NHTSA – CMS - Feedback

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To what extent could possible CMS features which cannot be provided using mirrors (e.g. zoom, night vision) offset the loss of mirror-specific properties (e.g. depth perception, ability to rapidly change FOV by changing head position)?

Feature	CMS Capability	Mirror Capability
Zoom	Manual or automatic zoom could be focused towards the most critical point within field of view of the camera	Not available
Night Vision	Digital cameras and specific IQ algorithms allow improved night performance even for people with night vision difficulties	Limited to what human eyes can see
Blinding by Bright Lights	No blinding by any kind of lights due to reflections	High likelihood of being blinded
Depth Perception	Depth perception can be supported by implementation of graphic overlays. Users can adopt to this augmented 3D information over time.	Full 3D information available. No overlays available to support mis-judged distances
Change of FOV	Careful system design can provide a FOV in a digital display that is larger than the FOV provided by a traditional mirror, thus reducing the requirement for head movement to adjust FOV. Manual FOV panning and automatic (triggered by driver-facing sensor) FOV panning can also be implemented; these features can benefit users with limited physical range of motion	Good performance; only limited by range of motion of the driver.

To what extent could possible CMS features which cannot be provided using mirrors (e.g. zoom, night vision) offset the loss of mirror-specific properties (e.g. depth perception, ability to rapidly change FOV by changing head position)? Continued

Feature	CMS Capability	Mirror Capability
Advanced Warnings	As any kind of overlay can be shown on display, smart new dynamic overlays (HMI) lead to quicker understanding of situations based on detection algorithms.	NO advanced warnings available. Only icon in glass (static).
ADAS	CMS camera sensors can be used to contribute ADAS data & features to a vehicle to support pre-crash applications, warnings, parking, emergency stop for reverse drive, etc.	Conventional mirrors offer no ADAS support without additional sensors
Lane Change Assist	Extended FOV during lane change allows full coverage of blind spot	Blind spots are difficult or impossible (based on geometry and glass swing of a particular vehicle) to mitigate with traditional mirrors
Ground View	Extended view e.g. on the bottom of the FOV (display) helps means that objects adjacent to the rear-facing FOV (e.g. Road shoulder, curbs) are simultaneously visible without the need to adjust the FOV	By moving mirror glass down showns bottom and hence changes FOV

Comment on performance of current world-market vehicles equipped with CMS when evaluated according to ISO 16505/UNECE R46.

Feature	ISO 16505	R46
German PV OEM	Compliant (expected) Display technology is very good during night (true black, very high contrast) but not as good during day time (wash out), as installation is key for performance. Active visible area is limiting the FOV due to „magnification factor“	Compliant (expected)
Japan PV OEM	Compliant (expected)	Not sold in EU Auto-zoom is critical due to rapid changes of distance perception
German Truck OEM	Compliant (expected)	Compliant (expected)

Whether NHTSA should permit CMS that use multiple cameras to provide multiple fields of view to the driver in the same image display area

Requirement	Pro	Con
Multiple camera FOV in (1) digital display	By combining information in a smart way, multiple FOV can be represented on a single display. For example, backup camera and interior mirror views can be presented as a vertically-stacked, panoramic view to enhance comprehension of rear conditions & limit required head movement of the driver.	Careful display location & packaging is critical to expedite acceptance and reduce confusion of the driver; poor display placement has the potential to degrade benefits of this type of display.
	Stitching of multiple FOV from multiple cameras on the same side of a vehicle (i.e. Commercial vehicles) can lead to better understanding of ground conditions, surround traffic, pedestrians, etc.	Display placement is again critical; displays should be placed in such a way that the driver is not discouraged from checking their traditional blind spots (by looking out side windows).

What are the concerns, if any, regarding a multi-camera visibility system and how can they be mitigated?

Requirement	Concern	Mitigation
Multiple Camera in 1 Display	Blind spot	Cameras are not to be placed too far from each other for single focal point
	Vanishing objects	
	Information overload (too wide FOV)	Tailor the FOV for comfort and safety reasons in pre-defined driving situations
	Confusion by redundant information	Careful cropping & combination of multiple FOV; When multiple images are shown with redundant information, drivers may get confused by different magnification factors, sizes, positions; careful selection of camera optics and positioning is critical to prevent driver confusion/information overload.

What would be the appropriate minimum camera and visual display parameters and performance metrics for a CMS?

Explanation	Minimum camera angle	Minimum display parameter (size)
These two parameter are defined by driver to display distance and regulation required FOV (R46, FMVSS111, …)	~30° (horizontal) Less than mirrors have today (in Europe) Extension of blind spot Mounting position @ conventional mirror position Excluding production tolerances Excluding features such as panning	5 inch diagonal Displays should be packaged minimum of 50cm from the driver‘s eyes Excluding displays build in angles
Based on ISO 16505 and req. Magnfication factor	For a flat glass simulation, this angle might be a bit less, same with the display	

Should the parameters and metrics for a CMS differ from those for a backup camera system and, if so, how and to what extent?

