Headlight Performance/ Safety Matters?

John D. Bullough, Ph.D., FIES
Light and Health Research Center, Icahn School of Medicine at Mount Sinai

DVN US Workshop: Lighting the Future
August 29th-30th, 2023

Outline

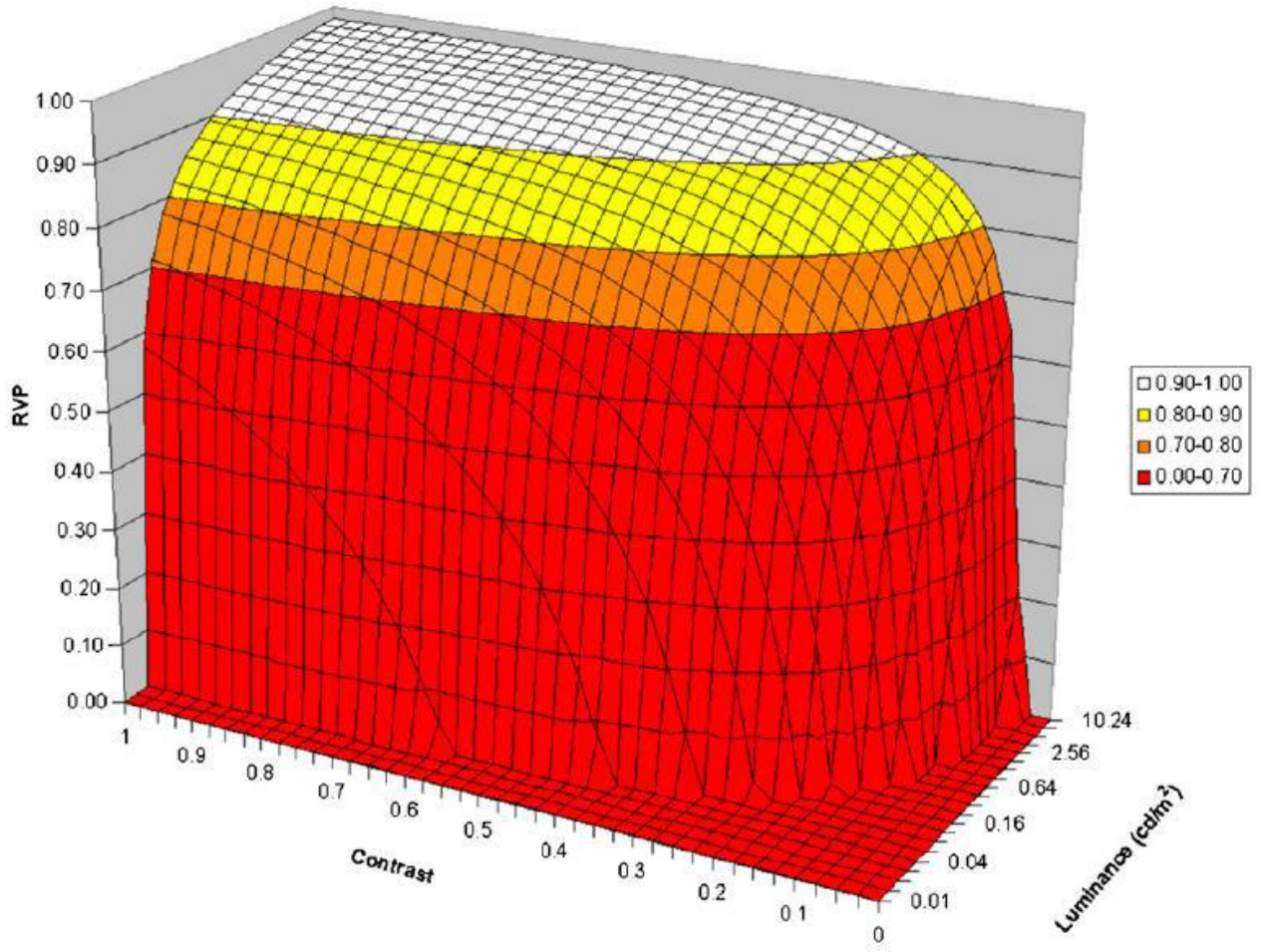
- Needed safety solutions
- Proven technologies
- Uncertain regulations
- Powerful market forces
- Confusing voices

- What do we know?
- Where do we go?

Need for Improved Safety

Visual Performance

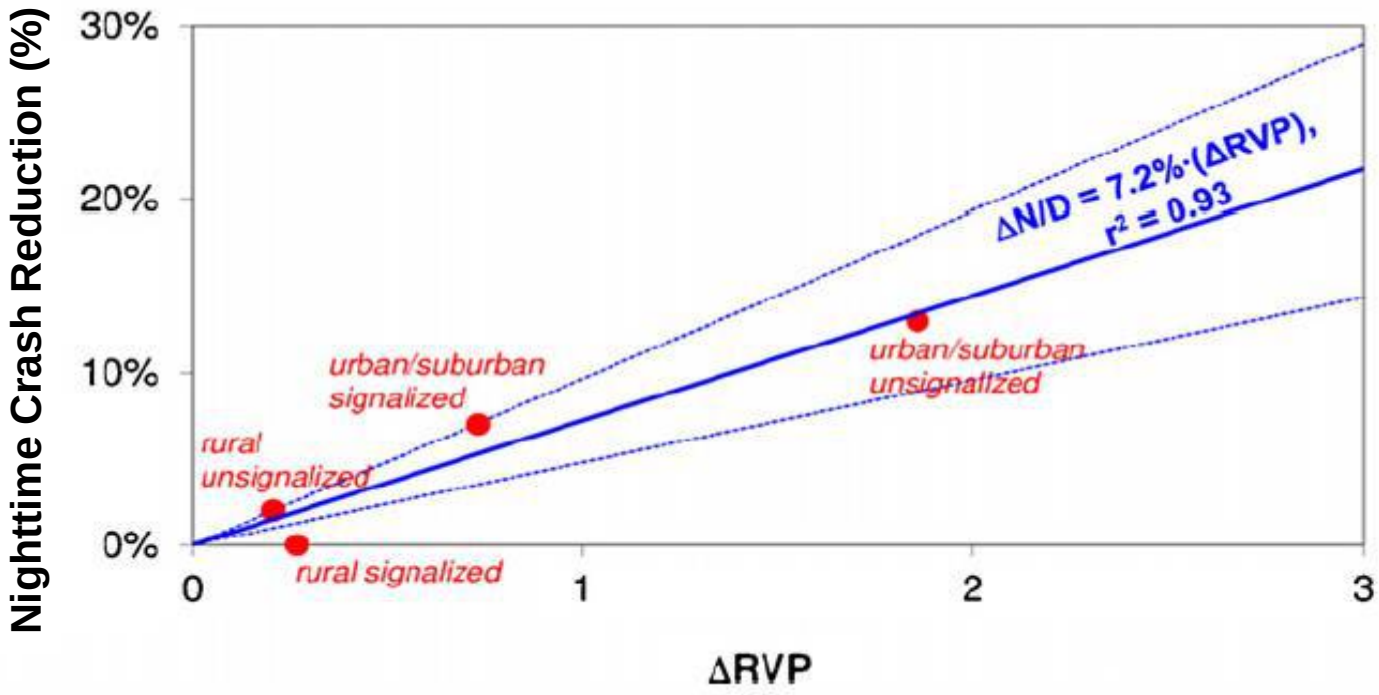
- Speed and accuracy of visual processing depends upon:
  - Overall light level
  - Contrast
  - Size
  - Age of observer



