DEPARTMENT OF TRANSPORTATION

National Highway Traffic Safety Administration

49 CFR Part 571

[Docket No. NHTSA-2018-0021]

RIN 2127-AM02

Federal Motor Vehicle Safety Standard No. 111, Rear Visibility

AGENCY: National Highway Traffic Safety Administration (NHTSA), Department of Transportation (DOT).

ACTION: Advance notice of proposed rulemaking (ANPRM).

SUMMARY: NHTSA seeks public comment on permitting camera-based rear visibility systems, commonly referred to as "Camera Monitor Systems" or "CMS," as an alternative to inside and outside rearview mirrors. Federal motor vehicle safety standard (FMVSS) No. 111, "Rear Visibility," currently requires that vehicles be equipped with rearview mirrors to provide drivers with a view of objects that are to their side or to their side and rear. This notice responds to two rulemaking petitions from manufacturers seeking permission to install CMS, instead of outside rearview mirrors, on both light vehicles and heavy trucks. This ANPRM builds on the agency's prior efforts to obtain supporting technical information, data, and analysis on CMS so that the agency can determine whether these systems can provide the same level of safety as the rearview mirrors currently required under FMVSS No. 111.

DATES: Written information should be submitted by **[INSERT DATE 60 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER]**.

ADDRESSES: You may submit comments identified by the docket number in the heading of this document or by any of the following methods:

- *Federal eRulemaking Portal*: Go to *http://www.regulations.gov*. Follow the instructions for submitting comments on the electronic docket site by clicking on "Help" or "FAQs".
- *Mail:* Docket Management Facility. M-30, U.S. Department of Transportation. 1200 New Jersey Avenue S.E., West Building, Ground Floor, Room W12-140, Washington, D.C. 20590.
- *Hand Delivery*: U.S. Department of Transportation, 1200 New Jersey Avenue S.E., West Building, Ground Floor, Room W12-140, Washington, D.C. 20590 between 9 a.m. and 5 p.m. Eastern Time, Monday through Friday, except Federal Holidays.
- *Fax:* 202-493-2251.

Regardless of how you submit comments, must include the docket number identified in the heading of this notice.

You may call the Docket Management Facility at 202-366-9826.

Instructions: For detailed instructions on submitting comments and additional information on the rulemaking process see the Public Participation heading of the **SUPPLEMENTARY INFORMATION** section of this document. Note that all comments received will be posted without change to *www.regulations.gov*, including any personal information provided.

Privacy Act: In accordance with 5 U.S.C. 553(c), DOT solicits comments from the public to better inform its decision-making process. DOT posts these comments, without edit, including any personal information the commenter provides, to *www.regulations.gov*, as described in the system of records notice (DOT/ALL-14 FDMS), which can be reviewed at *www.transportation.gov/privacy.* In order to facilitate comment tracking and response, we encourage commenters to provide their name, or the name of their organization; however,

submission of names is completely optional. Whether or not commenters identify themselves, all timely comments will be fully considered.

Docket: For access to the docket to read background documents or comments received, go to *www.regulations.gov*, or the street address listed above. Follow the online instructions for accessing the dockets.

FOR FURTHER INFORMATION CONTACT: Contact Mr. Andrei Denes, Office of Crash Avoidance Standards (Phone: 202-366-9544; FAX: 202-366-7003) or Mr. Daniel Koblenz, Office of Chief Counsel (Phone: 202-366-2992; FAX: 202-366-3820).

SUPPLEMENTARY INFORMATION:

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I. Executive Summary

Part of NHTSA's responsibility in carrying out its safety mission is not only to develop and set new safety standards for new motor vehicles and motor vehicle equipment, but also to

modify existing standards as appropriate to respond to changing circumstances such as the introduction of new technologies. Examples of previous technological transitions that triggered the need to adapt and/or replace requirements in the FMVSS include the replacing of analog dashboards by digital ones, the replacing of mechanical control systems by electronic ones, and the first production of electric vehicles in appreciable numbers.

NHTSA is publishing this ANPRM to gather information and receive feedback to enable the agency to decide whether (and if so, how) to propose amending FMVSS No. 111, "Rear visibility," to permit camera-based rear visibility systems (commonly referred to as "Camera Monitor Systems" or "CMS"[1]) as an alternative compliance option in lieu of outside rearview mirrors or in lieu of all rearview mirrors, both inside and outside ones. Specifically, NHTSA hopes this ANPRM, through the public comment process, will provide the agency with additional safety-related research and data to support a potential future rulemaking on this subject.

