Ford 2021 AV Exemption

NHTSA Discussion – Telltales and Indicators

08/26/2021

Redacted Version

NHTSA / Ford - Chat about Telltales and Indicators

Thursday, August 26, 2021
3:30 p.m. – 4:30 p.m.

Meeting Purpose:

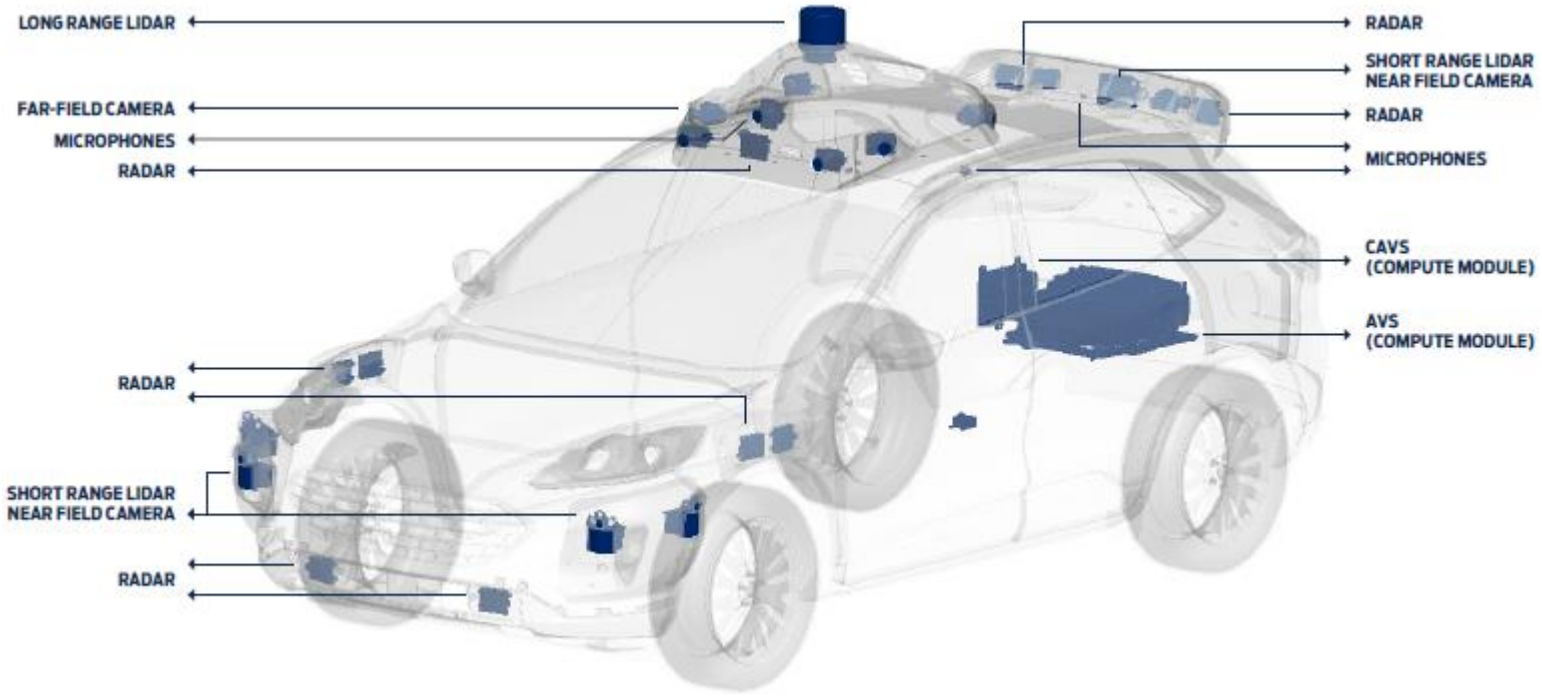
- To review Ford's telltale and indicator strategy as presented in the AV exemption petition.

