OUTLINE

• Glare complaints and problems
• Differences between HID and Halogen headlamps
• Factors affecting Discomfort and Disability glare
• Hypotheses about glare complaints
• Preliminary research findings
• Future research directions
Forward Lighting
Glare Concerns

• Over 4900 responses to request for comments on glare
• Public wanted reduced glare from:
  – Auxiliary Lamps
    • Fog Lamps
    • Driving Lamps
    • Auxiliary Low Beam Lamps
  – High-mounted headlamps
  – High Intensity Discharge (HID) Lamps
Glare Consequences Identified by Public

- Causes annoyance and road rage
- Reduces vision
- Increases difficulty of using mirrors
- Distracts drivers; Causes eyes to look away from road
- Causes drivers to stop driving at night
- It hurts the eyes
- Causes fear of being in crash
National Survey

Glare has been:
- Cause of crash, Near Miss
- Disturbing
- Noticeable but Acceptable
- Barely Noticeable
- Not Noticeable

From Bureau of Transportation Statistics, 2002
(sample size ~4321)
Oncoming Glare Rated ‘Disturbing’ by Each Age Group

From Bureau of Transportation Statistics, 2002
Sample size ~ 1373
Key Research Questions

- Why are drivers complaining about headlamp glare?
- What rulemaking options might reduce glare problems?
  - New photometric specifications
  - Reduced mounting height
  - Improved aim (static and dynamic)
  - Others (e.g., washing systems, lamp color)
HID vs Halogen

• Color
  Blue/white vs. Yellow

• Horizontal Intensity
  Wide spread vs. limited spread
HID vs Halogen

Intensity Gradient:
Sharp Cutoff vs Gradual
Lens Optics: 2002 Mercedes Benz E/C Class

Projector optics: 2002 Audi A6

Complex reflector optics 2003 Acura RL
Lamp Design Differences

- Lamp size (luminous area)
- Aiming methods

![Graph showing comparison between HID and Halogen lamps](image)
Two Types of Glare

• Discomfort
  – Subjective, measured w/De Boer scale
    | Just Noticeable | Satisfactory | Just acceptable | Disturbing | Unbearable |
    | 9             | 8            | 7               | 6          | 5          | 4          | 3          | 2          | 1          |
  – Influenced by: illuminance from glare source, task difficulty, ambient brightness, angle from line of sight
  – May affect performance through distraction and eye strain

• Disability
  – Direct effect on visibility distance
  – Increases with glare intensity, driver age, and smaller angle from line of sight
Illustration of glare effects on detectability
CONTRAST

CONTRAST

CONTRAST

CONTRAST

CONTRAST
Sensitivity of Eye to Spectrum

**Sensitivity of Eye to Spectrum**

![Graph](image)

**Glare Source Spectral Power Distributions**

- **Scotopic**
  - \( K'(\lambda) = K_m V'(\lambda) \)
  - \( K_m = 1700 \text{ lm/W} \)

- **Photopic**
  - \( K(\lambda) = K_m V(\lambda) \)
  - \( \lambda_m = 555 \text{ nm} \)
  - \( \lambda_m = 507 \text{ nm} \)

**Graph Details**

- **x-axis**: Wavelength (nm)
- **y-axis**: Luminous Efficiency (lm/W)
- **Legend**:
  - halogen
  - HID
  - blue-filtered halogen
Hypotheses

• HID Blue color: Novelty attracts attention
• HID Blue color: Eyes more sensitive
• Wider Beam Pattern: Drivers exposed to glare longer during meeting scenarios
• Sharper intensity gradients: More sensitive to misaim, flickering
• Smaller lamps: Brighter luminance
NHTSA Glare Research
at U of Iowa (completion: Fall, 2003)

How do beam intensity distributions of HID lamps compare to Halogen lamps?
How do seeing distances and glare compare for HID and halogen lamps under different meeting scenarios, lamp aim, and mounting heights?
NHTSA Glare Research
(at U Iowa, completion Fall, 2003)

Do drivers take longer or more frequent glances at bluish headlamps?
NHTSA Glare Research
(at Rensselaer’s Lighting Research Center, completion 6/2003)
Measure effects of spectral distribution, lamp size, and illuminance on glare and visual performance

- **Illuminance**: 0.2, 1, 5 lx (500, 2500, 12500 cd)
- **Spectrum**: halogen, blue-filtered halogen, HID
- **Size/luminance**: 9 cm²/1400000 cd/m², 26 cm²/480000 cd/m², 77 cm²/160000 cd/m²
## Preliminary Findings

<table>
<thead>
<tr>
<th></th>
<th>Disability Glare</th>
<th>Discomfort Glare</th>
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<tbody>
<tr>
<td><strong>Illuminance</strong></td>
<td><strong>Significant</strong></td>
<td><strong>Significant</strong></td>
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<tr>
<td><strong>Spectrum</strong></td>
<td>Not Significant</td>
<td><strong>HID Significant</strong></td>
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<tr>
<td><strong>Size</strong></td>
<td>Not Significant</td>
<td>Not significant But trend</td>
</tr>
</tbody>
</table>
Preliminary Conclusions: Intensity, Spectrum, Lamp Size

• Current FMVSS method to photometer lamp intensity seems sufficient to predict disability glare for foveal and peripheral vision

• For discomfort glare,
  – illuminance has greatest effect
    (implications for beam intensity and aiming)
  – spectrum is much smaller effect
    (HID more discomforting)
  – size much less so
Feasibility of an adaptive headlight system which reduces intensity on lighted roads

Objectives:

- Measure visual performance with reduced headlamp intensity on lighted roads
- Determine improvement in discomfort and disability glare from reduced headlamp intensity
Future Glare Research

• Use photo-logging technique to study real world glare exposure and effects on driving behaviors (2003-04)
Future Research (2003-04)

- Determine effect of duration & intensity of HID glare exposure on visual recovery time
- Quantify the level of misaim of different headlamp designs; assess effect of lens degradation
- Further exploration of Adaptive Forward Lighting to determine its effect on visibility and glare