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Needed: Light Control Specifications for Automotive Displays

Since the early days of motorized vehicles, illuminated dashboard displays have improved safety and driver convenience. Over time, these displays have grown in number, size and brightness; in response, dashboards evolved “brows” that shielded windshields from light and protected drivers from distracting and unsafe nighttime reflections.

Today, that configuration is changing. Designers are introducing brow-less dashboards at the same time that displays are becoming larger and brighter. This makes reflection management more challenging and more important.

Brighter displays and brow-less dashboards make reflection management more challenging and more important.

Multiple technical solutions are available to balance brightness and windshield reflectivity. In fact, suppliers have the tools to create a wide array of displays designs—from high brightness/high reflection to low brightness/low reflection—depending on each automaker’s preferences. However, such an individualized approach, with each automaker deciding on the balance between brightness and reflectivity, also creates several problems.

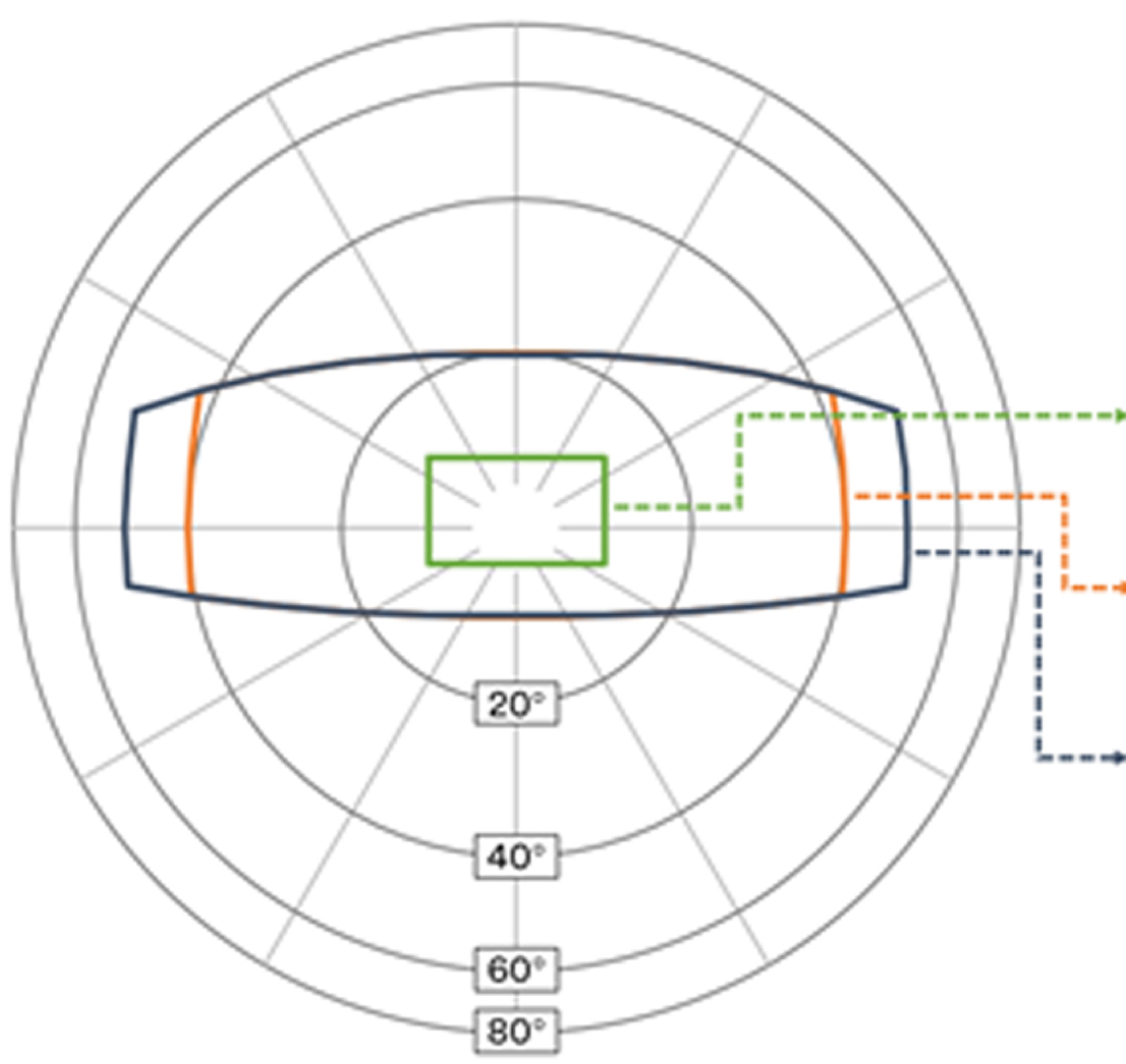
- The decision-making will not necessarily take into account driver safety; in the absence of clear safety standards, aesthetic or economic considerations could have a disproportionate influence.
- The greater the customization for each auto maker, the higher the cost to the display manufacturer and, ultimately, the consumer.
- Automotive displays have a relatively long supply chain; when a prototype cockpit fails to achieve the intended mix of brightness and reflection management, correcting the failure can be exceedingly expensive and time-consuming.

