



# FMVSS 111

## Camera Monitoring Systems

January 10, 2017

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# Background

- Alliance/Tesla Petition for Rulemaking 3/28/14
  - Allow the use of camera-based rear and/or side vision systems as a compliance option to conventional mirror systems.
  - Petition for Rulemaking needs more supporting data to be granted.
  - CMS naturalistic driving study is about to begin in Virginia (will include seasonal weather effects).
- Discussion organized around NHTSA questions on CMS 6/30/16



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# Existing Industry Standards/Regulations

*How do current world-market vehicle camera monitor systems perform when evaluated according to the International Organization for Standardization (ISO) and the draft United Nations Economic Commission for Europe (ECE) standards?*

- ECE R46 for camera monitor system was only recently approved by UNECE WP29 and became effective on 18 June 2016.
- At this time there are no vehicles available in the European market and only prototype vehicle fleets are being evaluated on the public roads.
- These vehicles based on ISO 16505 and ECE R46 are performing comparably with those of the BAST study (attached) and mirror systems.



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# Existing Industry Standards/Regulations

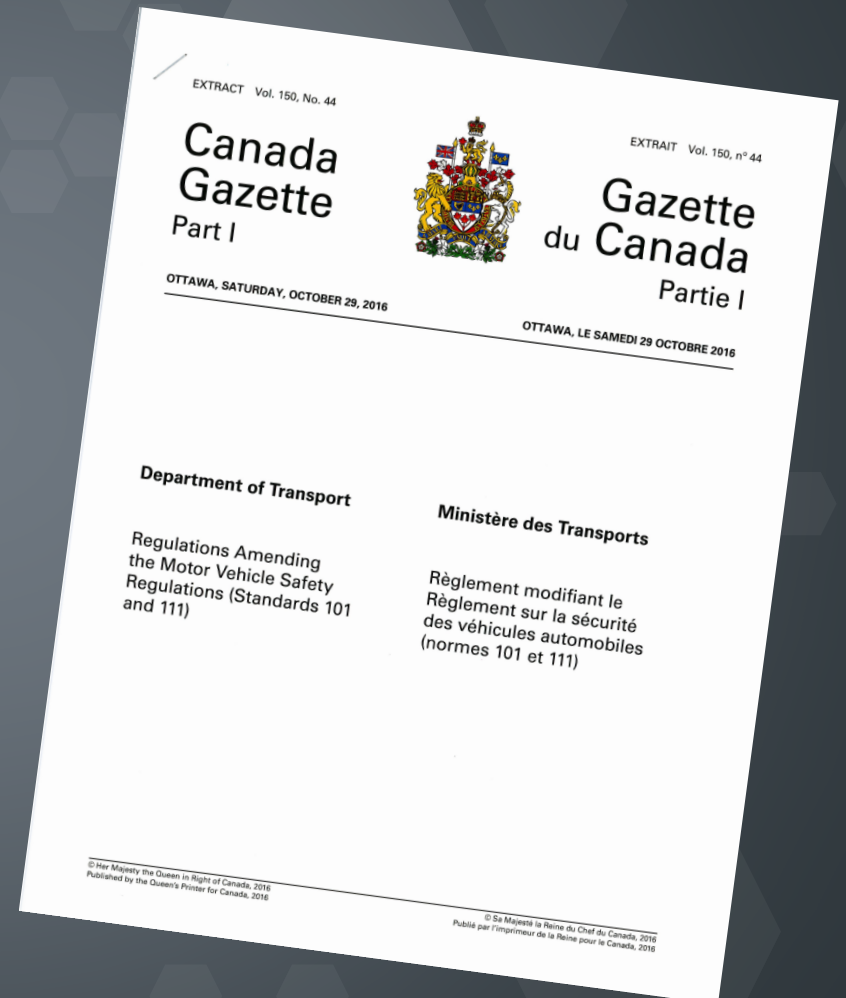
- ISO/FDIS 16505:2013
  - December 1, 2013
  - Requirements
    - Operating readiness (system availability)
    - Field of view
    - Magnification and resolution
    - Magnification aspect ratio
    - Monitor integration inside the vehicle
    - Image quality
    - Time behavior
    - Failure behavior
    - Influences from weather and environment
- UNECE R46
  - Published, 11 July 2016
  - Effective, 18 June 2016
  - Requirements
    - ISO 16505 and ISO 15008 by reference



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# Proposed Regulations

- CMVSS 101 and 111
  - Part 1 Proposal Published, October 29, 2016
  - Solicits comments regarding potential amendments to the Canadian safety standard to allow rear-view cameras and in vehicle displays to replace conventional rear-view mirrors.



