December 9, 2019

BY ELECTRONIC SUBMISSION

Docket Management Facility
M-30, U.S. Department of Transportation
West Building, Ground Floor, Room W12-140
1200 New Jersey Avenue, SE
Washington, DC 20590-0001

Re: **Request for Comments on Advance Notice of Proposed Rulemaking:**
Federal Motor Vehicle Safety Standard No. 111, Rear Visibility
Docket No. NHTSA-2018-0021

Dear Sir or Madam:

Panasonic Automotive and Ficosa Corporation provides these comments in support of the National Highway Traffic Safety Administration's ("NHTSA") proposal to revise Federal Motor Vehicle Safety Standard ("FMVSS") No. 111 to allow the use of camera monitoring systems ("CMS") instead of rearview mirrors. The modernization of FMVSS No. 111 would allow for innovation in motor vehicle rear visibility systems and provide enhanced safety benefits to drivers. Allowing for the use of CMS instead of rearview mirrors would also allow the replacement of conventional side mirrors to reduce emissions.

If NHTSA amends FMVSS No. 111 to allow CMS instead of rearview mirrors, the United States would join Europe and a number of other nations who have adopted UNECE R46. As noted by the agency in its Advanced Notice of Proposed Rulemaking ("ANPRM"), UNECE R46 permits CMS as an alternative to mirrors.

PANASONIC'S EXPERTISE AND CAPABILITY IN ADVANCED VISION TECHNOLOGIES

Panasonic Automotive Systems Company of America (a wholly owned subsidiary of Panasonic Corporation of North America[1]) and Ficosa Corporation[2] (collectively "Panasonic" – both are subsidiaries of Panasonic Corporation), are industry leaders in advanced vision and sensing technologies. Ranging from camera to image processing to sensors, our technology allows drivers to see today's roads more clearly. Panasonic's decades of camera and vision processing expertise has been brought into the automotive space to enable greater reliability of machine vision and better driver information.

[1] Panasonic Corporation of North America is a leading technology partner and integrator to businesses, government agencies and consumers across the region. The company is the principal North American subsidiary of Osaka, Japan-based Panasonic Corporation and leverages its strengths in Immersive Entertainment, Sustainable Energy, Integrated Supply Chains and Mobility Solutions to enable its business-to-business customers. For more about Panasonic Automotive, please visit: https://na.panasonic.com/us/automotive-solutions.

[2] Ficosa Corporation is a top-tier global provider devoted to the research, development, manufacturing and marketing of high-technology vision, safety, connectivity and efficiency systems for the automotive and mobility sectors, with the desire to contribute to society through a commitment to technological innovation, human values and energy efficiency. Ficosa is present in 16 countries in Europe, North and South America and Asia. In 2017, Panasonic Corporation acquired a majority share in Ficosa International, S.A.

In collaboration with Panasonic, Ficosa has developed an electronic mirror composed of cameras and displays which provides an alternative option to the exterior rear-view mirrors of the car. This pioneering CMS system supports an authentic revolution for the automotive industry as well as an important progress towards the autonomous car.[3]

Ficosa and Panasonic collaborated to develop intelligent rearview mirror (IRMS). IRMS is a system, which has an integrated display in the structure of the rearview mirror, that works as a mirror or as a display that relays images from the camera located at the rear of the vehicle, according to the driver's needs. This solution added value to the conventional mirror, enhancing the driving experience and increasing safety and driving comfort.[4]

Ficosa also has worked with Audi to launch, within the e-tron model, the first digital rear-view system that will hit the European market. [5] This ground-breaking vision system developed by Ficosa, also known as CMS (Camera Monitoring System), is made up of cameras and displays that replace the traditional external side mirrors, providing a new driving experience that is safer, more efficient and more comfortable. This vision system is comprised of two cameras, integrated into the sides of the car's chassis, and two tactile displays inside the doors.

NEED FOR NHTSA TO AMEND FMVSS N0. 111 IS URGENT

NHTSA action to establish CMS regulation for the United States is urgent, as many other countries have already promulgated or will soon allow CMS operation, including:

- ECE R46: Applicable to Europe and UN Contracting parties (Japan, South Korea, etc.)
- GB 15084: Applicable to China (currently under revision to include CMS)

Moreover, there is significant vehicle manufacturer interest, reflecting consumer demands and other industry trends in vehicle automation:

- Commercial vehicles already equipped with CMS: Audi e-tron[6], Lexus ES[7]
- Upcoming vehicles with CMS: Honda E[8], Mercedes Benz Concept EQ[9], BMW Concept i8[10], NISSAN IMs Concept[11], etc.

For these reasons, Panasonic urges NHTSA to expeditiously move to a Notice of Proposed Rule-Making after review of public comments to this ANPRM, to meet consumer demands, improve fuel efficiency, and ensure the U.S. market does not lag behind the rest of the world in advanced vehicular technology.

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[3] See: "Ficosa develops an electronic mirror composed of cameras and displays" (Ficosa International, Oct. 14, 2015) at: https://youtu.be/1w0nk5ZPLSc

[4] See: "IRMS - Intelligent Rearview Monitoring System" (Ficosa.com) at: https://tinyurl.com/r7z7q4t

[5] See: "Ficosa develops and manufactures the digital rear-view system of the Audi e-tron, the first automobile to market with this technology "(Ficosa.com, Sept. 28, 2018) at: https://tinyurl.com/sdq7srl

[6] See: "How aerodynamics influence an electric car's range" (Audi.com) at: https://tinyurl.com/u8dod8m

[7] See: "Toyota to replace side-view mirrors with cameras in new model" (Nikkei Asian Review, Sept. 13, 2018) at: https://tinyurl.com/y7tdawtj

[8] See: "Honda e Side Camera Mirror System" (Honda Video) at: https://youtu.be/Urf9JK5Szn8

[9] See: "Electro-aesthetics. The Mercedes-Benz Concept EQ" (Daimler.com) at: https://tinyurl.com/vecxh93

[10] See: "BMW i8 shows Mirrorless Camera technology" (BMW Blog, Jan. 5th, 2016) at: https://tinyurl.com/udfh4ep

[11] See: "Nissan's IMs concept: Introducing the 'elevated sports sedan'" (Nissan News USA, Jan. 14, 2019) at: https://tinyurl.com/vr8l5ga

PANASONIC RESPONSE TO NHTSA'S ANPRM QUESTIONS:

The following information is intended to provide feedback in response to the NHTSA ANPRM soliciting comments on potential updates to FMVSS 111 to permit camera-based rear visibility systems – or Camera Monitoring Systems (CMS) – as an alternative to interior and exterior rearview mirrors. The NHTSA ANPRM specific request was *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.

