HYUNDAI MOBIS

December 3, 2019

James Owens
Acting Administrator
National Highway Traffic Safety Administration
1200 New Jersey Avenue S.E., West Building
Washington D.C. 20590-0001

Subject: Federal Motor Vehicle Safety Standard No. 111, Rear Visibility; Camera Monitoring System
Notice of Proposed Rulemaking, Docket No. NHTSA-2018-0021, October 10, 2019, 84 FR 54533

Dear Acting Administrator Owens,

Hyundai MOBIS, a Tier 1 automotive supplier, affiliated with Hyundai Motor Group, appreciates the opportunity to provide input on the National Highway Traffic Safety Administration's (NHTSA's) Notice of Proposed Rulemaking for Camera Monitoring Systems (CMS). In North America, Hyundai MOBIS Technical Center develops autonomous and advanced driver assistance systems technology. Hyundai MOBIS is currently developing CMS to replace the side mirrors on both sides and the rearview mirror, which recognize the rear and posterolateral driving environments while displaying them in real-time on monitors located in the vehicle.

Our comments, which were developed in an effort to provide NHTSA with technical information and data pertinent to this rulemaking, were prepared with the support of our advanced engineering teams which have extensive experience and expertise with CMS. Hyundai MOBIS has extensive experience and knowledge of current research and best practices for CMS – this includes test procedures published from the International Organization for Standardization (ISO) and the United Nations Economic commission.

Hyundai MOBIS appreciates NHTSA's consideration of our comments. For related questions, please contact Joseph Dadoush, via email jdadoush@mobis-usa.com, or phone 248-819-2986.

Based on our experience with CMS, we offer the following input.

Respectfully submitted,

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Existing Industry (Standards)

Question 1: Please explain your views on how CMS-equipped vehicles would impact light and heavy vehicle driver behavior and situational awareness while driving.

Hyundai MOBIS RESPONSE:

(1) While driving, CMS would make it possible to zoom in or out temporarily (e.g. for the purpose of increased field of view when executing lane changes), which would affect a drivers' perception of vehicles that are proximate to the CMS vehicle. A driver may misunderstand the distance of vehicle behind them, which may increase the chances of an accident. These comments are based on our current development of CMS for interior and side mirrors.

Question 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?

Hyundai MOBIS Response:

(2) As the driver moves or turns their head, the CMS must be able to show the typical or desired viewing angle through any manipulation (e.g. Region of Interest (ROI) adjustment) to offset the loss of mirror specific properties. The CMS viewing angle (ROI) can be adjusted through a power mirror switch on the driver's door module.

Question 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?

Hyundai MOBIS Response:

(3) When frame rate (Hz) is low, it may be an obstacle to driving due to heterogeneity caused by the discontinuity of object movement at high speed (e.g. dizziness).
We recommend 60 Hz operation for daytime driving and 30 Hz or more for nighttime driving (which is more stringent than UN R46, 6.2.2.3.4.1), to offset the effect of driver dizziness.
UN R46, 6.2.2.3.4.1 Frame Rate

Movements of objects in front of the camera shall be rendered smooth and fluid. The minimum frame rate of the system (update rate of the image information) shall be at least 30 Hz. At low light conditions or while maneuvering at low speed, the minimum frame rate of the system (i.e. update rate of the image information) shall be at least 15 Hz.
It is necessary to specify the speed limit guaranteed by CMS for high speed driving, drivers will need to be aware that beyond certain high speeds, it is possible the CMS may delay the image shown on screen. Hyundai MOBIS is developing CMS utilizing test procedures with a speed of 150 km/h (93.2 mph) without image disruption and no latency detected to the naked eye.
As the image represented by CMS may have a delay compared to the mirror, it is necessary to call attention to the driver by specifying the high-speed driving (speed – km/h or mph) that CMS guarantees.

System Field of View and Related Test Procedures

Question 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.

Hyundai MOBIS Response:

(4) When the CMS Field of View (FOV) is set to a level similar to mirrors, the CMS FOV should be applied differently to reduce potential blind spots because the CMS viewing angle is unlike the viewing angle found with traditional mirrors.
If the display is small, the FOV needs to be increased to ensure sufficient viewing angle for limited display size.

