NHTSA Forward Lighting Research

Michael Perel
Human Factors Engineering Integration Division
Office of Human Vehicle Performance Research

Dec 5, 2005

Glare Complaints Sent to NHTSA

- It hurts the eyes
- Reduces vision
- Increases difficulty of using mirrors
- Distracts drivers
- Limits night driving
- Causes annoyance and road rage

One Hundred Ninth Congress
of the
United States of America

Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users'' or ''SAFETEA–LU''.

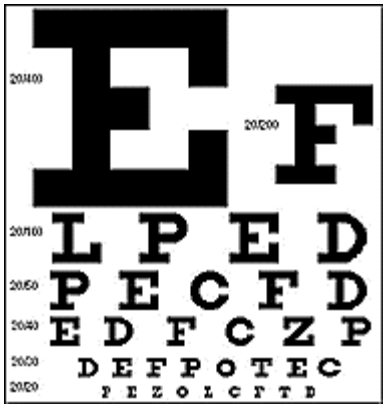
SEC. 2015. DRIVER PERFORMANCE STUDY.

(a) In General- Using funds made available to carry out section 403 of title 23, United States Code, for fiscal year 2005, the Secretary shall make $1,000,000 available to conduct a study on the *risks associated with glare* to oncoming drivers, including increased risks to drivers on 2-lane highways, increased risks to drivers over the age of 50, and the overall effects of glare on driver performance. (and how to reduce risks)