PANASONIC FEEDBACK:

VTTI Naturalistic Driving Study

VTTI Naturalistic Driving Study (NDS) is currently being performed using outside rearview CMS with non-unitary magnification factor (adjusted according to ECE R46 requirements):

- Driver side average magnification factor: 0.33
- Passenger side average magnification factor: 0.21

Results obtained during the study are expected to reinforce the usage of non-unitary magnification requirements for CMS. As it can be seen on the Figure below, CMS have a positive safety impact during lane changes at multiple distances. Blind spots and changes at closer distances are safer, while lane changes at larger distances are not prejudiced although having greater field of view and smaller object sizes. These results also reinforce the usage of non-unitary magnification factor requirements on CMS.

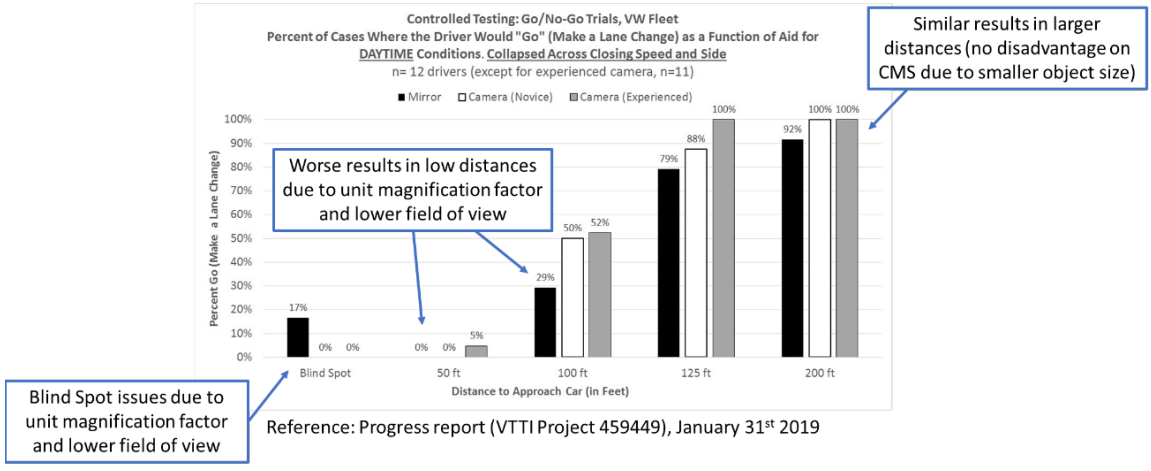

Figure 1. VTTI Naturalistic Driving Study Progress report

Following points are considered as major advantages in comparison with conventional rearview mirrors:

- Greater field of view – Better field of view with elimination/minimization of blind spots
- Better dawn and night visibility
- Improved aerodynamics - Reduced Aerodynamic Drag
- Improved Fuel Efficiency Can give more miles per Charge to Electrical Vehicles
- Wind noise reduction
- The Ability to Perform Perception Algorithms like Object Detection
- User personalization: zoom, pan, etc.
- Cameras are Shaped so that they won't be obscured by rain or snow

CMS provide an increased field of view with respect to conventional rear view mirrors that almost eliminates blind spots. It is very important to cover such areas, because the driver should be aware of the surroundings of his car at all moments without having to put any effort. On the image below the performance in terms of field of view and magnification factor can be analyzed:

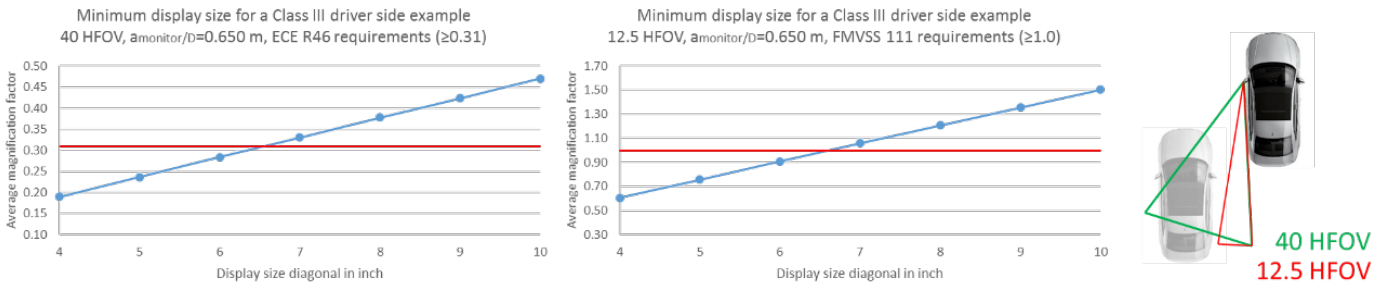

Figure 2. Field of view and Average magnification factor requirements comparison (ECE R46 vs FMVSS 111)

Blooming effects caused by external light sources (e.g. vehicle headlights or sunlight) are reduced when a CMS is properly designed (e.g. according to ECE R46 and ISO 16505 requirements). Due to the intrinsic technology of a camera system, the lights are shown with a proper image quality on the CMS monitor under multiple driving conditions. Cameras have also the ability to perform better at low light conditions than human eyes, improving the visibility at night. All the before mentioned combined allow drivers to improve their awareness while driving in situations where the human eye is not capable of discerning between objects.

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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?

PANASONIC FEEDBACK:

View is only obstructed by the vehicle's bodywork in the same way it obstructs rear view mirrors' view. Camera holders are designed so that they resemble a conventional rear view mirror regarding position. However, their shape and materials allow to reduce fuel consumption due to improved aerodynamics and to minimize noise.

Drivers' issue of not being able to modify field of view by looking at the system from different angles would no longer be an issue due to the field of view gain that CMS provide. By gazing at the display, drivers will automatically see all information to their sides, which eliminates the need to modify the field of view of the system.

