ZF North America, Inc.
12001 Tech Center Drive | Livonia | MI 48150

ZF North America, Inc.

From	Sarah A. Kirkwood
Phone	+1 734.855.3539
Email	sarah.kirkwood@zf.com
Date	December 6, 2019

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 James C. Owens
Acting Administrator
National Highway Traffic Safety Administration

RE: Docket No. NHTSA-2018-0021

Dear Administrator Owens:

ZF North America (ZF) appreciates the opportunity to provide its perspective in response to NHTSA's Advanced Notice of Proposed Rulemaking (ANPRM) regarding the possible amendment of FMVSS 111 to enable the use of camera monitor systems (CMS) as an alternative to inside and outside rearview 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 used for forward object recognition (supporting functions such as automatic emergency braking and lane keep assist) in Marshall, Illinois, and other technology across the United States.

Increasingly connected mobility will continue to facilitate the introduction of new technologies that can enhance safety, user convenience, and the driving experience. ZF believes that CMS technology is one such use case, and is pleased to provide feedback in response to questions raised in this ANPRM. The feedback below focuses primarily on the insights and observations of ZF experts developing CMS-related technologies, and endorses the pursuit of additional information regarding CMS design and user experience optimization that we hope will serve useful in NHTSA's rulemaking process.

Highlights of ZF's Comments:

- ZF has not conducted independent research on many of the topics raised in this ANPRM.
- However, we are strongly supportive of a thorough review of available research, and of the funding of additional research to answer questions NHTSA has raised that are not adequately answered.
- CMS technologies may to continue to improve the user experience as technology advances, but that progress should not come at the expense of existing safety-beneficial features of mirrors.
- Features to consider in assessing equivalent safety should include camera and display resolution, field of view, and update rate, among others, as well as the human experience related to these attributes.
- ISO 20653 IP6K9K is recommended as the standard of protection for CMS weatherproofing to prevent condensation.
- A lens heater and cleaner subsystem could be a requirement for CMS deployment, with SAEJ942 and SAEJ2111 standards as useful guidelines.
- We suggest that CMS be activated upon vehicle unlock or front door opening, and remain active at the end of a journey until after ignition is turned off and until the drivers' side door is opened.

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

Again, ZF appreciates this opportunity to provide our perspective to NHTSA regarding future deployment of CMS. We stand ready to provide further clarification or information regarding the following response, as needed.

Best regards,

Sarah Kirkwood
Senior Vice President
Head of Legal NA and Secretary,
ZF North America, Inc.

ZF Response to ANPRM – NHTSA FMVSS 111

ZF is pleased to offer its perspective on NHTSA's ANPRM on CMS technology, which we believe can offer enhanced features without adversely impacting safety. Our complete responses to NHTSA's questions can be found below.

Existing Industry Standards

1) Please provide research data concerning the safety impacts of replacing rearview mirrors with CMS. Please explain your view of the significance of those data. In addition, please explain your views on how CMS-equipped vehicles would impact light and heavy vehicle driver behavior and situational awareness while driving.

ZF has not performed independent research on this topic. We recommend that available research be reviewed, and that studies be funded to conduct needed research if the available research is found to be insufficient for purposes of this rulemaking.

2) Are the physical properties of mirrors necessary to meet the stated purpose of FMVSS No. 111 to provide a "clear and reasonably unobstructed view?" As an example, because each eye of a driver viewing objects reflected in a mirror has a slightly different angle of view of those objects, just as the eyes of a driver viewing those objects directly would have, mirrors provide depth perception similar to that provided by direct vision. As another example, mirrors offer drivers the possibility to modify their field of view rapidly by looking at the mirror from different angles. To what extent could possible CMS features which cannot be provided using mirrors (e.g., zoom, night vision) offset the loss of these mirror-specific properties?

ZF has not performed independent research on this topic. We recommend that available research be reviewed, and that studies be funded to conduct needed research if the available research is found to be insufficient for purposes of this rulemaking. However, the ability to expand display field of view (FOV) might offer useful and unique capacity as compared to mirrors.