Vision Metrics

Vision

Metrics



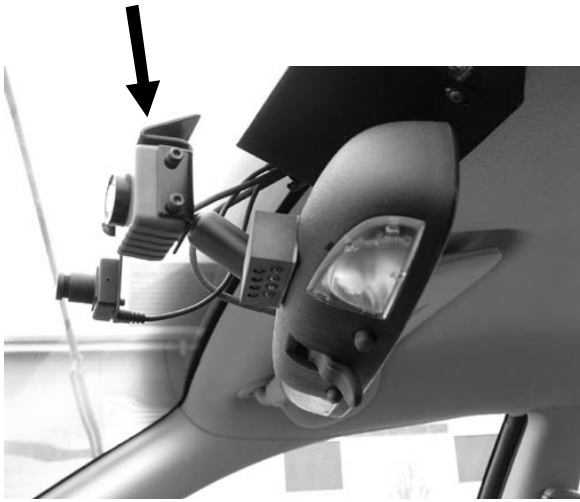
Solutions

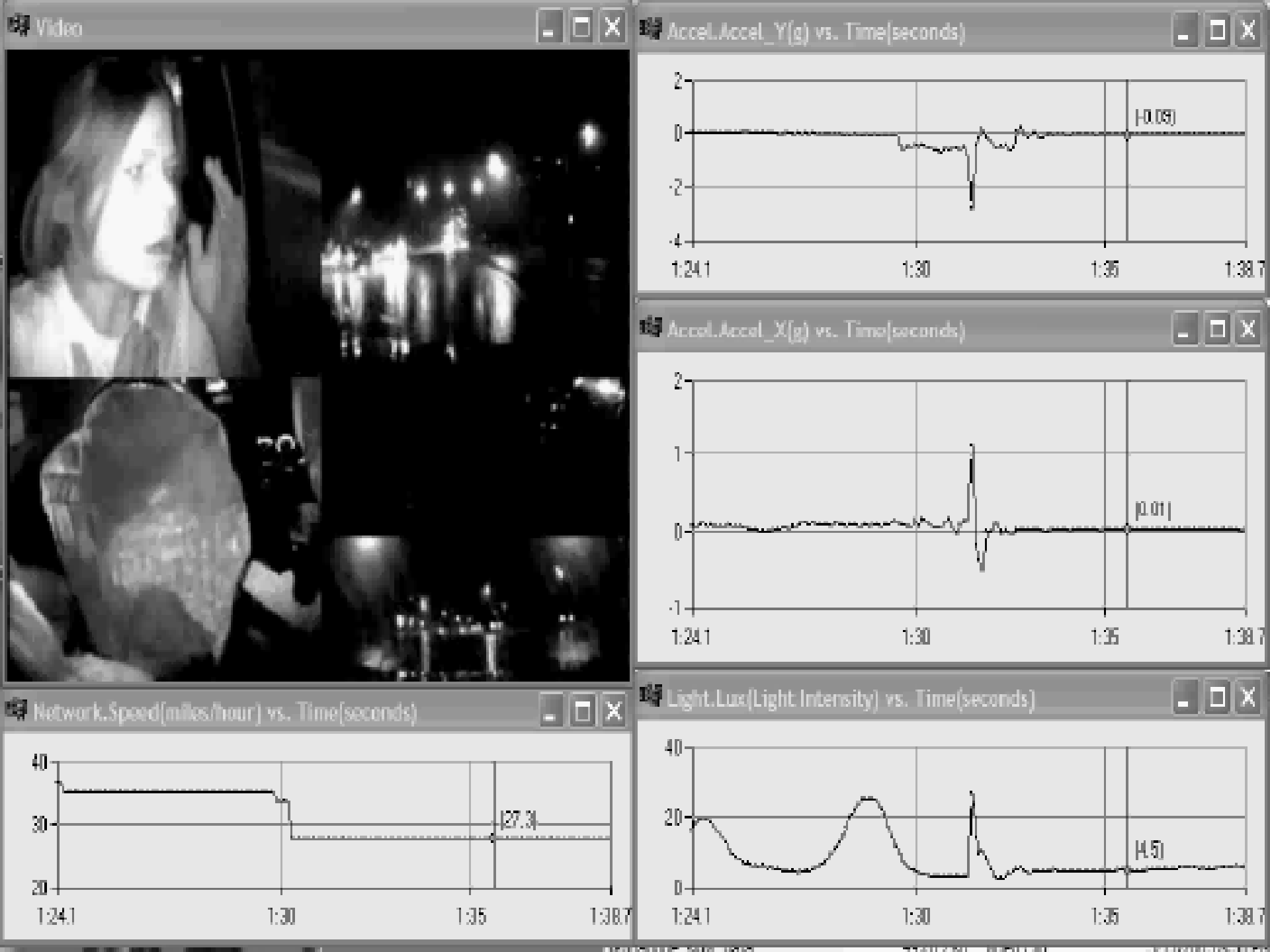
- Crashes
- Subjective ratings
- Driver Performance
- Driver Behavior

- New Beam Patterns
- Reduced mounting height
- Improved aim
- Advanced Lighting

Behavioral Measure Example

- **From Va Tech naturalistic study data**
- 100 cars driving for year with photosensor looking forward
- Identifying effects of glare and roadway illumination on driver behavior (e.g., visual distraction, speed changes)




Video
Accel.Accel_Y(g) vs. Time(seconds)
2
0
-2
-4
(-0.09)
1:24.1
1:30
1:35
1:38.7
Accel.Accel_X(g) vs. Time(seconds)
2
1
0
-1
(0.01)
1:24.1
1:30
1:35
1:38.7
Network.Speed(miles/hour) vs. Time(seconds)
40
30
20
(27.3)
1:24.1
1:30
1:35
1:38.7
Light.Lux(Light Intensity) vs. Time(seconds)
40
20
0
(4.5)
1:24.1
1:30
1:35
1:38.7

Key Research Questions

- What headlamp characteristics are causing drivers to complain about glare and increase safety risks?
- What solutions can reduce the risks and improve nighttime visibility and safety?

What's causing complaints?

- Blue color of High Intensity Discharge (HID)Lamps: Does novelty attract attention?
  - *Color not key, drivers more attracted to brighter lights*
- Are eyes more sensitive to shorter blue wavelength?
  - *Affects discomfort not disability glare*
  - *Intensity most influential factor*
- Does brighter luminance from smaller HID affect glare?
  - *Has small effect compared to intensity*

What's Causing Complaints?