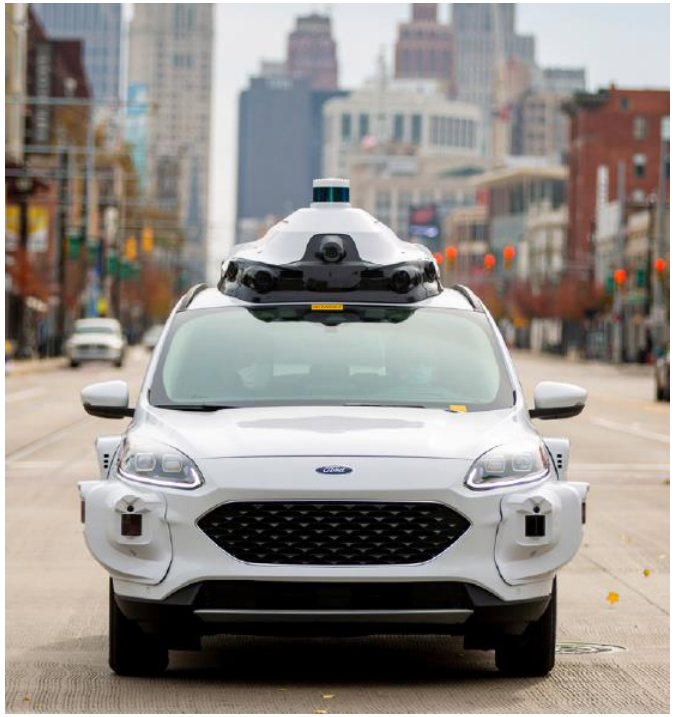
#	Topic	Lead(s)	Purpose	Timing
1.	Welcome / Introduction	D. Ujkashevic	• Review meeting purpose, agenda topics and desired outcomes	5 min. (3:30 – 3:35 pm)
2.	Ford's Telltale and Indicator Strategy	A. D'Amato A. Smith J. Bell T. Glenn	• Review Ford's approach to telltales and indicators for the exempted AV	45 min. (3:35– 4:20 pm)
3.	Next Steps	G. Vemulakonda	• Alignment on next steps	10 min. (4:20 – 4:30 pm)

Ford's AV Highlights

Ford's AV Plans

- Planned deployment for AV on an Escape Hybrid platform
- The Ford Escape AV adds sophisticated technology to enable the automated driving system (ADS) to perform the dynamic driving task (DDT) and ensure it is robust to failures
- Vehicle design does not have traditional manual controls and therefore faces regulatory barriers





AV Exemption Petition Discussion: Telltales & Indicators

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2021 Ford AV Exemption Content

Exemption request is under the basis of Part 555.6(d), presenting an overall level of safety at least equal to that of nonexempted vehicles. Telltales and indicators contained within the exemption request fall under category I in the chart below.

Reg	Description	Sections	Categories		
			I	II	III
101	Controls and Displays	S5.1, S5.2, S5.3, S5.4	X	X	
102	Transmission Shift Position Sequence, Starter Interlock, and Transmission Braking Effect	S3.1.4.1	X		
108	Lamps, Reflective Devices, and Associated Equipment	S6.6.1, S6.6.2, S9.1.1, S9.3 – S9.8	X		
111	Rearview Mirrors	S6.2.4			X
126	Electronic Stability Control Systems	S5.3	X		
135	Light Vehicle Brake Systems	S5.3.1, S5.5	X		
138	Tire Pressure Monitoring	S4.3.1, S4.4	X		

Categories:

