Headlamp Glare Complaints: Why Are They Rising?

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Whenever we meet anyone…

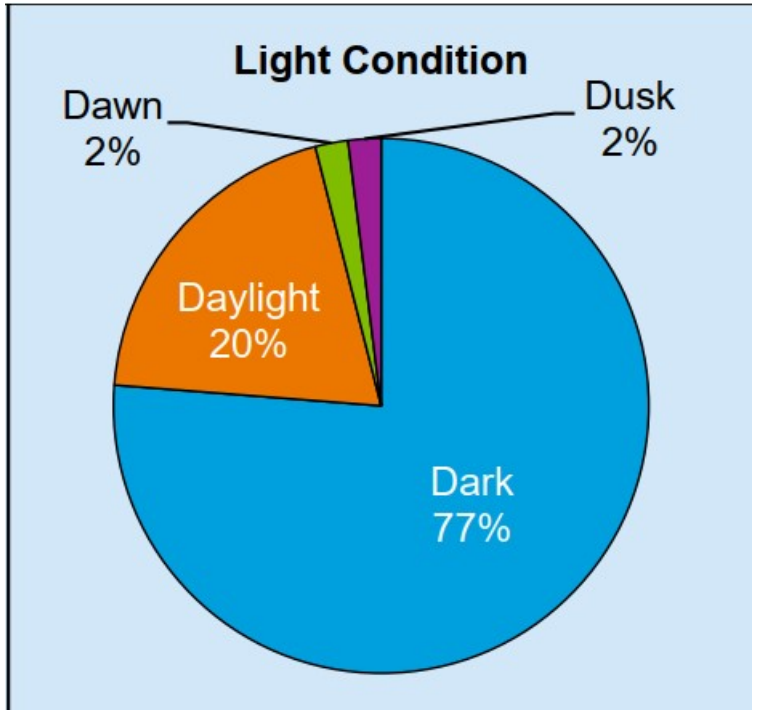
Me: "Hi, I'm _____. I do automotive lighting engineering."

Response: "Oh, cool! When are you going to do something about those bright glaring headlights?"

Why this is important

Motor vehicle accidents are a leading cause of death in the USA.

77% of pedestrian fatalities occur in dark conditions



Lack of sufficient light, not glare, is a key factor in motor vehicle accidents in darkness. It would probably be better to increase the light output of all headlamps, *even if that increases glare*, because the added visibility could lead to a reduction in accidents.

But this is not widely known to the public…

Headlamp glare complaints-- have they increased in recent years?

Government of Canada / Gouvernement du Canada
Transport Canada

Yes, absolutely they have. But unfortunately this cannot be quantified -- headlamp-glare-specific complaints are not logged in a searchable database.

NHTSA

Yes, in the preamble to the NPRM to allow ADB (10/12/20218), NHTSA states "*The harmful effects of glare are highlighted by the thousands of consumer complaints NHTSA has received from the public over the years, Congressional interest, and the Agency's research.*"

- Federal Register / Vol. 83, No. 198, Page

So do the regulations now allow higher-glare headlamps that were previously prohibited?

- **No!** The regulations have not changed with respect to allowable glare.
- Replaceable-bulb headlamps with visual aim first became available on the market in about 1983. Today's headlamps are essentially required to meet the same glare requirements.

So do the regulations now allow higher-glare headlamps that were previously prohibited?

1999
Figure 27-2

Upper Beam

Test Points (degrees)	Candela maximum	Candela minimum
2U-V	—	1,000
1U-3L and 3R	—	2,000
H-V	75,000	20,000
H-3L and 3R	—	10,000
H-6L and 6R	—	3,250
H-9L and 9L	—	1,500
H-12L and 12R	—	750
1.5D-V	—	5,000
1.5D-9L and 9R	—	1,500
2.5D-V	—	2,500
2.5D-12L and 12R	—	750
4D-V	5,000	—

Lower Beam

Test Points (degrees)	Candela maximum	Candela minimum
10U-90U	125	—
4U-8L and 8R	—	64
2U-4L	—	135
1.5U-1R to 3R	—	200
1.5U-1R to R	1,400	—
1U-1.5L to L	700	—
0.5U-1.5L to L	1,000	—
0.5U-1R to 3R	2,700	500
H-4L	—	135
H-8L	—	64
0.6D-1.3R	—	10,000
0.86D-V	—	4,500
0.86D-3.5L	12,000	1,800
1.5D-2R	—	15,000
2D-9L and 9R	—	1,250
2D-15L and 15R	—	1,000
4D-4R	2,500	—
4D-20L and 20R	—	300