(Rea and Ouellette 1991)

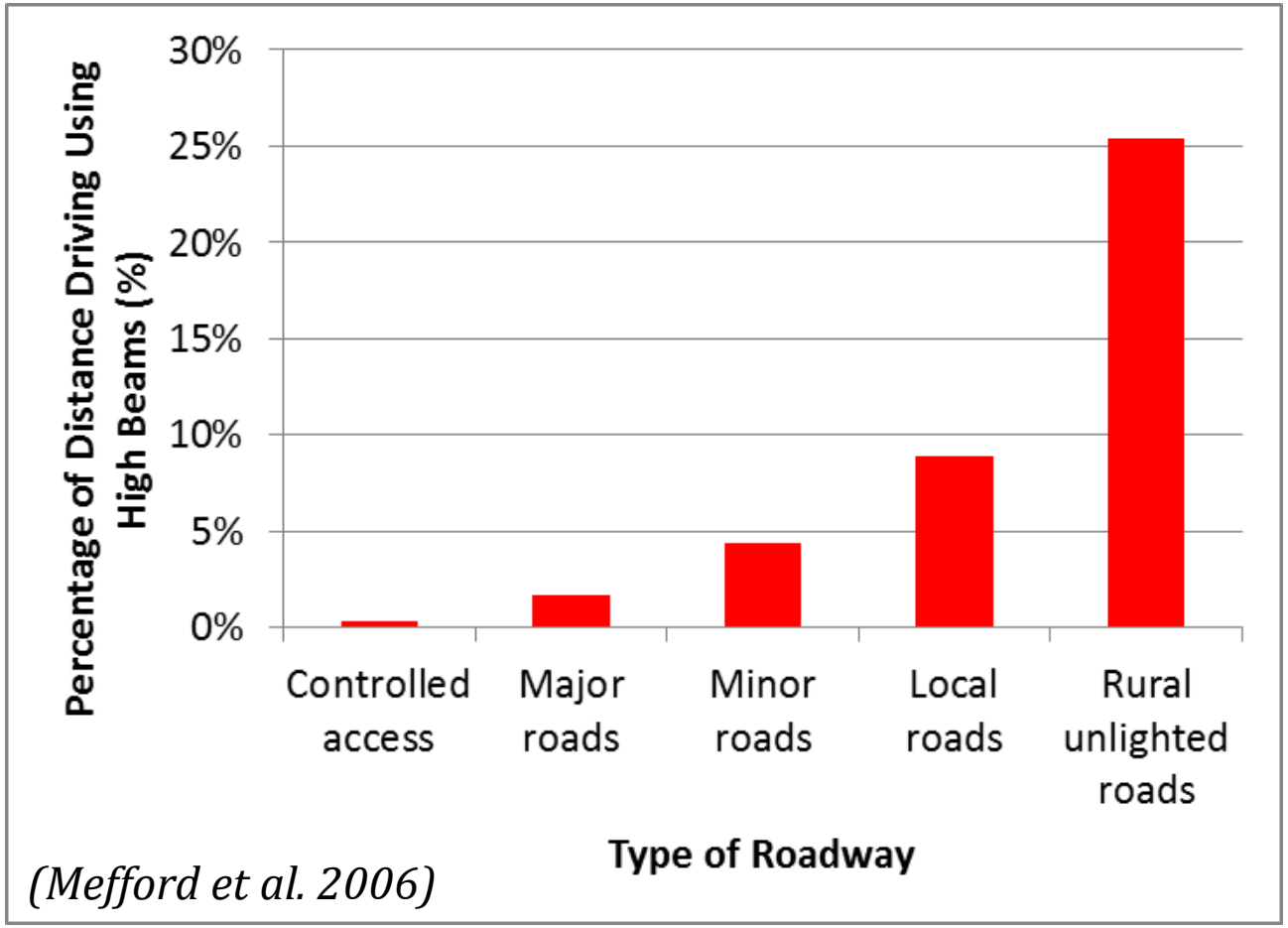
Role of Automotive Lighting

- Most roads in the U.S. are not illuminated (NHTSA 2007) so vehicle headlights are critical
- Visual performance improvements from lighting are directly correlated with nighttime crash reductions associated with lighting



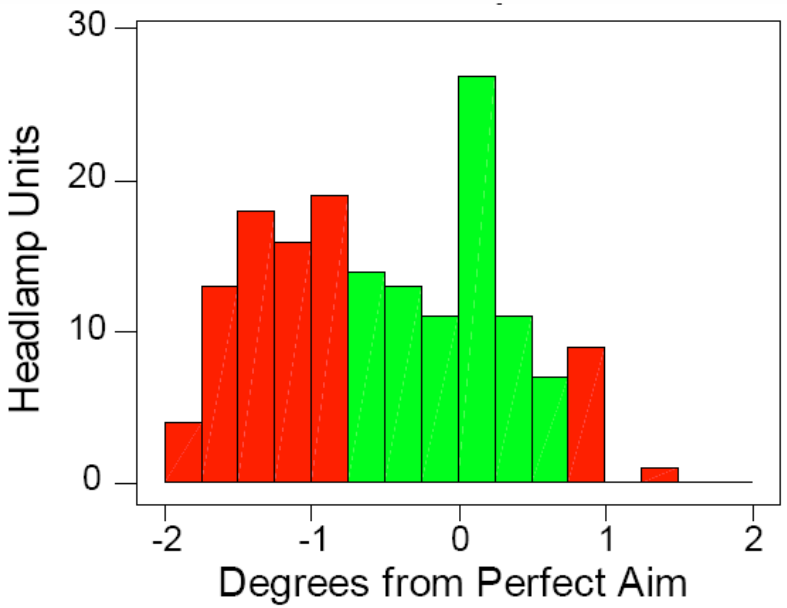
(Bullough et al. 2013)

Driver Behavior is not Always Optimal

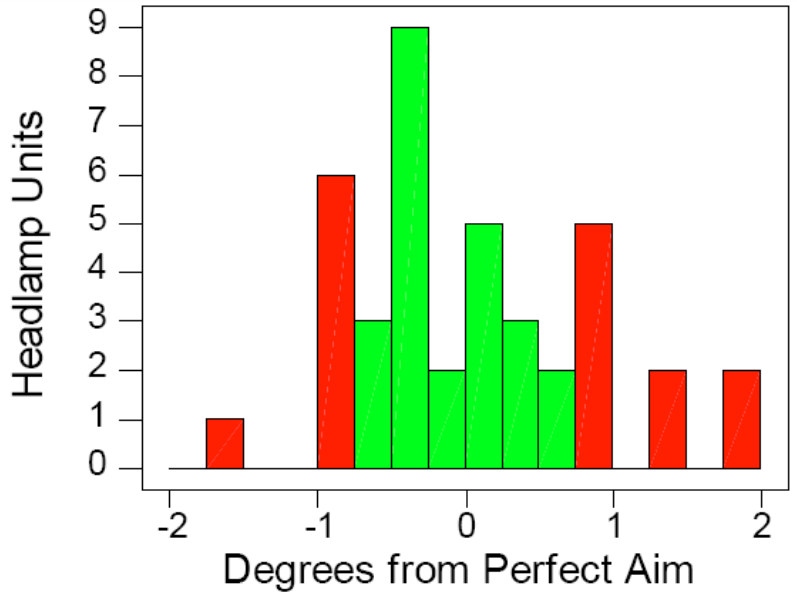


(Mefford et al. 2006)