- How does exposure to glare affect visual recovery time after vehicles pass?
  - *Pilot testing shows that some lamp beam patterns increase recovery time*
- What are the effects of lamp misaim and mounting height on glare and driver performance?
  - *Under investigation*

Effect of Headlamp Glare Exposure on Visual Recovery

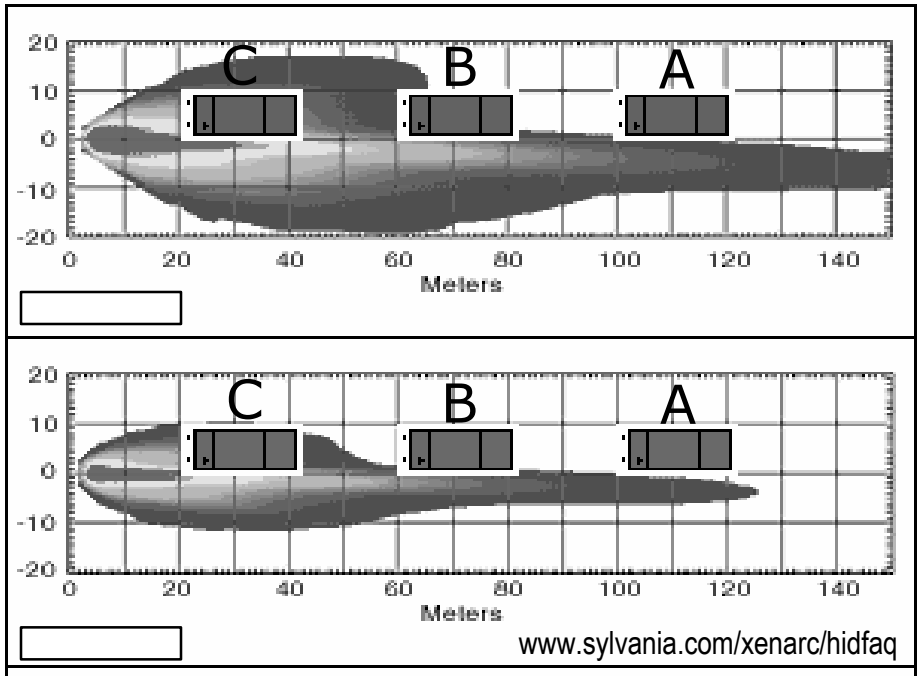
(Rensselaer Lighting Research Center)

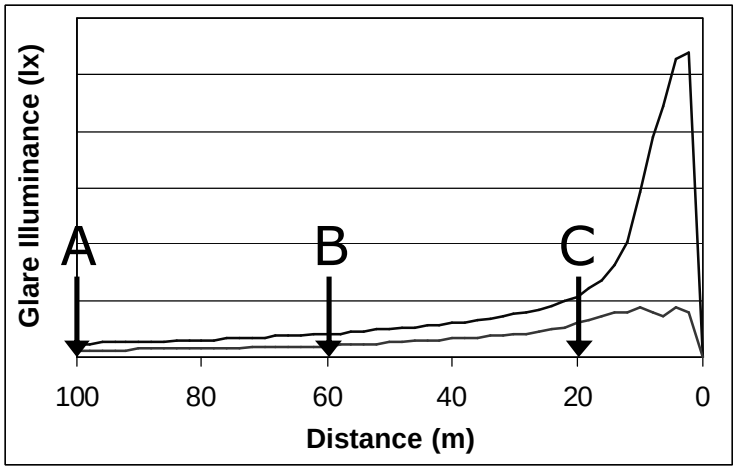
Headlights can impair vision for some time after meeting oncoming vehicles

- "and I can't see for moments after the car has passed."
- "Aside from being painful and annoying, headlight glare has the more serious effect of temporarily blinding the recipient"