Currently, FMVSS No. 111 requires that all passenger cars, multipurpose passenger vehicles, trucks, buses, school buses, motorcycles be equipped with one or more rearview mirrors for rear visibility. However, in recent years, there has been a growing interest among industry stakeholders in using CMS to supplement or replace rearview mirrors on both light and heavy vehicles. These systems use rear-facing cameras mounted outside of the vehicle to capture and transmit images to electronic visual displays mounted inside the vehicle, in view of the driver. Over the past few years, the International Organization for Standardization (ISO) has

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[1] In the balance of this notice, NHTSA uses the term "Camera Monitor System" or "CMS," instead of the terms "camera-based rear visibility systems" and "camera-based visibility system". The petitioners urge that rulemaking to permit CMS be based on ISO 16505, and UNECE R46.

developed and published performance requirements and test procedures for these systems. These requirements and procedures have been incorporated into the most recent update to the United Nations Economic Commission for Europe's Regulation No. 46 (UNECE R46), which has been adopted in a number of countries in Europe and Asia. We note that, to date, only two vehicle models equipped with a CMS in place of rearview mirrors have been offered for sale commercially and only one of those two is in currently production anywhere in the world, although manufacturers have announced plans to offer additional CMS-equipped models.

In the United States, industry stakeholders have petitioned NHTSA to modify the requirements of FMVSS No. 111 to allow the installation of CMS as a compliance option. To date, NHTSA has received two such petitions: one pertaining to light vehicles from the Alliance of Automobile Manufacturers (the Alliance) and Tesla, Inc. and one from Daimler Trucks North America relating to heavy vehicles.[2]

This ANPRM seeks information that the agency believes would provide fuller understanding of the merits of these rulemaking petitions. One reason why NHTSA is seeking additional information is because research conducted by NHTSA and others conducted between 2006 and 2017 has consistently shown that prototype and preproduction CMS systems can exhibit safety-relevant performance issues such as blooming.[3] Moreover, the CMS-related research of which NHTSA is aware does not focus on human factors issues, such as how well

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[2] In addition, NHTSA has received exemption petitions from some manufacturers requesting permission to install such systems in lieu of FMVSS No. 111-compliant mirrors, and the Federal Motor Carrier Safety Administration (FMCSA) has recently granted a similar exemption petition for commercial trucks.

[3] Blooming is a type of image distortion that occurs on a video display when the scene being shown on the display includes an intensely bright light source. On the display, the light from that light source bleeds or spills into adjacent areas of the image. The spillover effect is particularly noticeable in any dark areas of the image immediately adjacent to the bright area. This could potentially occur in a CMS-equipped vehicle when other vehicles' headlights shine at night into the CMS camera.

drivers may be able to acclimate to the use of CMS and potentially different image locations. (We note that NHTSA raised these concerns and requested additional information in letters sent to the Alliance and Tesla in 2016, but has not yet received a response.[4]) NHTSA hopes that the comments received in response to this ANPRM will provide the agency with information (along with data) that addresses these concerns.

II. Background

a. FMVSS No. 111

FMVSS No. 111, "Rear visibility," sets out performance requirements for new motor vehicles for the purpose of "reduc[ing] the number of deaths and injuries that occur when the driver of a motor vehicle does not have a clear and reasonably unobstructed view to the rear."[5] Among these is the requirement that all passenger cars, multipurpose passenger vehicles, trucks, buses, school buses, and motorcycles, be equipped with inside and, at least on the driver's side, outside rearview mirrors. The mirrors must be must be mounted according to certain specifications, and must provide the driver with a specified minimum field of view. The FMVSS No. 111 requirements relating to rearview mirrors have been largely unchanged for several decades.[6]

Although FMVSS No. 111 sets the minimum requirements for mirrors, an overwhelming majority of vehicle manufacturers voluntarily exceed the minimum rearview mirror requirements

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[4] These letters may be found in the docket identified in the header of the document.
[5] 49 CFR 571.111.
[6] We note that, although the agency recently amended FMVSS No. 111 in 2014 to require that most vehicles provide a backup camera system, that requirement will not be discussed in this notice. 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, as backup cameras are only intended to assist the driver while backing up. Accordingly, NHTSA believes that the safety concerns with CMS are not comparable to those with backup camera systems, but lessons from backup cameras can and will inform any potential rulemaking.

set forth in FMVSS No. 111 to satisfy customer demand and ensure an efficient, global-scale manufacturing and marketing process.

Manufacturers voluntarily exceed the standard's rearview mirror requirements in two major ways. First, most light vehicle manufacturers voluntarily equip new passenger cars with a passenger-side outside rearview mirror, in addition to the required inside rearview mirror, even though such a passenger-side mirror is required for light vehicles only if the inside rearview mirror does not meet field of view requirements. A driver-side outside rearview mirror is required on all vehicles. Second, most manufacturers equip vehicles with outside rearview mirrors that are substantially larger than required under the standard.

b. Camera Monitor Systems

In recent years, there has been growing interest among industry stakeholders both in the United States and abroad in being allowed to install CMS, in lieu of inside and/or outside rearview mirrors.[7] A vehicle equipped with a CMS uses exterior cameras mounted on the sides and/or rear of the vehicle to capture an image of the rear and/or side of the vehicle, which the system transmits to one or more electronic visual displays are located in the occupant compartment within view of the driver.