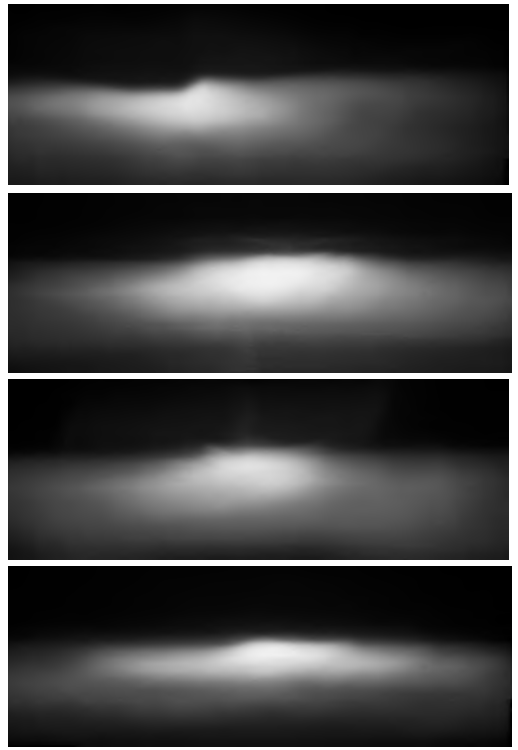
Lighting's Implementation is not Always Optimal



In-service vehicles



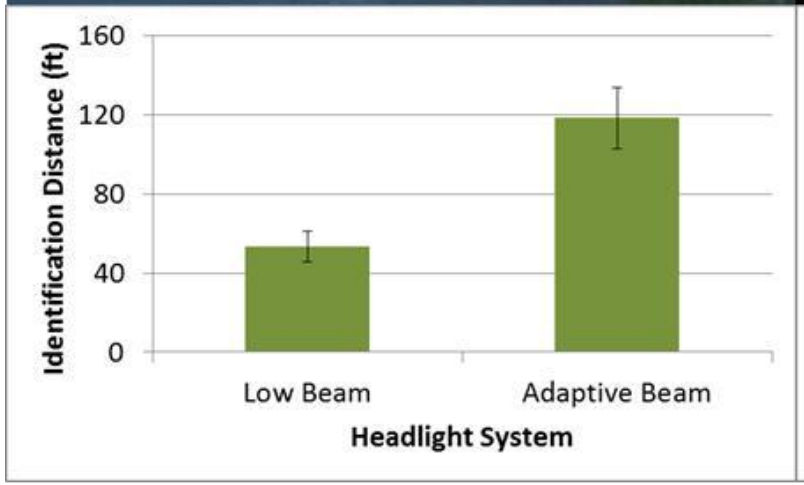
New vehicles

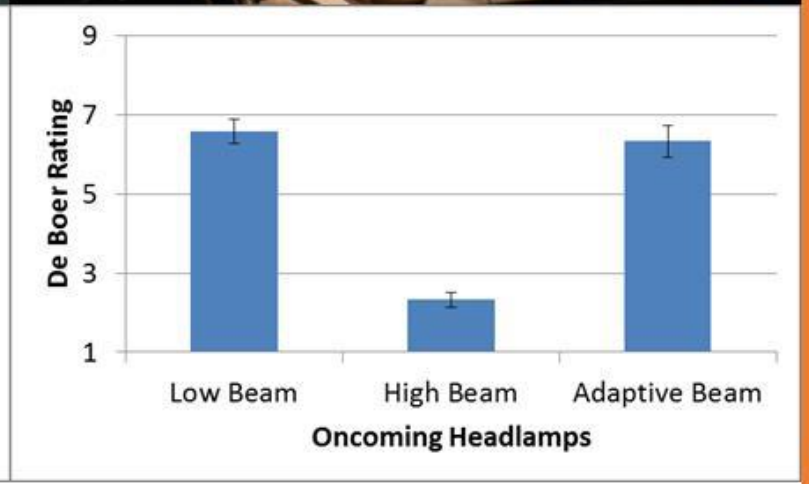


(Skinner et al. 2010)

