January 10, 2020

The Honorable James Owens
Acting Administrator
National Highway Traffic Safety Administration
US Department of Transportation
1200 New Jersey Avenue, S.E.
Washington, DC 20590

Re: Advanced Notice of Proposed Rulemaking to Amend Federal Motor Vehicle Safety Standard (FMVSS) No. 111- Rear Visibility; Docket No. NHTSA-2018-0021

Dear Acting Administrator Owens,

Robert Bosch LLC ("Bosch") and its cooperation partner MEKRA Lang North America, LLC ("MEKRA Lang") appreciate the opportunity to provide their perspective on NHTSA's Advanced Notice of Proposed Rulemaking (ANPRM) concerning camera-based rear visibility systems (commonly referred to as "Camera Monitor Systems" or "CMS").

Bosch and MEKRA Lang strongly support the agency's efforts and believe it would be appropriate to permit incorporation of CMS technology into the U.S. commercial vehicle fleet.

CMS for Commercial Vehicles

Bosch and MEKRA Lang were among the first companies to introduce this technology into the market in Europe and our joint system was the first system to garner worldwide homologation according to ISO 16505 and UN/ECE-R46[1]. As this system is considered safety-relevant, it also fulfills the defined ASIL-rated safety goals according to ISO26262.

The display has been optimized to show several different fields of view based on different driving situations such as driving forward, turning left or right, reversing, and maneuvering. Due to the features and functionalities described below, we believe that CMS will improve safety in the commercial vehicle fleet by:

- Improving direct forward-looking view by removing the massive outer mirrors and introducing a monitor intelligently integrated into the A-pillars of the vehicle cab;
- Enhancing indirect rear-view, especially in challenging curve-driving situations, by enabling the driver to have optimum field of view of the truck and trailer;
- Dramatically improving nighttime visibility by providing automatic and manual adjustment to the brightness of the video displayed on the monitors within a predefined range; and
- Significantly reducing the risk of collisions of outer mirrors with other vehicles and objects due to high mounting position and slim design of the camera arm outside the cab.

[1] UN/ECE-R46 is available at the following link: http://www.unece.org/trans/main/wp29/wp29regs41-60.html

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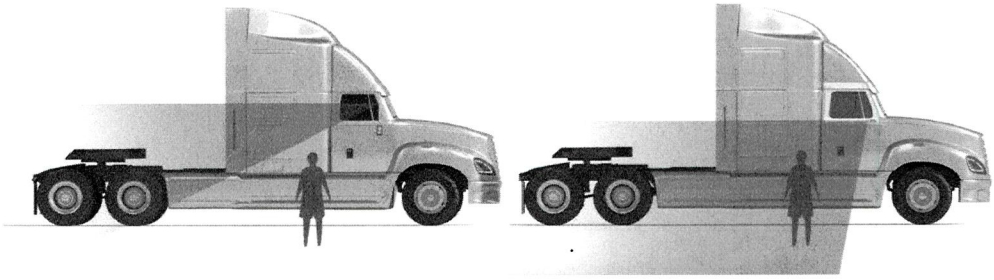
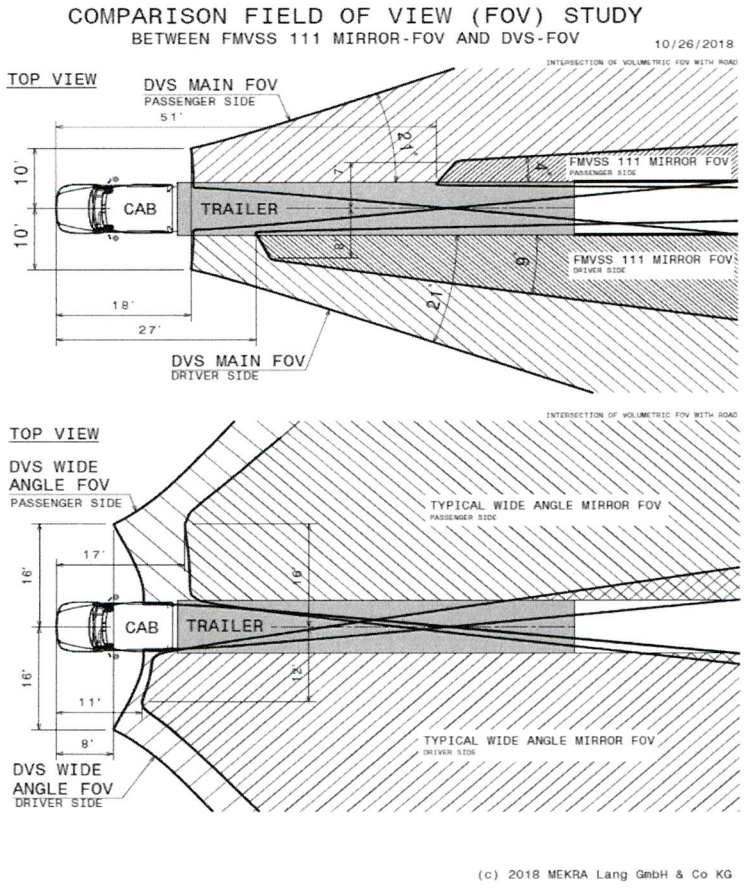
Illustration 1: Example of a blind-spot comparison between a conventional mirror and a CMS