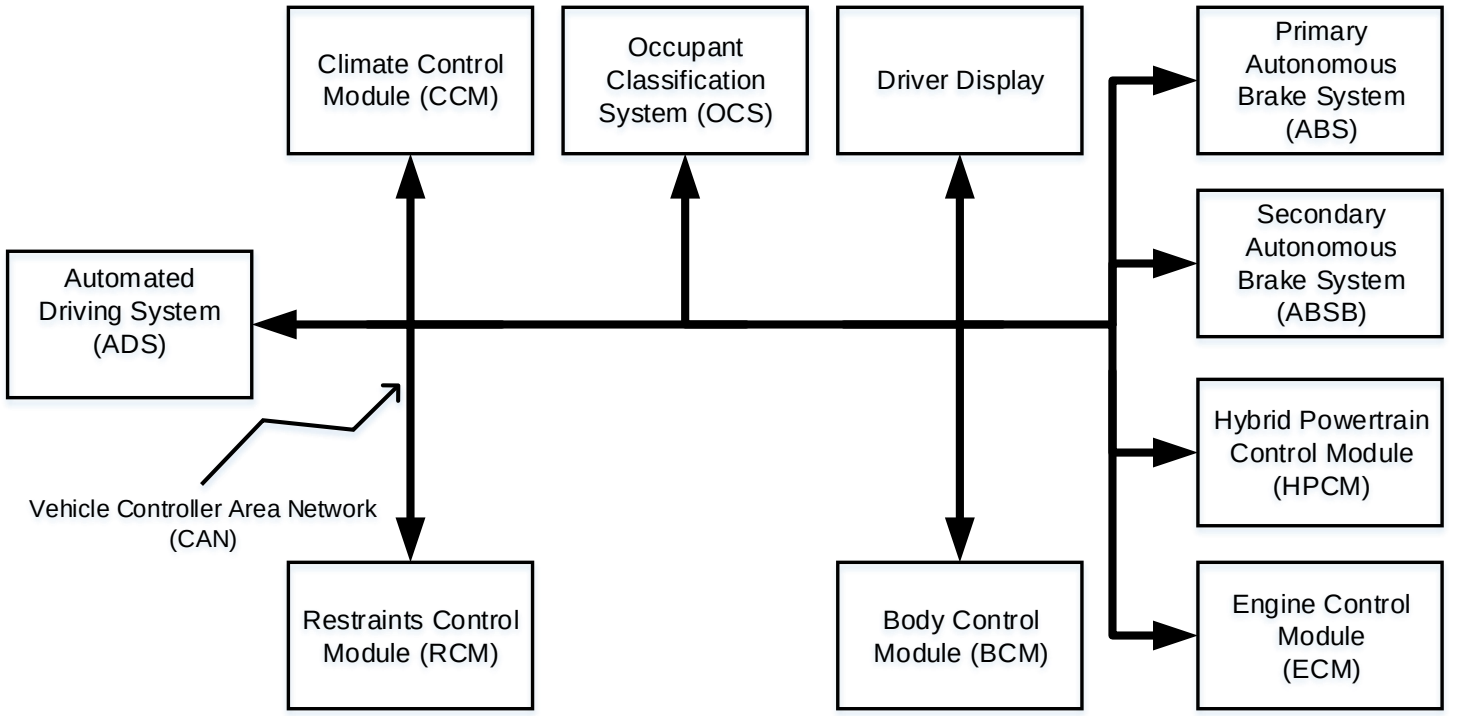
I. Subsections related to driver controls and communications
II. Subsections related to a driver's seating position
III. Subsections related to driver's visibility

Ford's 2021 Exemption Petition Includes 6 FMVSS Regulating Telltales And Indicators (101, 102, 108, 126, 135, And 138).

Redacted Version

Driver Communication – Ford's AV Design

- In Manual Mode, all regulated controls and communications will be available to the human driver
- In AV Mode, regulated telltales and indicators are communicated to the ADS by the vehicle's modules directly over the CAN-bus or vehicle network
- The ADS is programmed to take appropriate fallback measures based on the information communicated by the modules



Fault Management Strategy

In human operated vehicles the driver is a critical aspect of fault management

- Interpreting failures either through "kinesthetically apparent“ and/or diagnostic information presented by the platform, resulting in a driver action that the individual determines to be appropriate

In our AV, the human does not play a role in fault management

- The platform and ADS diagnose and action an appropriate response based on failure severity

Fallback Level	Vehicle Behavior	Example conditions
1	Vehicle completes trip and is scheduled for service	sensor cleaning faults, low beam fault (day), etc.
2	Vehicle finds a suitable parking location or pulls over to the shoulder	low beam fault (night), loss of braking redundancy, etc.
3	Vehicle comes to a controlled stop in path	degradation of motion control, ADS primary compute failures, etc.