- A zoom can be applied to the display image if the user wishes to apply it.
- Night vision could be improved with respect to conventional rear view mirrors.
- Perhaps the field of view that the driver gains when moving his head is equivalent or lower to the one the CMS can provide (remember that field of view in Europe is greater than in USA).
- Depth dimension is lost because images are projected onto a 2D surface.
- There is no negative IQ impact. However, there is a reduction in objects size (lower magnification factor).

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3. NHTSA seeks comment on the performance of current world-market vehicles equipped with CMS when evaluated according to the ISO 16505/UNECE R46 standards. In particular, the agency seeks 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?

PANASONIC FEEDBACK:

Mainly all ECE R46 requirements are necessary as they take into account multiple use cases which can be found on the road (field of view, resolution, luminance conditions, image quality, etc.). Proposed values are also well correlated with the performance that could be achieved based on current technology, although some revision might be considered:

- View modes and overlay requirements are more restrictive in comparison with ISO 16505, which should be the reference for these requirements
- Luminance and contrast rendering under direct sunlight condition is too restrictive in both ISO 16505 and ECE R46 (inclination angle delta should be changed from 15 to 20 deg as it was done in SAE J1757:2015 and ISO 15008:2017)
- European magnification factor requirements for CMS should be considered as they include one of the major advantages of the CMS (more FOV), which is currently limited by FMVSS 111 regulation

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System Field of View and Related Test Procedures

4. NHTSA seeks 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.

PANASONIC FEEDBACK:

ECE R46 requirements currently permits the usage of expanded views, in compromise of the object size. European magnification factor values are considered as an advantage in comparison with current FMVSS 111 requirements for outside rear view mirrors. When comparing the display size vs. the average magnification factor of both markets we can see how the field of view is hightly perjudiced. Blind spot areas are higher in comparison with European requirements.

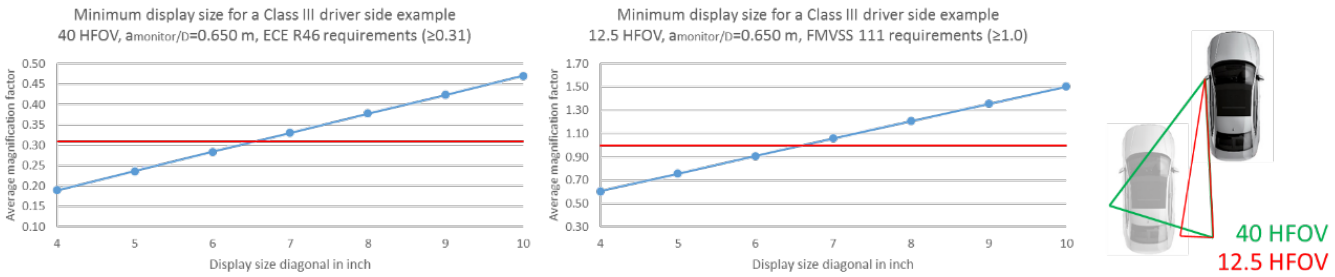

Figure 3. Field of view and Average magnification factor requirements comparison (ECE R46 vs. FMVSS 111)

On the other hand, field of view requirements for both ECE R46 and FMVSS 111 standards are similar. As shown in the image below, the minimum FOV requirements are usually lower in comparison with the total FOV that could be achieved by either a conventional mirror or a CMS while fulfilling the rests of ECE R46 requirements.

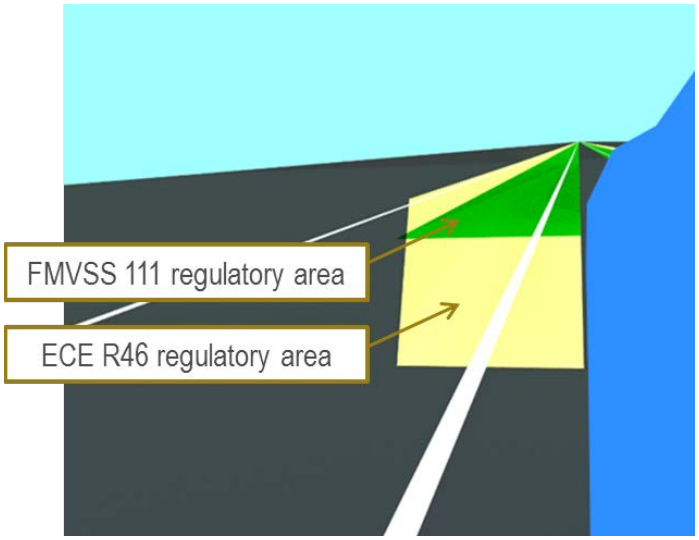

Figure 4. FOV requirements comparison for outside CMS (ECE R46 vs. FMVSS 111)

5. NHTSA seeks 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?

PANASONIC FEEDBACK: Stitching different video streams in the same display is allowed in Europe although currently exists some restrictions (e.g. display position constraints). There may appear artifacts of different nature during the processing of frames that could cause blind spots depending on the position of each camera although if the requirements are fulfilled and the limitations are correctly indicated to the driver there shouldn't be any disadvantage in comparison with standalone camera monitor systems.

The usage of using multiple fields of view from a single or multiple cameras offers also a noticeably advantage for trucks and larger vehicles. While multiple mirrors are required for covering different field of views, the camera monitor system can be used to obtain a better visibility of the surroundings.

Fig. 12 Comparison of different presentation concepts (*left to right*): 1:1 replacement; 1:1 replacement with camera panning; combined replacement; combined replacement with maneuver view

Figure 5. Handbook of Camera Monitor Systems, Design of Camera Monitor Systems on Commercial Vehicles (pages 322-325)

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.

PANASONIC FEEDBACK:

Based on current ISO 16505 and ECE R46 requirements, currently is not technically possible to combine the two systems and fulfil these requirements. Some key metrics are highly differentiated between both products:

- Frame rate: 25-30 fps (backup camera) vs 30-60 fps (CMS)
- FOV: 160-200 degree (backup camera) vs 30-80 degree (interior / exterior CMS)
- Dynamic range: 80-90 dB (backup camera) vs 110-120 dB (CMS)

Image Quality and Related Test Procedures

7. NHTSA seeks 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 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?