Question 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?

Hyundai MOBIS Response:

(5) There has been insufficient research on the use of multiple cameras to provide multiple FOV to the driver in the same image display area. One screen display of multiple FOVs can show the overall vehicle environment at a glance, and it can solve the problem of limiting the mounting position of the displays due to the use of a single display. However, heterogeneity is expected when CMS is used due to the deviation from conventional mirror positioning.

It is expected that driver confusion and adaptation will result if multiple views within a single display are provided; further suggestions are needed to clearly distinguish between views. (E.g. For drivers to understand separation defined between views in the display).

Questions 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.

Hyundai MOBIS Response:

(6) It is possible to combine the rear camera and the CMS (e.g. use the camera for rearview and CMS simultaneously) if the sharpness requirement is eased in UN R46 regulation.
Typically, rear cameras utilize wide angle cameras, while CMS cameras utilize narrow angle cameras.
Currently, UN R46 regulation and ISO 16505 regulate the CMS to provide a certain level of modulation transfer function (MTF) performance.

(a) Horizontal and vertical $MTF50_{(1:1)}$ at center

$$MTF50_{(1:1)} \geq \frac{1}{2} MTF10_{MIN(1:1)}\langle LW|PH\rangle$$

(b) Horizontal and vertical $MTF50_{(1:1)}$ at corners (70 percent of image height)

$$MTF50_{(1:1)} \geq \frac{1}{2} \cdot \frac{1}{2} (MTF10_{MIN(1:1)})\langle LW|PH\rangle$$

As the purpose for use of rear camera and CMS are clearly different, combination is not allowed:

- CMS: provides a mirror level image without distortion.
- Rear Camera: There is distortion around the image by applying a wide-angle camera to recognize obstacles in a wide range viewing angle (at least 130 degrees), when reversing.

Rearview Image Display Type Related Human Factors

Question 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.

Hyundai MOBIS Response:

(9) When viewing distant images while driving, dizziness may occur due to the change of focus when viewing the display at close range.

Question 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.

Hyundai MOBIS Response:

(11) CMS malfunctions should be displayed to the driver via some type of On-Screen Display (OSD). The OSD should show on the monitor, where the malfunction has occurred, in order to be recognized by drivers. If the screen does not power on due to a monitor malfunction, it is necessary to show the fault status via another channel such as the instrument cluster's telltales or through the vehicle infotainment system screen (E.g. Display with phrases ((L/R) No camera input, (L/R) No display output, etc.) or some icons for redundancy.

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

Question 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.

Hyundai MOBIS Response:

(12) It may be difficult to respond if the display is placed at a location other than the A-pillar, when it is necessary to check the front side and the rear side at the same time such as lane change while driving (e.g. lane change in traffic situation).
UN R46: 16.1.5.2.
The arrangement of the monitor(s) inside the vehicle shall be convenient to the driver. 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, defined in paragraph 12.6. 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.
If the CMS shows more than one field of vision on one display, non-continuous images shall be clearly separated from each other. Provided that the required field of vision of different classes of devices for indirect vision are shown on the monitor(s) without hiding any part of the required field of vision, a combined continuous image without clear separation is allowed.

System Availability When Vehicle Ignition is Off

Question 19: Although it is not one of the primary safety purposes of rearview mirrors, drivers often use the outside rearview mirrors after turning off the ignition and preparing to exit the vehicle to determine

whether it is safe to open the vehicle door when parked alongside a traffic lane. We seek comment on whether NHTSA consider requiring that a CMS be capable of serving this function by being operational in some capacity either at all times or for a specified period of time after opening the driver's car door. What new performance criteria would need to be developed for this purpose and what has been done to develop those criteria?

Hyundai MOBIS Response:

(19) The driver should be able to activate the CMS when needed to check the rear view at times even when the vehicle is off.
UN R46: 16.1.1. Intended use, activation and deactivation.
The CMS shall not 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, the requirements mention in paragraph, 15.2.1.1.2, after each engine switch-off the system shall remain operational for a period of at least T1 = 120s. 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 12.