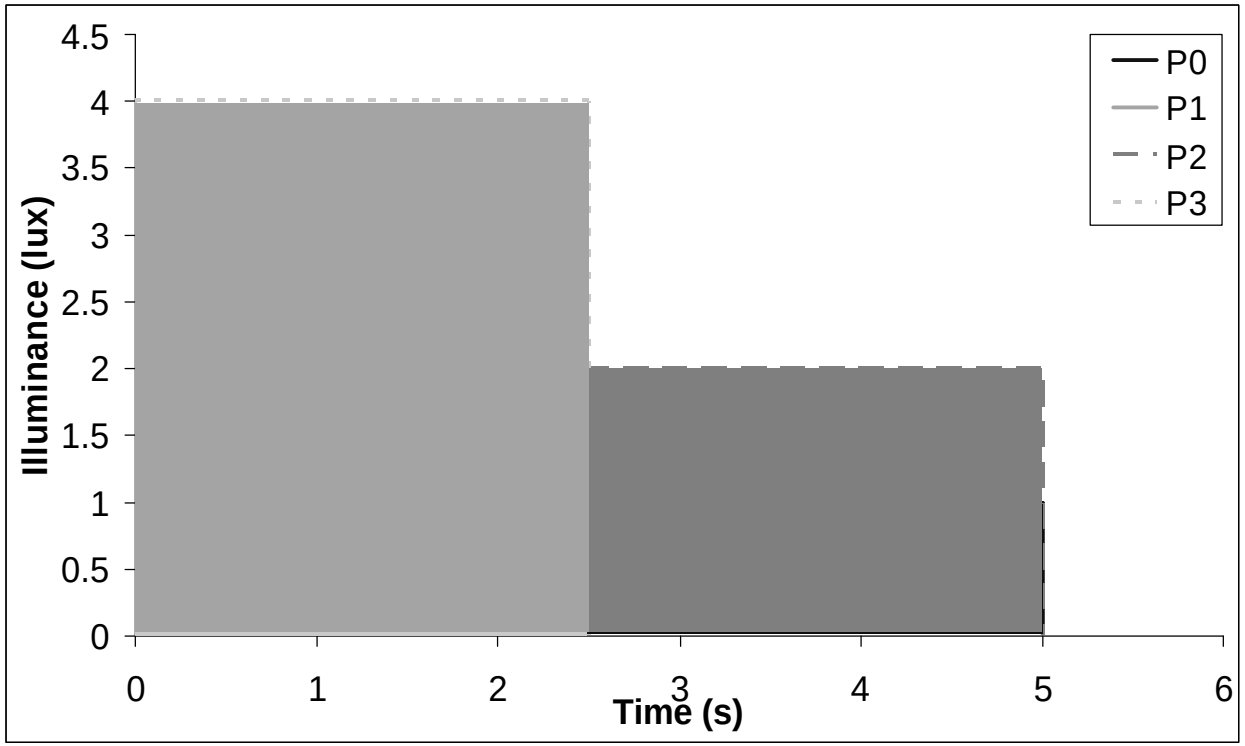
Why Do We Care?

- **Visual recovery is an often overlooked aspect of glare**
- **New headlamp systems are creating different glare scenarios**
  - **May result in higher glare exposures to drivers for longer times**





Test Glare Profiles to compare peak illuminance and exposure duration



Target contrast (% threshold)

- 125%
- 200%

Experiment 1:
Relation between glare peak illuminance and exposure duration on recovery

