Good Headlamp

- Engineer or Driver's Perspective?

A Presentation to NHTSA Workshop

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Outline

I. What Is a "Good" Headlamp?

II. Evaluations by Engineers vs. Drivers

III. Who Is Right?

IV. What Can Be Done Better?

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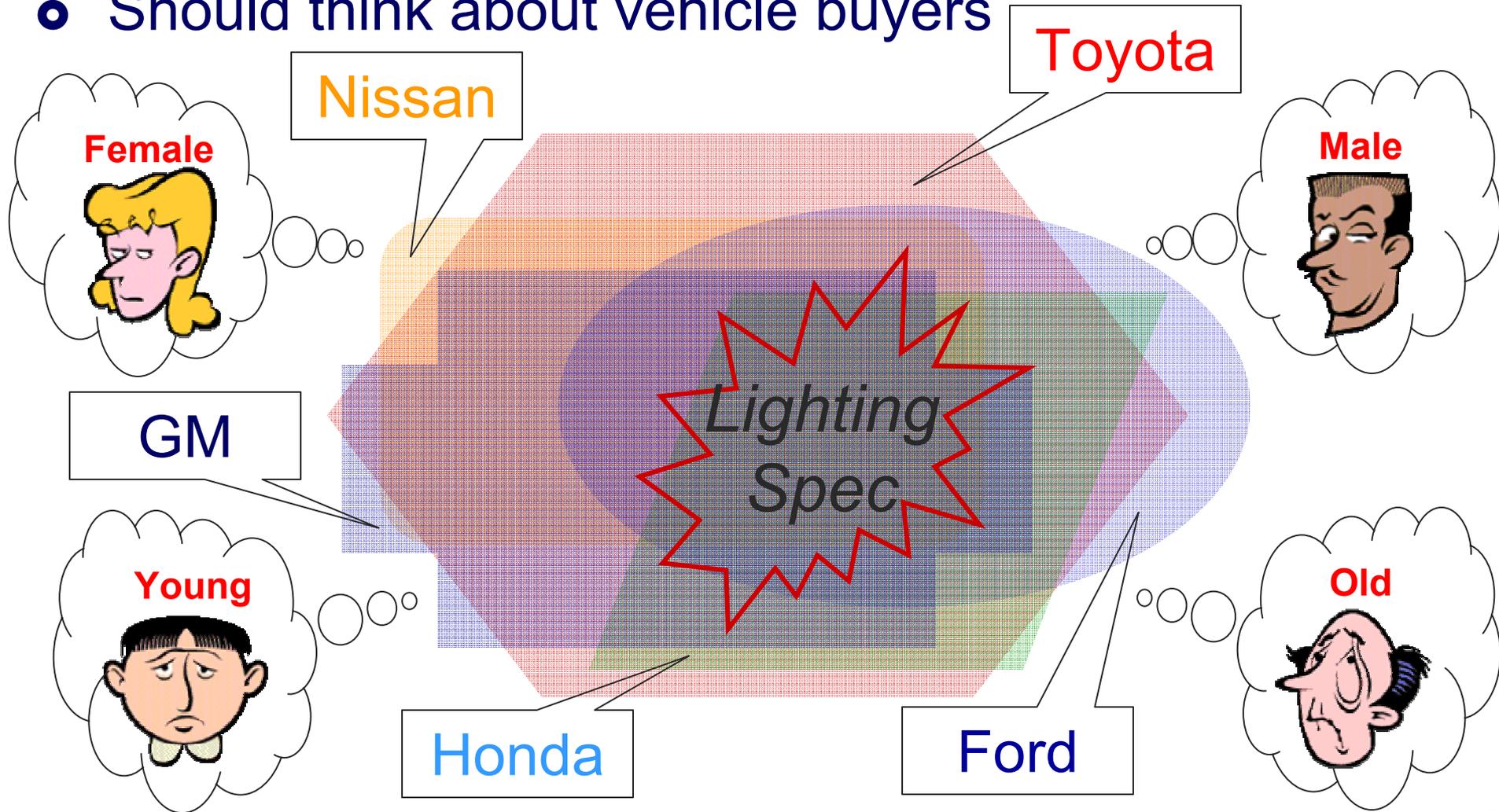
What Is a "Good" Headlamp

Top of the List …

Good Headlamp: what vehicle makers say?

