Active & Passive Safety Technology

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Docket Management Facility
M-30, U.S Department of Transportation
1200 New Jersey Avenue SE
West Building, Ground Floor, Room W12-140
Washington, DC 20590

Attention: The Honorable Tim J. Johnson
Acting Associate Administrator for Vehicle Safety Research
National Highway Traffic Safety Administration

RE: Docket No. NHTSA-2019-0082

Dear Mr. Johnson;

ZF North America (ZF) appreciates the opportunity to provide its perspective in response to NHTSA's Request for Comments (RFC) concerning the design of a study to evaluate drivers' use of camera-based rear visibility systems versus traditional mirrors.

ZF North America is headquartered in Livonia, Michigan, and is a primary developer and producer of active and passive safety systems, serving all major vehicle manufacturers. We proudly manufacture cameras in Marshall, Illinois, and other technology across the United States.

Increasingly connected mobility provides ample opportunity for the introduction of new technologies designed to enhance safety, user convenience, and the driving experience. ZF is encouraged by this review of camera technology and its potential to replace standard mirrors, which will help instruct future regulations and potential implementation. ZF's comments focus primarily on technological and user experience design considerations, which could have a direct impact on the quality of the information gleaned from this study. These responses can best be categorized as addressing initiative (iii) of this RFC, "how to enhance the quality, utility, and clarity of the information to be collected."

Highlights of ZF's Comments:

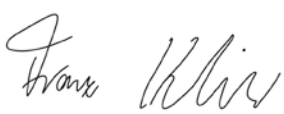
- NHTSA should consider design elements that accommodate far sighted individuals, including the elderly, to reduce the risk that these individuals have an adverse user experience in transitioning from mirrors to camera displays. In meeting with that consideration, we recommend the study include participants who require corrective lenses but do not typically wear them for driving.

- It is recommended that the camera and monitor are placed at roughly the same height on the vehicle, in order to avoid driver disorientation arising from an image that is unaligned with the display screen.
- Embedded image processing functions can add significant benefit to mirror replacement systems. These functions can provide enhanced utility over mirror-only systems, including greater visibility in scenarios with poor lighting or sub-optimal weather. Additionally, technology to avoid distortions including rain that could deteriorate field of view could be considered for inclusion in this study.
- Video processing for side cameras must provide undetectable latency in order to provide real-time imaging, avoid driver disorientation, and maximize safety.
- It is recommended that NHTSA consider combining multiple camera feeds on a single monitor, including consideration of replacement of rear center mirrors, and that several blind spot alert alternatives be tested for optimal user experience as part of this study.
- It is recommended that users be enabled a level of control over the cameras, including an ability to adjust images to match their preferences through features such as camera panning and zoom.
- Responses are also provided to questions previously posed under a 2018 NHTSA study related to camera monitoring system design.

ZF's full comments are provided on the following pages.

Again, ZF appreciates the opportunity to comment on this important matter and looks forward to further engagement with NHTSA regarding potential future implementation t of cameras in place of outside rearview mirrors. We stand ready to provide further clarification or information regarding the following response, as needed.

Best regards,



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ZF Response to Request for Comment – NHTSA FMVSS 111

ZF is pleased to offer its perspective on NHTSA's planned study of camera monitoring system (CMS) technology, with a specific focus on design elements which we believe will have a significant impact on user experience and study response, and therefore future FVMSS 111 standards.

Vehicle Design for Far Sighted Individuals:

ZF suggests that special consideration should be given to the impact that displays could have on specific segments of the population. In-vehicle displays project light from an approximate one meter distance from the eyes, which could result in disorientation or blurred vision for far sighted individuals that do not wear near focus corrective lenses while driving, specifically in the older population. It is recommended that the study include candidates who require reading glasses but do not typically wear them while driving in order to analyze this effect.

Field of View and Resolution:

FMVSS 111 requires driver side mirror unit magnification (Standard No. 111; S5.2). However, since the driver can no longer move his/her head to change the field of view with a CMS, it is recommended that a demagnification factor is used (this would also comport with ISO 16505 and ECE Reg UN No. 46, which require that the minimum visual acuity of the system must meet that of a traditional mirror).

The viewing distance coupled with display pixel size and screen resolution will have a direct impact on the perceived resolution of the image. Since the camera image sensor and optics will drive the best-attainable resolution offered by the CMS and the degree to which it can replicate the visual acuity provided to drivers using glass mirrors, a minimum resolution for these cameras of 1.7 megapixels (MP) is recommended, with a preference of greater than 2MP.

Camera Locations and Mounting:

When positioning the cameras on the exterior of the vehicle, it is helpful to have the horizontal field of view intersect the side of the vehicle. This gives the driver a visual reference of where the vehicle is in space which helps to alleviate disorientation caused by the display.

Additional items to consider are the camera and display heights. If the vertical distance between the display and the camera is too great, the driver may be disoriented because the output on the display is not showing the expected view. One such example is when the camera is placed very low on the vehicle, the driver will see the grill of a rearward approaching vehicle at eye level. Considering this, it is recommended that the camera and display are placed at the same approximate height.