Ideally, the auto industry—after appropriate research—should create industry-wide specifications that define an ideal balance of brightness and reflectivity. The creation of such standards would ensure a focus on safety, help control costs and minimize the likelihood of significant changes late in the design cycle.

Past success

Automotive display specifications have been developed to good effect in the past. For example, in 2000, the Deutsches Flachdisplay Forum e.V. (DFF) Automotive OEM Working Group promulgated a set of display specifications in response to the introduction of “louvered” films to control display brightness and reflectivity. (Originally developed as computer privacy films, louvered films use microreplicated slats or louvers to direct light.)

A key section of the DFF specifications defined minimum luminance (cd/m2) requirements within three viewing zones. (The A+ zone is a narrow center zone where the driver is the primary viewer; the wider A and B zones address center information displays where the passenger and driver are both viewers.) This specification became an industry benchmark for displays with and without louver films.



Zone	Viewing Angle Range (H,V) [deg]	EU 5.0 Spec [cd/m²]
A+	(-10,8) (10,8) (10,-4) (-10,-4)	> 800
A	(-40,20) (40,20) (40,-10) (-40,-10)	> 450
B	(-50,20) (50,20) (50,-10) (-50,-10)	> 300

Standards defined by the Deutsches Flachdisplay Forum have captured the best thinking about brightness in defined viewing zones, thereby clarifying OEM expectations for display manufacturers.

Setting standards, as the DFF has done with luminance in the prescribed zones, ensures that films and displays reliably meet the demands of OEMs and their customers. Additionally, the Japan Automobile Manufacturers Association (JAMA) Guideline for In-vehicle Display Systems -Version 3.0 [2] is helping to refine the requirements for display component suppliers and OEMs.

While the DFF display specification has been valuable in guiding the development of display outputs, it lacks definition in a key area: it does not define the zones most likely to create windshield reflection and does not specify a maximum amount of luminance allowed in those zones. Because of this, light control film developers have been left to guess at how much luminance outside the defined zones (also called leaked light) was acceptable.

This has led to a divergence among film suppliers. Some suppliers (including 3M) have focused on minimizing light leak at high vertical angles (e.g., beyond 35 degrees) while others focused more on maximizing on axis or DFF zone brightness (with an increased likelihood of light leak). Nothing in currently available DFF specifications recommends one of these approaches over the other.

Two key metrics

To write a broad industry specification for leaked light, two sets of information are needed. First, we need an understanding of what light output angles cause windshield reflections for the driver; obviously, this will depend in part on the angle of the windshield and will therefore vary from vehicle to vehicle. Second, we need to know what relative luminance at those angles prevents visible display reflections.