Adaptive Driving Beam (ADB) Headlights

ADB Improves Visibility and Reduces Glare



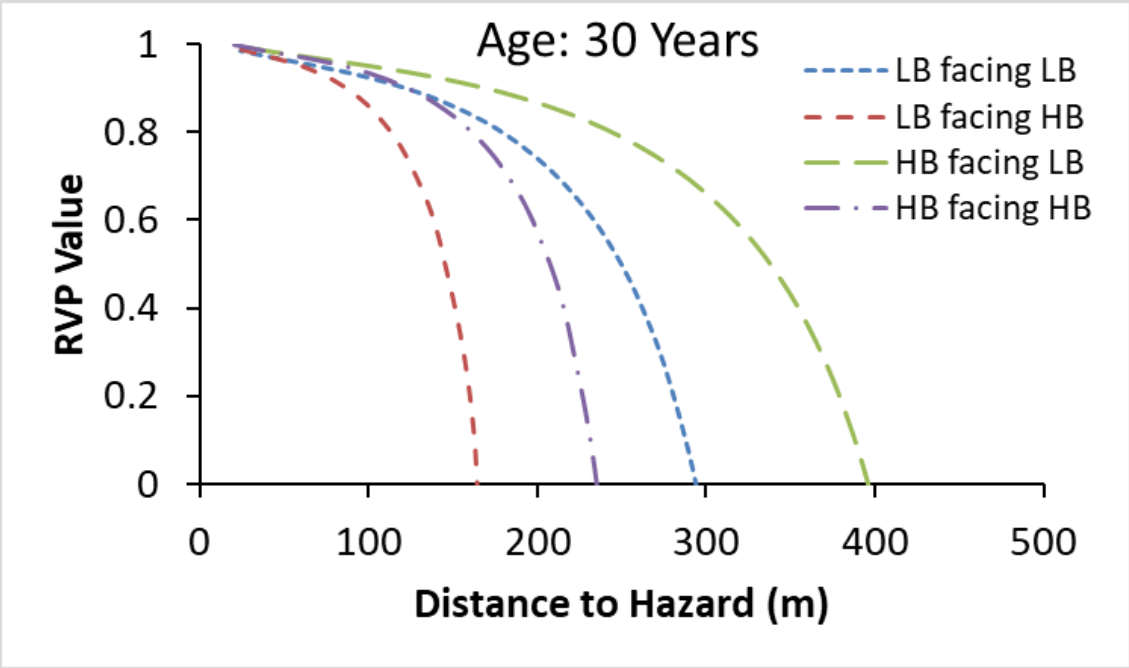


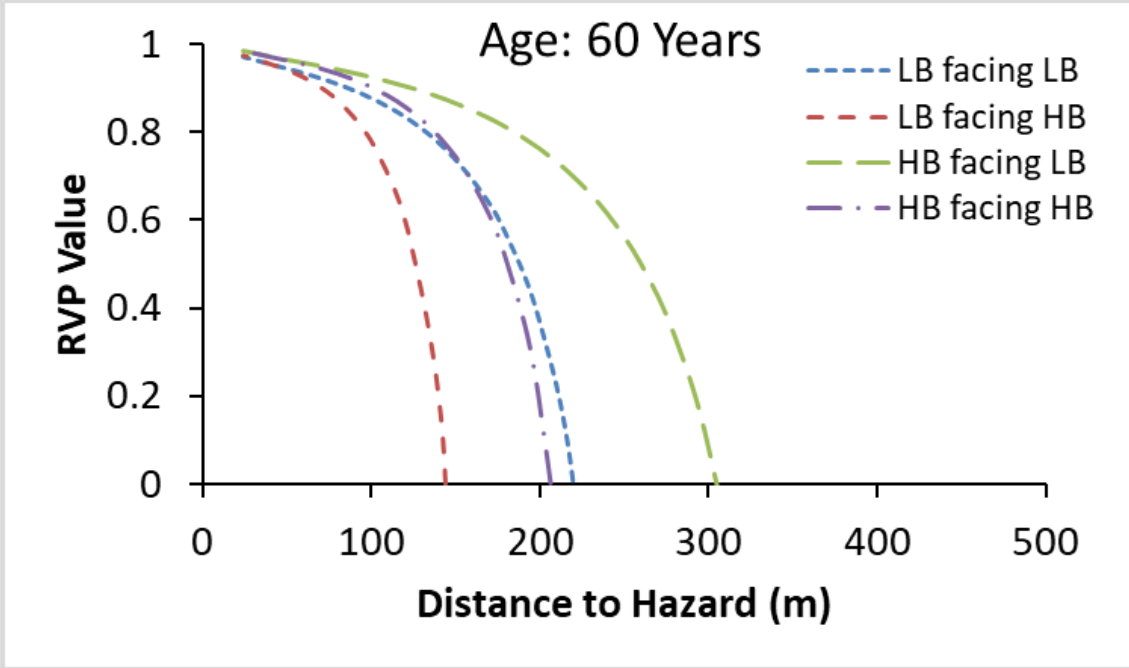
De Boer Rating Scale

9 Unnoticeable glare
8
7 Satisfactory
6
5 Just permissible
4
3 Disturbing
2
1 Unbearable

(Bullough et al. 2016)

Visual Performance Benefits of ADB





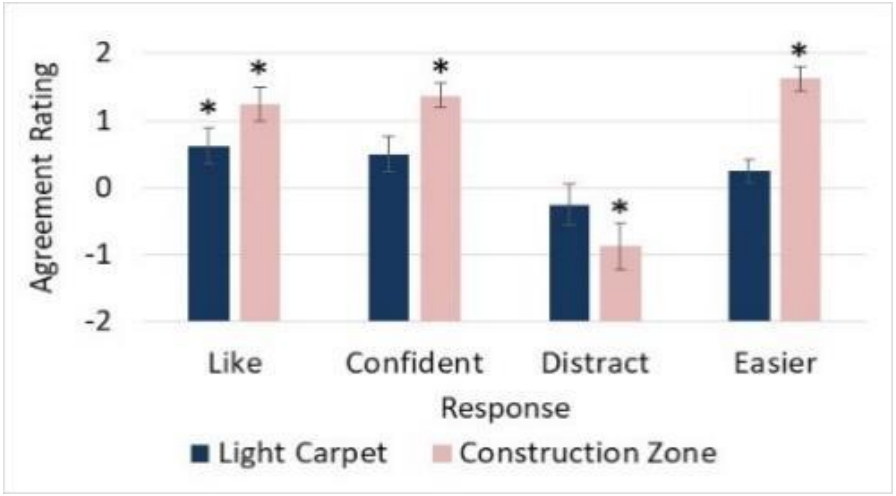
At minimum safe stopping distance for highway driving, ADB headlights are predicted to result in (relative to low beam headlights):

- **5.3%** nighttime crash reduction for 30 year old drivers
- **12.3%** nighttime crash for 60 year old drivers

(Bullough 2021)

Value and Benefits of Projected Road Images

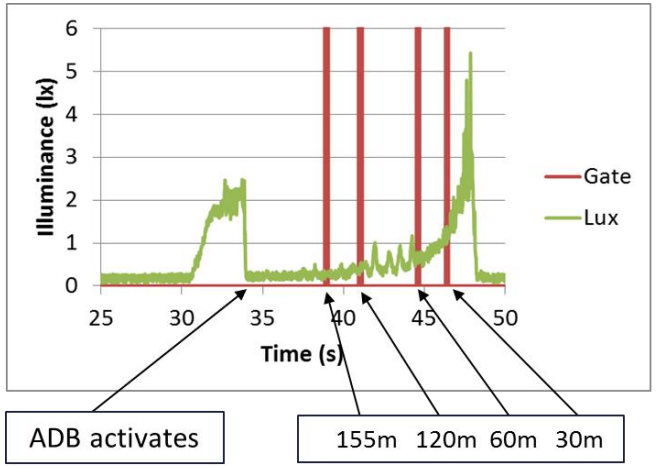
(Bullough and Skinner 2022)

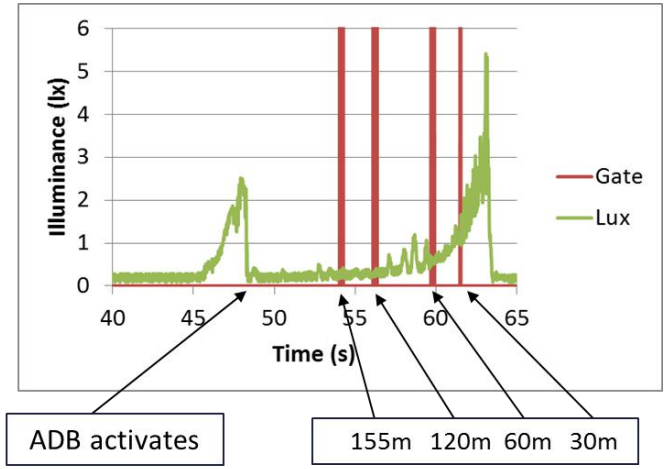


Portion of Road	Luminance (cd/m²)	Contrast	Relative Visual Performance (RVP)*
Lighted "carpet" 50 ft from vehicle	3.3	0.33	0.96
Adjacent area 50 ft from vehicle	2.2		
Lighted "carpet" 150 ft from vehicle	1.1	0.55	0.94
Adjacent area 150 ft from vehicle	0.5		