PANASONIC FEEDBACK:

ECE R46 and ISO 16505 requirements already cover the minimum quality that the CMS should provide. They take into account multiple use cases which can be found on the road (field of view, resolution, luminance conditions, image quality, etc.), proposing a test method with a minimum acceptance criteria for each case. Proposed values are also well correlated with the performance that could be achieved based on current technology, although some revision might be considered:

- View modes and overlay requirements are more restrictive in comparison with ISO 16505, which should be the reference for these requirements

- Luminance and contrast rendering under direct sunlight condition is too restrictive in both ISO 16505 and ECE R46 (inclination angle delta should be changed from 15 to 20 deg as it was done in SAE J1757:2015 and ISO 15008:2017)
- European magnification factor requirements for CMS should be considered as they include one of the major advantages of the CMS (more FOV), which is currently limited by FMVSS 111 regulation

Current FMVSS 111 requirements applicable to backup cameras shouldn't be used as reference as the intended product usage is more limited and hence the requirements are not as restrictive as the ones applicable to a CMS.

Figure 6. CMS performance evaluation under multiple weather conditions ©FICOSA International SA

8. The agency seeks 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?

PANASONIC FEEDBACK:

ECE R46 and ISO 16505 test methods already cover the necessary performance requirements to evaluate display aberrations:

- Directional / Lateral uniformity: evaluation of display uniformity and viewing angle taking into account monitor's design viewing direction and vehicle integration
- Luminance and contrast rendering in multiple lighting conditions: evaluation of the display contrast with diverse illuminations (direct sunlight, ambient light, night condition and camera artefacts), taking into account monitor's design viewing direction and vehicle integration
- Smear / Blooming and lens flare / Point light sources: evaluation of multiple light artifacts that might influence both camera and display components in order to restrict the maximum amount of image contamination

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Rearview Image Display Type Related Human Factors

9. NHTSA seeks 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 the agency is 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.

PANASONIC FEEDBACK:

This point refers to automotive display technology and its completely a reference to **SAE J1757/1_201505** that explain the Standard Metrology for Vehicular Displays. Where they explain (point 3.29) the perceived brightness response:

3.29 PERCEIVED BRIGHTNESS

Is the human eye perception (subjective) of the display Luminance (L) or reflected Illuminance (E). Sometimes brightness is wrongfully substitute by luminance because both provide information on "light intensity". In order to avoid any confusion, it is recommended to use the term "perceived brightness" when non-linear response of the eye is considered. CIELUV (1976) or CIELAB (1976) are standardized color spaces considering a non-linear eye response. As a good approximation "perceived brightness" is a cube root of luminance, except at low light levels when it is linear.

Figure 7. CMS evaluation of perceived brightness in low light environment, comparison between a system adjusted based in the SAE J1757 standard (left) and a system adjusted without using SAE J1757 standard as reference (right)

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10. NHTSA seeks 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.

PANASONIC FEEDBACK:

According to the information found in *Handbook of Camera Monitor Systems by Anestis Terzis, chapter 7 Human Depth Perception*, it is commonly assumed that human depth perception is mainly derived from the binocularity of the visual system. However, human binocular sight is strongly limited by its inter-ocular distance and resolution. In a closer analysis, the limits of depth resolution of this system are surprisingly low.

Studies by Glennester concluded that the depth cue of binocularity is specialized for short distances < 5–10 m.

Fig. 13 Angular binocular disparity σ for the eyes baselength of b for objects in the distance o while fixating the point P, resulting in a shear angle of γ

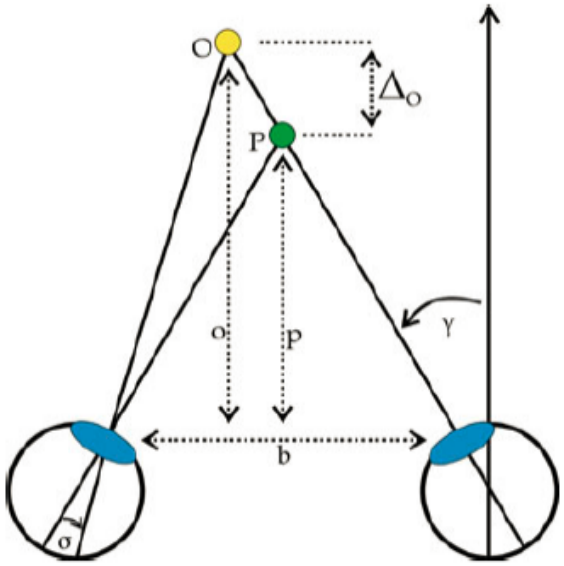

Figure 8. Handbook of Camera Monitor Systems, Human Depth Perception, Binocular Disparity (pages 299-301)

The reason for strong depth and distance perception despite missing or limited stereo cues is the capability of the HVS to process additional pictorial as well as dynamic monocular depth cues, which are embedded in the 2D projection of the sensed scene. Dynamic cues arise from apparent motion of the visible objects or ego-motion (motion parallax) as well as the orientation of the eyes (vergence) or focused distance (accommodation). Dynamic cues will not be considered in detail since they do not suit to be manipulated within still images or video sequences to enhance the perception of depth. However, pictorial cues encode, dependent on their origin, metric and ordinal depth information as well. They can be divided into two categories of predefined and modifiable cues.

Predefined cues are specified by the scenery and the object arrangement itself and cannot be altered, removed, or added in a trivial way to captured images of real scenes. These cues are **relative Retinal Image Size, Height in Visual Field, Parallel Perspective, Foreshortening** and **Interposition**.

Based in the *Handbook of Camera Monitor Systems by Anestis Terzis*, with a good control and a **Cue Combination** we can generate the sensation of depth and distance in 2D image:

- Texture Density Gradient
- Blur from Defocusing
- Artificial Blur from defocus
- Shading as Depth Cue (Shading handle or improve)
- Saturation

We can Create a 2D projection with depth perception, example of Enhanced Texture and Depth Perception:

Fig. 17 The local contrast is increased from *left* to *right*. With growing neuronal stimulation at edges the cue of depth from texture gradient gets stronger. Therefore, the sensation of depth increases from *left* to *right* (**a** Bilateral filtered; **b** Original; **c** Unsharp masking)

Figure 9. Handbook of Camera Monitor Systems, Human Depth Perception, Monocular Depth Perception (pages 301-307)

On the other hand, if strong cues are not present (e.g. binocularity for 2D images), the visual system automatically evaluates the available (monocular) cues to gather the required distance information.