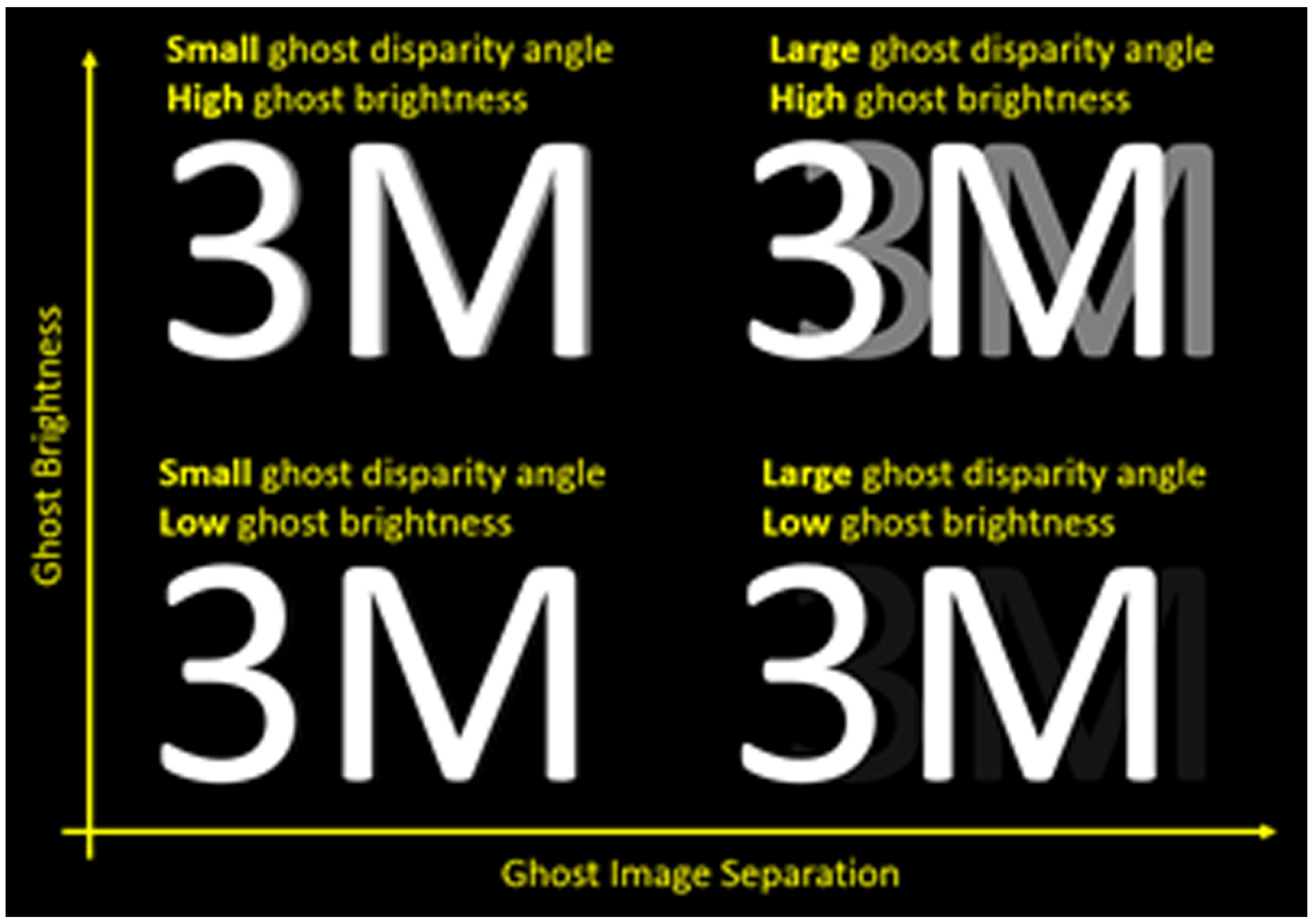
Once that information has been gathered, two preliminary angle-specification metrics could be promulgated:

- First, a metric should be recommended that would describe how quickly the display cuts off and how high the relative luminance is for the border (worst case). This could specify that the luminance at 35 degrees be no higher than a certain percent of the peak luminance of the display. Current louver film technology generally falls in the range of 2% to 7% relative luminance at 35 degrees. (The specification at 35 degrees is especially important for louvers that are tilted to raise the viewing profile. The louver tilt pushes out the cutoff region and if pushed out too far, relative luminance at 35 degrees could spike and reflections would become visible on low-angle windshields.)

- The second specification should establish the average luminance from 35 to 80 degrees relative to the peak luminance. Current louver film technology generally falls in the range of 1% to 5% relative luminance averaged from 35-80 degrees from normal in the direction orthogonal to the louvers.

Emerging technology increases the need for specifications

The need for an industry-wide “leaked light” standard will likely increase in the near future. New emissive display technologies (such as μ-LED and OLED) offer high contrast, rich color and the ability to create a curved display. However, unlike LCDs where the louver can reside in the backlight, these emissive displays require that the louver film be applied directly on the front of the panel. With this placement, light from a subpixel can reflect off the louver side wall and create the appearance of a secondary “ghost” subpixel. This artifact is especially visible for white lettering on a black background, in which case a second ghost letter will appear next to the real letter. This is an obvious distraction and a potential safety issue.



Ghost images are an obvious distraction and a potential safety issue.

The issue of ghost images can be resolved by designing louvers with an appropriate mix of materials and louver wall shape and reflectivity. These designs can provide clear, readable images without compromising brightness or light leak at low viewing angles; at higher angles, however, the elimination of ghost images can require a compromise in either brightness or light leak. To achieve low ghosting at these angles or beyond, the louver design will need to allow a higher brightness real image (thereby reducing the appearance of the ghost image); this, however, can compromise performance of the primary function of the film, which is to limit high-angle light leak.

Designers will need to balance all three elements of an attractive and functional vehicle display: brightness, light leak (nighttime windshield reflections) and image ghosting at high viewing angles. In theory, the interplay of these elements presents the possibility of a wide array of designs; in practice, too much emphasis on any one element could undercut the functionality of the display. Achieving this balance to ensure driver safety and an acceptable cost environment for automakers will be greatly facilitated by the introduction of industry-wide specifications.

For additional information, please see: Philippi, Matt (2019) Driving Toward Performance Standards in Light Control for Automotive Displays, Society for Information Display 2019 Digest of Technical Papers.