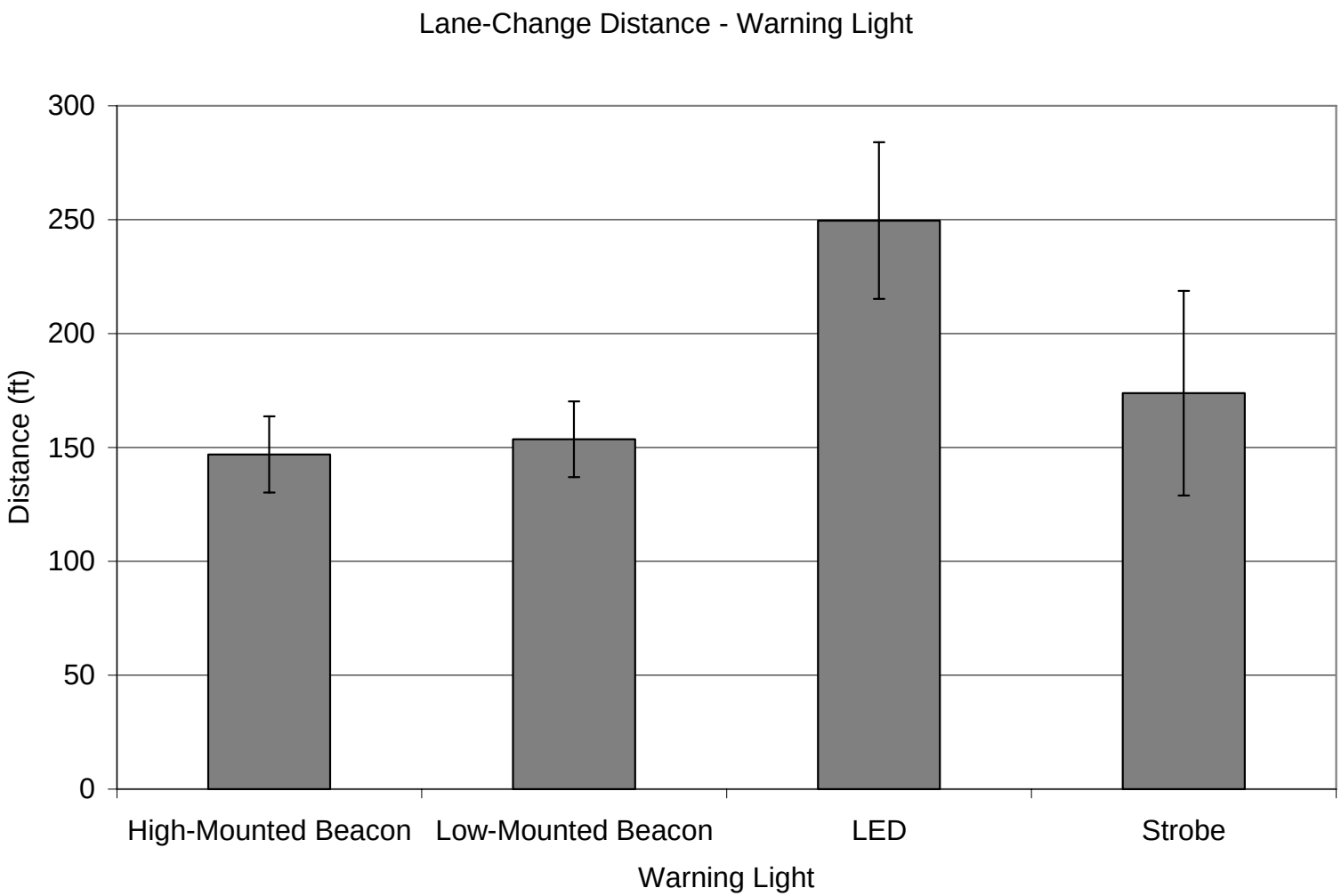
Results – Uninformed Trial



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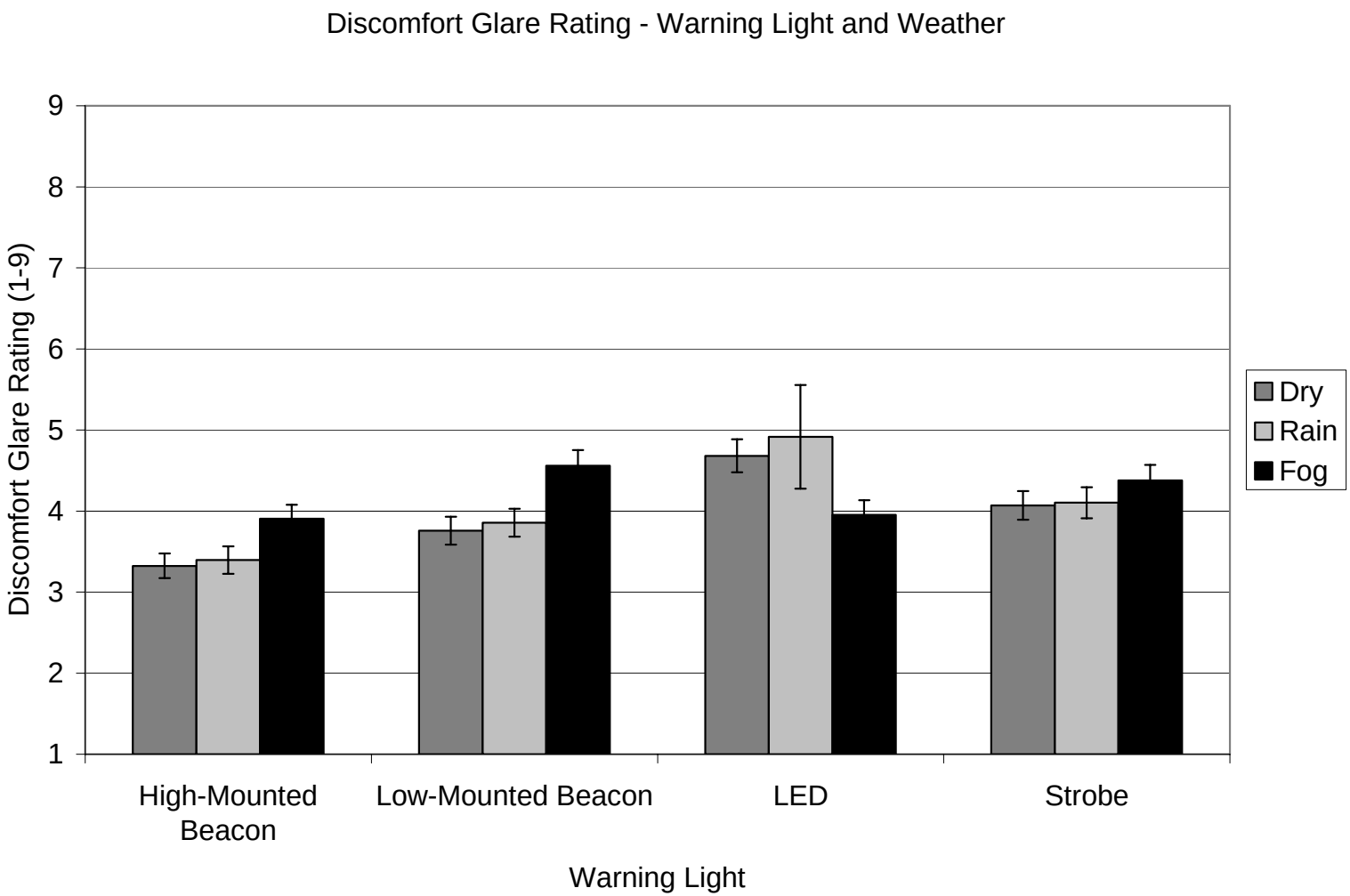
Weather and Glare



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