

Highway Visibility Concerns Related to Artificial Lighting *MoDOT DRAFT*

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MoDOT lighting



Mo Billboard

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Background

Excerpt from HB1402: “226.500. The general assembly finds and declares that outdoor advertising is a legitimate commercial use of private property adjacent to the interstate and primary highway systems and that it is necessary to regulate and control same to promote highway safety, to promote convenience and enjoyment of highway travel, and to preserve the natural scenic beauty of highways and adjacent areas.”

One of the principal responsibilities of a governing agency is to seek the safe use of government provided facilities. In the instance of roadways, the agency seeks to adopt practices that allow a driver to commute with minimal hazard and distraction. To this end, this report will be looking at the effects of artificial lighting on visibility.

Glare

“Visibility is one of the basic needs for safe driving. Any type of reduction in visibility can lead drivers to change driving behavior resulting in changes in flow or speed, disorder on the network as a result of braking or driver error, or in the worst case to an incident or a crash. Glare can be caused by sun, headlights of other vehicles or other light sources can cause substantial reductions in vision performance.”¹

As light enters the eye, the eye must adapt. Visible responses include the constriction and dilation of the pupil as a reflex action. While constriction happens quickly, dilation after a bright light is encountered may take several minutes. Additionally, this response time increases with age². Another important consideration relates to how the lens in the eye develops with age. As we age, the lens grows by adding layers, much like an onion. Small imperfections between these layers results in light becoming increasingly scattered. While a youth may perceive a pinpoint of light, an older adult may see a starburst. Astigmatism, cataracts, and other physiological conditions may further complicate the effects of glare on visibility.

The negative effects of artificial lighting upon safety is one of the drivers behind the American Medical Association’s *REPORT 4 OF THE COUNCIL ON SCIENCE AND PUBLIC HEALTH (A-12) Light Pollution: Adverse Health Effects of Nighttime Lighting*³ and subsequent policy:

H-135.937 Advocating and Support for Light Pollution Control Efforts and Glare Reduction for Both Public Safety and Energy Savings

Our AMA: (1) will advocate that all future outdoor lighting be of energy efficient designs to reduce waste of energy and production of greenhouse gasses that result from this wasted energy use; (2) supports light pollution reduction efforts and

¹ [An Empirical Investigation of the Impacts of Sun-Related Glare on Traffic Flow](#), Paper 08-0773, Benjamin Auffray, Christopher M. Monsere, Robert L. Bertini, Nov 9, 2007

² [Latency of pupillary reflex to light stimulation and its relationship to aging](#), Podolak, Edward; Feinberg, Richard (September 1965), Federal Aviation Agency, Office of Aviation Medicine, Georgetown Clinical Research Institute, p. 12, [OCLC: 84657376](#)

³ [REPORT 4 OF THE COUNCIL ON SCIENCE AND PUBLIC HEALTH \(A-12\) Light Pollution: Adverse Health Effects of Nighttime Lighting](#). American Medical Association, 2012

glare reduction efforts at both the national and state levels; and (3) supports efforts to ensure all future streetlights be of a fully shielded design or similar non-glare design to improve the safety of our roadways for all, but especially vision impaired and older drivers. (Res. 516, A-09).



MoDOT lighting at night during rain

Constraining Glare

All sources of light have the potential to create visibility problems, including those placed intentionally and unintentionally. A security light on private property, a poorly shielded roadway light and a brightly lit sign all have the same effect on the driver. The eye must adapt to the brightest light in the field of view. The return to normal visibility is also dependant upon the background lighting levels. A particular light may have no impact upon the eye within a cityscape that is filled with similar lights, but the same light viewed on a dark highway may result in disability glare the prevents the driver from seeing hazards such as a deer crossing the road for several minutes.

The perceived brightness (or luminance) of a surface is measured with an instrument called a luminance meter. The results are most often measured in *nits* or *candela per square meter* (cd/m^2), which is equivalent. It has the appearance of a specialized camera and operates as such to take a reading upon a limited area.