A CMS's cameras are typically mounted on the exterior of the vehicle near where traditional rearview mirrors would be installed, so that they provide a similar field of view. Conversely, the visual displays showing the rearview image to the driver may be mounted in a

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[7] It should be noted that, while FMVSS No. 111 requires that new vehicles be equipped with mirrors, it does not prohibit manufacturers from supplementing those mirrors with CMS or other features, and in fact, some manufacturers have been offering CMSs as optional equipment. For example, since 2013, Honda has been offering its LaneWatch™ system which uses a camera in the passenger-side outside rearview mirror to capture the area to the right of the vehicle and displays this side rearview image in the vehicle's center console display when the driver activates the right turn signal or the LaneWatch™ button is pressed.

variety of locations in the interior of the vehicle, because there is no need for there to be a direct line of sight between the cameras and the visual displays. Although most prototype CMSs that NHTSA has seen have displays mounted on or near the vehicle's A-pillars, in the vicinity of where a traditional outside rearview mirror would be located, other configurations are possible.[8] For example, CMS could use a single electronic visual display located in the position of a traditional inside rearview mirror or in the center of the dashboard to display images from side-mounted cameras either separately or as a combined (i.e., "stitched") image that integrates a center rearview image.[9]

c. International Regulatory Efforts

International standards and regulatory bodies have taken steps in recent years to develop performance standards and test procedures for CMS. Most notably, in 2015, the ISO published ISO 16505, "Road vehicles — Ergonomic and performance aspects of Camera Monitor Systems — Requirements and test procedures," which includes detailed test procedures for evaluating the performance of cameras and displays used in CMSs. In addition, UNECE R46, the type-approval standard used by most European countries for "devices for indirect vision," [10] was amended in 2016 to incorporate much of ISO 16505 and now permits CMSs.[11] CMSs are now permitted as an alternative to mirrors in the dozens of countries for which UNECE R46 is in

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[8] See, e.g., photo of the "interior of a Volkswagen XL-1 concept with a side-view camera has a screen on the passenger side to check outside the vehicle." http://www.autonews.com/article/20140407/OEM06/304079935/teslas-push-to-replace-side-view-mirrors-sparks-safety-fears. Accessed January 30, 2018.

[9] "Gentex to Offer Unique Three-Camera Automotive Rear Vision System" January 5, 2017 https://ir.gentex.com/news-releases/news-release-details/gentex-offer-unique-three-camera-automotive-rear-vision-system Accessed March 4, 2019

[10] UNECE R46 sets out field of view requirements that are comparable to those for inside and outside mirrors in FMVSS No. 111. Prior to the 2016 revision, UNECE R46 required that vehicles meet those field of view requirements using mirrors.

[11] See Appendix for a brief description of the UNECE R46 CMS requirements.

force without objection.[12] We note that, to date, only two vehicle models equipped with a CMS in place of rearview mirrors have been offered for sale commercially, and only one of those two is in production anywhere in the world. [13] However, at least one manufacturer has announced plans to offer further CMS equipped models.[14]

d. Consideration of CMS in the United States

In the United States, industry stakeholders have requested that NHTSA amend FMVSS No. 111 to permit CMS as an alternative to rearview mirrors. In 2014, NHTSA received a petition from the Alliance and Tesla, Inc. requesting that the agency modify the requirements of FMVSS No. 111 to "allow the use of camera-based rear and/or side vision systems [i.e., CMS] as a compliance option for meeting the performance requirements specified for rear and/or side view mirrors for each location where conventional mirrors are currently required or permitted (i.e., applicable portions of 49 CFR 571.111 S.5, S.6)."[15] In 2015, NHTSA received a similar petition relating to heavy vehicles from Daimler Trucks North America (DTNA). [16] Both of these petitions cited improved fuel economy (not safety) as the primary benefit of allowing this change. Neither petition provided objective data or analysis to aid the agency in determining the net effect on safety of amending FMVSS No. 111 to permit a CMS compliance option for rear visibility. [17, 18]

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[12] See "Adoption of Amendments to Regulation No. 46" (July 10, 2017), https://treaties.un.org/doc/Publication/CN/2017/CN.358.2017-Eng.pdf. Accessed May 6, 2019.
[13] 2019 Lexus ES CMS version commercialized only in Japan, and the 250-vehicle limited production 2014 VW XL-1 commercialized in E.U. under the type approval process before the publication of the latest version of UNECE R46, allowing CMS.
[14] Audi E-tron CMS option is expected to be available for purchase in E.U. in 2019.
[15] This petitions and related documents can be found at Docket No. NHTSA-2018-0021-0001.
[16] *Id.*
[17] DTNA's petition argued that CMS "can provide an expanded field of view" and "eliminate blind spots," and asserted that the "technology can achieve the same or better level of safety as outside rearview mirrors in providing

Although NHTSA has not yet formally responded to these petitions,[19] in September 2017, Velvac (a mirror manufacturer for the truck, commercial and RV industries) sent a letter to NHTSA expressing concerns over possible safety impacts should NHTSA decide to grant a petition to amend FMVSS No. 111 to permit CMS as a compliance option.[20] Velvac argued that ISO 16505 should not be applied to U.S. vehicles without making changes to the requirements to account for U.S.-specific vehicle configurations and applications. Velvac also suggested that a hybrid regulatory approach that would require the installation of both a camera and a mirror would be preferable. Velvac's reasoning was that FMVSS No. 111 already provides manufacturers the flexibility to use a hybrid approach (CMS technology in combination with an aerodynamic FMVSS No. 111-compliant mirror system) to achieve the fuel economy, aerodynamic, and visibility improvements while still addressing the human factors issues and maintaining a fail-safe mechanism.