- Should think about vehicle buyers

Toyota

Nissan

Female

Male

GM

Lighting Spec

Young

Old

Honda

Ford

What Is a "Good" Headlamp

Vehicle Makers Believes

(besides the lamps should look good or cool)

- Good headlamp beam that has:
  - Wide Spread
  - A lot of foreground light
  - Uniform light distribution (no streaks or spots on the road surface)
  - Cutoff line (gradient) should not be too sharp
- Good headlamp should also:
  - Project enough light onto the road and overhead sign, but
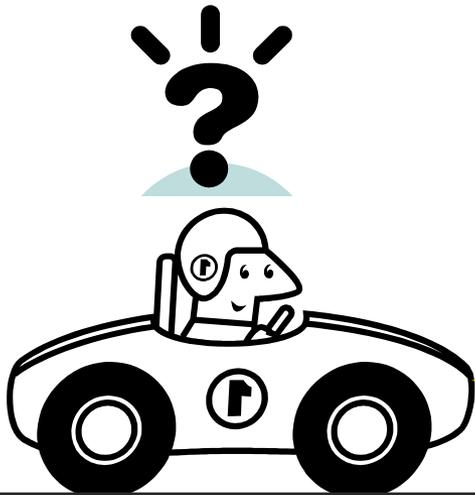 - No glare to oncoming vehicle drivers

(make sense)

Good Headlamp: what human factor experts say?

- Think about drivers
  - Safety: visibility, seeing distance, …
  - Drivers comfort: distraction, fatigue, stability, …

What Is a "Good" Headlamp

Human Factor Experts Believe:

- Safety (primarily means driver's visibility) should be a high priority

  - **Seeing distance**: When driving on a highway, driver's seeing distance should be longer than vehicles' stopping distance.

  - **Headlamp light projection distance**: When driving on a highway at night, low-beam should provide sufficient down-the-road light that reaches to the seeing distance.

(sounds logical)

What Is a "Good" Headlamp

## Good Headlamp: what lighting engineers do?

- Design and make lamp to achieve performance of:
    - Beam pattern brightness (total lumen)
    - Down-the-road visibility (hotspot candela value)
    - Beam width (spread)
    - Light on the road (uniformity, foreground light, …)

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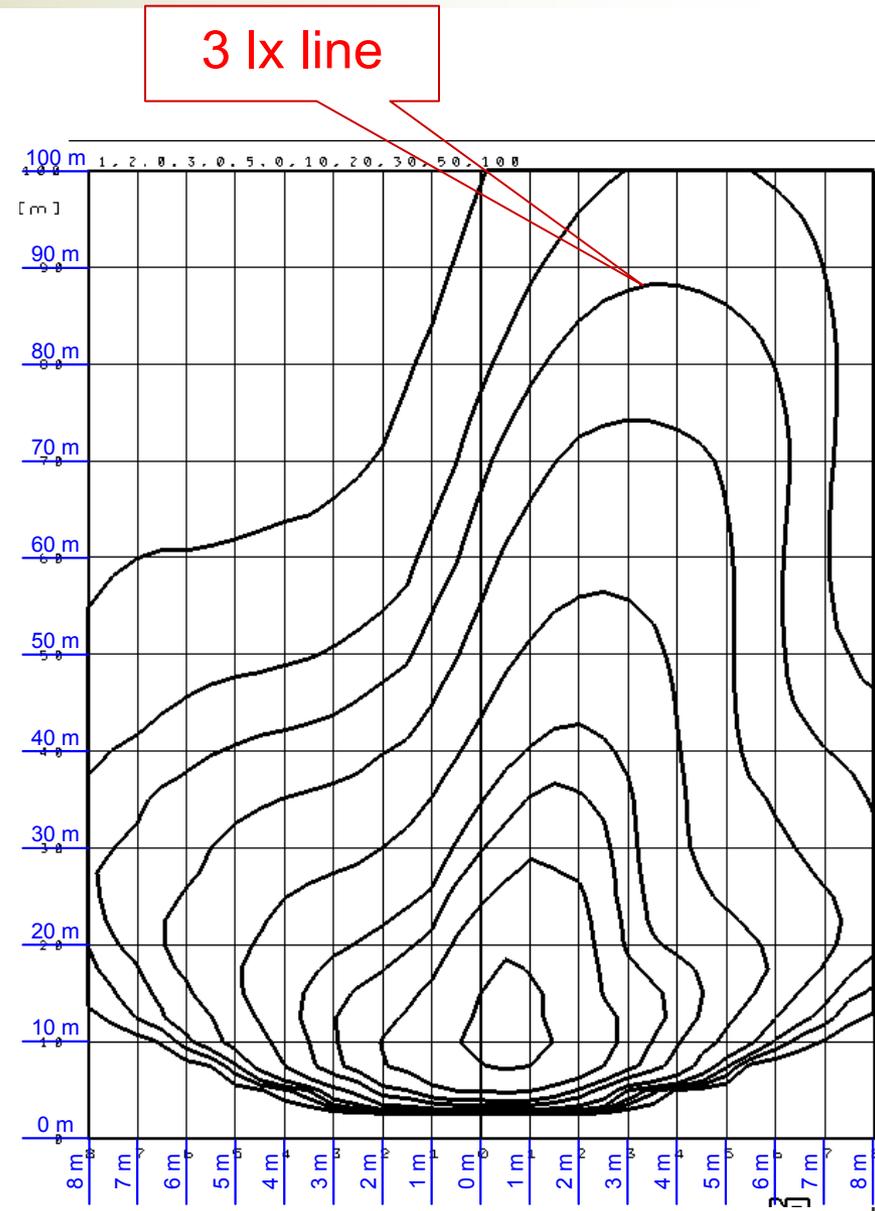
Evaluation of a Headlamp

Vehicle Makers Evaluation (example)

- **Visibility range**
  - Lx value at 65 m?
  - How far is 3 lx line?