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

PANASONIC FEEDBACK:

CMS malfunction

OEM should define the CMS safety concept and the Tier I should implement it based on ISO 26262 (functional safety) as defined in both ECE R46 and ISO 16505. The safety concept should include all indications that will be provided to the driver in case of malfunction (e.g. visible / audible / haptic warning signal, message display, etc.).

Typical Hazards of CMS:

- No image (display completely dark).
- Image does not clearly display scenery according specification (e.g. adaptation to varying light conditions fails, leading to an overly dark or bright image).
- Frozen image (formerly correct image appears continuously as still image).
- Delayed image w.r.t. reality (more than specification allows).

- Wrong field of view.
- Wrong or unexpected zoom factor (e.g. wide-angle zoom factor for parking mode displayed on highway, making objects appear further away than they actually are).
- Artifacts on display (e.g. double or phantom objects, light spots, dark areas).

Software Updates

ISO 13400-1:2011 describes the general use cases and communication scenarios which are covered by an Internet Protocol-based vehicle communication standard. Each use case drives specific communication capabilities of the vehicle communication interface, for instance in order to be interoperable in an existing computer network.

The diagnostic communication over Internet Protocol (DoIP) protocol supports the standardized service primitive interface as specified in ISO 14229-2.

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

12. NHTSA seeks 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, NHTSA seeks 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.

PANASONIC FEEDBACK:

ECE R46 and ISO 16505 include minimum monitor integration requirements to guarantee that the position won't affect vehicle safety. Although both regulations complement each other, ECE R46 regulation is more restrictive in terms of monitor arrangement:

Thus, the image of the right side field of view shall be presented to the right of the longitudinal vertical plane through the ocular reference point […]. The image of the left side field of view shall be presented to the left of the longitudinal vertical plane through the ocular reference point.

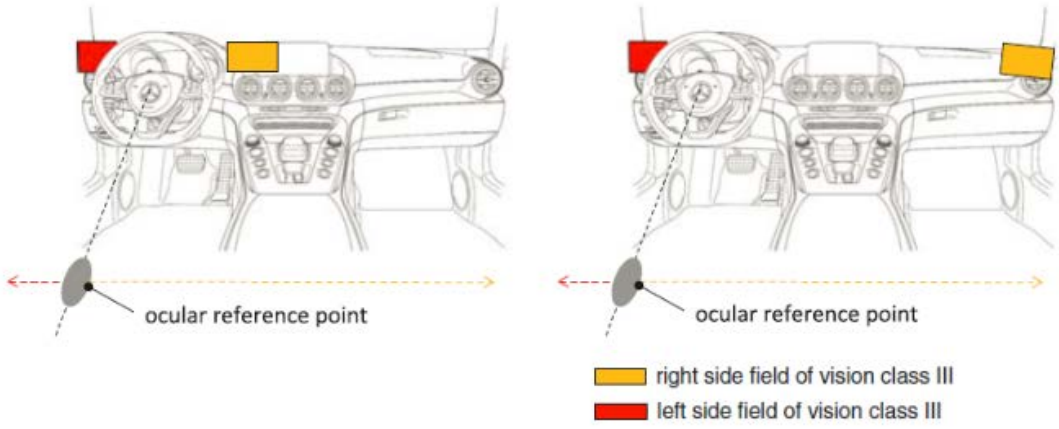

Fig. 22 Examples for permitted monitor arrangements of a Class III CMS (© Daimler AG)

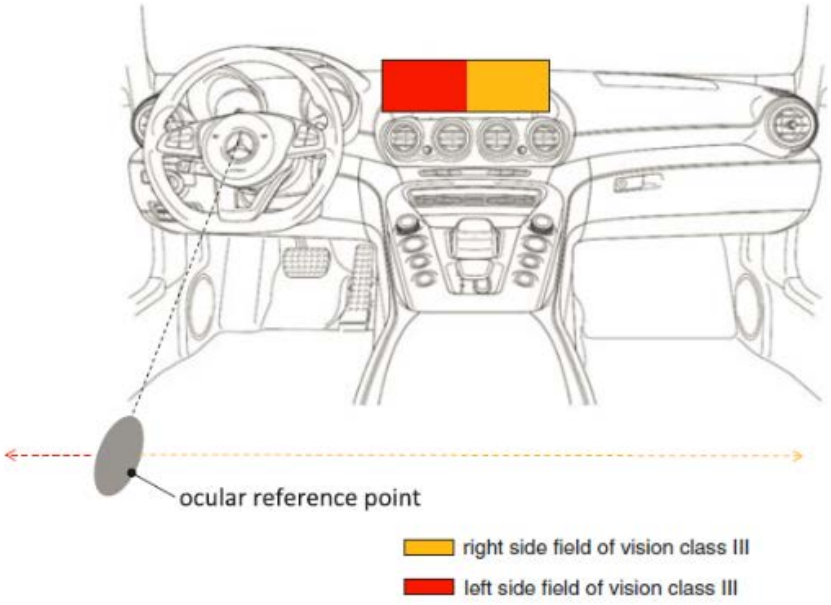

Fig. 23 Example for a monitor arrangement of Class III CMS which is not permitted by UN R-46 (© Daimler AG)

Figure 10. Handbook of Camera Monitor Systems, Requirements for CMS in UN Regulation No. 46, Requirements for Class I–IV Camera Monitor Systems (pages 77-86)

European regulation also takes into account the maximum blind spot on the direct field of view caused by the monitor integration (ECE R125 – Uniform provisions concerning the approval of motor vehicles with regard to the forward field of vision of the motor vehicle driver). These requirements guarantee that the obstructions created by the different vehicle components ("A" pillars, mirror division bars, windscreen wipers, camera-monitor devices, etc.) are kept to the minimum.