The issue of permitting CMS as a compliance option for rear visibility was again raised in comments submitted in response to the DOT's October 2, 2017 Notice of Regulatory Review

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the driver a view to the rear along both sides of the vehicle." However, it did not provide evidence to support these claims.

[18] While recent interest among stakeholders has focused primarily on replacing outside mirrors with CMS, at least one manufacturer—Cadillac—has commercially produced a passenger car equipped with a CMS which provides drivers with a view of objects to the rear. We explained in a 2016 interpretation that Cadillac's CMS, which is integrated into the vehicle's inside mirror, was permissible because FMVSS No. 111 does not require that a passenger car's inside mirror meet the inside mirror field-of-view requirements (S5.1.1), if the vehicle is equipped with compliant driver's and passenger's side outside mirrors. See letter to Brian Latouf (Feb. 22, 2016), available at https://www.nhtsa.gov/interpretations/full-display-mirror-system-1-gm-feb-11.

[19] On June 30, 2016, in response to the Alliance/Tesla petition, NHTSA sent a letter to both petitioners requesting additional information to enable the agency to evaluate the petition. The safety-relevant questions posed in the letter focused on human factors information gaps and performance concerns, and requested input regarding performance requirements and test procedure details that would be needed to ensure that camera-based systems provide an equivalent level of safety to that of standard rearview mirrors. NHTSA notes that, because the agency did not receive a complete response to that letter from either petitioner, many of the questions in this ANPRM are based on the questions in that letter.

[20] Docket No. NHTSA-2017-0007-0005.

(82 FR 45750).[21] Comments by the Alliance reiterated its support of its rulemaking petition to amend FMVSS No. 111 to improve fuel economy, and further asserted that CMS could expand the driver's field of view.[22] Comments by the Truck and Engine Manufacturers Association also supported amending FMVSS No. 111 on the basis that installing CMS, in lieu of mirrors, on large trucks would reduce aerodynamic drag and potentially expand the driver's field of view.[23]

III. Summary of Research

To evaluate the safety impacts of CMS, NHTSA has conducted its own research and testing, examined the research and testing done by others, and requested research data from industry stakeholders. This research is summarized below. In addition, NHTSA's own research reports on this subject can be found in the docket for this ANPRM.

From 2006 to 2011, NHTSA conducted a multi-year research project to develop of performance specifications for a CMS that would supplement (rather than replace) traditional mirrors on heavy vehicles.[24, 25, 26] The CMS studied in this research was designed to supplement traditional mirrors by providing "enhanced views to the sides and rear of a heavy vehicle with an operating envelope that includes daytime and nighttime, as well as clear and inclement weather."[27] NHTSA believed that such a supplemental CMS would be beneficial to safety because it would improve the situational awareness of the heavy vehicle driver, thereby reducing

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[21] In that notice, the Department sought public comments on existing rules and other agency actions that are good candidates for repeal, replacement, suspension, or modification.
[22] Docket No. DOT-OST-2017-0069-2700.
[23] Docket No. DOT-OST-2017-0069-2786.
[24] "Development of a Performance Specification for Camera/Video Imaging Systems on Heavy Vehicles - Final Report: Specifications." July 2008, DOT HS 810 958. National Highway Traffic Safety Administration.
[25] "Development of a Performance Specification for Camera/Video Imaging Systems on Heavy Vehicles - Final Report: Supporting Research." July 2008, DOT HS 810 960. National Highway Traffic Safety Administration.
[26] "Field Demonstration of Heavy Vehicle Camera/Video Imaging Systems: Final Report." June 2011, DOT HS 811 475. National Highway Traffic Safety Administration.
[27] *Id.*

sideswipe crashes when heavy vehicles merge or change lanes. To explore CMS performance specifications, researchers conducted analyses of driver needs and human factors, examinations of video technology, systems analyses, focus groups and on-road tests. Researchers also conducted a study that surveyed commercial drivers using supplemental CMS, in which they observed neutral and potentially positive findings with respect to safety-critical events and drivers' forward attention.[28] They also identified a number of potential safety concerns or challenges. For example, drivers indicated that the glare produced from the system's electronic visual displays was "too bright and affected their ability to see details in the forward roadway" and that "glare from the visual displays could be uncomfortable at night."[29]