- **Beam width**
  - 40 m half-width 5 lx line?
  - 20 m width 5 lx line?

- **Foreground light**
  - Lx value between 10 – 20 m?

Evaluation of a Headlamp
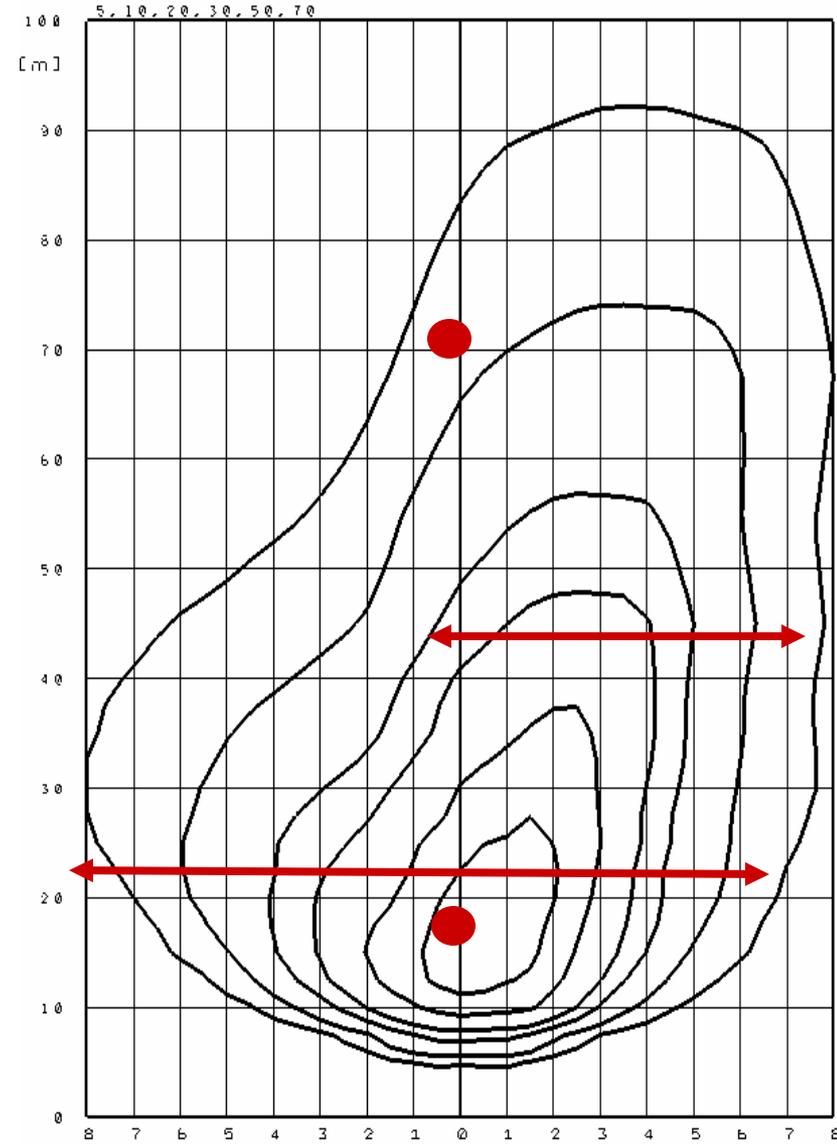
Human Factor Experts Evaluation

- ◎ Safe seeing distance
  - ■ 100 m on a highway
  - ■ Minimum 3 lx level up to 100 m

- ◎ Typical US low-beam pattern (UMTRI)
  - ■ In 2001, 50th percentile of US top 20 selling passenger vehicles, the 3 lx lines reaches less than 90 m

3 lx line

Evaluation of a Headlamp

Lighting Engineers Evaluation

- Performance – Lighting Spec
  - Safety
  - Comfort

- Design restrictions:
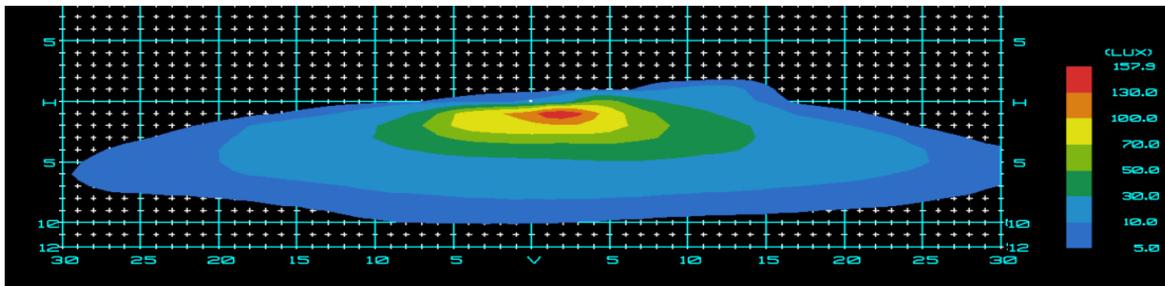 - Type of light sources
  - Type of optics
  - Lamp package size