13. NHTSA seeks 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.

PANASONIC FEEDBACK:

ECE R46 and ISO 16505 have specific requirements to guarantee that the CMS will perform correctly under specific lighting conditions. These test procedures were designed based on SAE J1757:2007 and ISO 15008:2009 standards. Following points shall be noted:

- Contrast requirements for night condition differ between ECE R46 and ISO 16505 (10:1 for ECE R46 and 5:1 for ISO 16505 or ECE R46 interior mirror with dual function)
- Day condition with diffuse ambient light test procedure differs between ECE R46 and ISO 16505. While the luminance of the diffuse illuminator is fixed on ISO 16505, ECE R46 value is dependent of the vehicle integration. Although this point only applies to the described test, it shall be considered to use same procedure for determining the maximum ambient illumination range in direct sunlight test
- Inclination angle delta used in luminance and contrast rendering test should be changed to be aligned with last revision of SAE J1757:2015 and ISO 15008:2017 (from 15 to 20 deg)

ECE R46 test description

6.2.2.3.3.2. Luminance and contrast rendering
For luminance and contrast rendering the following requirements shall apply:
(a) The minimum luminance contrast at the monitor (including any screen protector) reproducing a high contrast pattern shall be:
(i) For direct sunlight condition: 2:1;
(ii) For day condition with diffuse ambient light: 3:1;
(iii) For sunset condition: 2:1;
(iv) For night condition: 10:1 except in the case of Mirror and CMS dual function system of class I: 5:1.
(b) The night condition for the camera's field of view is replicated in a dark environment such that the maximum illuminance on the objects to be measured shall not exceed 2.0 lx;
(c) The background luminance of the monitor shall be limited under the night condition. The maximum background luminance under the night condition shall be less than 2.0 cd/m²;
(d) The instructions for use shall contain a note that sunlight or light from other intense light source upon the monitor reduces the luminance contrast which may require the driver to be particularly alert and attentive.

6.2.2.3.3.2.1. Day condition with diffuse sky-light exposure test

For the day condition with diffuse sky-light exposure, the test method given in ISO 16505:2015, subclause 7.8.2., Test 2 shall be applied, but a value of 4,000 to 4,200 cd/m2 for luminance diffuse illuminator shall be used.

At the request of the manufacturer, the value for luminance diffuse illuminator may be determined by using the diagram of figure below.

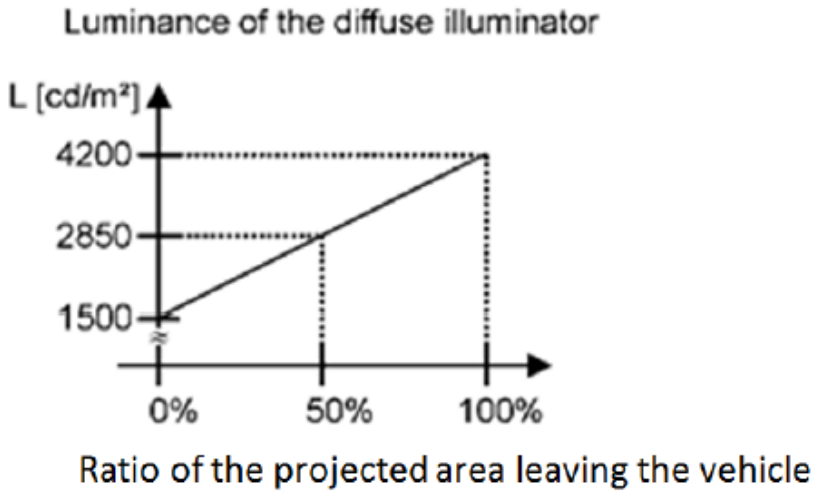

Figure 11. Ratio of projected area vs. luminance of the diffuse illuminator

Procedure for determining the ration of the projected area leaving the vehicle:

(a) Determine the projected area in the vehicle that represents the mirror reflected direction from the monitor extended isotropy range.
(b) Evaluation shall be made in the centre of the monitor defined size, under consideration of the monitor design viewing direction (see figure below).

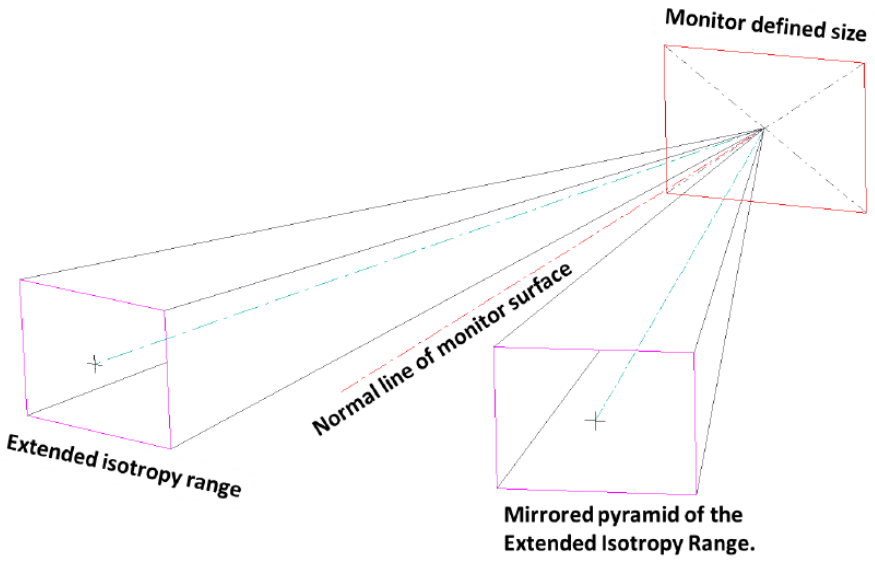

Figure 12. ECE R46 procedure for determining the ratio of the projected area leaving the vehicle

Based on virtual testing, evaluate the ratio of the projected area that leaves the vehicle openings (e.g. through a side door window, rear window or sunroof; however, for example a sunroof having an opaque shutter shall not be considered an opening).

Case when the orientation of the mirror and CMS dual function system of Class I is adjustable:

Based on virtual testing, if the applicant demonstrates that the Mirror and CMS dual function system of Class I adjustment range permits a driver to avoid any incident specular light from the vehicle opening while a driver's eye is within any fixed position of the standard isotropy range, then the value for luminance diffuse illuminator shall be the one of ISO 16505:2015 subclause 7.8.2., Test 2: 1,300 to 1,500 cd/m².

Camera Durability, Reliability, and Related Test Procedures

14. NHTSA seeks comment on the anticipated lifespan of the electronic visual display and camera components Start Printed Page 54539that 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?

PANASONIC FEEDBACK:

Similar to any other automotive product, CMS reliability requirements should be defined by the OEM and agreed with the Tier I considering the complete lifespan of the product. Although no specific CMS reliability requirements are described in ISO 16505 or ECE R46, product deterioration should be considered when defining these requirements (i.e. display brightness might decrease after several working hours) or CMS requirements should be decreased if they apply to the complete product lifespan. Similar requirements applicable to backup cameras are proposed for CMS after durability tests (field of view and magnification factor).