- Industry best practices (ex. ISO26262) and rigorous system engineering is used to ensure we have both an appropriate detection mechanism and ability to achieve safe states/minimal risk conditions

The AV responds objectively to failures through a tiered approach.
The response is dependent on failure severity.

Telltale & Indicator Rationale and Responsibility for Safety

- Customers are not expected to mitigate vehicle faults related to the driving task
  - Regulated telltales communicate a need for vehicle service and recommended actions are made in owner's manual
  - Communicating these telltales to customers may inadvertently lead them to believe that they are responsible for the safe operation of the vehicle

- We will use the vehicle HMI to communicate to passengers during all fallback maneuvers
  - Information includes that the ride is ending and includes instructions and recommendations of what to do during and after the vehicle has performed the fallback maneuver
  - Displaying regulated telltales and indicators may distract occupants from the critical information being communicated via the passenger HMI

- The ADS receives information related to vehicle faults and the ADS constantly assesses its ability to perform the DDT and will execute a fallback maneuver if it determines its capability is degraded

FMVSS 101 – Controls and displays

FMVSS 101 Purpose: The purpose of this standard is to ensure the accessibility, visibility and recognition of motor vehicle controls, telltales and indicators, and to facilitate the proper selection of controls under daylight and nighttime conditions, in order to reduce the safety hazards caused by the diversion of the driver's attention from the driving task, and by mistakes in selecting controls.

Exemption Elements:	**Equivalent Safety Rationale:**
• *S5.1.2 The telltales and indicators listed in Table 1 and Table 2 and their identification **must be located so that, when activated, they are visible to a driver** under the conditions of S5.6.1 and S5.6.2.* • *S5.2 Identification* • *S5.3 Illumination* • *S5.4 Color* • *S5.6.1 The driver has adapted to the ambient light roadway conditions.* • *S5.6.2 **The driver is restrained by the seat belts** installed in accordance with 49 CFR 571.208 and adjusted in accordance with the vehicle manufacturer's instructions.*	Manual Mode: • All regulated telltale and indicators will be available to the human driver. AV Mode: • Telltale and indicator information will be communicated to the ADS over the vehicle network and to fleet management (when fallback action is necessary due to faults or warnings) • Select telltales and indicators related to occupant protection will be provided to passengers (e.g. seatbelt status) • The ADS is capable receiving more detailed and real-time information from the vehicle modules (e.g. TPMS), addressing the safety need expressed through FMVSS 101's requirements

Visually Displayed Indicators And Telltales Are Not Required To Support The ADS Performing The Driving Task And Will Not Be Offered To Occupants. Instead, They Are Communicated Directly To The ADS Over The Vehicle Network.

Other FMVSS "Status" Telltales & Indicators

FMVSS 102 Purpose: to reduce the likelihood of shifting errors…

FMVSS 108 Purpose: The purpose of this standard is to reduce traffic accidents and deaths and injuries resulting from traffic accidents, by providing adequate illumination of the roadway, and by enhancing the conspicuity of motor vehicles on the public roads so that their presence is perceived and their signals understood, both in daylight and in darkness or other conditions of reduced visibility.