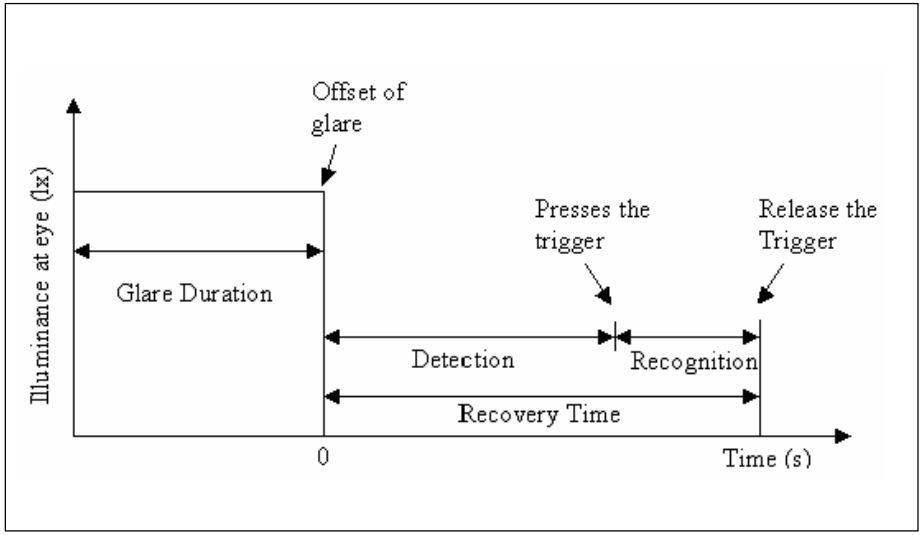
Recovery time measurement

1. Subjects were asked to look at the fixation point

   The subject was exposed to a glare profile

3. As soon as glare was extinguished, a target with a given contrast, location, and orientation, was presented on the screen
4. As soon as the subject detected the target on the screen, the subject was asked to press the trigger
5. As soon as the subject recognized the target's orientation, the subject was asked to release the trigger, and provide the orientation
6. A new screen was presented to subjects with DeBoer and difficulty rating scales

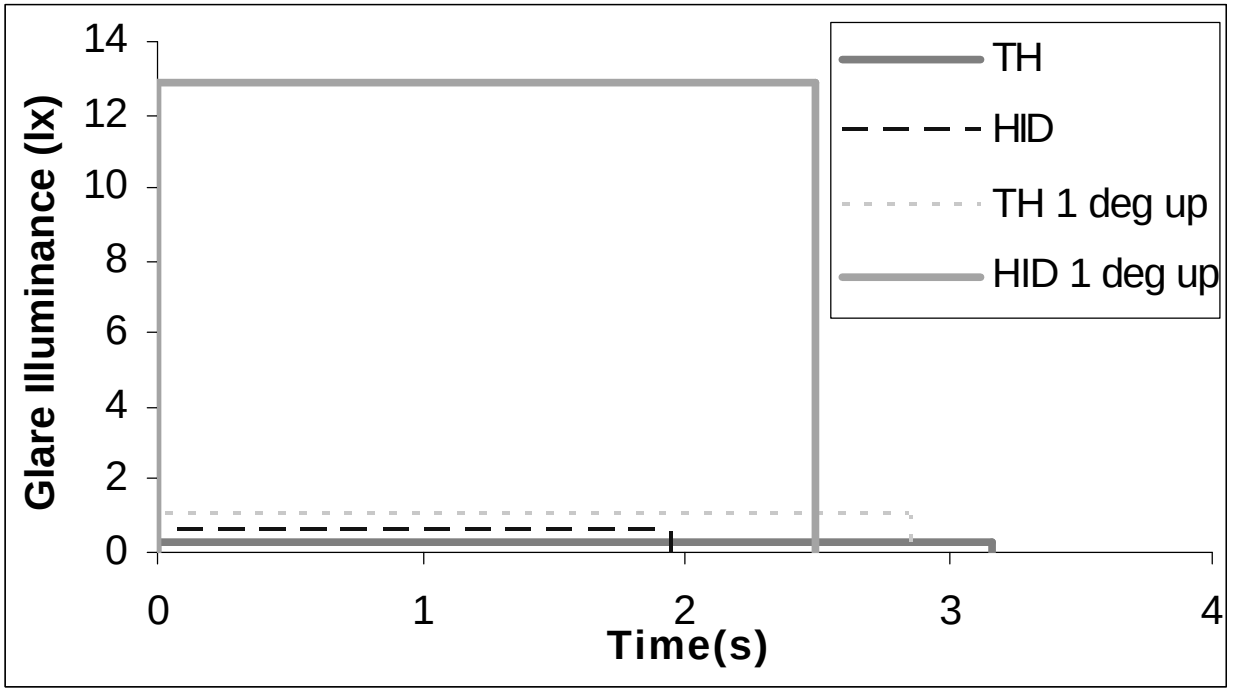
   Subjects were asked to provide the DeBoer rating for each condition