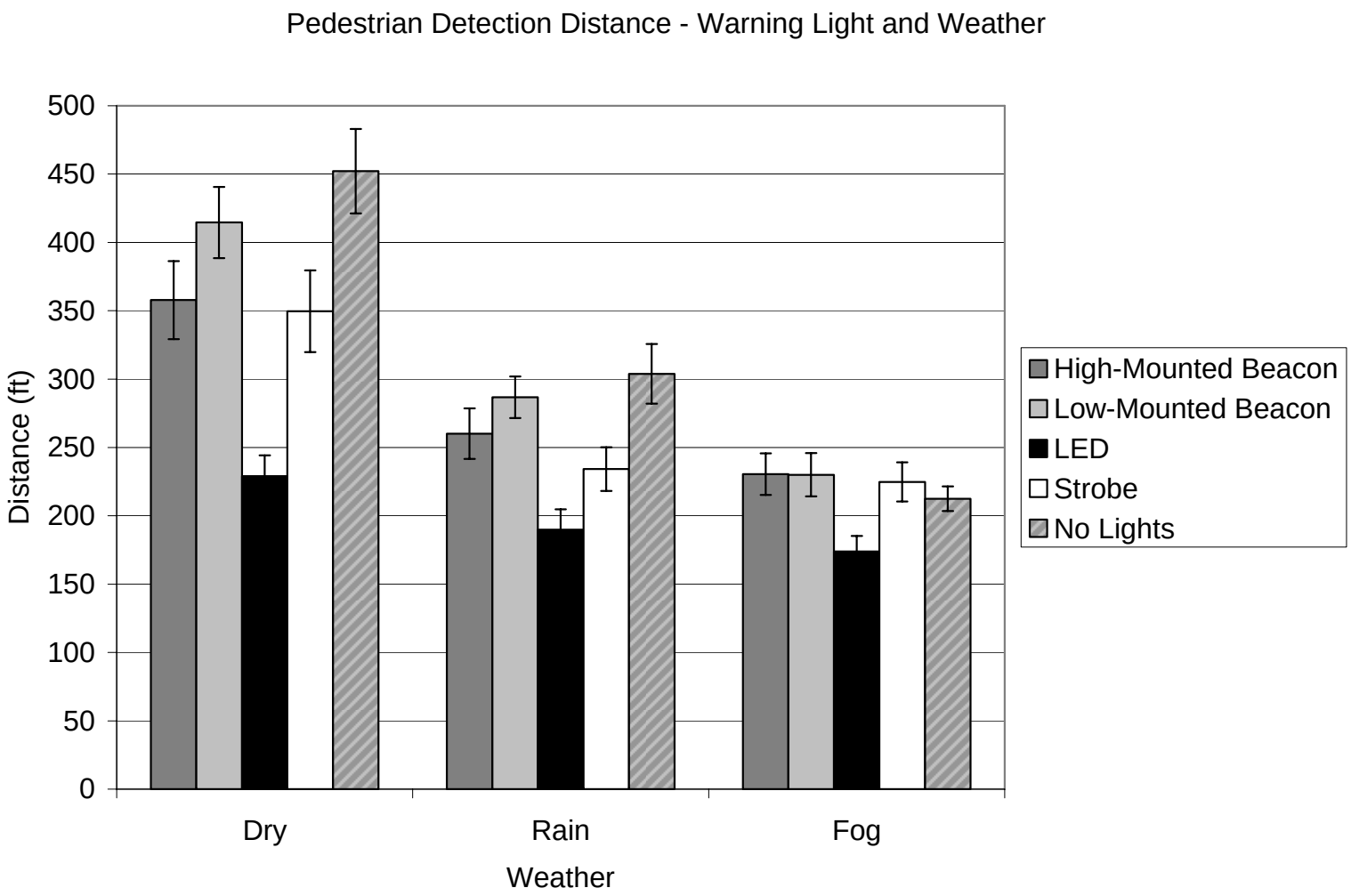
Weather – Pedestrian Detection



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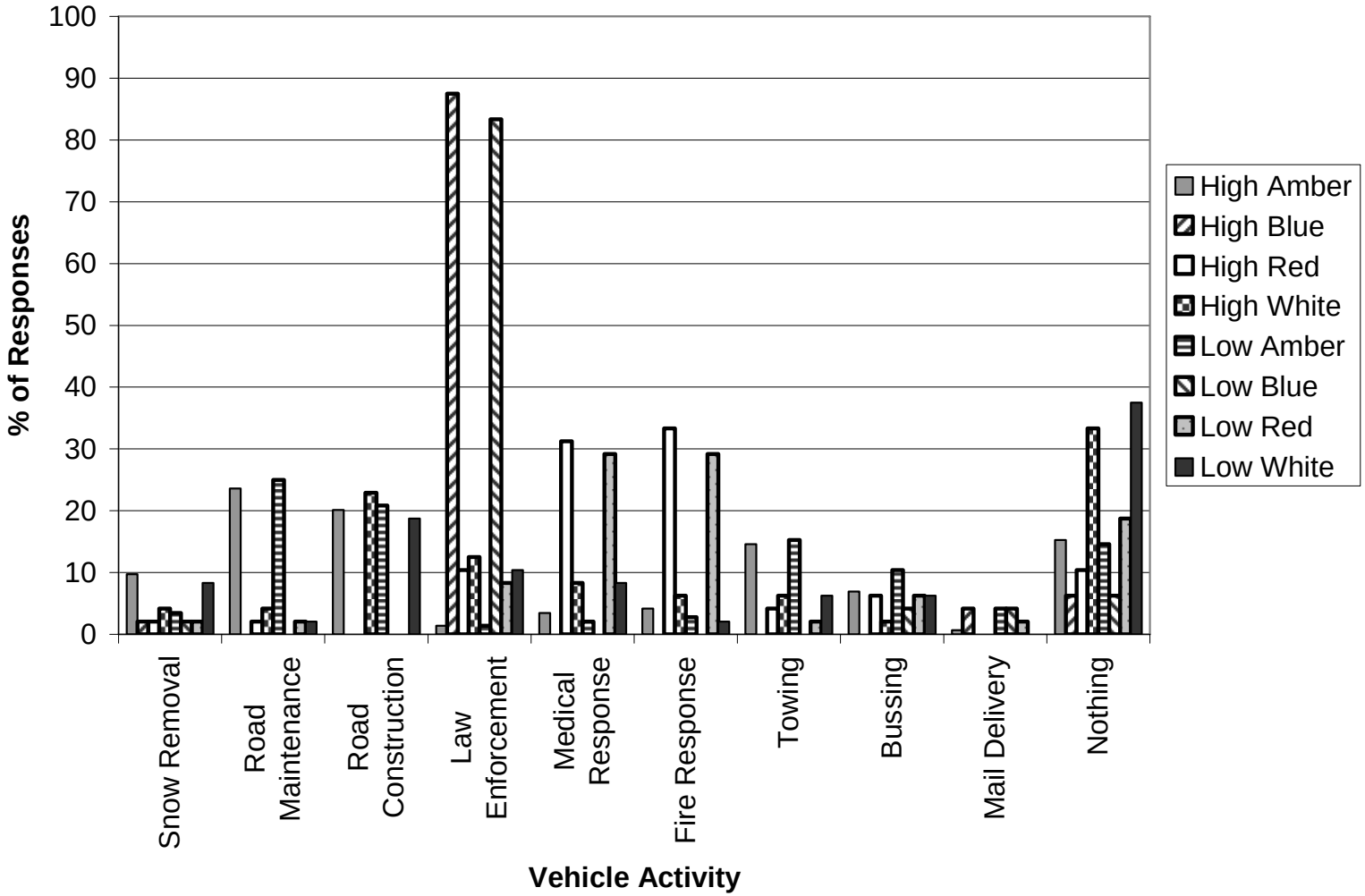
Vehicle Identification