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# Field of View

*Alternative technologies used to provide the field of view traditionally provided by mirrors would likely need different objective test procedures to ensure that the same or improved area of visibility is provided to the driver.*

*What procedures exist and how do they appropriately address known safety issues for NA drivers such as unit magnification and safe gap acceptance judgments?*

- Meet ISO 16505/ECE R46 Requirements
- Analyzed and evaluated in CAD
- Validated in prototypes
- Work with SAE and NHTSA to develop self certification test procedures.
- NDS to assess and compare glance times



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# Field of View (ECE R46 Requirements)

- ECE R46 Field of View Requirements:
  - Default view – meets that required for mirrors (R46 paragraph 15.2.4., with at least the required magnification and resolution as defined in R46 paragraph 16.1.3
- It is expected that the field of view requirements would be established to provide default views that are equal to or greater than those currently required for mirror systems in FMVSS 111.



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# Field of View

*To the extent that procedures that address the known safety issues do not exist, what new procedures need to be developed? What have you done to develop those procedures? What more do you plan to do and when do you plan to do it?*

- At this time Alliance members are satisfied with the current state of ECE R46 and ISO 16505 and how they address known safety issues. However, we recognize that these will need to be examined and potentially revised to be appropriate for use in a self certification environment.
- We envision working with SAE (with NHTSA support) to develop revisions to those standards to make them appropriate for incorporation into FMVSS.



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# Field of View

*Some companies have stated that providing drivers with expanded views would be advantageous for drivers. Are there any potential disadvantages, such as increased eye glance durations, that currently exist for wide view images? What research can you provide that evaluates whether these wider views present challenges for image quality or overall usability?*

- Some Alliance members are in the process of executing a naturalistic driving study of vehicles equipped with camera monitoring systems to evaluate how drivers' use these systems as well as an assessment of driver eye glance patterns and use of wider image views.
- Based on the BAST study we do not believe that there will be any significant differences between eye glance patterns/durations for mirrors and CMS.



# Field of View

*What current flexibilities in FMVSS No.111 have been evaluated that would allow you to provide camera monitor systems that meet many of your objectives in a safe manner?*

- While the right hand side (RHS) mirror is not required by FMVSS 111, CMS provides an opportunity to compare RHS improvements in field of view, aerodynamics, and human factors.



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# Image Quality

*It is reasonable to assume that a side-view image presented via electronic visual display should have good image quality. Likewise, the lack of image distortion seems important in providing useful visibility to drivers. For example, past NHTSA research identified image blooming as an issue for some camera monitor systems when driving at night.*

*What established, objective, and repeatable performance test procedures could you provide that could evaluate image blooming and other display aberrations to ensure that image quality is sufficient to support safe driving?*

- ISO 16505 and ECE R46 provide acceptable minimum requirements for image quality including blooming.



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# Image Quality

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*Question for NHTSA*  
*Does the agency have concerns about the level of specification (either certain factors not specified or evaluation criteria not sufficiently robust), or are the test procedures not sufficiently objective for use in FMVSS?*

*to ensure that image quality is sufficient to support safe driving?*

- ISO 16505 and ECE R46 provide acceptable minimum requirements for image quality including blooming.



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# Image Quality

*To the extent that procedures that appropriately evaluate display aberrations do not exist, what new procedures need to be developed? What have you done to develop those procedures? What more do you plan to do and when do you plan to do it?*

- At this time Alliance members are satisfied with the current state of ECE R46 and ISO 16505 and how they address image quality including blooming. However, we recognize that these will need to be examined and potentially revised to be appropriate for use in a self certification environment.
- NDS to enhance our knowledge base with high dynamic range camera optics and signal algorithms to mitigate blooming
- We envision working with SAE (with NHTSA support) to develop revisions to those standards to make them appropriate for incorporation into FMVSS.