Conclusions

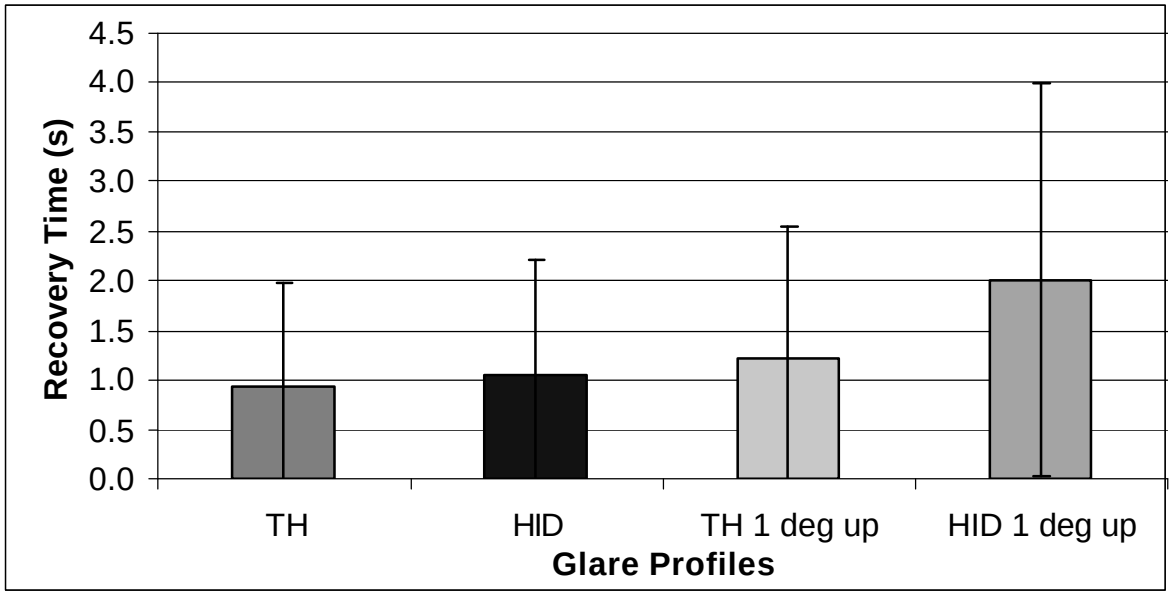
- **Recovery time is dependent on glare profile**
  - **Correlated with the total glare dosage**
- **Under the conditions tested here, the discomfort rating is not dependent on glare dosage**
  - **Correlated with peak glare illuminance**
- **This may indicate a mismatch of driver discomfort with glare recovery**
  - **Drivers can be drawing wrong conclusions about how well they can see after a glare encounter based on the discomfort they feel**