In 2015, the German Federal Highway Research Institute (BASt) published a report summarizing a study that directly compared outside rearview mirrors with a CMS for side rearview image display in passenger vehicle models and heavy trucks under various testing conditions.[30] The study concluded that a CMS that meets "specific quality criteria" can provide "sufficient" rear visibility for drivers.[31] The study also found that the change from outside rearview mirrors to a CMS requires a period of driver familiarization, but noted that the familiarization period is "relatively short," and that it does not necessarily result in "safety-critical situations."[32] The BASt study provided valuable insight into the operational capabilities of CMS technology at the time, and looked into some human factor issues, such as how long or

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[28] "Field Demonstration of Heavy Vehicle Camera/Video Imaging Systems: Final Report." June 2011, DOT HS 811 475. National Highway Traffic Safety Administration.
[29] *Id*. The report concluded that the issue of display glare was "resolvable," although subsequent research suggests the issue still persists in more advanced CMS displays.
[30] "Camera-Monitor Systems as a Replacement for Exterior Mirrors in Cars and Trucks" (2015). Federal Highway Research Institute (BASt).
[31] *Id.*
[32] *Id.* According to the study, a "safety critical" task is one that requires four glances at the CMS, and that the glances have a mean duration of more than 2 seconds.

frequently drivers glanced at the CMS when performing various driving maneuvers as compared to mirrors. However, the BASt study left a number of questions unanswered, including what minimum quality criteria for a CMS would provide the same level of safety as mirrors, and whether the time it takes for a driver to become acclimated to the system will affect vehicle safety. The study also notes, but does not explore, the safety impact of the inherent differences between the image provide by a CMS and the image provided by a mirror. Specifically, the BASt study notes that mirrors provide 3-dimensional spatial information to drivers,[33] and that mirrors allow drivers to change the field of view through head movements, neither of which is possible with a CMS.

In 2017, NHTSA conducted additional testing to further evaluate the performance of prototype light vehicle CMS to determine whether there were any potential safety concerns, with particular focus on the quality of the image displayed by the CMS.[34] NHTSA's study compared the observed performance of a prototype CMS installed on a MY 2016 Audi A4, with traditional mirrors installed on a 2017 Audi A4. Researchers compared the performance of the prototype CMS with traditional rearview mirrors in a variety of environments, including public roads, test track courses, and a laboratory. The systems were tested in different environments, including public roads, laboratories, and test track facilities. Tests were performed in both day and night conditions, and in conditions with various levels of precipitation.[35] Although researchers found that the CMS was generally usable in most environments, and provided a better image than

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[33] Although the images that mirrors produce are 2-dimensional, mirrors permit drivers to perceive depth through stereoscopy.

[34] "Examination of Prototype Camera-Based Visibility System for Light Vehicle Outside Mirror Replacement" (2018), DOT HS 812 582.

[35] Since NHTSA had access to the leased system-equipped vehicle for only a short period of time, a limited amount of testing was performed. Tests performed were ones for which needed equipment and test facilities were readily available.

mirrors in certain conditions (such as in dusk or dawn lighting conditions), researchers identified a number of potential safety concerns, including:

- The image appeared to be horizontally compressed, such that objects displayed on the CMS screen were narrower and thus more difficult to detect.
- The CMS display was mounted lower than traditional mirrors, which may be temporarily disorienting for drivers. (It should be noted, however, that despite initial disorientation, drivers were able to acclimate to the CMS.)
- The display appeared very bright in certain conditions, even when set to "nighttime" mode, which may negatively impact the driver's ability to see obstacles at night.
- The system appeared to have blooming and lens flare that exceeded the level permitted under the new ISO standard for CMS under certain conditions.
- In rainy conditions, droplets on the lens would obscure the image displayed to the driver.

The full report describing this study along with related documents may be viewed online in the docket for this ANPRM.

In addition to the government-sponsored research described above, NHTSA is aware of two other studies that examined relevant issues relating to rearview display locations. The first of these, is a naturalistic study by Ali and Bazilah published in 2014, in which researchers observed the on-road driving behavior of subjects using vehicles equipped only with CMS and no rearview mirrors.[36, 37] The study found that the use of the CMS in the study improved drivers'

[36] Mohamed Ali, J. S. and Bazilah, F. (2014). "Mirrorless Car: A Feasibility Study." Applied Mechanics & Materials, 663: 649–654.

attention to the forward roadway, but increased off-road downward glances at the center rearview display and motion sickness, leading the authors to recommend against a low location for a rearview display. In 2016, Large et al. published a similar study based on observations of subjects using a driving simulator of a vehicles equipped with a CMS. Researchers analyzed drivers' eye glance behavior and subjective feedback for five layouts of three in-vehicle displays (one rear and two side view displays) versus traditional mirrors during overtaking maneuvers performed without urgency.[38] The study found that subjects tended to prefer a CMS display layout that matched traditional mirror locations.

Finally, NHTSA has been made aware through media reports that some portion of the driving population not be physiologically capable of using CMS. In February of 2018, Steve Downing, the Chief Executive Officer of Gentex, Inc. (a CMS manufacturer), stated that the company had observed that "roughly 5 to 10 percent of motorists suffer motion sickness or have depth-of-vision problems" when viewing the video image.[39] NHTSA researchers have personally experienced this phenomenon when driving CMS-equipped test vehicles, but this information is, at present, anecdotal. NHTSA is not aware of any research having been done in this area, but the possibility that some percentage of drivers cannot use a CMS is something that NHTSA believes deserves further research.