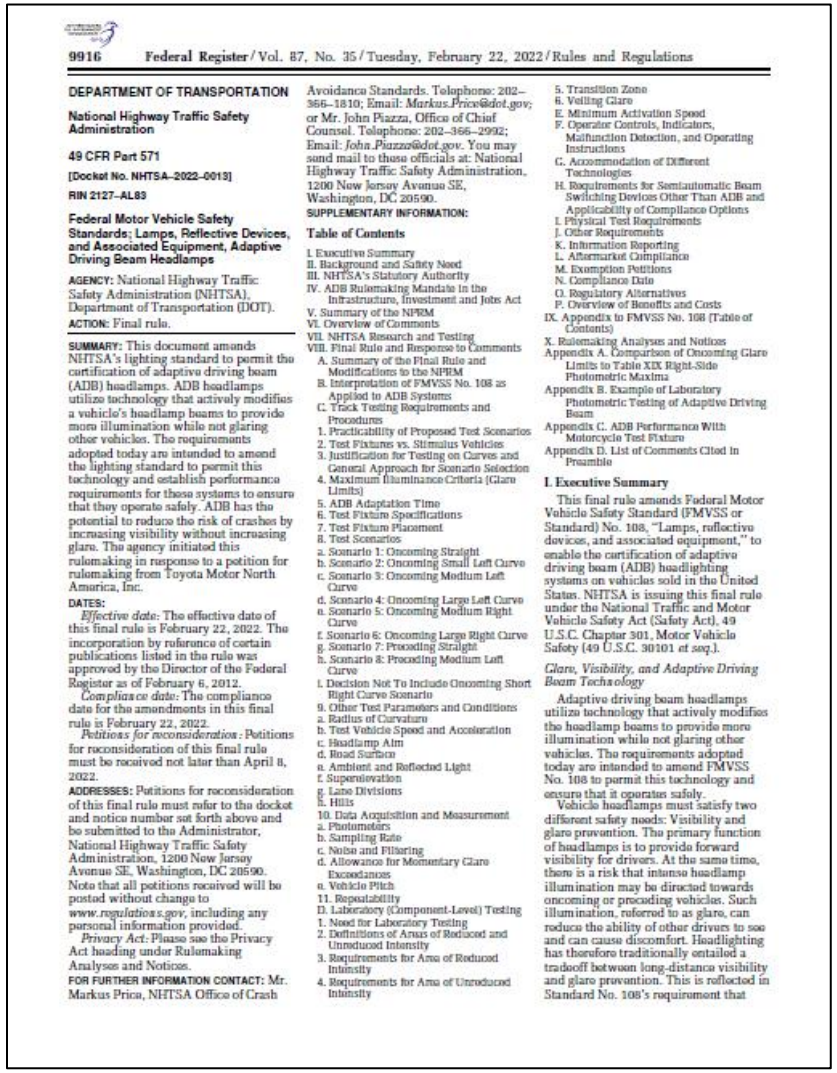
Steps Toward ADB Regulation

- Field tests of an ADB vehicle were made along a flat, straight road using procedures developed for SAE J3069
- Measurements were feasible and repeatable





Regulatory Uncertainty



9916 Federal Register / Vol. 87, No. 35 / Tuesday, February 22, 2022 / Rules and Regulations

DEPARTMENT OF TRANSPORTATION

National Highway Traffic Safety Administration

49 CFR Part 571

[Docket No. NHTSA–2022–0013]

RIN 2127–AL83

Federal Motor Vehicle Safety Standards; Lamps, Reflective Devices, and Associated Equipment, Adaptive Driving Beam Headlamps

AGENCY: National Highway Traffic Safety Administration (NHTSA), Department of Transportation (DOT).

ACTION: Final rule.

SUMMARY: This document amends NHTSA's lighting standard to permit the certification of adaptive driving beam (ADB) headlamps. ADB headlamps utilize technology that actively modifies a vehicle's headlamp beams to provide more illumination while not glaring other vehicles. The requirements adopted today are intended to amend the lighting standard to permit this technology and establish performance requirements for those systems to ensure that they operate safely. ADB has the potential to reduce the risk of crashes by increasing visibility without increasing glare. The agency initiated this rulemaking in response to a petition for rulemaking from Toyota Motor North America, Inc.

DATES:

Effective date: The effective date of this final rule is February 22, 2022. The incorporation by reference of certain publications listed in the rule was approved by the Director of the Federal Register as of February 6, 2012.

Compliance date: The compliance date for the amendments in this final rule is February 22, 2022.

Petitions for reconsideration: Petitions for reconsideration of this final rule must be received not later than April 8, 2022.

ADDRESSES: Petitions for reconsideration of this final rule must refer to the docket and notice number set forth above and be submitted to the Administrator, National Highway Traffic Safety Administration, 1200 New Jersey Avenue SE, Washington, DC 20590. Note that all petitions received will be posted without change to *www.regulations.gov*, including any personal information provided.

Privacy Act: Please see the Privacy Act heading under Rulemaking Analyses and Notices.

FOR FURTHER INFORMATION CONTACT: Mr. Markus Price, NHTSA Office of Crash Avoidance Standards. Telephone: 202–366–1810; Email: *Markus.Price@dot.gov*; or Mr. John Piazza, Office of Chief Counsel. Telephone: 202–366–2992; Email: *John.Piazza@dot.gov*. You may send mail to those officials at: National Highway Traffic Safety Administration, 1200 New Jersey Avenue SE, Washington, DC 20590.

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I. Executive Summary

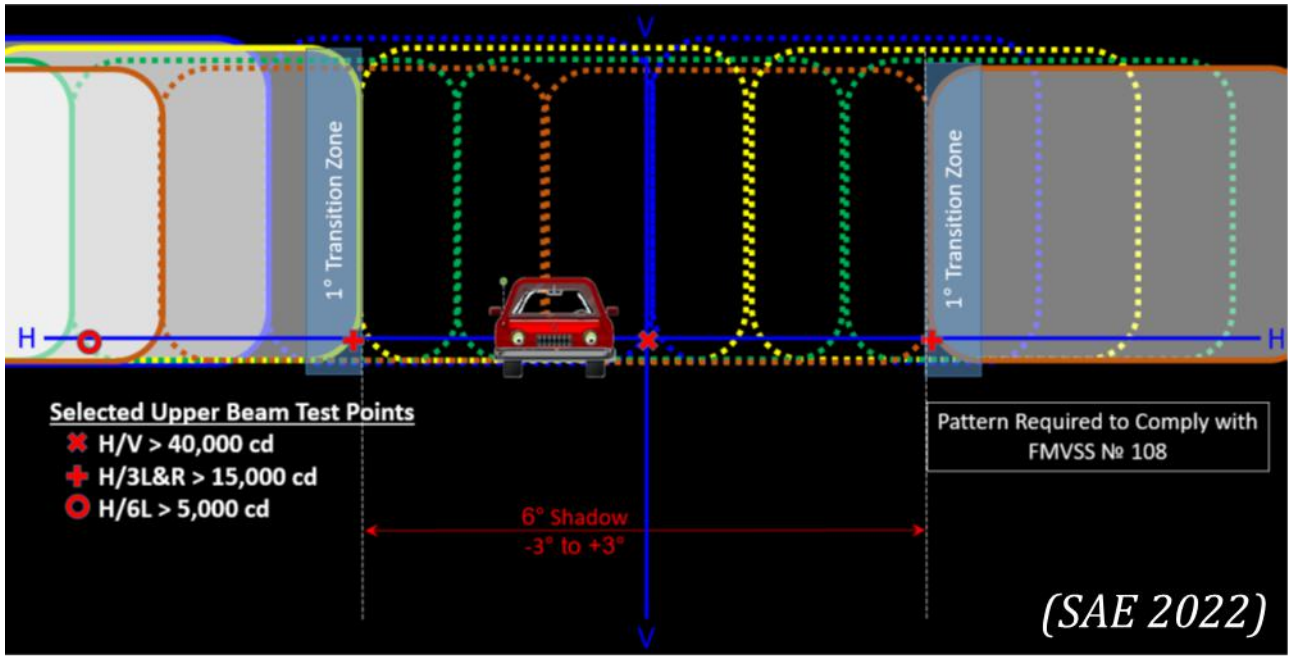
This final rule amends Federal Motor Vehicle Safety Standard (FMVSS or Standard) No. 108, "Lamps, reflective devices, and associated equipment," to enable the certification of adaptive driving beam (ADB) headlighting systems on vehicles sold in the United States. NHTSA is issuing this final rule under the National Traffic and Motor Vehicle Safety Act (Safety Act), 49 U.S.C. Chapter 301, Motor Vehicle Safety (49 U.S.C. 30101 *et seq.*).