Konica Minolta LS-100/LS-110⁴. price over \$3,000

Additional measurement of light entering the public right of way, or light leaving the roadway may be determined with a standard lux meter (or light meter). This measures in lux and is a common method for communities to monitor light trespass (inexpensive models are available under \$50).

To summarize, due to the change of lighting conditions throughout a twenty-four hour period, it would be appropriate to establish maximum luminance during the day, and nighttime for rural and urban settings. Light trespass standards may also be established for light entering and leaving the roadway.

What is Being Regulated?

Browsing through Jerry Wachtel's report⁵, we find a variety of unique aspects related to electronic billboards that are being regulated. These include:

- Minimum Message Display Duration (Message On-Time)
- Interval Between Successive Displays
- Visual Effects Between Successive Displays (Special Transitional Effects)
- Message Sequencing (Like old "Burma Shave" signs)
- Amount of Information Displayed (number of words, phone numbers, websites)
- Information Presentation
- Digital Billboard Size
- Brightness, Luminance and Illuminance
- Display Luminance in the Event of Failure
- Longitudinal Spacing Between Digital Billboards
- Digital Billboard Placement with Relation to Traffic Control Devices and Driver Decision and Action Points
- Annual Operating Permits

I recommend reading the report to gain a complete understanding of these concerns.

Additional items that may be of concern include:

- Run Time – Time of night when no message should be illuminated or displayed. For both digital and standard billboards
- Scenic Byways, conservation area, Location

⁴ [Sample luminance meter](#)

⁵ [Safety Impacts of the Emerging Digital Display Technology for Outdoor Advertising Signs](#), Final Report, NCHRP Project 2007, Jerry Wachtel, CPE, April 2009, Pg 145

- Requirement to join National Emergency Alert System
- Indemnify State against accident + health issues. Rising concerns of health issues related to exposure to Light at Night.
- Light Trespass (1-3 Lux – recommendation by Outdoor Advertising Association of America, Ian Lewis Study)

Research Related to Sign Luminance

[Digital LED Billboard Luminance Recommendations: How Bright Is Bright Enough?](#), Christian Luginbuhl, November 2010

[Safety Impacts of the Emerging Digital Display Technology for Outdoor Advertising Signs](#), Final Report, NCHRP Project 2007, Jerry Wachtel, CPE, April 2009

FHWA: [Research Review of Potential Safety Effects of Electronic Billboards on Driver Attention and Distraction](#), September 11, 2001

FHWA: [The Effects of Commercial Electronic Variable Message Signs \(CEVMS\) on Driver Attention and Distraction: An Update](#), FHWA-HRT-09-018, February 2009

FHWA: [Outdoor Advertising Control Practices in Australia, Europe and Japan](#), May 2011

OAAA: [Digital Billboard Recommendations and Comparisons to Conventional Billboards](#), Ian Lewin, Lighting Sciences, Inc. Prepared for Outdoor Advertising Association of America under contract

Examples of Existing Regulation

Maryland Report. [A Critical, Comprehensive Review of Two Studies Recently Released by the Outdoor Advertising Association of America](#). Jerry Wachtel, October 2007

Banned⁶:

Alaska, Vermont, Maine, Hawaii, Montana
 San Francisco, CA; Denver, CO; Gilbert, AZ; Pima County, AZ; Amarillo, TX; Fort Worth, TX; Dallas, TX; Austin, TX; Galveston, TX; Houston, TX; St. Petersburg, FL; Knoxville, TN; Durham, NC; St. Petersburg, FL; Largo, FL

Moratorium:

Los Angeles, CA; El Paso, TX; San Antonio, TX; Minnetonka, MN; Oakdale, MN; St. Louis, MO, Pinellas, FL;

⁶ [More cities ban digital billboards](#), USA TODAY, 3/24/2010

Missouri⁷ Ban – St. Louis, Kansas City, Columbia, Jefferson City, Lake of the Ozarks, Lake St. Louis and Eureka

Considering Bans:

Minnesota, Michigan
Atlanta, GA

Regulated:

[Arizona](#), HB0326: From sunset until 11:00 P.M., the dimmer for electronic outdoor advertising signs, displays and devices shall not be set to exceed three hundred forty-two (342) nits in full white mode for signs that are smaller than six hundred seventy-two (672) square feet in area and three hundred (300) nits in full white mode for signs that are equal to or larger than six hundred seventy-two (672) square feet in area.