IV. Subjects on which NHTSA Seeks Public Comment

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[37] The sideview CMS screens (which replaced the outside rearview mirrors) were positioned in the dashboard immediately to the left and right sides of the instrument panel, while the center rearview CMS screen (which replaced the inside rearview mirror) was positioned in place of the instrument panel.

[38] Large, D. R., Crundall, E., Burnett, G., Harvey, C. and Konstantopoulos, P. (2016). "Driving without Wings: The Effect of Different Digital Mirror Locations on the Visual Behaviour, Performance and Opinions of Drivers." Applied Ergonomics 55: 138–148.

[39] "Gentex's two-way mirror strategy Balancing core product with advanced digital displays" February 19, 2018. Automotive News. *http://www.autonews.com/article/20180219/OEM06/180219767/gentex-mirrors-technology*. Accessed October 18, 2018.

Although NHTSA believes that CMS is a promising technology, the agency has some lingering safety concerns that it believes should be addressed prior to deciding whether to propose amending FMVSS No. 111 to permit CMS as a compliance option for rear visiblity. Accordingly, the agency has compiled a list of issues on which the agency requests additional information to adequately evaluate the safety of permitting CMS as an alternative compliance option to rearview mirrors. NHTSA invites comments on all aspects of permitting camera-based technologies to be installed as an alternative to mirrors to meet the FMVSS No. 111 rear visibility requirements. However, the agency requests that commenters provide as much research, evidence, and/or objective data as possible to support their comments to inform the agency in determining the appropriate next steps.

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.
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?

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. 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. Please identify any requirements that you believe should be added and explain the basis for your beliefs. Which CMS have performed relatively well, and which have performed relatively poorly, on the road? What explains the difference in performance?

<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.
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?

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.[40] NHTSA requests comments on this tentative conclusion.

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. In

[40] NHTSA believes that sharing a camera would not be possible because the CMS camera would need to be aimed much higher than the backup camera, and that sharing a single display area would not be possible because both the CMS and backup camera images would need to be displayed simultaneously to provide the driver with all required fields of view when the vehicle is in reverse.

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

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?

<u>Rearview Image Display Type Related Human Factors</u>

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.

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.

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.

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.

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.

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?

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.

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.

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?

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?

<u>System Availability when Vehicle Ignition is Off</u>

19) Although it is not one of the primary safety purpose 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?

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?

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.

V. Public Participation

a) How can I influence NHTSA's thinking on this subject?

NHTSA welcomes public review of this ANPRM. NHTSA will consider the comments and information received in developing its eventual proposal for how to proceed on permitting

CMS technology as a compliance option for the outside rearview mirror requirements of FMVSS No. 111.

b) How do I prepare and submit comments?

Your comments must be written and in English. To ensure that your comments are filed in the correct docket, please include the docket number of this document (NHTSA-2018-0021) in your comments.

Your primary comments should not be more than 15 pages long. However, you may attach additional documents, such as supporting data or research, to your primary comments. There is no limit on the length of the attachments.

Please submit one copy (two copies if submitting by mail or hand delivery) of your comments, including the attachments, to the docket following the instructions given above under ADDRESSES. Please note, if you are submitting comments electronically as a PDF (Adobe) file, we ask that the documents submitted be scanned using the Optical Character Recognition (OCR) process, thus allowing NHTSA to search and copy certain portions of your submission. Please note that pursuant to the Data Quality Act, in order for substantive data to be relied upon and used by the agency, it must meet the information quality standards set forth in the OMB and DOT Data Quality Act guidelines. Accordingly, we encourage you to consult the guidelines in preparing your comments. OMB's guidelines may be accessed at *https://www.gpo.gov/fdsys/pkg/FR-2002-02-22/pdf/R2-59.pdf;* DOT's guidelines may be accessed at *https://www.transportation.gov/sites/dot.gov/files/docs/DOT%20Information%20Dissemination%20Quality%20Guidelines.pdf.*

c) How can I be sure that my comments were received?

If you submit comments by hard copy and wish Docket Management to notify you upon its receipt of your comments, enclose a self-addressed, stamped postcard in the envelope containing your comments. Upon receiving your comments, Docket Management will return the postcard by mail. If you submit comments electronically, your comments should appear automatically in Docket No. NHTSA-2018-0021 on *https://www.regulations.gov*. If they do not appear within two weeks of posting, we suggest that you call the Docket Management Facility at 1-800-647-5527.

d) How do I submit confidential business information?

If you wish to submit any information under a claim of confidentiality, you must submit three copies of your complete submission, including the information that you claim to be confidential business information, to the Office of the Chief Counsel, NHTSA, U.S. Department of Transportation, 1200 New Jersey Avenue S.E., Washington, D.C. 20590.