Conventional Mirror Camera Monitor System

Illustration 2: Example of a field of view comparison between a conventional mirror and CMS
DVS = Digital Vision System (MEKRA Lang/Bosch system name) = CMS

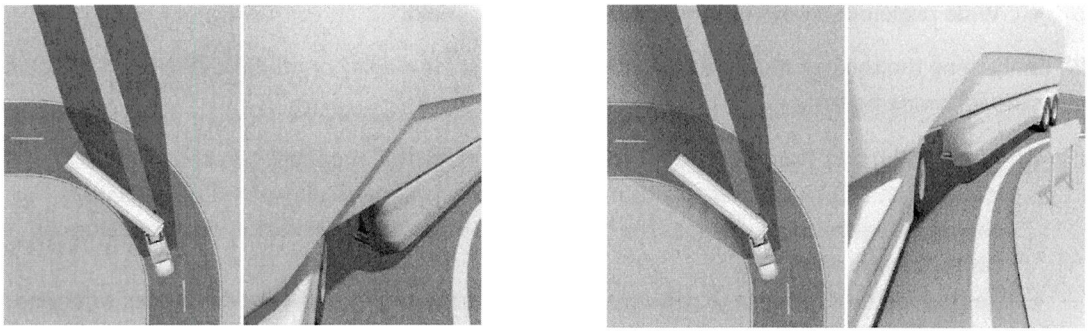


The CMS approach offers additional benefits, such as:

- Optimization of aerodynamics of the vehicle cab by exchanging classical mirrors with a slim camera arm that reduces air drag;

- Improvements in the ergonomics for the driver as the CMS concept allows automatic and manual adjustments of the field of view as well as brightness control;
- Intelligent integration in the driver's workplace with optimum positioning to provide clear and unobstructed view of the monitors thanks to optically bonded and specifically treated cover glass;
- Elimination of the manual removal of ice due to integrated heating of the external cameras; and
- Digital panning technology that provides dynamic field of view under specific driving conditions, specifically around curves and maneuvering.

Illustration 3: Example field of view comparison with and without "Digital panning" possible with CMS mirrors



FOV Without "Digital Panning"

FOV With "Digital Panning"

Bosch and MEKRA Lang reviewed the questions included in Section IV of the ANPRM and wish to offer the following information for NHTSA's consideration.

Existing Industry Standards:

(2) The physical properties of mirrors are not necessary to provide a clear and reasonably unobstructed view because a CMS fulfills the same purpose.

The following list included types of depth perception eliminated by the use of CMS but irrelevant to judge distances behind a semi-trailer:

- Binocular vision (Stereopsis) - works only up to 10m
- Convergence (Eyeball rotation to converge vision on a point) - works only up to 3m
- Accommodation (adjusting the lens to gain sharp image) - works only up to 2m

Types of depth perception still present when using CMS:

- Motion parallax
- Depth from motion
- Perspective
- Relative size
- Familiar size
- Aerial perspective
- Occultation
- Texture gradient

- Elevation

Further, it is possible to provide the driver with information about distances through overlays like "distance lines" within the shown image.