Safety:
- *Seeing Distance*

Comfort:
- *Foreground*
- *Spread*
- *Uniformity*
- *Glare*

Evaluation of a Headlamp

Headlamp Evaluation Example

- Desired low beam photometry performance
  - Total lumen inside beam pattern: > 400 lm
  - Maximum intensity: 30,000 cd
  - Sharpness of cutoff: G > 0.15
- Best design results
  - In order to project higher than 3 lx to 100 m (near 1.5 m right), light intensity at 0.6D-1.3R should be greater than 16,000 cd
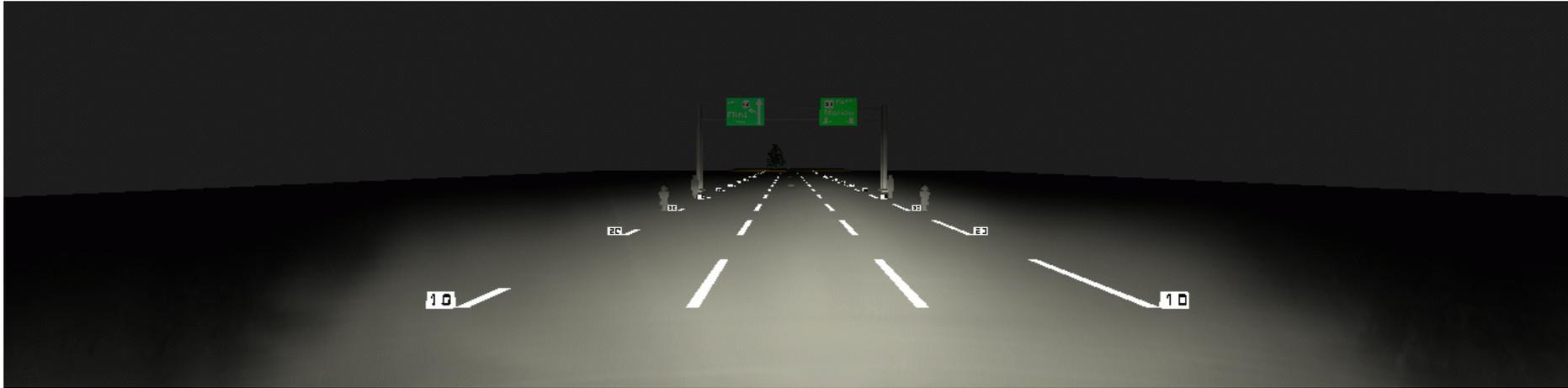
Headlamp Evaluation Example (cont.)