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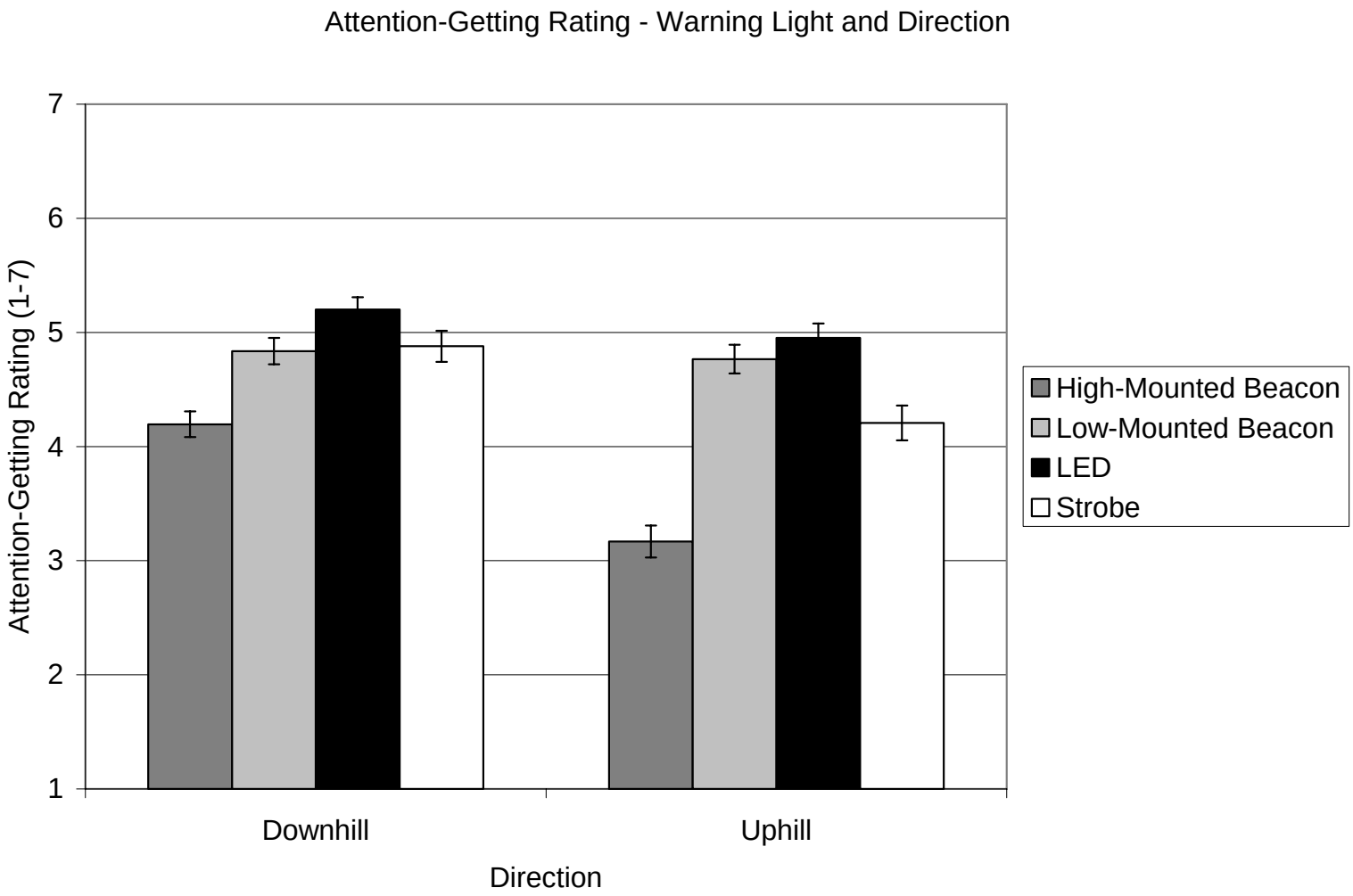
Impact of Appearance against Sky



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Photometric Comparison

- The photometric and screening results were used to define