3) We seek comment on the performance of current world-market vehicles equipped with CMS when evaluated according to the ISO 16505/UNECE R46 standards. In particular, we seek comment on the performance requirements in these standards, and the on-road performance of CMS that meet these standards.
    a. Please identify any performance requirements for CMS that you believe are not stringent enough, are too stringent, or are unnecessary, and explain the basis for your beliefs.

ZF believes that an assessment is needed to compare safety benefits yielded by current glass mirrors to the capabilities of CMS products. It seems CMS technologies might be able to continue to improve the user experience as technology advances, but that progress should not come at the expense of existing

safety-beneficial features of mirrors. We recommend review of existing research on this topic, and if that is found to be insufficient, we suggest studies be funded to conduct that research.

b. Please identify any requirements that you believe should be added and explain the basis for your beliefs.

We recommend that a requirement be added to enable electronic pan and tilt as these are functions currently (mechanically) enabled by the glass side mirrors. We also suggest requiring functionality to expand FOV (zoom function not to limit FOV beyond that of existing mirrors) in CMS systems, a benefit not made possible with the use of mirrors.

c. Which CMS have performed relatively well, and which have performed relatively poorly, on the road? What explains the difference in performance?

Differentiating factors in how current CMS technologies perform include excessive image processing prior to display (sharpness and contrast enhancement, temporal filtering) that can distract the vehicle operator.

<u>System Field of View and Related Test Procedures:</u>

4) We seek comment on whether and, if so, why minimum field of view requirements for CMS should differ from the current minimum field of view requirements for mirrors under FMVSS No. 111. Petitioners have stated that providing drivers with expanded views, larger than those required by FMVSS No. 111, would be advantageous. What data exist to support this assertion? What, if any, potential advantages and disadvantages, such as increased eye glance durations, may be observed for wide-view images? Please provide research or data that addresses how wider views will affect image quality.

ZF has not independently researched human interaction with CMS with regard to FOV. We recommend ensuring that FOV is not limited below the current minimum, but that expansion of FOV be enabled based on driver preference, assuming driver vision of minimum FOV remains clearly perceptible.

5) We seek comment on whether NHTSA should permit CMSs that use multiple cameras to provide multiple fields of view to the driver in the same image display area. In particular, we seek comment on the safety benefits/disbenefits of permitting multiple fields of view. As an example, CMS that operate using multiple fields of view might have missing sections on the processed image, or image latency issues stemming from increased processing time. What are the concerns, if any, regarding a multi-camera visibility system and how can they be mitigated?

ZF agrees that review of this capability, including benefits and pitfalls to avoid, should be conducted. We recommend initiating third-party research to analyze this topic.

6) NHTSA considered whether there might be any opportunities to combine either the cameras or the displays for the CMS with the camera or display for backup camera system that is required by FMVSS No. 111. The agency tentatively concludes that there would not be any such opportunities. Although CMS and backup camera systems would likely operate in a similar way, the systems serve different safety purposes and are used in different circumstances. Specifically, the purpose of a CMS would be to assist the driver in avoiding all crashes during normal driving, while the purpose of a backup camera is to assist the driver in avoiding backover crashes while in reverse. Perhaps more important, given the likely differences between the field of view and display image quality parameters that would apply to CMS versus backup camera systems, NHTSA believes it is unlikely that it would be technically possible to combine the two systems in such a way that they share either a camera or display monitor. NHTSA requests comments on this tentative conclusion.

ZF agrees with this assessment.

Image Quality and Related Test Procedures

7) We seek comment on the minimum quality of the image presented on a CMS electronic visual display to provide the same level of safety as traditional FMVSS No. 111-compliant mirrors, as well as how image quality could be objectively measured.
    a. In particular, we seek comment on what would be the appropriate minimum camera and visual display parameters and performance metrics for a CMS (i.e., camera/display resolution, screen brightness, contrast, color, tone, and their adjustments). Should the parameters and metrics for a CMS differ from those for a backup camera system and, if so, how and to what extent?