○ **Look closely to the beam pattern**
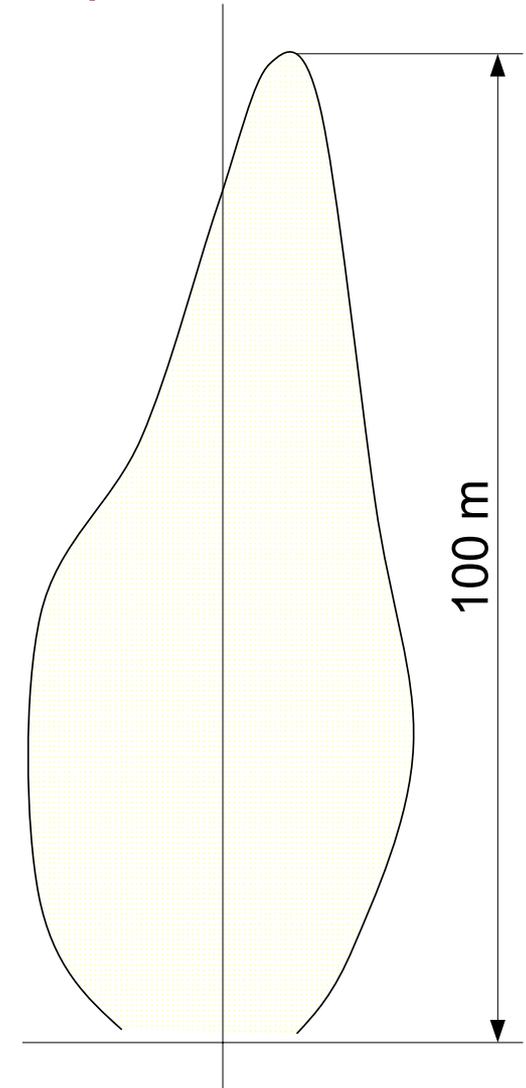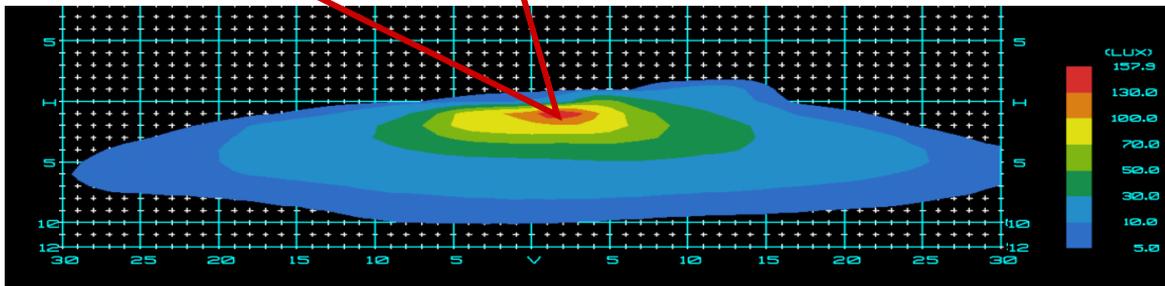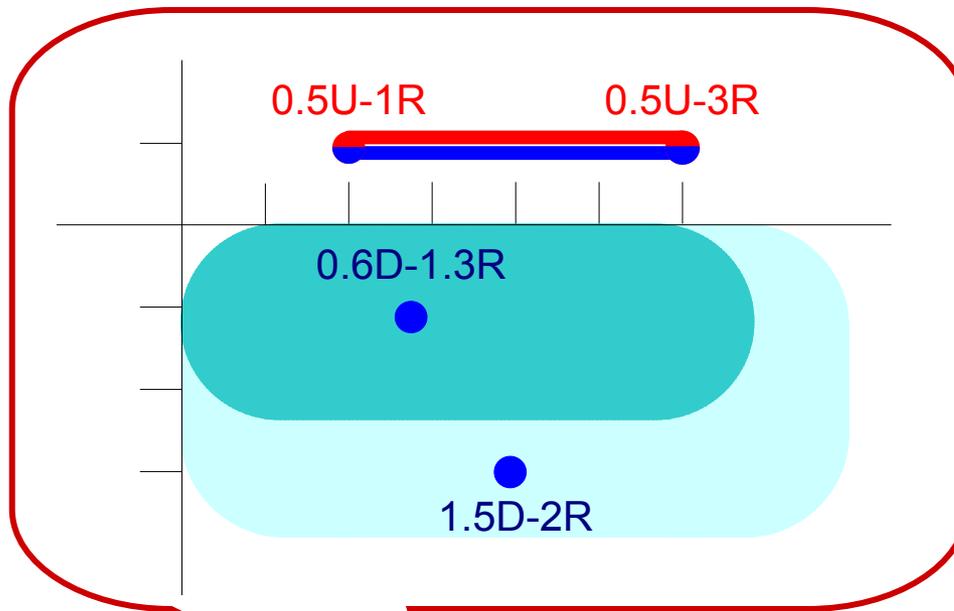
0.5U-1R   0.5U-3R

0.6D-1.3R

1.5D-2R

100 m

(LUX)
157.9
130.0
100.0
70.0
50.0
30.0
10.0
5.0

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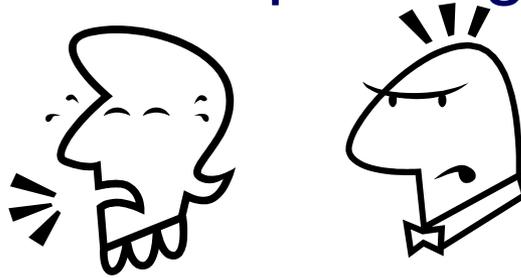IV. What Can Be Done Better?

Should Everyone be Happy?

- Lighting engineers have done their job as good as they can …

What Happened to "Perfectly Designed" Headlamps?
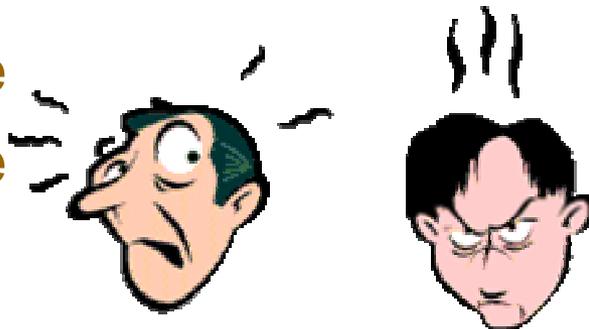
- Customers are complaining!
  - Glare
  - Glare
  - Glare