Video Processing:

It is noted that embedded image processing functions can add significant value to mirror replacement systems, including high dynamic range capability for enhanced visibility in bright daylight, nighttime/tunnel or in-rain operation and white balance/color correction to enhance contrast of items in the scene.

Despite those benefits, additional considerations may help avoid a potential adverse user experience associated with CMS. It is recommended that the CMS used in the study include some form of LED flicker mitigation to avoid the operator experiencing a stroboscopic effect from oncoming vehicle headlights or from certain self-illuminated signs in the scene. Additionally, there must be no perceived delays between "live" and "displayed" images.

Additional User Experience Display Considerations:

ZF recommends consideration of the following design elements, which could further enhance the user experience:

- Merging multiple camera outputs onto one display and including Class 1 (rear center) mirror replacement in this study.
- Maintaining pan and zoom functions in the CMS.
- Test different types of blind spot overlays to solicit driver feedback and determine the most beneficial, least intrusive alternative. Options might include different colored outlines around the entire display (i.e. yellow=caution, red=do not merge), a bounding box around approaching vehicles, or a LED indicator similar to what is currently used in mirror systems.
- It is recommended that the displays have a shroud shade to protect against reflections from the sunlight.

Interaction with International Design Standards:

It would be helpful to understand how the elements of this study will interact with international design standards. The study does not address many technical implementation areas that are detailed by ISO 16505 and UN ECE 46. If ISO/UN ECE standards are not followed within the confines of this study, it could result in adverse user experiences which could impact the results of this study and a lack of global alignment of standards.

For example, the ISO/UN ECE standards place an emphasis on display resolution and viewing distance as they impact reproduction of visual acuity. At the same time, FMVSS 111 requires a 1:1 magnification for class III and class I mirrors. If a choice is made between following existing FMVSS 111 and international standards, and if consequently the results of the study show a poor user experience, an analysis of the decision between FMVSS and ISO/UN ECE standards and its impact on results should be conducted.

DOT HS 812 582 Response

In 2018, NHTSA completed a study titled, "DOT HS 812 582: Examination of a Prototype Camera Monitor System for Light Vehicle Outside Mirror Replacement." In the executive summary there is a list of questions related to CMS design. These questions and ZF responses are listed below.

<u>Two questions related to display brightness:</u>

1. Can night mode be improved to have lower display luminance?
2. Will display brightness annoy and/or compromise forward vision?

The display brightness can be tuned based on the output from the vehicle ambient light sensor. Additionally, the driver could have manual control of the display brightness by rotating the illumination control knob that is currently used to adjust the brightness of the instrument panel.

The use of Organic Light Emitting Diode (OLED) displays will also reduce the overall brightness of the display vs an LED display. LED screens use a backlight to illuminate their pixels, while OLED's pixels produce their own light. The light of an OLED display can be controlled on a pixel-by-pixel basis, rather than having the entire display backlit.

<u>A question related to water-related distortions:</u>

Can image obscuration from water droplets be remedied?

For a passive solution, hydrophobic coatings on the lens will help mitigate this issue. An active solution would incorporate a heater and cleaner system that uses a combination of washer fluid, compressed air, and heating elements to clean and defrost the camera. If only water droplets are present on the lens, air can be used to clean debris from the camera independent of the heater and washer fluid. Either lens occlusion detection algorithms or manual control can be used to blow air across the lens.

<u>A question related to the "blooming" effect:</u>

Can following vehicle headlight blooming be reduced?

Image processing that "compress" bright areas and lens designs that minimize "flare" may offer improvements to the displayed image from trailing headlights, reducing blooming effects.

<u>Three questions related to display location:</u>

1. Is there an optimal downward viewing angle for such displays that maximize drivers' comfort and situational awareness?
2. Will drivers acclimate easily to electronic displays for side visibility?
3. Will display location (inside the vehicle) and visual angle difference from traditional mirror location bother drivers enough to impact safety?

It is likely that CMS monitors will result in different sightline angles for drivers, and NHTSA's study should consider those alternative angles and resultant impacts on driver comfort and situational awareness. Generally, the system setup proposed in NHTSA-2019-0082-0001 includes a driver monitoring camera. It is recommended that the driver monitor camera is used to characterize typical actions and duration of these actions throughout a lane change maneuver. This data can be used to answer the questions related to display placement. The pipelines in Appendix A suggest how to characterize the data.

On a related topic for question 1, some vehicles have a side mirror "tilt down" function when reversing, to enable drivers to see a curb or other low obstacles. We recommend this function be mimicked in the CMS used in this study.

Appendix A

1. **Current Lane Change Pipeline:** Lane Change Maneuver using traditional mirrors
2. **CMS Lane Change "Acclimation" Pipeline – Simple Mirror Replacement:** Driver naïve to CMS performing a lane change using three separate displays in place of mirrors.
3. **CMS Lane Change Pipeline – Simple Mirror Replacement:** Driver experienced with CMS performing a lane change using three separate displays in place of mirrors.
4. **CMS Lane Change Pipeline – Merged views into one display:** Driver experienced with CMS performing a lane change using three views merged into one display in place of mirrors. This will likely not be available for the drive in NHTSA-2019-0082-0001 but is a forward-looking view of where the technology could go.