ZF suggests that a research study be conducted to assess what camera and display performance metrics will ensure the safety levels provided by CMS are at least equivalent to those enabled by FMVSS 111 mirrors. It may be true that the same visual acuity as provided by existing mirrors is not required to ensure the same level of safety, and that question could be considered within the research conducted to assess the technology. Features to consider in assessing equivalent safety could include camera and display resolution, FOV, and update rate, among others. This could include extensive vehicle CMS prototype testing with a broad test subject base and multiple driving scenarios and conditions.

    b. To what extent do existing CMS regulations (e.g., ISO 16505/UNECE R46) provide objective and repeatable performance requirements and test procedures to evaluate

image quality? To the extent that those regulations do not provide such requirements and procedures, what changes or additions would need to be made?

Existing CMS regulations provide adequate requirements and procedures for evaluating CMS image quality. Alternate procedures for evaluating image quality could be solicited and considered, incorporating a determination of the exact performance thresholds that will ensure that safety is not adversely impacted as compared to glass mirror usage.

c. What new procedures, if any, would be needed to evaluate image quality appropriately and what has been done to develop such procedures?

Research proposals to address this image quality issue should incorporate proposed test procedures to assess image quality.

8) We seek comment on what disruptive display aberrations (blooming, etc.) should be addressed if the agency were to develop a CMS performance standard. To what extent do existing CMS regulations (e.g., ISO 16505/UNECE R46) provide objective, and repeatable performance test procedures to evaluate display aberrations? What new procedures, if any, would be needed to evaluate display aberrations appropriately and what has been done to develop such procedures?

Image processing that 'compress' bright areas and lens designs that minimize 'flare' may offer improvements to the displayed image from trailing headlights.

We believe that existing regulations provide adequate test conditions and performance requirements for display aberrations.

Rearview Image Display Type Related Human Factors

9) We seek comment on what research has been done to identify and address human factors issues like eye strain or visual fatigue from long periods of intermittent electronic visual display viewing. While we are particularly interested in research comparing driver eye strain and/or visual fatigue for users of a CMS versus users of traditional rearview mirrors, other analogous research could be useful.

ZF has not performed research on this topic, and we suggest that this subject be included in research authorized by NHTSA in furtherance of this rulemaking.

10) We seek comment on research concerning differences in the ability of drivers to visually discern and focus on objects in an electronic visual display as compared to objects reflected by traditional rearview mirrors.

ZF has not performed research on this topic, and we suggest that this subject be included in research authorized by NHTSA in furtherance of this rulemaking.

11) We seek comment on how a driver should be alerted that a CMS is not operating correctly, such as during a malfunction or a software update.

ZF believes that both an audio and visual warning should be provided if the system is not operating correctly. NHTSA could also consider standardizing these alerts so that vehicle users would receive them in a consistent manner regardless of vehicle manufacturer and model.

Side Rearview Image Display Locations, Driver Acclimation, and Related Test Procedures

12) We seek comment on whether and how placing the CMS displays in non-traditional locations (e.g., in the center console) would affect vehicle safety, as compared to placing the displays close to where the outside rearview mirrors would be mounted near the A-pillars. In particular, we seek research concerning the impact of different image locations on the level of safety and performance among any driver demographic, and whether different image locations may lead to driver confusion.

ZF has not performed research on this topic, and we suggest that this subject be included in research authorized by NHTSA in furtherance of this rulemaking. As a result of this research, NHTSA could also consider standardizing the display locations so that vehicle users would receive them in a consistent manner regardless of vehicle manufacturer and model.

13) We seek comment on whether research has been performed concerning the impacts of glare from sunlight and other vehicles' headlights on the CMS display, and whether test procedures have been developed to measure glare. If performance requirements and test procedures have not yet been developed to address these problems, when and how can they be developed? What are potential strategies to mitigate glare to ensure that useful images would be provided to drivers over the greatest range of conditions possible.

ZF has not performed research on this topic, and we suggest that this subject be included in research authorized by NHTSA in furtherance of this rulemaking. Based on limited ZF field testing of CMS prototypes, a light shield/hood could assist with the CMS side view displays (those replacing left/right mirrors).

Camera Durability, Reliability, and Related Test Procedures

14) We seek comment on the anticipated lifespan of the electronic visual display and camera components that would be installed in a typical CMS. Will the performance (e.g., display brightness) of components be maintained within specifications consistent with desired image quality over that lifespan, or will performance decrease due to age and/or being subject to outdoor conditions with wide temperature ranges and precipitation?