Nevertheless, in the current projects of CMS this is taken in consideration according to an OEM Requirement. There are some strategies to handle with this, a recommendation and the most critical point is the display brightness behavior that is decreasing against the time handle. For that we can start to know the Display Decrease Rate of Brightness vs Time table (Display Datasheet Information), since here we can provide some specific solutions to solve it, since a software control strategy that consider a time counter and perform a brightness compensation response or others strategies, but again all this according to the OEM requirements.

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15. NHTSA seeks 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.

PANASONIC FEEDBACK:

According to ECE R46, equivalent reliability requirements apply between CMS and outside rearview mirrors. Based on FICOSA expertise as manufacturer for Audi e-tron CMS and Audi e-tron outside rear mirror, both products where designed taking into account similar reliability requirements.

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17. NHTSA seeks 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?

PANASONC FEEDBACK:

CMS requirements at both component and vehicle level should take into account water ingress protection and soiling conditions which are dependent of camera mounting and CMS design. Several water protection mechanisms shall be considered during CMS design (lens coatings, protecting cover glass, heater, etc.). FMVSS 111 durability tests should be adequate for evaluating these requirements although usually they are complemented with specific OEM requirements.

When the CMS is integrated in a proper way it offers an advantage during rainy conditions. As the camera lens surface is largely smaller in comparison with a conventional mirror and as the water droplets are outside the depth of focus of the camera, the road visibility is improved when using a CMS. While the conventional mirror and the lateral window are highly affected by the water droplets, the monitor is showing a clear image from the interior of the car.

Figure 13. CMS performance evaluation under rainy weather condition ©FICOSA International SA

Additional information can be found in *Handbook of Camera Monitor Systems, section 3.5.8 Behavior in Extreme Cold and Heat* for more details.

18. Depending on the mounting location, cameras may be subject to environmentally-caused lens obstructions (e.g., dirt, ice, rain drops). NHTSA seeks 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?

PANASONIC FEEDBACK:

Similar reliability requirements should apply to both rearview mirrors and CMS. As the camera lens surface is largely smaller in comparison with a conventional mirror and as the soil is outside the depth of focus of the camera, the road visibility is improved when using a CMS. See *Handbook of Camera Monitor Systems, section 3.5.9 Effects of Soiling* for more details.

Fig. 54 Monitor image with soiling, step 2

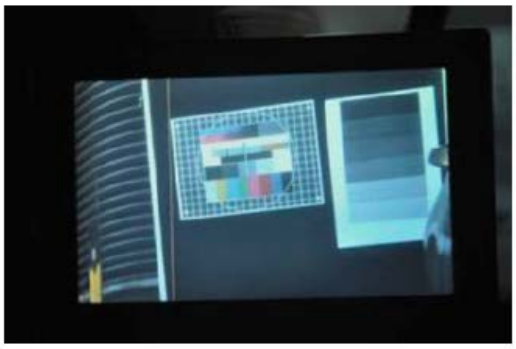

Fig. 55 Mirror image with soiling, step 2

Figure 14. Soiling comparison between CMS and conventional mirror. Handbook of Camera Monitor Systems, Effects of Soiling (pages 405-407)

System Availability When Vehicle Ignition Is Off

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. The agency seeks 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?

PANASONIC FEEDBACK:

ECE R46 activation and deactivation requirements should be used as reference, which describes the maximum start-up time of the system at different conditions:

16.1.1. Intended use, activation and deactivation

The intended use shall be mentioned within the operator's manual. The procedure for activation and deactivation of the CMS of Classes II and III shall allow a safe use of the vehicle.

CMS shall be activated when the vehicle is opened (e.g. unlocking of the doors, opening of a front door or any other means by the choice of the manufacturer).

In addition to the requirements mentioned in paragraph 15.2.1.1.2., after each engine switch-off the system shall remain operational for a period of at least T1 = 120 s. After T1 period and for a period of at least T2 = (420-T1) seconds the system shall be able to be reactivated such that the required field of vision is made available within 1 second by maneuvering any front door opening automatically and, if available, manually by the driver. After T2 period the system shall be able to be reactivated within 7 seconds (e.g. by initiating any front door opening process).

Notwithstanding the provisions above, any other concept to activate or deactivate the system shall be demonstrated to the satisfaction of the Technical Service within the safety concept that is provided according to the provisions in Annex 12, paragraph 2.

Additional information can be found also in the *Handbook of Camera Monitor Systems by Anestis Terzis, section 3.2.3 Installation Requirements*:

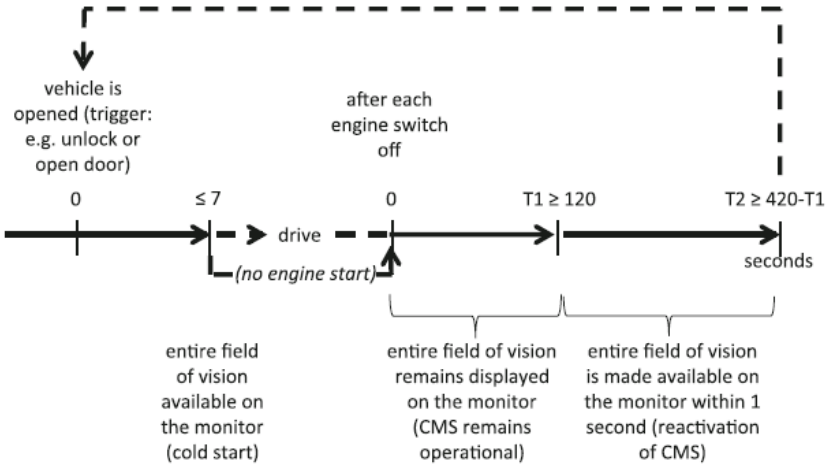

Fig. 21 System availability—activation and deactivation

Figure 15. Handbook of Camera Monitor Systems, Requirements for CMS in UN Regulation No. 46, Requirements for Class I–IV Camera Monitor Systems (pages 77-86)

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?

PANASONIC FEEDBACK:

Wing mechanical requirements shall be considered as same FMVSS 111 requirements applicable to conventional rearview mirrors should be defined for CMS wing. Similar procedure was done in Europe for ECE R46, where both mirrors and CMS are described to guarantee that both products fulfill mechanical reliability tests.