In addition, you should submit a copy (two copies if submitting by mail or hand delivery) from which you have deleted the claimed confidential business information to the docket by one of the methods given above under ADDRESSES. When you send a comment containing information claimed to be confidential business information, you should include a cover letter setting forth the information specified in NHTSA's confidential business information regulation (49 CFR Part 512).

e) Will the agency consider late comments?

NHTSA will consider all comments received before the close of business on the comment closing date indicated above under DATES. To the extent possible, NHTSA will also consider comments received after that date.

f) How can I read the comments submitted by other people?

You may read the comments received at the address given in the ADDRESSES section. The hours of the docket are indicated above in the same location. You may also read the comments on the internet, identified by the docket number at the heading of this notice, at https://www.regulations.gov.

Please note that, even after the comment closing date, NHTSA will continue to file relevant information in the docket as it becomes available. Further, some people may submit late comments. Accordingly, NHTSA recommends that you periodically check the docket for new material.

VI. Rulemaking Notices and Analyses

a. Executive Orders 12866, 13563, and DOT Regulatory Policies and Procedures

Executive Order 12866, ”Regulatory Planning and Review” (58 FR 51735, October 4, 1993), provides for making determinations whether a regulatory action is ”significant” and therefore subject to OMB review and to the requirements of the Executive Order.

NHTSA has considered the impact of this ANPRM under Executive Order 12866, Executive Order 13563, and the DOT’s regulatory policies and procedures found in DOT Order 2100.6, "Policies and Procedures for Rulemakings." As discussed above, the agency lacks the necessary information to develop a proposal at this time due to a number of unanswered questions and unresolved considerations. This rulemaking has been determined to be not “significant” under DOT Order 2100.6 and the policies of the Office of Management and Budget.

b. Executive Order 13771 (Reducing Regulation and Controlling Regulatory Costs)

This action is not subject to the requirements of E.O. 13771 (82 FR 9339, February 3, 2017) because it is an advance notice of proposed rulemaking.

c. Regulatory Flexibility Act

Pursuant to the Regulatory Flexibility Act, 5 U.S.C. 601 et seq., no analysis is required for an ANPRM. However, vehicle manufacturers and equipment manufacturers are encouraged to comment if they identify any aspects of the potential rulemaking that may apply to them.

d. Executive Order 13132 (Federalism)

As an ANPRM, NHTSA does not believe that this document raises sufficient federalism implications to warrant the preparation of a federalism assessment. NHTSA believes that federalism issues would be more appropriately considered if and when the agency proposes changes to FMVSS No. 111 to permit CMS.

e. Executive Order 12988 (Civil Justice Reform)

With respect to the review of the promulgation of a new regulation, section 3(b) of Executive Order 12988, "Civil Justice Reform" (61 Fed. Reg. 4729, February 7, 1996) requires that Executive agencies make every reasonable effort to ensure that the regulation: (1) Clearly specifies the preemptive effect; (2) clearly specifies the effect on existing Federal law or regulation; (3) provides a clear legal standard for affected conduct, while promoting simplification and burden reduction; (4) clearly specifies the retroactive effect, if any; (5) adequately defines key terms; and (6) addresses other important issues affecting clarity and general draftsmanship under any guidelines issued by the Attorney General. This document is consistent with that requirement.

f. Paperwork Reduction Act

Under the Paperwork Reduction Act of 1995 (PRA), a person is not required to respond to a collection of information by a Federal agency unless the collection displays a valid OMB control number. There are no information collection requirements associated with this ANPRM. Any information collection requirements and the associated burdens will be discussed in detail once a proposal has been issued.

g. National Technology Transfer and Advancement Act

Section 12(d) of the National Technology Transfer and Advancement Act (NTTAA) requires NHTSA to evaluate and use existing voluntary consensus standards in its regulatory activities unless doing so would be inconsistent with applicable law (e.g., the statutory provisions regarding NHTSA's vehicle safety authority) or otherwise impractical. Voluntary consensus standards are technical standards (e.g., materials specifications, test methods, sampling procedures, and business practices) that are developed or adopted by voluntary consensus standards bodies, such as the Society of Automotive Engineers. The NTTAA directs us to provide Congress (through OMB) with explanations when we decide not to use available and applicable voluntary consensus standards. As NHTSA has not yet developed specific regulatory requirements, the NTTAA does not apply for purposes of this ANPRM.

h. Unfunded Mandates Reform Act

The Unfunded Mandates Reform Act of 1995 requires agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditure of State, local, or tribal governments, in the aggregate, or by the private sector, of more than $100 million annually (adjusted for inflation with base year of 1995). NHTSA has determined that this ANPRM would not result in

expenditures by State, local, or tribal governments, in the aggregate, or by the private sector, in excess of $100 million annually.

i. National Environmental Policy Act

NHTSA has analyzed this rulemaking action for the purposes of the National Environmental Policy Act. The agency has preliminarily determined that implementation of this rulemaking action would not have any significant impact on the quality of the human environment.

j. Plain Language

The Plain Language Writing Act of 2010 (Pub. L. 111-274) requires that Federal agencies write documents in a clear, concise, and well-organized manner. While the Act does not cover regulations, Executive Orders 12866 and 13563 require each agency to write all notices in plain language that is simple and easy to understand. Application of the principles of plain language includes consideration of the following questions:

- Have we organized the material to suit the public's needs?
- Is the discussion in the notice clearly written?
- Does the notice contain technical language or jargon that is not clear?
- Would more (but shorter) sections be better?
- Could we improve clarity by adding tables, lists, or diagrams?