Glare, Visibility, and Adaptive Driving Beam Technology

Adaptive driving beam headlamps utilize technology that actively modifies the headlamp beams to provide more illumination while not glaring other vehicles. The requirements adopted today are intended to amend FMVSS No. 108 to permit this technology and ensure that it operates safely.

Vehicle headlamps must satisfy two different safety needs: Visibility and glare prevention. The primary function of headlamps is to provide forward visibility for drivers. At the same time, there is a risk that intense headlamp illumination may be directed towards oncoming or preceding vehicles. Such illumination, referred to as glare, can reduce the ability of other drivers to see and can cause discomfort. Headlighting has therefore traditionally entailed a tradeoff between long-distance visibility and glare prevention. This is reflected in Standard No. 108's requirement that

- SAE J3069 (1st edition): 14 pages
- Docket No. NHTSA-2022-0013: 111 pages
- Issues include small/restrictive "transition zones" that could result in large "dim" regions

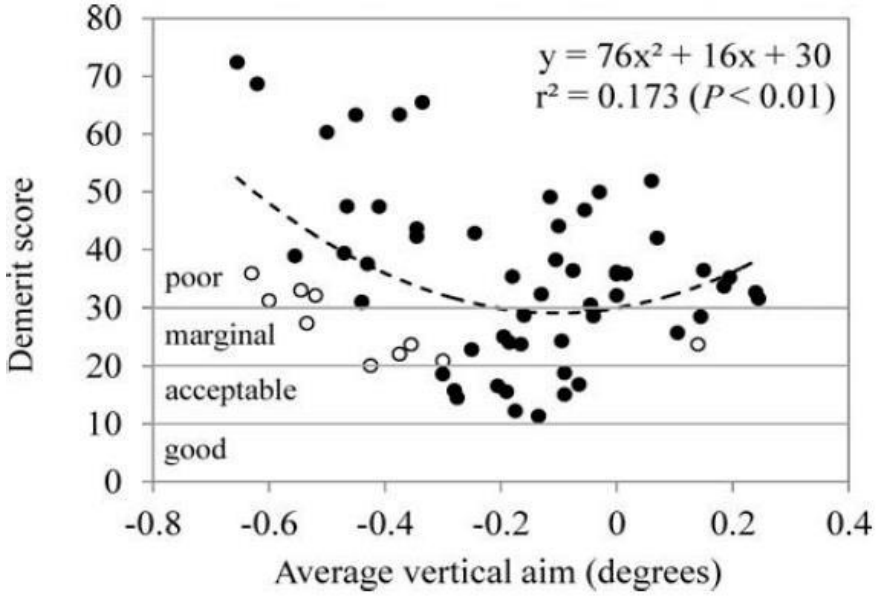


Powerful Market Forces

- Despite ADB's promise, much focus is on **low beam** headlight performance
- Numerous rating systems to evaluate vehicle headlights have been developed
- Insurance Institute for Highway Safety (IIHS) system is influential in the U.S.