Methodology – Experiment 2 Test Glare Profiles



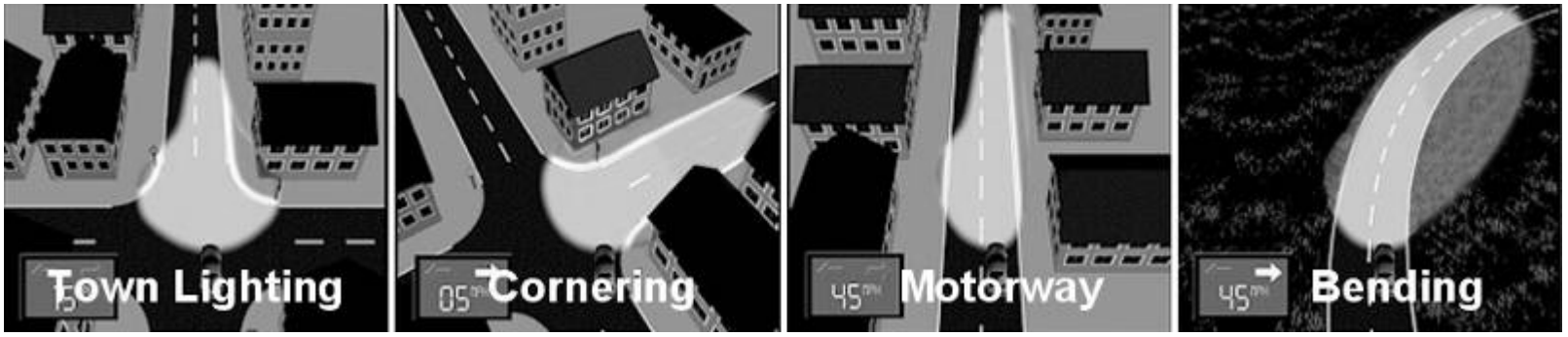
Experiment 2 Findings

- **Under correct aiming**
  - **HID lamps resulted in approximately the same recovery time as TH lamps**
- **Both lamps result in longer recovery times when misaimed 1^{o} up**
  - **The increase in recovery time from HID is much greater**



Advanced Forward Lighting

- How can Advanced Forward Lighting provide safety benefits without excessive glare?
- What Metrics should be used to evaluate Advanced Forward Lighting?