If you have any responses to these questions, please include them in your comments on this ANPRM.

k. Regulatory Identifier Number (RIN)

The Department of Transportation assigns a regulation identifier number (RIN) to each regulatory action listed in the Unified Agenda of Federal Regulations. The Regulatory

Information Service Center publishes the Unified Agenda in April and October of each year. You may use the RIN contained in the heading at the beginning of this document to find this action in the Unified Agenda.

Appendix: Aspects of light vehicle CMS performance regulated under UNECE R46

Aspect of Performance[41]	Description	UNECE R46 Citation
Structural design	Requirement that the CMS meet various size, shape, and material restrictions.	6.2.2.1
Monitor Luminance	Requirement that CMS monitor luminance be adjustable.	6.2.2.3.1, 6.2.2.3.5.1
System availability indicator	Requirement that the CMS indicate to the driver if the system is unavailable.	6.2.2.3.2, 16.1.2
Monitor isotropy	Requirement that the monitor show a uniform image. Limits for luminance when measured at various viewing angles (directional uniformity) and at various locations on the screen (lateral uniformity).	6.2.2.3.3.1
Luminance and contrast rendering	Monitor luminance and contrast limits for different conditions (direct sunlight, diffuse ambient light, sunset and night).	6.2.2.3.3.2
Grey scale rendering	Requirement that the CMS be able to display a minimum tonal range of distinguishable different grey steps.[42]	6.2.2.3.3.3
Color rendering	Requirement that the CMS be able to accurately reproduce certain colors.[43]	6.2.2.3.3.4
Image artifacts (aberrations)	Requirement that CMS image aberrations be noted in the owner's manual.	6.2.2.3.3.5
Smear	Limits for the white stripes artifact appearing on an image created by very bright light sources.	6.2.2.3.3.5.1
Blooming and lens flare	Limits for the area of image loss caused by bright lights flooding the image (blooming) and light scattering inside the lens (lens flare).	6.2.2.3.3.5.2
Point light sources	Requirements for CMS to show distinctively two point light sources (e.g. passing beam headlights).	6.2.2.3.3.5.3
Sharpness	Requirements for the monitor to accurately show zones of different tones, or colors, without blurring the boundaries between set zones. Limits are provided for the horizontal and vertical direction.	6.2.2.3.3.6.1
Depth of field	Requirements for resolution of the CMS to show a sufficiently clear image at various distances.	6.2.2.3.3.6.2

[41] Performance metrics used for these aspects of performance are performed per ISO 16505:2015, unless otherwise noted.
[42] Grey scale chart per ISO 14524:2009.
[43] Color coordinates per CIE 1976 UCS.

Geometric distortion	Limits for the level of distortion of the CMS image relative to a rectilinear or pinhole projection.	6.2.2.3.3.7
Flicker	Requirement that the monitor be free of flicker.[44]	6.2.2.3.3.8.1
Frame rate	Requirement that the CMS operate at a minimum frame rate, and that the movements of objects in front of the camera be rendered smooth and fluid.	6.2.2.3.4.1.
Image formation time	Limit on the amount of time permitted for the monitor to form an image.[45]	6.2.2.3.4.2
System latency	Limit on the time delay between when an event occurs and when it is rendered on the monitor.	6.2.2.3.4.3
Impact testing	Requirement that an externally mounted CMS camera meet certain impact requirements.	6.3.1
Field of vision	Requirement that CMS devices meet the same minimum field of vision requirements as mirror.	15.2.4
Activation and deactivation	Requirements for when and under what conditions a CMS must activate or deactivate.	16.1.1
Default view	In default view the system is required to show the minimum required field of vision.	16.1.1.1
Overlays	Requirements relating to what information may be overlaid on the CMS image, and limits on the size of overlays.	16.1.1.3
Magnification factor	Requirement that the magnification of the CMS image be within a certain range.	16.1.3.1
Resolution	Requirement for the minimum distinguishable details observable in an image.	16.1.3.2
Magnification aspect ratio	Limits for the ratio of horizontal to vertical magnification of the image.	16.1.4
Monitors	Requirements relating to where the monitors may be located inside the vehicle and how the left and right fields of vision may be displayed.	16.1.5

[44] Test performed per ISO 13406-2:2001.
[45] Test performed per ISO 9241-305:2008

Issued in Washington, DC under authority delegated in 49 CFR part 1.95 and 501.4.

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James Clayton Owens
Acting Administrator

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