- NHTSA has concerns!
  - Glare
  - Glare
  - Glare

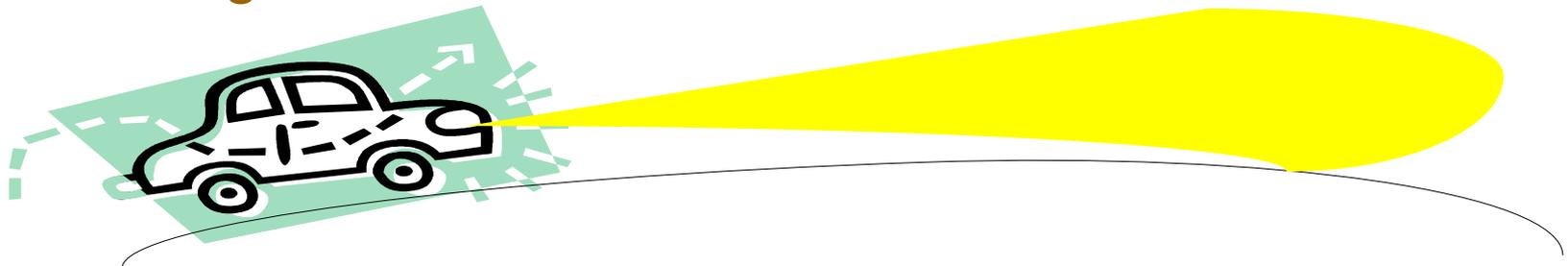THE SHINING

What Could be Wrong?

- **For lighting engineers**
  - Headlamps have best photometry performance for a stationary situation

- **For drivers**
  - Not so "stable" and inconsistent "use" of headlamps in a real driving environment

Who Is Right?

Unstable and Inconsistent Use of Headlamps

- Aiming
  - Not perfectly aimed on the vehicle
  - Even headlamps are perfectly aimed during vehicle assembly, vehicle is not leveled when driving
  - Roads are never leveled

- Mounting height
  - Regulations permits large variation for lamp mounting heights

- Headlamp lens
  - Dust accumulation
  - Rain and snow
  - Haze

Who Is Right?

Aiming Effect

- Vehicle load vs. headlamp leveling

Vehicle Load	Angle (α) change
Driver	0.000 degrees
Driver + 1 front passenger	-0.098 degrees
Driver + 1 front & 1 rear passenger	0.745 degrees
Driver + 1 front & 2 rear passengers	0.919 degrees
Driver + 1 front & 2 rear passenger + load in trunk	1.322 degrees
Driver + load in trunk	**2.515 degrees**
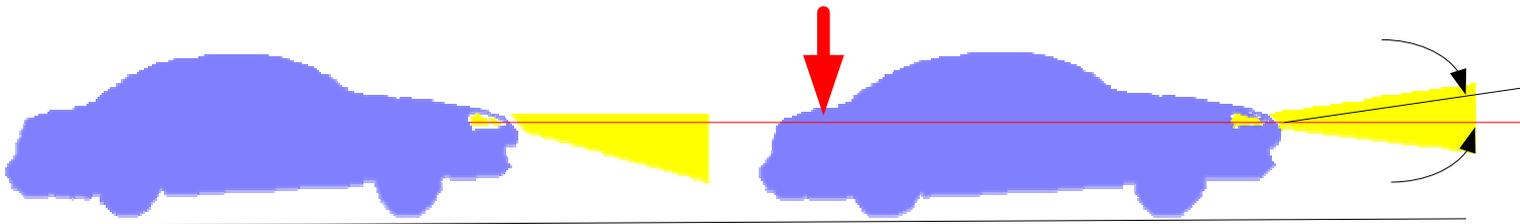
- Vehicle acceleration & deceleration

Who Is Right?

Part of Reasons for Complains

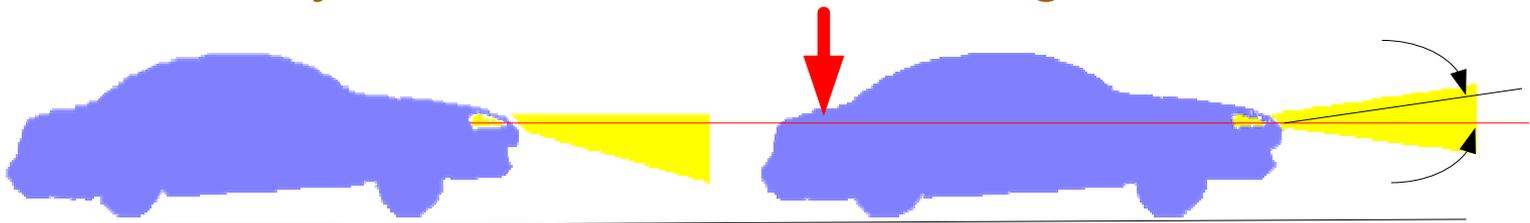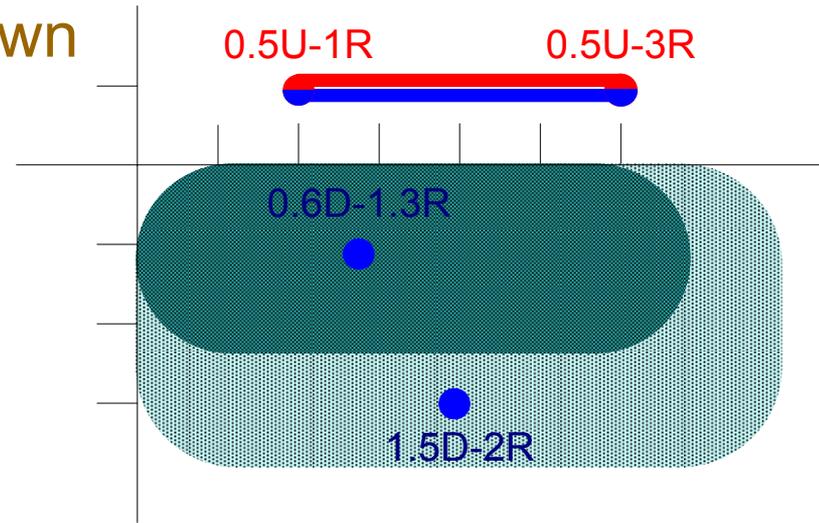- ◉ Lamp design intend
  - ■ >16,000 cd at 0.6 degrees down
  - ■ > 30,000 cd at 1.5 degrees down
- ◉ Misaim in reality
  - ■ Headlamp can be aimed
    2.5 degrees
    higher!
  - ■ The brightest part of the beam
  could be directly aimed toward on-coming vehicle drivers