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# Image Display Locations and Driver Acclimation

*Outside rearview mirrors displaying the areas to the sides of a vehicle have to date been geometrically constrained in terms of location in order to provide the required field of view. However, ISO's International Standard 16505, and the United Nations ECE's pending revision to its Regulation No. 46 both allow flexibility in the location of the right-side image to be anywhere to the right of the driver .*

*What research or information can you share that demonstrates that such an arrangement will not introduce driver confusion or other driver performance issues among various driver demographics?*



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# Image Display Locations and Driver Acclimation

- CMS NDS with real world driving will provide first hand data on the human factors associated with monitor location.
- Current testing of prototypes is validating ECE R46 and ISO 16505
- The naturalistic driving study will help identify driver concerns, which will be shared with NHTSA. We believe the BAST CMS study is still valid.



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# Image Display Locations and Driver Acclimation

*What test procedures have you developed to measure the impacts of monitor glare from sunlight and other vehicles' headlights which may cause a safety issue? Please provide those procedures. If you have not yet developed procedures sufficient for this purpose, what are your plans to develop them?*

- Direct sunlight into a camera or mirror are comparable in their interruption of an image. ECE R46 evaluation procedures are currently in practice
- All displays within a car and mirrors are affected by glare, but the degree of glare is dependent on the integration and features.



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# Type Approval Status

- Certification Agencies are developing CMS T/A reports
- List all requirements
- Up to manufacturer to demonstrate compliance
- Only inside mirrors at this time.
- Very expensive equipment needed
  - Rely on supplier for certification certificate.
- UNECE Requirement can mostly become objective test requirements



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# Image Display Locations and Driver Acclimation

*Please provide an assessment of potential glare-causing factors and, if warranted, potential ways to mitigate glare to ensure that useful images would be provided to drivers for the greatest range of conditions possible.*

- ISO standard 16505 requires a number of special tests for glare measuring the contrast which are based on typical in-vehicle display glare requirements to establish limits which include: directional / lateral uniformity, luminance and contrast rendering with different light conditions.
- All displays within a car and mirrors are affected by glare, but the degree of glare is dependent on the integration and features.
- An implementation can be improved to avoid direct light into the display which is achievable through covers or other features around the display.
- Antiglare and antireflective coatings which are considered successful and common on display technology can be applied.





# Image Display Locations and Driver Acclimation

*Please provide an assessment of potential glare-causing factors and, if warranted, potential ways to mitigate glare to ensure that useful images would be provided to drivers for the range of conditions possible.*

- ISO standard 15700-2:2013 Question for NHTSA  
Does the agency have concerns about the level of specification (either certain factors not specified or evaluation criteria not sufficiently robust), or are the test procedures not sufficiently objective for use in FMVSS?
- Glare from a car and mirrors are affected by glare, but the degree of glare is dependent on the integration and features.
- An implementation can be improved to avoid direct light into the display which is achievable through covers or other features around the display.
- Antiglare and antireflective coatings which are considered successful and common on display technology can be applied.



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# Image Display Locations and Driver Acclimation

*Please share any data that you have which demonstrates that replacing outside rearview mirrors with camera monitor systems will not negatively impact light and heavy vehicle driver behavior, situational awareness while driving, and over all safety in the U.S.*

- Field testing of prototype fleets are being monitored for negative aspects of CMS.
- The proposed CMS NDS with scenario and real world driving will provide such data. Displays and cameras located in similar locations as Class I & III rear view mirror, giving the same point of view or rear vision.
- The naturalistic driving study will help identify driver concerns, which will be shared with NHTSA. We believe the BAST CMS study is still valid..



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# Camera Durability and Reliability

*What is your assessment of the anticipated rate of failure of these cameras monitor systems and the anticipated cost to replace them, along with your anticipated consumers ' willingness to replace them?*

- We note that the replacement rate for outside rearview mirrors is likely not reliably indicative of the replacement rate for malfunctioning camera monitor systems .*
- While it is easy to spot a vehicle with a missing outside mirror , it would be impossible to spot a malfunctioning camera system.*
- We also note that the replacement rate for malfunctioning camera systems might decline as a vehicle passes from the original owner to subsequent owners.*



# Camera Durability and Reliability

- Conventional mirror systems with gimbal controlled two axis motor control and heated surfaces are not low cost equipment. As a result, replacement costs are not expected to be significantly different.
- Additionally, since CMS are much smaller and will not protrude away from the vehicle as far as conventional mirrors, we expect them to be significantly less likely to be damaged in real world usage situations.
- Since they do not require direct line of sight with the driver, they can also be located in places that provide superior fields of view and further damage protection.