[Arkansas](#): Various, timing – 8 seconds, no glare allowed section: 7.7

[Alabama](#): 450-10-1-.13. Various, timing – 8 seconds, no glare

Alaska: Ban on billboards 1959

[California](#): ODA 2011, No glare allowed 5408.1

[Colorado](#): 2 CCR 601-3, No glare

[Connecticut](#): minimal

[Delaware](#): No Glare, 10 second fixed message

[Florida](#): minimal

[Georgia](#): minimal

[Hawaii](#): ban 1981

[Idaho](#): prohibited along scenic highways, 8 seconds

[Illinois](#): 10 seconds, no glare section 522.150

[Indiana](#): 8 seconds, no glare

[Iowa](#): may not impair vision, 8 seconds

[Kansas](#): glare, 8 seconds

[Kentucky](#): glare, 2 seconds

[Louisiana](#): glare

Maine: Ban 1979

[Maryland](#): glare

[Massachusetts](#): Sign brightness, lighting, glare, draft regulations

[Michigan](#): moratorium

[Minnesota](#): 5-6 seconds, glare

[Mississippi](#): glare, 10 seconds dwell

[Missouri](#): pending, glare, 8 seconds “signs which are not effectively shielded so as to prevent beams or rays of light from being directed to any portion of the traveled way of an interstate or primary highway or which are of an intensity or brilliance as to cause glare or to impair the vision of the driver of any motor vehicle, or which otherwise interfere with any driver’s operation of a motor vehicle are prohibited”

[Montana](#): [ban 2008](#) in controlled areas, glare

[Nebraska](#): glare, 10 seconds

[Nevada](#): 6 seconds, glare

[New Hampshire](#): glare

⁷ [Missouri Billboard Initiative Aims to Reduce Advertising Costs](#), Yahoo, April 2012

[New Jersey](#): 4, 8 seconds, glare

[New Mexico](#): glare

[New York](#): 6 seconds

[North Carolina](#): glare, 8 seconds

[North Dakota](#): minimal

[Ohio](#): minimal

[Oklahoma](#): minimal

[Oregon](#): 8 seconds, glare “(v) [No electronic sign](#) lamp may be illuminated to a degree of brightness that is greater than necessary for adequate visibility. In no case may the brightness exceed 8,000 nits or equivalent candelas during daylight hours, or 1,000 nits or equivalent candelas between dusk and dawn. Signs found to be too bright shall be adjusted as directed by the department.”

[Pennsylvania](#): glare,

[Rhode Island](#): glare, 10 seconds

[South Carolina](#): glare

[South Dakota](#): glare, 6 seconds

[Tennessee](#): glare

[Texas](#): 8 seconds, glare

[Utah](#): minimal, glare

Vermont: Ban 1968

[Virginia](#): glare

[Washington](#): glare, 8 seconds, 8,000nits daytime, 1,000 nits night “No electronic sign lamp may be illuminated to a degree of brightness that is greater than necessary for adequate visibility. In no case may the brightness exceed 8,000 nits or equivalent candelas during daylight hours, or 1,000 nits or equivalent candelas between dusk and dawn. Signs found to be too bright shall be adjusted as directed by the department.”