2022
Table XVIII

TEST POINT (degrees)		UPPER BEAM #3 (UB3)	
		MAXIMUM PHOTOMETRIC INTENSITY (cd)	MINIMUM PHOTOMETRIC INTENSITY (cd)
2U	V	–	1,000
1U	3L & 3R	–	2,000
H	V	75,000	20,000
H	3L & 3R	–	10,000
H	6L & 6R	–	3,250
H	9L & 9R	–	1,500
H	12L & 12R	–	750
1.5D	V	–	5,000
1.5D	9L & 9R	–	1,500
2.5D	V	–	2,500
2.5D	12L & 12R	–	750
4D	V	5,000	–

TEST POINT (degrees)		LOWER BEAM # 2V (LB2V)	
		MAXIMUM PHOTOMETRIC INTENSITY (cd)	MINIMUM PHOTOMETRIC INTENSITY (cd)
(1) 10U to 90U	(1) 90L to 90R	125	
4U	8L & 8R	–	64
2U	4L	–	135
1.5U	1R to 3R		200
1.5U	1R to R	1,400	–
1U	1.5L to L	700	–
0.5U	1.5L to L	1,000	–
0.5U	1R to 3R	2,700	500
H	V		–
H	4L	–	135
H	8L	–	64
0.5D	1.5L to L	–	–
0.5D	1.5R	–	–
0.6D	1.3R	–	10,000
0.86D	V	–	4,500
0.86D	3.5L	12,000	1,800
1D	6L	–	–
1.5D	2R	–	15,000
1.5D	9L & 9R	–	–
2D	9L & 9R	–	1,250
2D	15L & 15R	–	1,000
2.5D	V	–	–
2.5D	12L & 12R	–	–
4D	V	–	–
4D	4R	12,500	–
4D	20L & 20R	–	300

Same glare limits

So what did change?

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Let’s speculate.

A wide variety of factors *may* be causing glare complaints to increase over time

1. Headlamps and lighting system technology
2. Automobile design, quality, performance
3. The driving environment & traffic patterns
4. Driver's vision and driving behavior

Headlamps

- Headlamp Low Beams (the main part of the beams, not the glare zones) have been getting **much brighter** over time. This could cause far more light to be reflected off the road into driver's eyes.
  - Typical “good” headlamp beam in 1999: 450 lumens on the road
  - Typical “good” headlamp beam in 2024: 800-1100 lumens on the road
- Headlamp Low Beams (the glare regions) may have also gotten brighter over time, within the limits allowed by regulation.
  - 1999: relatively large safety margins applied in design phase
  - 2024: **razor-thin margins** applied
    - Enablers: better CAE predictions, better manufacturing control
    - Benefits: more light near the horizon for extended range
- Headlamp **High Beams** may have also gotten brighter, so we could expect more complaints.
  - North America high beams allow 75,000 candela at H-V. But *outside of H-V*, there is no limit on intensity.

Lighting Systems

- Average headlamp **mounting height** may have increased over time. Note evidence of increasing sales of pickups & SUVs, compared to cars. These vehicles tend to have higher-mounted headlamps and signal lamps.
- New autos may be equipped with more **auxiliary lighting** which adds to the "glare load" of light reaching oncoming drivers' eyes. This especially means so-called "signature lighting". This added light output is not typically included when testing HB or LB performance.
- **Turn signals** may be getting brighter over time. More use of "2.5x" Turn configurations due to styling/design/technology/marketing factors.
- Similarly, **parking lamps** in recent years are likely to be significantly brighter now than in the past.

Automobiles: Design, Quality, Performance, Maintenance

- **Higher quality** longer-lasting cars. This can lead to a larger pool of cars on the road. Overall average **age of the vehicle fleet** has been increasing over time, with more older cars still on the road today, compared to past years.
  - Average age of a car on the road in 2023 is more than **double** that of 1973. [1]
  - This affects headlamp lens clarity
- **Windshield Clarity**: As the average age of the vehicle fleet increases (e.g. due to better quality), the average clarity of windshields may be decreasing. For example: on average windshield may have several years longer wear-and-tear (assuming most windshields don't get replaced).
- Headlamp aim: in recent years, automakers have more incentives to provide strong light very close to the horizon to achieve high IIHS ratings. According to IIHS, automakers are getting better at achieving **precise aim** on the assembly line.

(1) S&P Global Mobility

Automobiles: Design, Quality, Performance

- Headlamp **aim maintenance**: after a collision repair, will new replacement headlamps be aimed properly?
- **Aftermarket light sources**: many aftermarket bulbs have become availalbe, some of them are both brighter and more glare-producing than OEM bulbs. Examples include halogen-to-Xenon “conversion kits”, and LED "replacement bulbs" for halogen headlamps.
- **Color temperature** of light output may have shifted towards the more annoying blue end of the spectrum over time. Incandescent and halogen headlamp beams have a pronounced yellowish color temperature compared to LED and Xenon headlamps. This blue shift alone could increase glare complaints, even if light flux is held constant.