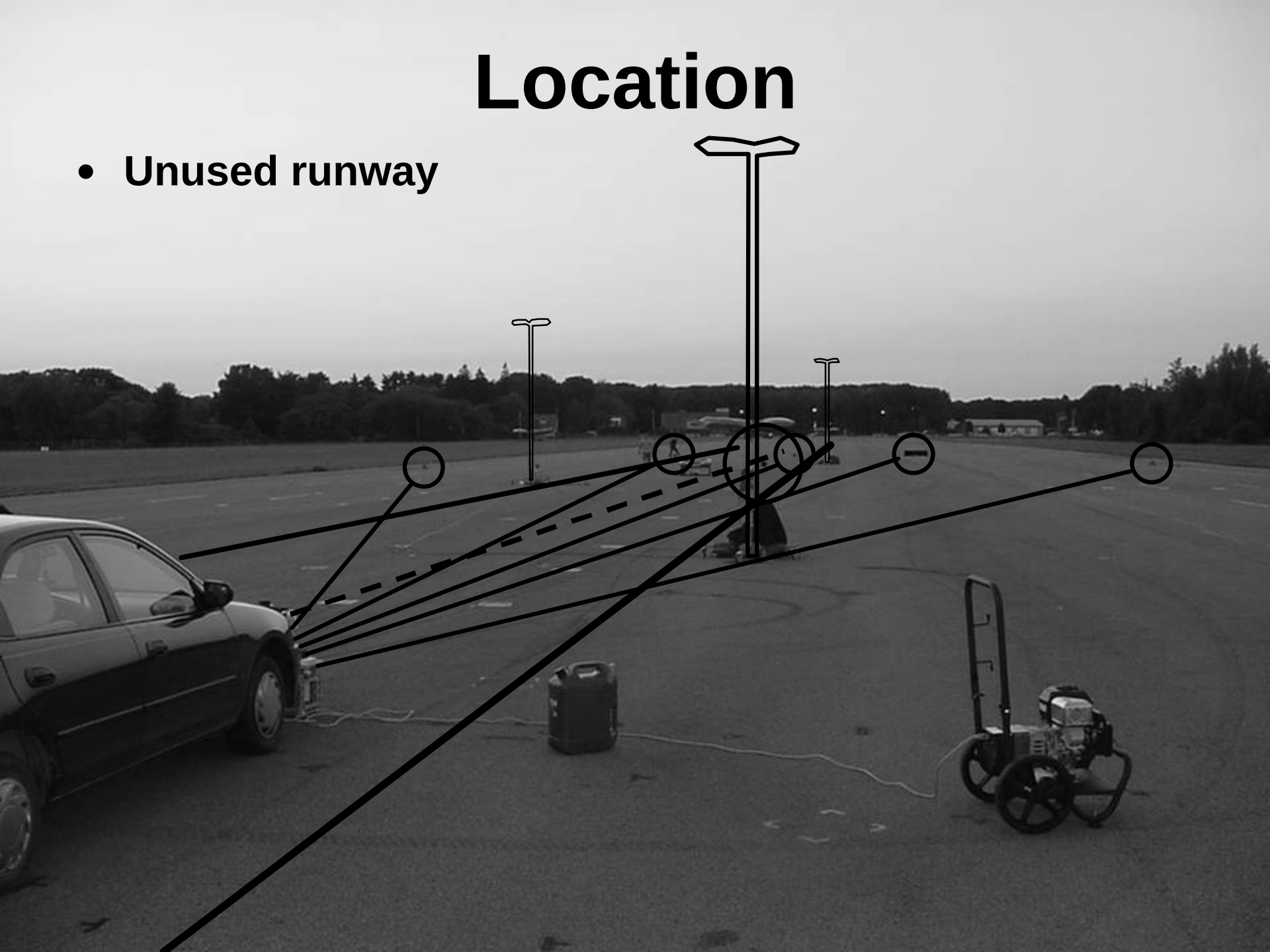


Proposed AFS beam patterns (from http://visteon.wieck.com/image_database).

Glare Reduction and Visibility Enhancement through Advanced Forward Lighting Systems (AFS)

Location

- **Unused runway**

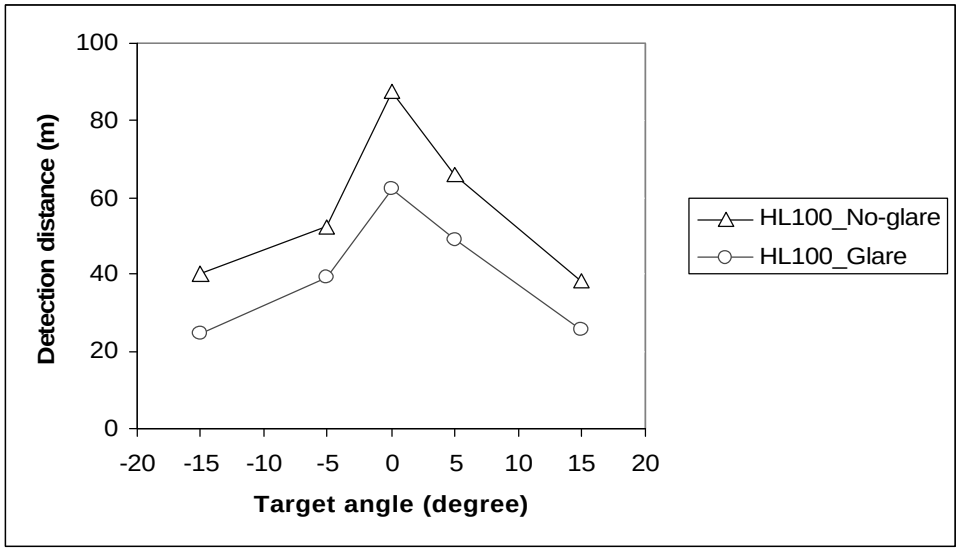


Key Questions & Findings

- **When there are street lights, can headlamp intensity be reduced without reducing visibility?**
  - **YES**
- **When headlamp intensity is reduced, can drivers benefit from reduced glare?**
  - **YES**

Additional Conclusions

- **On lighted roadways, oncoming headlamp glare impairs drivers' forward visibility**
- **On lighted roadways, the results suggest that a 30%-50% headlamp intensity reduction would reduce glare without impairing forward visibility**



Ongoing Research

- **Developing Metrics for Advanced Forward Lighting Systems**
- **Using Metrics to develop a Safety Advanced Forward Lighting Prototype**