Exemption Elements:	**Equivalent Safety Rationale:**
• *FMVSS 102: S3.1.4.1 …identification of shift positions, including the positions in relation to each other and the position selected,* ***shall be displayed in view of the driver****…* • *FMVSS 108: S9.3.1 …have an* ***illuminated pilot indicator*** *to provide a clear and unmistakable indication that the turn signal system is activated* • *FMVSS 108: S9.5.1 The upper beam headlamp indicator must have* ***a minimum area equivalent to that of a 3⁄16 in diameter circle, and be plainly visible to drivers of all heights*** *under normal driving conditions when headlamps are required.* • *FMVSS 108: S9.8.1 …pilot indicator* ***must flash*** *simultaneously while the vehicle hazard warning signal operating unit is turned on…*	Manual Mode: • All required telltales and indicators will be displayed to the driver AV Mode: • Like FMVSS 101, Telltale and indicator information will be communicated to the ADS over the vehicle network and to fleet management (when necessary) • Requirements of FMVSS 102 and 108 for how the information must be provided to the driver no longer apply, as the ADS is capable of commanding the desired gear or lighting state and receiving the status directly from the vehicle modules

The status of the telltales and indicators of FMVSS 102 and 108 Are Communicated Directly To The ADS Over The Vehicle Network.

FMVSS 126 – Electronic Stability Control Systems for Light Vehicles

FMVSS 126 Purpose: to reduce the number of deaths and injuries that result from crashes in which the driver loses directional control of the vehicle, including those resulting in vehicle rollover

Exemption Elements:	**Equivalent Safety Rationale:**
• *S5.3 ESC Malfunction. The vehicle **must be equipped with a telltale that provides a warning to the driver** of the occurrence of one or more malfunctions that affect the generation or transmission of control or response signals in the vehicle's electronic stability control system. When tested according to S7.10, the ESC malfunction telltale:* • *S5.3.1 As of September 1, 2011, must be **mounted inside the occupant compartment in front of and in clear view of the driver**;*	Manual Mode: • All required telltales and indicators will be displayed to the driver AV Mode: • Regulated telltales and indicators are communicated from modules directly to the ADS over the CAN-bus or vehicle network • The AV will execute a Fallback Level 2 maneuver during any faulted condition that would illuminate an ESC malfunction telltale in a compliant vehicle

The ADS Does Not Require A Visual Telltale To Be Informed Of Malfunctioning ESC. The ADS Will React to This Scenario In A Manner That Protects Vehicle Occupants and Other Road Users.

FMVSS 135 – Light Vehicle Brake Systems

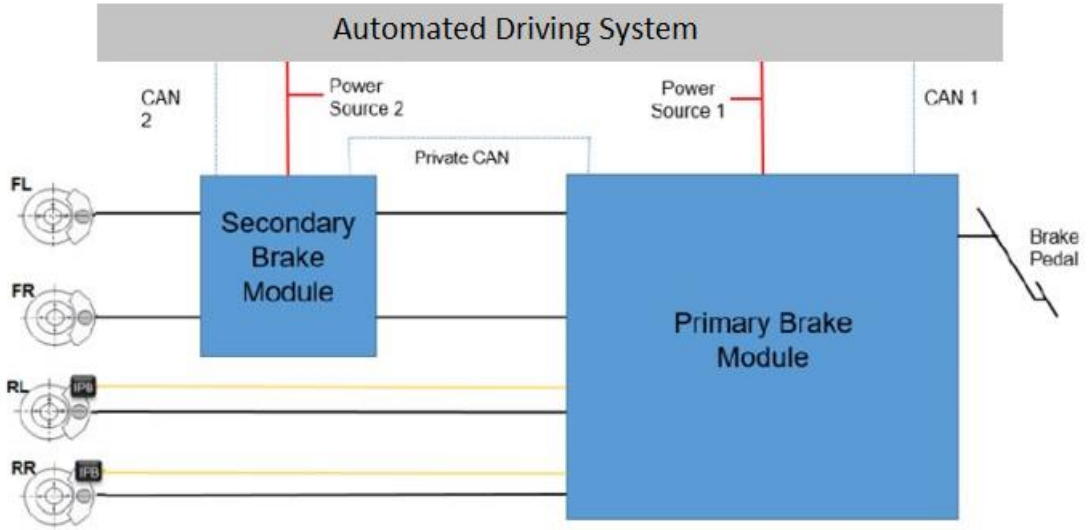
FMVSS 135 **Purpose:** to ensure safe braking performance under normal and emergency driving conditions