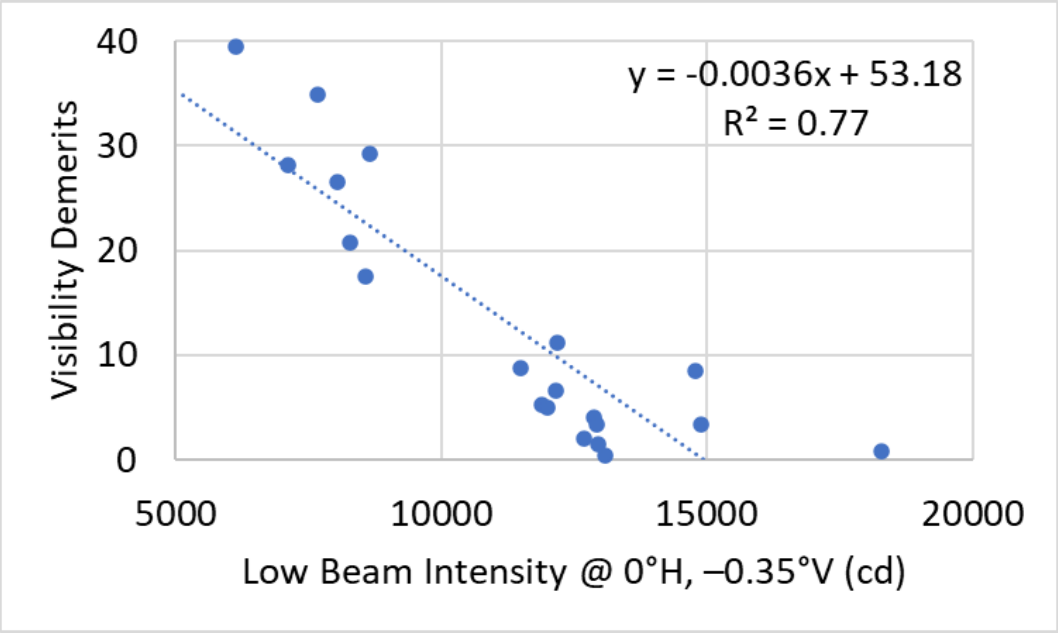
Influence of IIHS Rating System

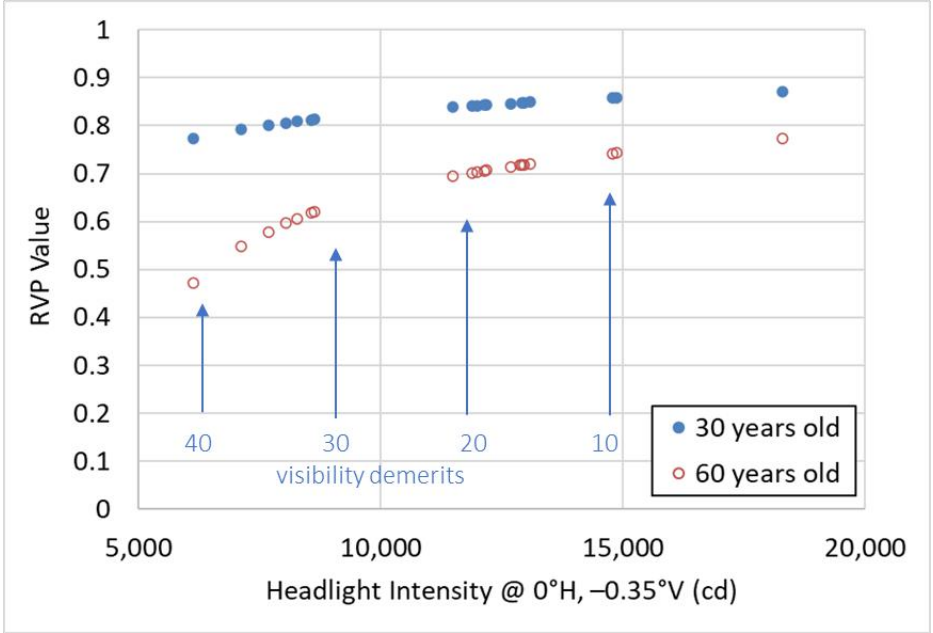
- IIHS tests headlights with vertical aim "as delivered"
- In 2016 the range of vertical aim was 0.9° (0.65° down to 0.25° up)
  - In practically none of them, the aim was "perfect" (0° up/down)
- In 2022 the range of vertical aim was 0.55° (0.31° down to 0.23° up)
  - In 25% of them the aim was "perfect" (0° up/down)



(Bullough 2016)

Relation between IIHS Ratings and Safety?





Visibility Demerits	Night Crash Reduction (30 Year Old)	Night Crash Reduction (60 Year Old)
40	-	-
30	2.8%	10.2%
20	1.6%	4.6%
10	1.1%	2.7%

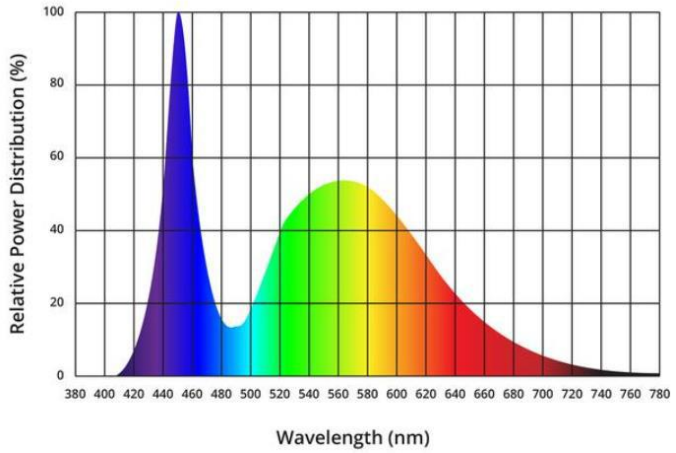
(Bullough 2023)

What are Drivers' Main Concerns?

- Glare, glare and glare
- More specifically, **discomfort glare** from **"bluish"** headlights!

The Squeaky Wheel

Figure 4 shows the relative Spectral Power Distribution from a so-called 5500 Kelvin LED. The relative distribution does not tell us the absolute energy of the blue wavelength light, but it does show us that the blue wavelength light at 450 nanometers has the most energy. This blue wavelength also happens to be the most damaging for the human eye and causes the most glare. Blue wavelength light also suppresses the hormone melatonin, reducing the ability of cells to repair themselves at night.

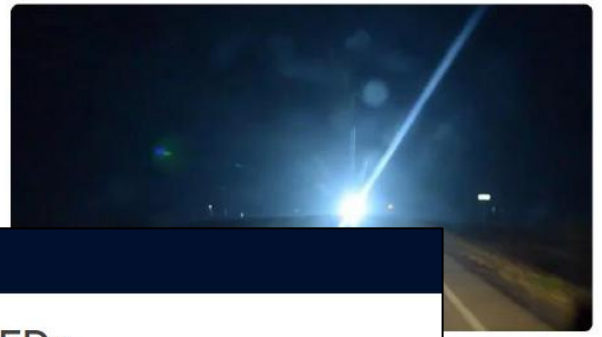


www.softlights.org

change.org Start a petition My petitions Browse Membership Log in

Petition details Comments Updates

Ban Blinding Headlights and Save Lives!