Parameter	Back up camera	CMS
FOV	Designed for near field application (up to 10m)	Designed for near & far field application (>250m)
Durability	Only functional in defined situations (on-time is typically less than 5 min.)	Always on, before vehicle start, after vehicle turned off (thermal management, chip selection, environmental performance, EMC performance)
Functional safety (ISO 26262)	Not required	Required (ASIL B – ASIL C)
Component design	Camera (e.g. lenses, housings) and performance can vary noticeably over environmental conditions and generate performance outside ISO 16505 specs	System must always comply to all global standards
FPS	15fps to 30fps is industry norm	60fps is typical OEM spec
HDR	Usually no HDR (more analog VGA)	Full HDR with >120 dB necessary to overcome missleading images

How should a driver be alerted that a CMS is not operating correctly?

Parameter	Hazard cases	CMS
Omission	System has to identify such situations	Show image or text on display & send information via CAN for alternative warning on instrument cluster or infotainment
Latency	System has to function within specified latency requirements; any other delay must be managed	
Frozen image	System must not show incorrect rear information	
*Broken Display	Not possible to display image on CMS display	Send information via CAN for alternative warning (e.g. on instrument cluster, infotainment)
		Information in vehicle user hand book required

What is the anticipated lifespan of the electronic visual display and camera components

Lifespan	Passenger Vehicles	Commercial Vehicles
Display	15K – kilometer 10K - hours	1.500K – kilometer 50K - hours
Camera		
ECU		
System	100 fit (ISO 26262) (ASIL B)	100 fit (ISO 26262) (ASIL C)
Working time	Before and after vehicle driver (e.g. 300 sec after vehicle turned off)	Before and after vehicle driver (e.g. 300 sec after vehicle turned off) & Special turn off situation when vehicle is off. E.g. during night for vandalism checks or surrounding checks when parking

What is the anticipated replacement cost for a CMS that becomes inoperable?

Scenario 1 (display broken)	Scenario 2 (camera broken)	Scenario 3 (mechanical installation broken)	Scenario 3 (ECU broken)
Price of display + Repair shop costs	Price of camera + Repair shop costs	Price of camera pod (usually incl. camera) as this camera is calibrated with the wing) + Repair shop costs	Price of ECU + Repair shop costs
~20% of system costs	~10% of system costs	5% of system costs (15% if camera is included)	30% of system costs

System price for end customer by OEM Pass. Veh ~ 2000€ /OEM Comm. Veh ~4000€

How can CMS be weatherproofed to prevent condensation, or large water droplets, forming inside the camera enclosure?

Water inside camera pod	Water inside camera	Water in front of camera	Water on display
IP-rated connectors and cables for camera coax cables IP-rated connectors and cables for power cables	Camera housing as well as lens fixation has to be IP-certified	By hydrophobic coatings, water does not stick too much on lens or cover glass and will be pushed away	Display and display package have to be IP-certified, sealings (e.g. 2K-molded parts)
Mechanical design such that no electrical or diecast component will lay in water (e.g. no water collection in wing possible)	Connector has to be IP-certified	By camera pod/aero design, water will be directed away from the camera;	
All components and package have to satisfy IP ratings. Industry offers solutions that are IP classified. System has to prove IP classifiation after manufacturing & assembly.			

Should CMS be operable after the vehicle is turned off and/or the driver door is open (safe exit)

Operation after turned Off	Door open
Yes, as drivers use rear vision for exit, surrounding checks etc. Min. 120 sec (for display turn off, not system) n sec for full system turn off (defined in state machine diagram)	Yes, as additional information that might not be visible to the person that opens the door can be displays inc. warnings based on sensor data (any sensor) or view next to the door

How to prevent and mitigate lens obstructions?

Obstruction	
Ice	Heater must be installed
Condensation	Heater must be installed
Soiling	Cleaning device to be installed - passive
Soiling	Cleaning device to be installed – active
Obstruction	Algorithm to identify obstruction to warn driver (plausibility checks)
Water (any form)	Coatings on lens (hydrophobic, anti, …) can help to prevent obstructions in active FOV area

Are there any other safety concerns closely related to performance of CMS that are not addressed in this notice?

Risks
Polarized sun glasses
Dynamic requirements on camera system and mis-judgement of system requirements
Lack of HDR performance during very bright & very dark ambient light
Backlight levels of displays (i.e. dimming)
IQ (correct MTF, colors settings, sharpness, SNR, tolerances of components)
ISO 26262 topics

What is the level of consumer interest in vehicles equipped with CMS?

Please refer to OEMs that offer CMS:

- Audi-E-Tron (2019)
- Honda E (2020)
- Daimler Actros (2019)
- McLaren Speedtail (2020)

*this excluded hybrid interior mirrors (CMS + conventional mirror functionality)

What is the cost differential (order of magnitude) between equipping a vehicle with CMS versus traditional mirrors?

Equipment	Conventional Mirror	CMS
Surround-view camera	x	x
CMS camera + display + ECU + wire harness	-	x
Turn signal	x	x
Logo lamp / approach lamp	x	x
Power fold actuator	x	x
Mechanical components	x	x
other	x	x
Cost vehicle set	100%	~400%

A CMS product is a complex configuration with latest high end technical components. Pricing is due to changes