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# Camera Durability and Reliability

*NHTSA has observed condensation in cameras mounted on the underside of the outside rearview mirrors of recent model year production vehicles resulting in image obscuration. What validation do you have that the petitioned performance specifications and test procedures for ensuring adequate real-world weatherproof performance of side-mounted cameras are adequate?*

- It is current practice for OEM's to follow existing SAE recommended practices for vehicle electronics.
- In addition, the same countermeasures that are currently employed for back up cameras (FMVSS 111 humidity requirements and test procedures) will be employed for the side view cameras.



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# Camera Durability and Reliability

*Depending on the mounting location, cameras may be subject to environmentally-caused lens obstructions (e.g., dirt, rain drops). What test procedures that simulate these conditions and their associated performance requirements have you developed to evaluate whether the camera is providing a useful image?*



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# Camera Durability and Reliability

- Cameras are subject to a variety of tests in development which simulates a lifetime of 15 years and validates design requirements which includes: humidity with temperature shock; salt spray and dust. ISO 16505 also includes internal testing. The cover of the rearward looking camera includes the following features to minimize collection of dirt or water in the field of view:
  - Aerodynamically optimized to optimize wind flow over cover glass
  - Coated protective cover glass
  - Heater to dry lens
  - Focus point of camera is well past the cover glass surface and “looks past” a significant amount of obstructions
  - If the driver does not notice that the view is being obscured, algorithms can be used to calculate the degree of obstruction to:
    - 1<sup>st</sup> : Turn the protective cover glass heater on to dry the cover glass
    - 2<sup>nd</sup> : Inform the driver that the cover glass needs to be cleaned



# Camera Durability and Reliability

- We expect the durability and reliability of CMS to be comparable to other electronic systems and displays already used in motor vehicles.
- Reliability models for electronics/cameras are available for setting life requirements



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# Camera Durability and Reliability

- We expect the durability and reliability of CMS to be comparable to other electronic systems and displays already used in motor vehicles.
- Reliability...

## Question for NHTSA

Does the agency have concerns about the level of specification (either certain factors not specified or evaluation criteria not sufficiently robust), or are the test procedures not sufficiently objective for use in FMVSS?



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# System Availability and Power Issues

*Drivers use the images provided by a vehicle's outside rearview mirrors frequently to acquire information about the environment and surrounding traffic. For camera monitor systems, it is important to provide this continuous view at all times when the ignition is on. What test procedures have you developed to evaluate the anticipated failure rate on such displays when used continuously?*

- SAE Recommended practices for continuous use electronics will be a foundation for starting. System behavior across the temperature and voltage range will be validated during reliability testing in development through specific testing in the OEM development release process.



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# System Availability and Power Issues

*Drivers also use the outside rearview mirrors when the ignition is off to help determine whether they can safely open a car door when parked alongside a traffic lane. Electrical power systems of vehicles equipped with camera monitor systems would need to be sufficient to accommodate this type of use without causing an unacceptable degree of battery drain to maintain the current level of functionality provided by outside mirrors.*

*What performance criteria have you developed to establish appropriate minimum residual power duration and test procedures for confirming systems meet the specified duration are needed?*

- Camera design is according to ISO16505 / ECE R46 specifications, specific tests are completed during design validation phases. Per the ECE R46 regulation the following requirements are defined for system activation:
  - Phase 1: ~120 sec. - System stays active and displays view
  - Phase 2: ~360 sec. – System is not required to display a picture but must restart with a max delay of ~1 sec
  - Phase 3: System is not required to display a picture and startup may last longer (~2 sec max ~7 sec)
  - Start Up retrigger can occur by ignition on, door unlock, or door open
- ECE R46 appears to be sufficient.
  - See ISO 16505. 120 seconds after shut off. Operate within 1 second after ignition “on”.



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*What performance...*

*residual...*

•

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# Type Approval vs Self Certification

- Subjective vs Objective
- Manufacturer must prove to T/A authority that it meets all the requirements.
  - Lab tests are conceivable for nearly all UNECE R46 CMS requirements
    - Smearing, blooming, lens flare, driver obstruction and safety concept are still subjective.
  - NHTSA would need to equip a contractor to test self certified CMS
- Manufacturers rely on suppliers for T/A of camera and monitor.
  - Camera and monitor certification equipment is expensive and of single purpose
- Currently only inside rearview cameras are being approved.
- Perhaps SAE can do prototype test procedures for CMS for NHTSA.



# Wrap up & Follow up Assignments



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