The Driving Environment: Traffic Patterns

- **Traffic density** may have increased
  - Lower gas prices; higher fuel efficiency
  - More affordable new cars
  - Larger population of vehicle owners
- Ratio of slow/winding roads to **straight/flat roads** may have changed. Either the overall mileage of such roads themselves, or the proportion of drivers who tend to travel these roads.
- Automobile travel may be increasing as a percentage of overall transportion. Factors that could cause more people to **choose automotive travel** include:
  - The rise of Uber / Lyft, making taxi-like travel much more convenient
  - Little progress in mass transit (trains, subways, streetcars)

The Driving Environment: Traffic Patterns

- Average **vehicular travel speeds** may be higher now than in the past, increasing the frequency of glare encounters. This could be due to several factors:
  - Modern vehicles have better driving dynamics and more safety features, encouraging drivers to feel safe while driving faster.
  - Road improvements over time. This includes both shifts from rural to more urban routes, as well as higher average speeds on any given stretch of road.
  - Lower rates of enforcement of speed limits?

Drivers and Driving Behavior

- As each driver gets older, their eyes become more sensitive to glare. Actually much of this glare is created within the eyes. This is true for everyone, but are there any health- or nutrition-related factors that may be accelerating this in recent years? Yes, per IALVS: **Diabetic Retinopathy** can both reduce nighttime vision, and increase sensitivity to glare.
- The population of drivers may have a **higher average age** than the driving population did years ago. This could be due to demographic shifts as the Baby Boomer generation ages.
  - With better health care systems such as improved diagnosis, treatment, and prevention of diseases, drivers are living to a higher age on average.
- A higher percentage of people may be **out at night**. For example, there may be more evening events or shift-based work that could lead to higher rates of driving in darkness.

Drivers and Driving Behavior

- **Higher average temperatures** may lead more people in temperate zones to prefer cooler night hours to travel.
- **Higher population** overall: an increase in population could lead to a corresponding increase in traffic:
  - USA 1999 population: 272,690,813
  - USA 2025 population: 341,459,109 (25% increase)
- Net migrations into the USA (about 80% of population increase) could lead to more **drivers with less experience** or training.
- Changes in use of **Daylight Savings Time** in recent years may have created a higher fraction of overall automotive travel in darkness.
  - Pre-2007: EDT from April to October
  - Post-2007: EDT from March to November
- More drivers **defaulting** to use Low Beam?

Factors That May Be Reducing Glare Complaints

- Increasing use of **AHB (auto high-beam)** functionality. This reduces the chances that drivers will encounter excessively high glare from High Beams.
  - *Or does it? Aren't attentive drivers better at reacting to oncoming traffic than AHB sensors?*
  - Also, it is possible that there are two offsets that could be at work here:
    - Cars that are easier and more convenient to be driven at night tend to be driven more at night, thus increasing the overall average percentage of total vehicle mileage driven in darkness.
    - People who regularly drive an AHB-equipped vehicle may forget to deactivate High Beam when they get behind the wheel of other cars. [not unlike regenerative braking?]
- Better control of **headlamp beams** via design analysis
  - *Or is this offset by other factors such as IIHS compliance?*
- **ADB (Adaptive Driving Beam)** deployment
  - First allowed in US on 2/22/2022
  - Perhaps 60k total vehicles in USA since early 2024, out of approximately 290M vehicles. ADB is on roughly 0.021% of all vehicles.
- Better **roadway lighting**
  - More miles of lighted roadways?
  - Better LED-based lighting replacing sodium-vapor lamps?

Increasing Glare Exposure

+ Brighter Low Beams
+ Sharper LB cutoff
+ More Low Beam glare
+ Brighter High Beams
+ Older vehicle fleet
+ Supplemental lighting
+ HL mounting height
+ Park lamp intensity
+ Turn signal intensity
+ Windshield wear
+ Headlamp lens wear
+ Aftermarket bulbs
+ Beam color temperature
+ Higher traffic density
+ More straight roads
+ Higher average speeds
+ Driver's eyes getting worse
+ Higher average driver age
+ Daylight savings time
+ More driving at night
+ Improper LB/HB usage
+ Higher headlamp aim sensitivity
+ Worse headlamp aim maintenance

Reducing Glare

– Auto High Beam usage?
– Better beam distributions?
– ADB?
– Better roadway lighting?

Thank You