Additional Feedback (based on ANPRM)

1. To what extent should the performance requirements and procedures from UNECE R46 be used as a foundation for updating FMVSS 111? Is there a need to amend any specific aspects of this standard?

PANASONIC FEEDBACK:

ECE R46 should be considered as baseline as it covers all main relevant aspects of a CMS. ISO 16505 should be considered also although both standards complement each other. Following requirements are identified:

ISO 16505	ECE R46	Requirement	Comments
Intended use			
NA	16.1.1	Activation and deactivation	Similar to FMVSS 111
6.1.1	16.1.1.1	Default view	
6.1.2	NA	Adjusted default view	ISO 16505 requirements should be included on FMVSS 111 to extend CMS functionality on specific use cases (parking, lane change, etc.)
6.1.3	NA	Temporary modified view	
6.1.4	6.2.2.3.1 16.1.1.2	Luminance and contrast adjustment	
6.1.5	16.1.1.3	Overlays	ECE R46 requirements are more restrictive
6.2	6.2.2.3.2 16.1.2	Operating readiness (system availability)	
6.3	15.2.4.3.2	Field of view	
6.4.1	16.1.3.1	Average magnification factor	ECE R46 magnification factors should be considered in order to achieve greater FOV values than conventional mirrors
6.4.2	16.1.3.1	Minimum magnification factor	
6.4.3	16.1.3.2	Resolution (MTF)	
6.5	16.1.4	Magnification aspect ratio	
6.6	16.1.5 16.1.6	Monitor integration inside the vehicle	
Image quality			
6.7.1.1	6.2.2.3.3.1.1	Directional uniformity	
6.7.1.2	6.2.2.3.3.1.2	Lateral uniformity	
6.7.2	6.2.2.3.3.2	Luminance and contrast rendering - direct sunlight	Vehicle integration should be considered as the quantity of light projected on the monitor

6.7.2	6.2.2.3.3.2	Luminance and contrast rendering - day condition with diffuse ambient light	can be reduced by design (see ECE R46 6.2.2.3.3.2.1.) Inclination angle delta should be changed from 15 to 20 degrees as it was done in SAE J1757:2015 and ISO 15008:2017
6.7.2	6.2.2.3.3.2	Luminance and contrast rendering - night condition	
6.7.2	6.2.2.3.3.2	Luminance and contrast rendering - sunset condition, camera artefacts	
6.7.2	6.2.2.3.3.2	Luminance and contrast rendering - sunset condition, camera contrast	
NA	6.2.2.3.3.3	Grey scale rendering	ECE R46 test method should be considered
6.7.3	6.2.2.3.3.4	Color rendering	
6.7.4.1	6.2.2.3.3.5.1	Smear	
6.7.4.2	6.2.2.3.3.5.2	Blooming and lens flare	
6.7.4.3	6.2.2.3.3.5.3	Point light sources	ECE R46 test method should be considered
6.7.4.4	NA	Color noise	
6.7.4.5	NA	Chromatic aberration	
6.7.5.1	6.2.2.3.3.6.1	Sharpness	
6.7.5.2	6.2.2.3.3.6.2	Depth of field	
6.7.6	6.2.2.3.3.7	Geometric distortion	
6.7.7.1	NA	Pixel faults	
6.7.7.2	6.2.2.3.3.8.1	Flicker	
6.7.7.3	NA	Visual artefacts	
6.7.7.4	NA	Gloss of the monitor housing	
Time behavior			
6.8.1	6.2.2.3.4.1	Frame rate	
6.8.2	6.2.2.3.4.2	Image formation time	
6.8.3	6.2.2.3.4.3	System latency	
6.9	NA	Failure behavior	
6.10.1.1	16.1.7	Decreasing accommodation	
6.10.1.2	6.2.2.3.5.1	Glare due to high luminance of the monitor	
6.11	NA	Influences from weather and environment	

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2. Should CMS be excluded from the FMVSS 111 requirements for S.5.5.4 (linger time), S.5.5.5 (deactivation) in cases where the CMS is also used to meet the rear visibility requirements for back up cameras? (i.e. when the CMS display is dual-purpose).

PANASONIC FEEDBACK:

Panasonic recommends that CMS be displayed during all driving conditions as it provides safety driving information to the driver. If a CMS display has a dual-purpose, we suggest keeping at least minimum CMS FOV requirements visible and to include a picture-in-picture mode for backup camera. See question 6 for additional details.

REFERENCES:

U.S. Department of Transportation, National Highway Traffic Safety Administration, TP-111V-01. Laboratory Test Procedure for FMVSS 111, https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/tp-111-v-01-final.pdf

UN Regulation No. 46 (Devices for indirect vision): ECE/TRANS/WP.29/2015/84. Uniform provisions concerning the approval of devices for indirect vision and of motor vehicles with regard to the installation of these devices, https://www.unece.org/fileadmin/DAM/trans/doc/2015/wp29/ECE-TRANS-WP29-2015-084e.pdf

ISO 16505:2019, Road vehicles — Ergonomic and performance aspects of Camera Monitor Systems — Requirements and test procedures, https://www.iso.org/standard/72000.html

Terzis, A. (2016). Handbook of Camera Monitor Systems. The Automotive Mirror-Replacement Technology based on ISO 16505. Springer International Publishing, https://www.springer.com/gp/book/9783319296098

ISO 15008:2017, Road vehicles — Ergonomic aspects of transport information and control systems — Specifications and test procedures for in-vehicle visual presentation, https://www.iso.org/standard/62784.html

SAE J1757/1_201505, Standard metrology for vehicular displays, https://www.sae.org/standards/content/j1757/1_201505/

UN Regulation No. 125: E/ECE/324/Rev.2/Add.124/Rev.2, E/ECE/TRANS/505/Rev.2/Add.124/Rev.2. Uniform provisions concerning the approval of motor vehicles with regard to the forward field of vision of the motor vehicle driver: https://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/2013/R125r2e.pdf

ISO 13400-1:2011, Road vehicles — Diagnostic communication over Internet Protocol (DoIP) — Part 1: General information and use case definition, https://www.iso.org/standard/53765.html

Panasonic thanks NHTSA for their the opportunity to provide feedback to the ANPRM. Please contact the undersigned if you have any questions or would like additional information.

Respectfully submitted,

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