ZF has not performed research on this topic, and we suggest that this subject be included in research authorized by NHTSA in furtherance of this rulemaking.

15) We seek comment on the anticipated reliability of CMS as compared to outside rearview mirrors, including any reliability data that may be available for production or prototype CMSs.

ZF has not performed research on this topic, and we suggest that this subject be included in research authorized by NHTSA in furtherance of this rulemaking.

16) We seek comment on the anticipated replacement cost for a CMS that becomes inoperable due to damage or malfunction, and how that cost compares to the replacement cost of traditional powered and unpowered outside rearview mirrors.

ZF has not conducted a cost assessment, but several factors might be considered in this analysis, including: presumed reduction in the number of cameras being damaged by close-passing vehicles because they are closer to the vehicle than the mirrors they would replace; production cost reduction associated with presumed broader deployment of CMS; potential that replacement requires only a subcomponent of the CMS, rather than the entire system. This could be carefully considered in research authorized by NHTSA in furtherance of this rulemaking.

Further, the use of powered mechanisms to enable CMS cameras to extend from, and fold into, the vehicle may offer additional protection and convenience, akin to power folding and extending mirrors in some vehicles today. The CMS cameras could be extended when the vehicle is pulling a trailer, for example, and retract when the vehicle is parked.

17) We seek comment on whether and, if so, how a CMS can be weatherproofed to prevent condensation, or large water droplets, forming inside the camera enclosure, which could reduce image clarity. NHTSA has observed condensation in cameras mounted on the underside of outside rearview mirrors of recent model year production vehicles resulting in part of the camera view being unusable (e.g., the water blocks a portion of the camera's field of view). How should adequate weatherproofing be defined? Would the durability tests in FVMSS No. 111, S14.3 for backup cameras be sufficient, and if so, why? What other test procedures exist for demonstrating adequate weatherproofing of cameras, and have those procedures been validated?

ZF suggests the use of ISO 20653 IP6K9K as the standard of protection CMS weatherproofing to prevent condensation. This standard is designed to protect electrical equipment against just this type of risk. IP6K9K has a test procedure to demonstrate adequacy of protection.

18) Depending on the mounting location, cameras may be subject to environmentally-caused lens obstructions (e.g., dirt, ice, rain drops). We seek comment on how to prevent or mitigate such lens obstructions. What performance requirements and associated test procedures simulating these conditions have been developed to evaluate whether the camera is providing a useful image?

A lens heater and cleaner subsystem could be a requirement for CMS deployment. Useful baseline requirements for consideration exist in SAEJ942 and SAEJ2111. These systems should be tested during NHTSA's additional research into CMS technologies.

System Availability When Vehicle Ignition Is Off

19) Although it is not one of the primary safety purposes of rearview mirrors, drivers often use the outside rearview mirrors after turning off the ignition and preparing to exit the vehicle to determine whether it is safe to open the vehicle door when parked alongside a traffic lane. We seek comment on whether NHTSA consider requiring that a CMS be capable of serving this function by being operational in some capacity either at all times or for a specified period of time after opening the driver's car door. What new performance criteria would need to be developed for this purpose and what has been done to develop those criteria?

We recommend that CMS should be activated upon vehicle unlock or front door opening, and remain active at the end of a journey until after ignition is turned off and until the drivers' side door is opened.

Miscellaneous

20) Are there any other safety concerns that are closely related to the performance of CMS that are not addressed in this notice? If so, what are they, and what is the degree of their importance?

We have no further suggestions regarding factors that should be considered within the context of this rulemaking.

21) We seek comment on the potential short-term and long-term economic impacts of CMS. In particular, we seek comment on the level of consumer interest in vehicles equipped with CMS. We also seek comment on the extent of reduced drag associated with the installation of CMS and on the resulting amount of improved fuel economy. Finally, we seek comment on the

magnitude of the cost differential between equipping a vehicle with CMS and equipping a vehicle with rearview mirrors, and on the extent to which improved fuel economy would offset increased equipment costs associated with CMS.

ZF has not performed research on these topics, and we suggest that these subjects be included in research authorized by NHTSA in furtherance of this rulemaking.