Exemption Elements:	**Equivalent Safety Rationale:**
• *S5.5. Brake system warning indicator.* ***Each vehicle shall have one or more visual brake system warning indicators, mounted in front of and in clear view of the driver****, which meet the requirements of S5.5.1 through S5.5.5. In addition, a vehicle manufactured without a split service brake system shall be equipped with an audible warning signal that activates under the conditions specified in S5.5.1(a).*	Manual Mode: • All required telltales and indicators will be displayed to the driver AV Mode: • Regulated telltales and indicators are communicated from modules directly to the ADS over the CAN-bus or vehicle network • The AV will execute a Fallback Level 2 maneuver during any faulted condition that would illuminate a brake warning indicator in a compliant vehicle

The ADS Does Not Require A Visual Telltale To Be Informed Of Brake System Failures. The ADS Will React to This Scenario In A Manner That Protects Vehicle Occupants and Other Road Users

FMVSS 135 – Light Vehicle Brake Systems

- Ford's AV has a brake architecture that allows the ADS to retain control of the vehicles brake system during different faulted conditions
- During normal operation, the ADS communicates with the primary brake module to perform braking actions
- During some faulted conditions, including the brake power unit inoperative test in S7.11 of FMVSS 135, the ADS communicates with a secondary brake module to perform braking actions
  - This ensures that the AV can safely execute a Fallback Level 2 maneuver in the event of a brake system failure



The Redundant Brake System Allows Ford's AV To Reach A Safe Condition During Brake System Failures

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FMVSS 138 – Tire pressure monitoring systems

FMVSS 138 **Purpose:** "to warn drivers of significant under-inflation of tires and the resulting safety problems"

Exemption Elements:	**Equivalent Safety Rationale:**

• *S4.3.1 Each tire pressure monitoring system **must include a low tire pressure warning telltale** that:*
*(a) Is mounted inside the occupant compartment **in front of and in clear view of the driver***
• *S4.4(a) The vehicle shall be equipped with a tire pressure monitoring system that **includes a telltale that provides a warning to the driver not more than 20 minutes after the occurrence of a malfunction** that affects the generation or transmission of control or response signals in the vehicle's tire pressure monitoring system. The vehicle's TPMS malfunction indicator shall meet the requirements of either S4.4(b) or S4.4(c)…*
	Manual Mode:
	• All required telltales will be displayed to the driver
	
	AV Mode:
	• Telltale information will be communicated to the ADS and to fleet management
	  • If pressure is >25% below placard pressure or there is a TPMS malfunction – at least a Fallback Level 1
	  • If pressure is >35% below placard pressure – Fallback Level 2
	  • If ADS ever detects degraded lateral control - Fallback Level 2
	  • Additionally, low pressure or TPMS malfunction will prevent entry into AV Mode

Our tire pressure fallback strategy ensures the vehicle performs an appropriate response to low tire pressure conditions and TPMS faults.

Summary

- How did Ford decide what telltales and indicators would be offered to occupants in AV Mode?
  - Ford assessed each telltale/indicator for the associated severity of the condition and the responsibility of the passenger to take action
- Why not show all telltales and indicators to the occupants in AV mode?
  - We believe it creates confusion about who is responsible for safety and may distract from the information we are providing to the occupants
- What are some examples of telltales/indicators that will be shown to occupants in AV Mode?
  - Seatbelt information will be communicated to all occupants (typically provided to driver only)
  - PADI will be provided for both front passenger seating locations
  - Restraints indicator lamp provided to all occupants
- Which telltales and indicators result in an ADS response?
  - All faults (regulated or otherwise) that affect the ability of the vehicle to perform the DDT or affect occupant protection systems will lead to an appropriate fallback maneuver
- What happens when a fault occurs prior to entering AV Mode?
  - The fault must be resolved before the vehicle can enter AV Mode

By the ADS receiving information and taking action in the presence of faults, Ford's AV provides equivalent overall safety to that of a non-exempt vehicle.