limits for the photometric quantities allowed for the lighting system
  - This is a balance between the conspicuity measures and the glare rankings
    - The limits for daytime and nighttime Performance would be different
    - Glare limits are between 5 and 6 ranking level

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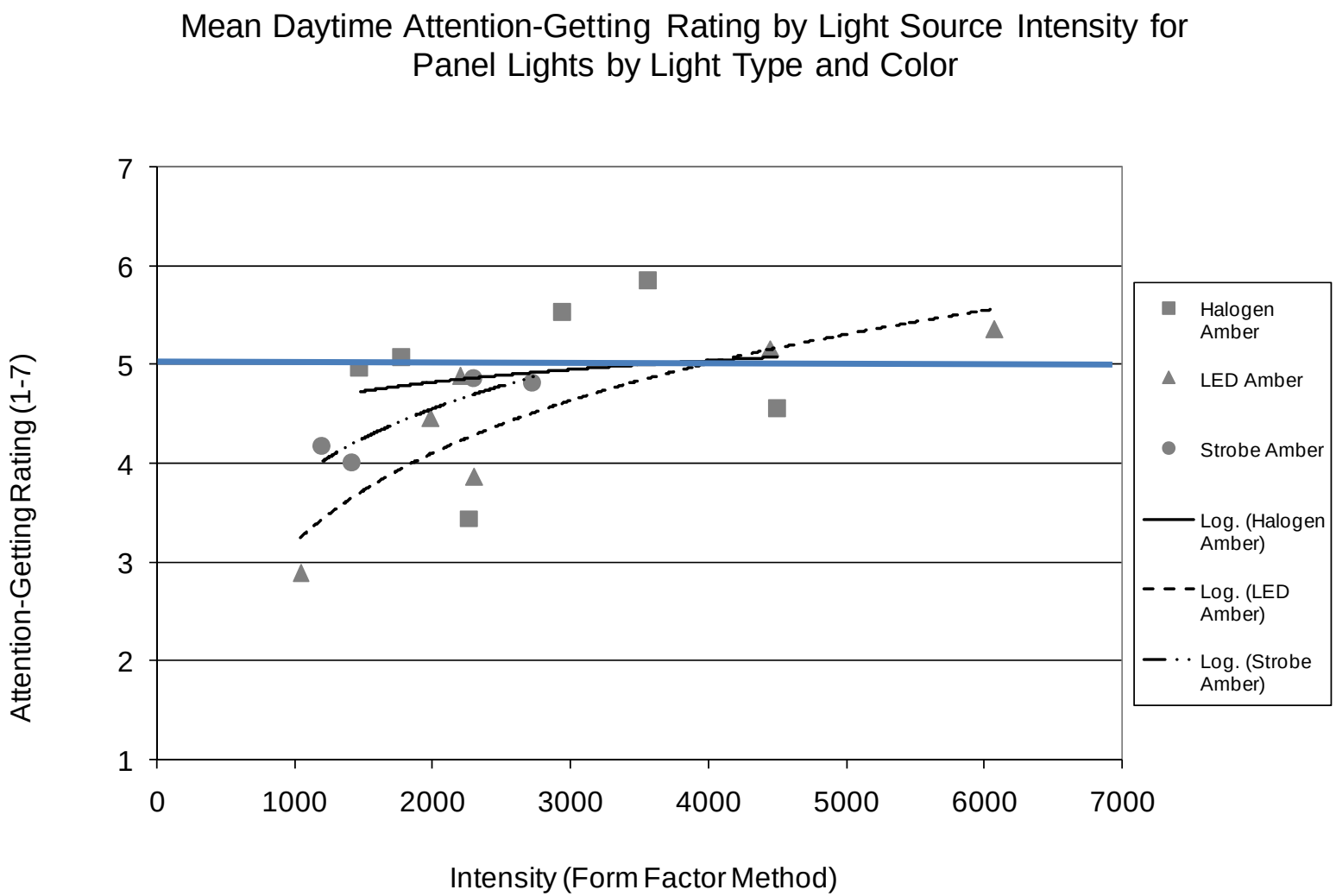
Daytime Conspicuity



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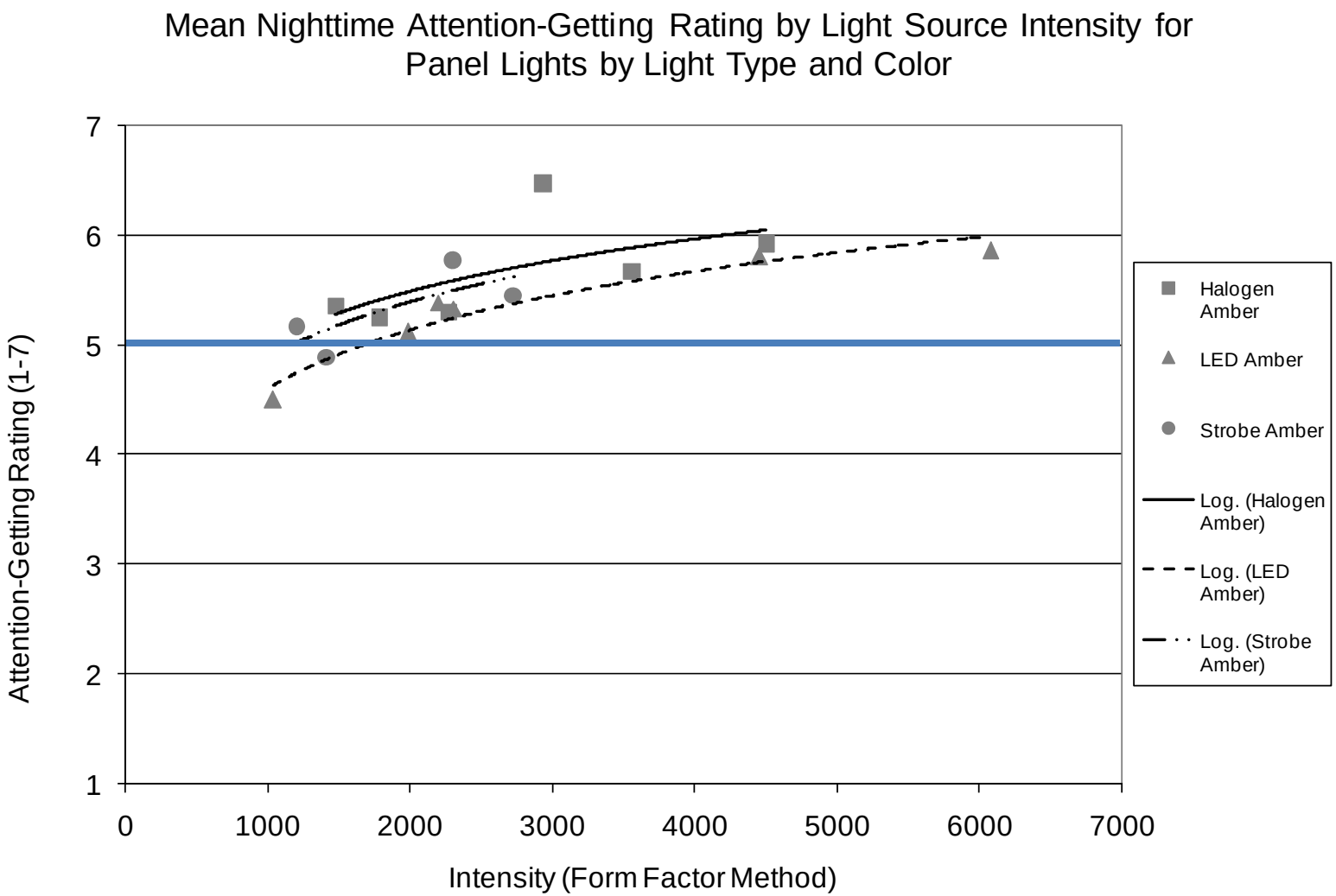