(3) The current Bosch and MEKRA Lang CMS fulfills all ISO 16505 and UN/ECE-R46 requirements. Where the two diverge, UN/ECE-R46 has been given preference since it is the legally binding document.

(4) Bosch and MEKRA Lang note that the positive effects of wider views include:

- Angular vibration effects are less noticeable;
- Situational awareness is dramatically increased; and
- Wide angle optical systems have a larger depth of field.

(5) Concerning the topic of multiple fields of view in the same display or multiple displays, we would offer the following points:

- Almost all trucks have a "main mirror" and a "spot mirror" mounted adjacent (on top of) each other. Displaying these fields of view together on one display or multiple displays should be permitted, as long as the images are permanently visible and do not overlap or obstruct each other.
- Temporary fields of view (e.g. picture in picture) should only be allowed in places where no mandatory field of view is obstructed.
- System latency must not be affected when displaying multiple Fields of View (FOV).
- Brightness and color-rendering mechanisms (e.g. exposure control, white balance, display white point, display backlight brightness control) for all displayed images or displays should be the same. (Rationale: looking at different displays should not change the visual impression/character of the displayed material).
- If the views originate from the same camera sensor the views will always be synchronized and equalized in brightness and color (emerging from the same image pipeline), therefore this setup is recommended.
- Homogeneous brightness and color rendering is of particular importance in case image content is intended for stitching.
- Stitching in general must not give rise to "lost" angular ranges within the FOV displayed.

System Field of View and Related Test Procedures:

(6) The image of a backup camera (for reversing motion) should not overlap or replace the main or wide angle required field of view of a CMS during reverse motion (i.e. while being on display). It could, however, be displayed in a designated area that is "reserved" for such view on the display or, alternatively, on an additional display. It is also conceivable that one of the other views could be displayed with smaller magnification to make space for this backup view depending on the driving situation. It should be possible to use a shared display showing Class VI while driving forward and the backup camera while driving in reverse.

Image Quality and Related Test Procedures:

(8) Present generation state of the art image sensors, also used in MEKRA Lang and Bosch's first generation CMS, are based on CMOS[2] sensor technology and as such show very little tendency for

[2] CMOS=Complementary Metal Oxide Semiconductor

blooming and smear. Bosch and MEKRA Lang would recommend that NHTSA consider alignment with the requirements specified in ISO 16505 and UN/ECE-R46.

As far as displays are concerned, the loss of contrast by external light is adequately addressed by the regulations mentioned above ("contrast rendering"). In addition, we deem adequate a provision for mandatory manual control of display (backlight) brightness since different driving situations may require different settings (e.g. long-distance highway driving in the dark vs. poorly illuminated areas in townships).

Rearview Image Display Type Related Human Factors:

(9) Display brightness and frame rate can induce fatigue (>=50 fps recommended). It is important that the brightness of the display is adjusted to be sufficient for the ambient lighting situation and sufficiently dark during certain scenarios such as long distance highway driving.

High dynamic range (HDR) cameras are typically required to capture real scene dynamic range. One resource on this topic would be the Institute of Electrical and Electronics Engineers Standards Association (IEEE-SA) P2020 Automotive Image Quality Working Group (P2020 Working Group)[3] (see p2020wg efforts to adequately define the dynamic range for HDR - in conjunction with typical noise phenomena).

Since typical displays cannot render HDR, there is a need for contrast reduction (compression, brought about by so-called tone mapping). The provisions set forth by the Chapter entitled "grey scale rendering" of the existing regulation UN/ECE-R46 (6.2.2.3.3.3.) are useful and should be seen as minimum requirement. Development of new Key Performance Indicators (KPIs), which might supersede the current provisions, is under way but will likely not be included in the first version of the p2020wg standard draft.

(10) The ability to discern and focus on objects is afforded by the capabilities of the human eye. The average human can discern objects or points that result in a 1 arc minute viewing angle. Current state of the art CMS and the resolution of the displays fulfill or exceed this at recommended viewing distances depending on the PPI (pixel per inch) of the display.