Discussion

Ford 2021 AV Exemption

NHTSA Discussion – FMVSS 111 Rearview Image and Regulated Controls

09/15/2021

Redacted Version

NHTSA / Ford - Chat about Controls and Rearview Image Strategies

Wednesday, September 15, 2021
8:30 a.m. – 9:30 a.m.

Meeting Purpose:

- To review Ford's rearview image approach and controls strategy as presented in the AV exemption petition.

#	Topic	Lead(s)	Purpose	Timing
1.	Welcome / Introduction	D. Ujkashevic	• Review meeting purpose, agenda topics and desired outcomes	5 min. (8:30 – 8:35 am)
2.	Ford's AV Overview	A. D'Amato	• Review Ford's AV plans and key design elements	5 min. (8:35 – 8:40 am)
3.	Ford's FMVSS 111 Rearview Image Approach	A. Smith	• Review Ford's rearview image plan for AV Mode	15 min. (8:40 – 8:55 am)
4.	Ford's Controls Strategy	A. Smith	• Review Ford's approach to controls for the exempted AV in AV Mode	15 min. (8:55 – 9:10 am)
5.	Next Steps	G. Vemulakonda	• Alignment on next steps	20 min. (9:10 – 9:30 am)

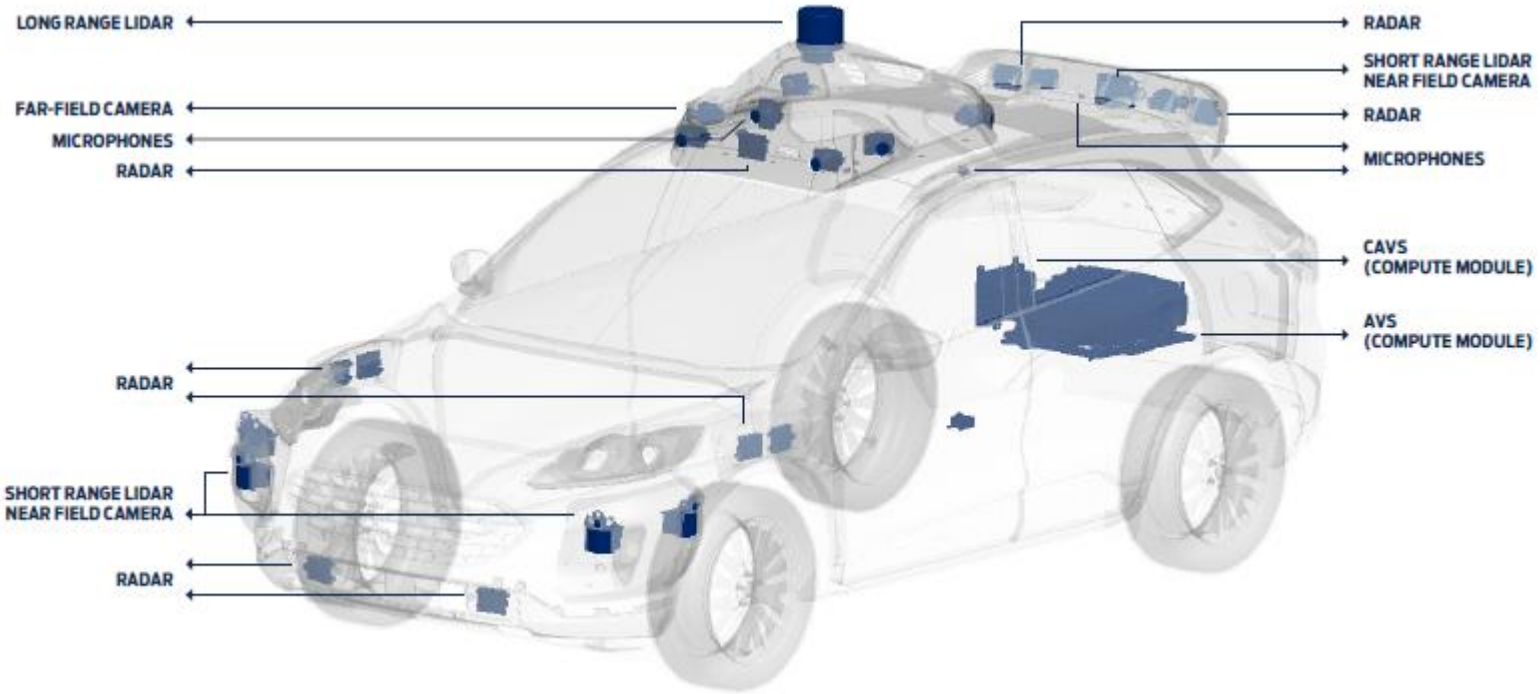
Ford's AV Highlights

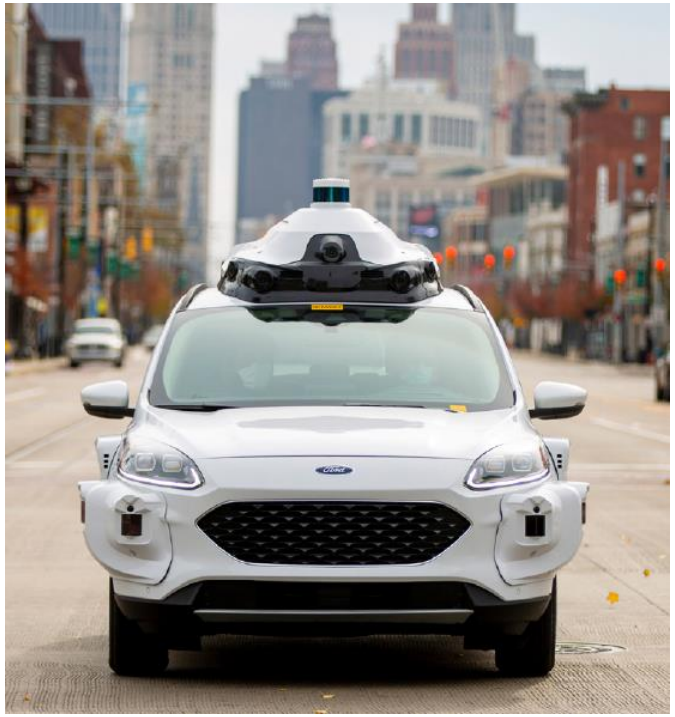
Ford's AV Plans

- Planned deployment for AV on an Escape Hybrid platform