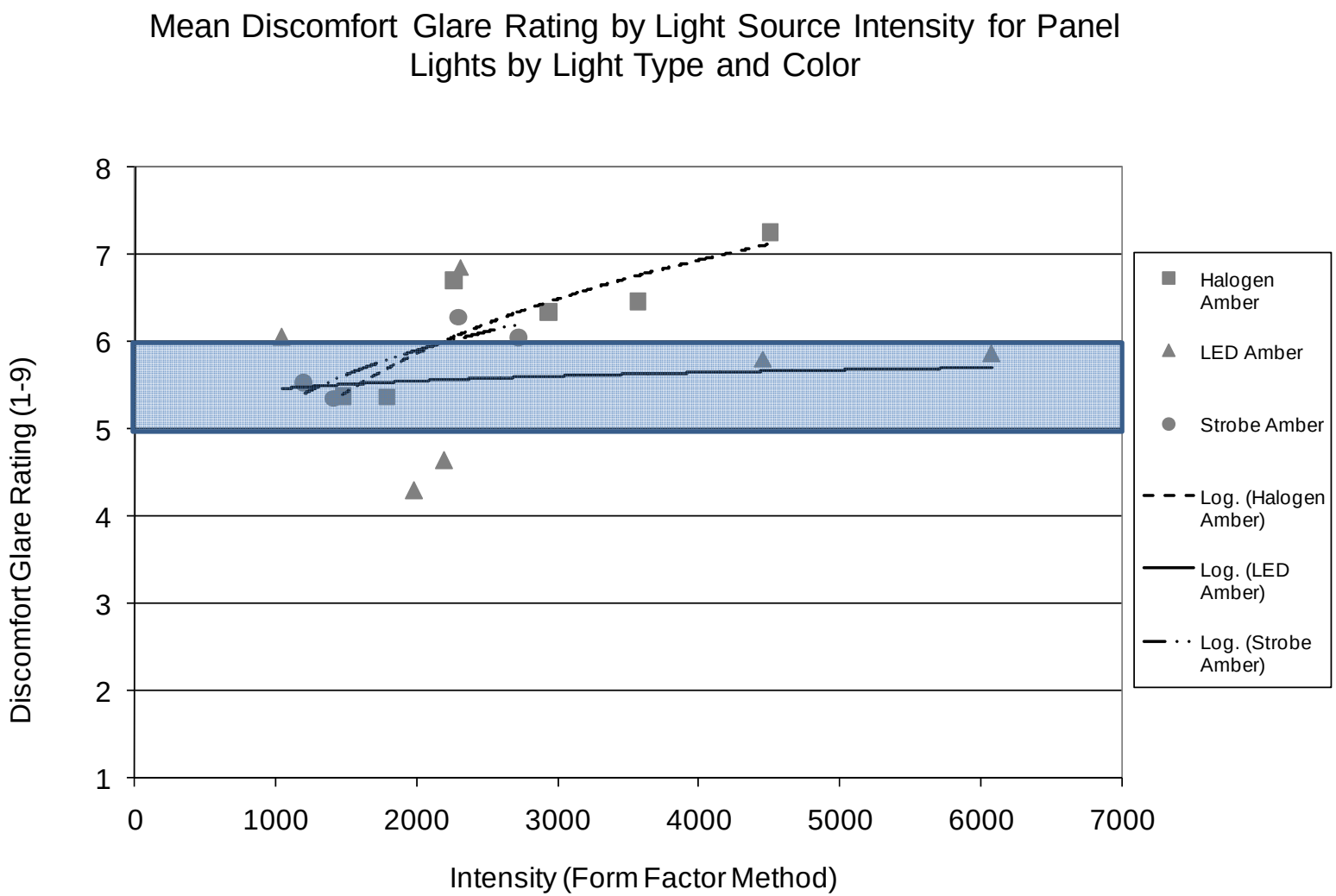
Nighttime Conspicuity



Glare Limits



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Draft Intensity Limits

Photometric Limits	Intensity (by Form Factor Method)		
	Daytime	Nighttime	
Light Source	Minimum	Minimum	Maximum
Halogen	3500	900	2200
LED	4000	1650	
Strobe	3500	1200	2200

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Contact

- Any questions or comments associated with this project or the draft results should be directed to the National Cooperative Highway Research Program (NCHRP)
  - Program Manager: Amir Hanna
    - ahanna@nas.edu
    - (202) 334-1892

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