[West Virginia](#): glare

[Wisconsin](#): glare, 6 seconds

[Wyoming](#): minimal

[LaCrosse, WI](#): “No electronic message unit shall be illuminated to a degree of brightness greater than necessary for adequate visibility or a maximum of 500 nits (candelas per square meter) between dusk and dawn, 5,000 nits during daylight hours, or the minimum standards set by the Federal Highway Administration, whichever is more restrictive. All electronic message units shall come equipped with automatic dimming technology that automatically adjusts the sign’s brightness in direct correlation with ambient light conditions. Signs found to be too bright will be adjusted to meet these standards after notification by the County.”

[Pittsburg, PA](#): “Brightness - During daylight hours between sunrise and sunset, luminance shall be no greater than forty-five hundred (4,500) nits. At all other times, luminance shall be no greater than three hundred fifty (350) nits. “

[Tulsa, OK](#): “No such digital sign shall display an illuminative brightness exceeding five hundred (500) NITs at any time between one-half (1/2) hour after sunset until one-half (1/2) hour before sunrise or six thousand five hundred (6,500) NITs between one-half (1/2) hour before sunrise until one-half (1/2) hour after

sunset.”

[Kerney, NE](#): “The surface/face illumination of any sign shall not exceed one thousand two hundred fifty (1,250) Nits after dusk or seven thousand five hundred (7,500) Nits during daylight hours. Such illuminated sign shall be equipped with a sensor and/or timer or other device to automatically adjust the day/night light intensity levels in accordance with the standard set herein.”

[Waukesha, WI](#): “(15) READER BOARDS. Reader board signs are permitted on properties zoned B-3, B-5, M-1, M-2 and M-3. The message area of reader board signs shall not exceed 25% of the sign’s total sign area. Reader board signs may change messages not more than once every 10 minutes and the change must be made in ½ second or less and not flash, scroll, alternate, move or show video. Message brightness cannot exceed 500 nits at night and 3000 nits during the day.”

[Kansas City, MO](#): “Electronic and digital signs must use automatic level controls to reduce light levels at night and under cloudy and other darkened conditions, in accordance with the standards set forth in this sub-section. All electronic and digital signs must have installed ambient light monitors, and must at all times allow such monitors to automatically adjust the brightness level of the electronic sign based on ambient light conditions. Maximum brightness levels for electronic and digital signs may not exceed 5000 nits when measured from the signs face at its maximum brightness, during daylight hours, and 500 nits when measured from the signs face at its maximum brightness between sunset and sunrise, as those times are determined by the National Weather Service.”

[Greensboro, NC](#): “Electronic message boards may not exceed a maximum illumination of 5,000 nits (candelas per square meter) during daylight hours or more than 500 nits during nighttime hours (between dusk and dawn), as measured from the sign’s face at maximum brightness. Electronic message boards must be equipped with automatic dimming technology that automatically adjusts the display’s brightness based on ambient light conditions.”

[Oakdale, MN](#): “Signs shall not exceed 4,500 Nits between the hours of civil sunrise and civil sunset and shall not exceed 500 Nits between the hours of civil sunset and civil sunrise, as measured from the sign face.
Signs adjacent to residential properties shall be shut off from 10 pm to 6 am or have a maximum of 250 Nits from civil sunset to civil sunrise.”

Observed and Recommended Levels of Brightness⁸		
Information Source	Product Type	Luminance (surface brightness)