48,489 Signatures

50,000 Next Goal

108 people signed this week

Sign this petition

First name

Last name

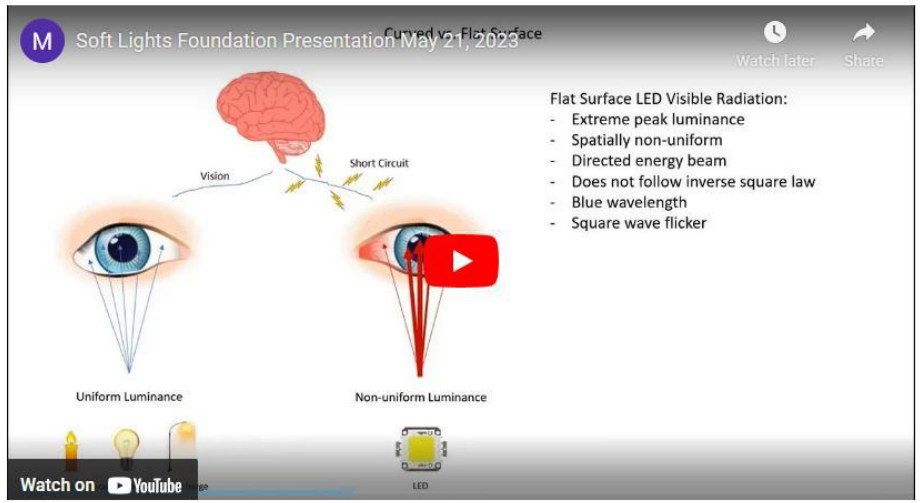
Email

Soft Lights Foundation

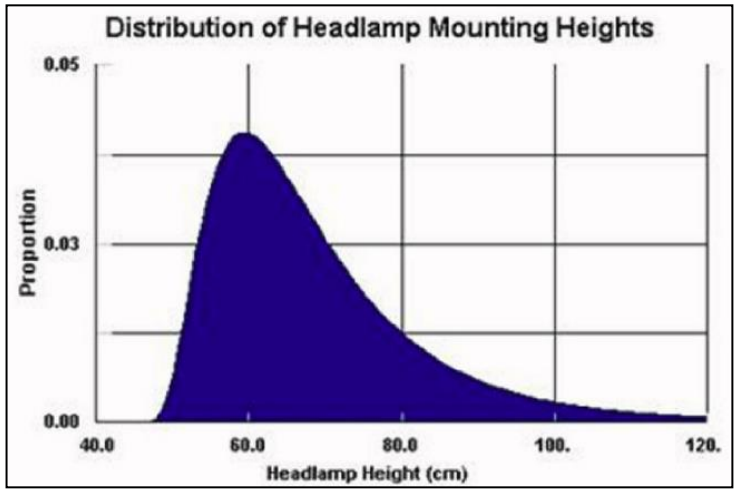
The Failure to Regulate LEDs

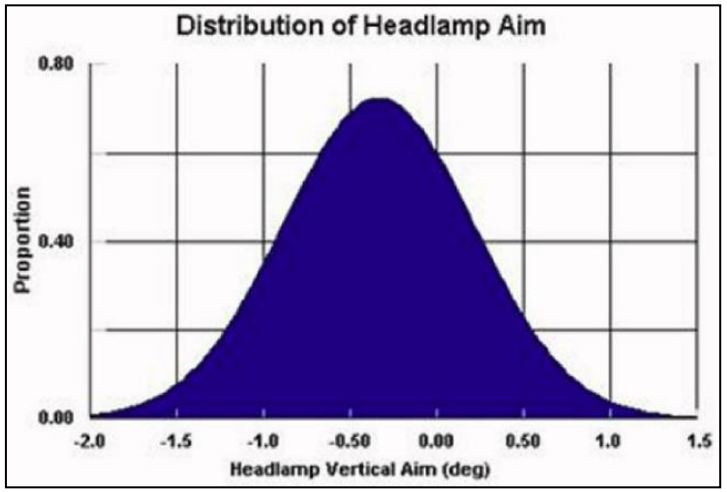
In the USA, the Food and Drug Administration has the legal mandate from Congress to regulate the visible radiation emitted by Light Emitting Diode products. Yet, the FDA has never published the required performance standards that would ensure the comfort, health, and safety of the public. The switch to LEDs is fundamentally based on the misinformation that LEDs save energy and the false claim that LED visible radiation is safe.

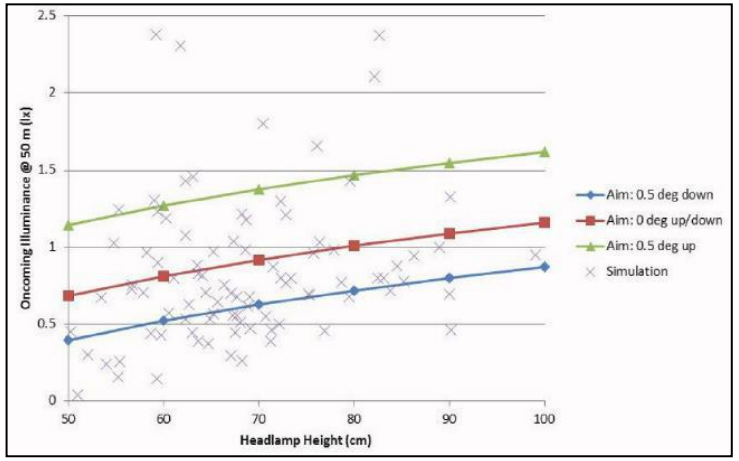
The video below is a presentation by Soft Lights Foundation president Mark Baker on the harms of LED visible radiation and the efforts of the Soft Lights Foundation to convince the government to regulate LED products.

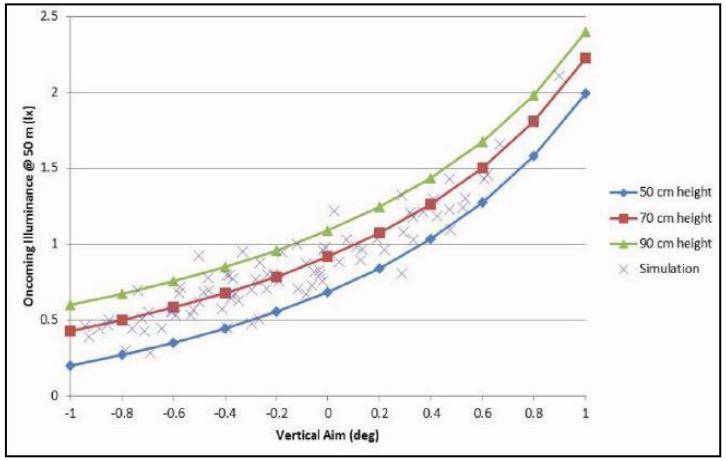


What Do the Data Say About Glare's Causes?



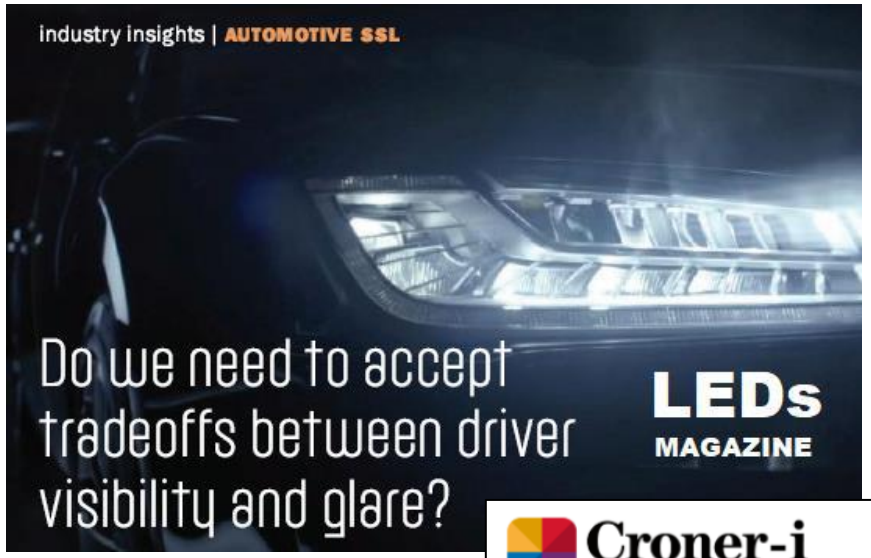






(Bullough 2013)

What Will Bring Clarity to the Issue?



NEWS

Blinded by the light: Cars in the U.S. still lack glare-reducing headlights

Blinded by the light: Cars in the U.S. still lack glare-reducing headlights

Adaptive driving beams have been used in Europe since 2012. They are now available on vehicles sold in every major automotive market worldwide, except the U.S.

May 11, 2023, 7:41 AM EDT

By Adiel Kaplan, Jean Lee, Joe Enoch and Vicky Nguyen

Croner-i
Inform · Advise · Protect

Headlamp glare — now and a view to the future

Last reviewed 27 March 2023

In this article, John Bullough and Mark Rea review some basic reasons for headlamp glare and foretell a brighter future when heavy goods vehicle drivers will see better at night and glare to oncoming drivers will become a thing of the past.

There seems little doubt that the driving public has become increasingly bothered by glare from vehicle headlamps. At least some of the complaints stem from developments in light source technologies over recent decades, from halogen filament to high-intensity discharge (HID) lamps, and now to light-emitting diodes (LEDs). But new light source technology is not entirely to blame. Mis-aimed headlights, particularly those with high mounting locations as seen on HGVs, are the primary culprit.

What Do We Know?

- Headlights have an important role to play in improving nighttime safety of pedestrians and drivers
- Despite their safety benefits, ADB headlights might not be widespread on U.S. vehicles for some time
- The driving public's view of glare is focused on the color of headlights
  - But compared to headlight aim, which is very widespread, color is a secondary issue

Where Do We Go?

Thank You!

- Light for Transportation Safety Partnership:
  - ams OSRAM, Audi, Forvia Hella, General Motors, Lumileds, Varroc
- Contact information:
  - John D. Bullough, Ph.D.
    Light and Health Research Center
    Icahn School of Medicine at Mount Sinai
    Web: http://icahn.mssm.edu/lhrc, http://www.light-health.org
    Email: John.Bullough@mountsinai.org