0.5U-1R   0.5U-3R

0.6D-1.3R

1.5D-2R

Who Is Right?

Mounting Height

- Regulation & Industry Standards
  - NHTSA Regulation for upper limit: 1.37 m
  - SAE Recommendation for upper limit: 0.9 m
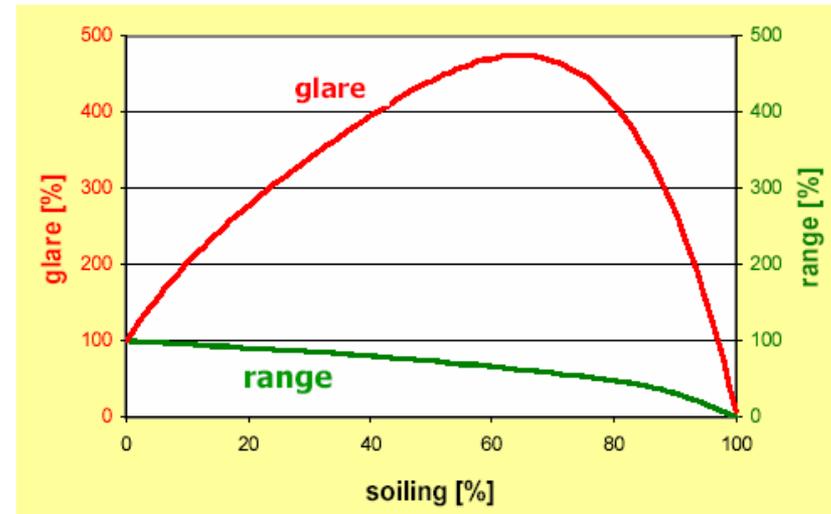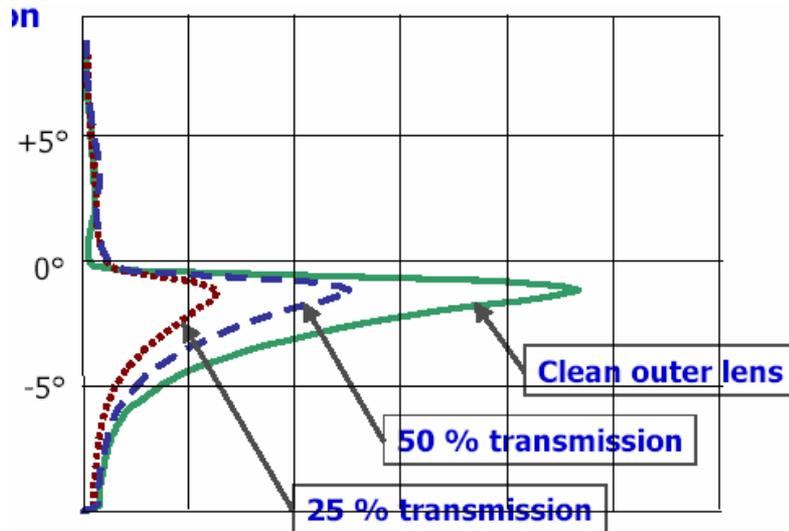- In reality (UMTRI)
  - Average US vehicle H = 0.62 m for cars, H = 0.83 m for SUVs, pickup trucks and vans
  - Average passenger car driver's eye heights = 1.01–1.14 m
  - Rearview mirror reflected light intensity could increase 300 – 500% if it is followed by a high mounted headlamp vehicle
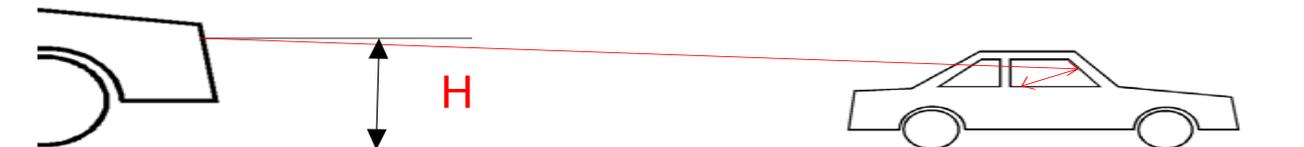
Headamp Lens Effects