(11) Concerning the question of how a driver should be alerted that a CMS is not operating correctly, such as during a malfunction or a software update, Bosch and MEKRA Lang would note that there are different warnings of which some are listed below. [Availability based on customer specifications]

- Overlay for system without calibration
- Overlay for foldable camera arm out of position (camera does not record required field of view)
- Black screen (safe state of system, functional safety mechanism)

We would strongly discourage the permission for over the air (OTA) software (SW) updates (or any SW updates) to be done while the vehicle is in a driving mode. Safer schemes can be envisioned (e.g. download while driving and update upon engine shutdown). Still, strong security measures to avoid misuse/malfunction have to be ensured.

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[3] P2020 Working Group. Please refer to the following website for additional information: https://site.ieee.org/sagroups-2020/

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

(12) ISO 16505 states that images from cameras on the left hand side must be displayed left of the driver, and images from cameras on the right hand side must be displayed to the right of the driver.

While "innovative" display screen placements are conceivable, it is to be expected that a significant amount of drivers will be exposed to driving both trucks with and without CMS. In the interest of safety, the look and feel of a CMS should therefore resemble the usual one of classical mirrors, while warranting the improvement of direct view provided by these systems.

(13) Refer to question (8): ISO 16505 and UN/ECE-R46 make provisions about system performance under direct sunlight impinging on the camera lens, which are achieved by state of the art cameras. Glare may emerge from dust and dirt on the lens and/or protective glass surface and appropriate instructions on how to remove dust and dirt should be included in the operator's manual.

Camera Durability, Reliability, and Related Test Procedures:

(14) The image quality over the lifetime of the vehicle will naturally decrease due to environmental influences (e.g. temperatures, humidity, dust, corrosion). Lifetime of a vehicle is different for each vehicle based on its intended function (e.g. heavy duty, earth moving, highway, city traffic). Therefore, it is not possible to ensure all parameters for the extended lifetime (e.g. 30 years...). It will be necessary to establish a scheduled maintenance cadence over each vehicle's lifetime based on expected degradation and on-board vehicle diagnostics.

(15) Current experience is that OEMs expect comparable reliability performance from a CMS as for classical mirrors and define their test requirements accordingly.

(17) ISO 16750 is considered as state of the art and describes different tests to validate electronics in road traffic.

(18) Hydrophobic coating of the lens can be used to minimize dirt/water droplets on the lens. In addition, heating systems for de-icing the optical system can be utilized. Optimization of aerodynamic design is recommended for minimization of droplet and dirt accumulation on lens surfaces.

System Availability When Vehicle Ignition Is Off:

(19) We would recommend a review of the relevant sections of ISO 16505 and UN/ECE-R46: e.g. the system has to be in operation mode "on" for 120 s after shutting down the vehicle and for another 300 s possible to restart in 1 s (standby). In addition, it is useful to have the possibility for a manual start of the system without system communication to the vehicle ("manual on" button). (Rationale would be to save power/battery by not enabling or booting up vehicle CAN system).

Miscellaneous:

(20) Bosch and MEKRA Lang would respectfully recommend that CMS should, at a minimum, be developed according to the safety aspects included in Annex 12 of UN/ECE-R46. Our current CMS has been developed according to the functional safety standard ISO 26262.

(21) Fuel economy will be improved with better vehicle aerodynamics by removing the large mirrors and replacing them with smaller cameras. Improvement of efficiency will vary depending on the overall aerodynamic concept of the OEM (vehicle-/cabin geometry). Due to partially higher speed limits in the US compared to Europe, fuel economy is expected to have higher impact.

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Conclusion

Bosch and MEKRA Lang appreciate NHTSA's ongoing efforts and research on this important topic and would respectfully recommend that NHTSA allow CMS technology to be installed as an alternative to mirrors which meet FMVSS No 111 rear visibility requirements. Thank you for your consideration of our input and feedback.

If you have any questions, please do not hesitate to contact Ana Meuwissen at Bosch at 202/815-7645 or Ana.Meuwissen@us.bosch.com or Stefan Paul at MEKRA Lang North America, LLC at 803/337-4998 or Stefan.Paul@mekralang.us.

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