⁸ Tacoma, WA [Billboard Regulation Packet](#), April 2011

(C. Luginbuhl study)	Typical Ambient Roadway Illumination	1 Nit
(C. Luginbuhl study)	Typical Floodlit Billboard	Approximately 100 Nits
Digital Billboards: New Regulations for New Technology by Drew Carhart	Traditionally lit static billboards	98% were under 150 Nits, 83% were under 100 Nits (Arizona Study); 124 Nits Average (New York Study)
IESNA recommendations	Recommendations for Digital Billboard Luminance	250 Nits (day), 125 Nits (night)
Outdoor Advertising Association of America (Ian Lewis Study)	Recommendations for Digital Billboard Luminance	300-350 Nits Suggested (study based on Light Trespass readings or .3Fc, 3 Lux)
Hewlett-Packard (Specs)	47" LCD Digital Signage Display	500 Nits
Corn Digital (Specs)	32" & 42" LCD Posters	500 Nits (32") 700 Nits (42")
Carhart Study	Daytime sky (sunny)	5,000-7,000 Nits
Virginia Tech Transportation Inst.	The Sun	6,500 Nits
Senzen Top Technology Co., Ltd (Specs)	Series PH12 (14'x48' full-color LED billboard)	8,000+ Nits
EraLED (Specs)	Series P20 full-color LED billboard (assorted sizes)	8,500 Nits
ProVIDEO Billboard Panels (Specs)	Series 1515-4, 14'x48' full-color LED billboard	11,000+ Nits
Optec Displays (Specs)	Model 1248, 14'x48' full-color LED billboard	11,000+ Nits
Optec Displays (Specs)	Model 2040, 14'x48' full-color LED billboard	11,000+ Nits

Summary of Current Regulations		
Daytime Limits	4,500 – 8,000 Nits	
Nighttime Limits (city)	250-1,000 Nits	
Nighttime Limits (rural)	250-1,000 Nits	
Duration	4-10 seconds	
Light Trespass (rural)	Varies by zone, 1-3 Lux above ambient	IESNA LZ E1-E2
Off-hours	10pm-6am	Oakdale, MN

My Recommendations

The topic of limiting brightness and other regulations is hotly debated at every turn. Any regulating group should make the effort to physically view any levels upon actual billboards. A billboard whose messages cannot be viewed will have problems maintaining business. Likewise, when the billboard becomes too bright compared to the surrounding ambient light, a visibility impairment will occur. As such, I am recommending very low levels, but would leave open an avenue for revisiting these levels should actual implementation result in unreadable messages. I am also suggesting a standard test message such as “Can you read this?” displayed in white letters upon on a black background, with a properly calibrated luminance meter. Many messages displayed on digital billboards suffer from poor contrast, and information overload. A driver must stare for several seconds in order to comprehend what is being presented. It is not the regulating agency’s responsibility to ensure digital messages are properly designed.

While seldom mentioned, off-hours present the driver with the lowest level of visibility distraction and allow enhanced concentration on the road⁹. As the eye is repeatedly exposed to bright lights, then dark roads, eye strain and eventual fatigue occurs. Drivers on highways late at night may be exposed to hundreds of bright and dark cycles. Providing off-hours will reduce this fatigue caused by both digital and standard billboards.

Light Trespass is a standard for measuring how much light falls upon the driver’s eye. Light is affected by distance; a dimmer source located near a highway may result in more light trespass than a bright source located further away. Light Trespass should be used to determine problematic billboards or other stationary, near-road light sources. It should not be a replacement for brightness standards, but a supplement to them.

Summary of Recommendations		
Daytime Limits	4,500 Nits	
Nighttime Limits (city)	250 Nits	Large cities only, in brightly light areas
Nighttime Limits (rural)	125 Nits	Carhart – no reason to be brighter than standard billboards
Duration	Once message during passing duration	
Light Trespass (city)	3 Lux	
Light Trespass (rural)	1 Lux	
Off-hours	10pm-4am	
Transitional Effects	Prohibited	
Message Sequencing	Prohibited	

⁹ NHTSA, [Drowsy Driving And Automobile Crashes](#).

Alert System	Billboards shall be subscribed to National Emergency Alert System (EAS) and carry any alerts immediately.	
Placement	Away from traffic control signs, decision and action points	
Display luminance in the event of a failure	In the event of any failure or combination of failures, the display will default to an acceptable maximum under normal operation or “off” until the problem can be resolved.	Wachtel recommendation
Illumination when not being leased	Non-digital – no lighting Digital – same as above	



My Background

BS. Engineering Management with a preference in Electrical Engineering from the University of Missouri – Rolla. 1991

International Dark-Sky Association, member, Board Member 2009-2012, Board President 2010

Scouting, 35-year Veteran

Advocate for low-glare, low-light pollution lighting.