- ◉ Dust effect
  - ■ Refer to UMTRI Reports
  - ■ Automotive Lighting, SAE Paper 2004-01-0666

- ◉ Haze effect
  - ■ Refer to UMTRI Reports

# Outline

What Can Be Done Better?

Rational from Engineers – Aiming

- Headlamp vertical aim sensitivity
    - Glare is largely contributed by headlamp misaim (unconsciously)
    - Greater the headlamp performance → higher glare sensitive
- Maintain headlamp proper aim
    - Headlamp leveling system

Rational from Engineers – Aiming (cont.)

- Studies on headlamp leveling systems
  - Koito studies
  - Automotive Lighting studies

What Can Be Done Better?
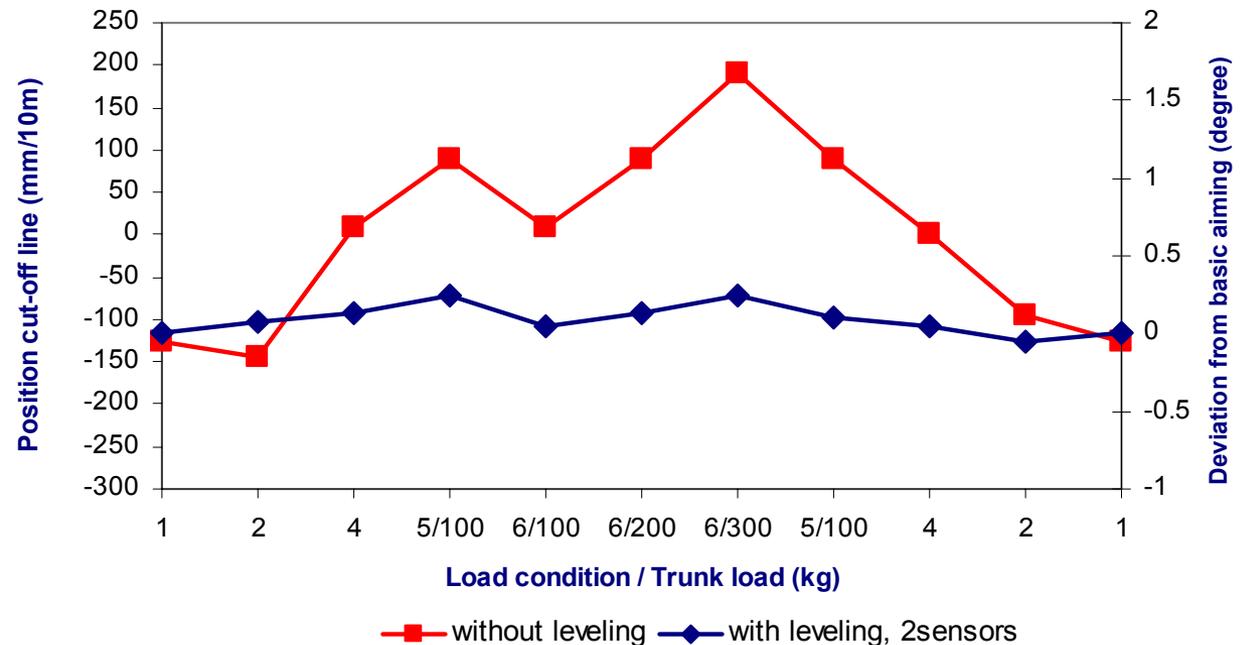
Rational from Engineers – Mounting Heights

- Headlamp mounting height dependability
  - Higher the headlamp mounted → better projection distance for the driver
  - Higher the headlamp mounted → greater glare for the front vehicle driver's rear view mirror
- Mounting height upper limit
  - Should regulation and standard be more stringent?

What Can Be Done Better?

Rational from Engineers – Lens Effects

- Headlamp lens effect
  - Less lens transmission → less seeing distance
  - Less lens transmission → higher glare
- Maintain lens transmission
  - Headlamp cleaning system

Summary

What Do We Know So Far?

- Good headlamp
  - A good headlamp should be safer, more comfortable, and less glare for drivers. However,
  - A good headlamp can easily cause more glare
- Good headlamp on the road
  - A good headlamp needs to be used properly on the road, e.g.,
  - Level (aiming) needs to be maintained
  - Mounting height needs no to be too high
  - Lens needs to be clean

The End
Thank You!