- The Ford Escape AV adds sophisticated technology to enable the automated driving system (ADS) to perform the dynamic driving task (DDT) and ensure it is robust to failures

- Vehicle design does not have traditional manual controls and therefore faces regulatory barriers





2021 Ford AV Exemption Content

Exemption request is under the basis of Part 555.6(d), presenting an overall level of safety at least equal to that of nonexempted vehicles. Controls contained within the exemption request fall under category I in the chart below, while the rearview image is under category III.

Reg	Description	Sections	Categories		
			I	II	III
101	Controls and Displays	S5.1, S5.2, S5.3, S5.4	X	X	
102	Transmission Shift Position Sequence, Starter Interlock, and Transmission Braking Effect	S3.1.4.1	X		
108	Lamps, Reflective Devices, and Associated Equipment	S6.6.1, S6.6.2, S9.1.1, S9.3 – S9.8	X		
111	Rearview Visibility	S6.2.3 – S6.2.5			X
126	Electronic Stability Control Systems	S5.3	X		
135	Light Vehicle Brake Systems	S5.3.1, S5.5	X		
138	Tire Pressure Monitoring	S4.3.1, S4.4	X		

Categories:

I. Subsections related to driver controls and communications
II. Subsections related to a driver's seating position
III. Subsections related to driver's visibility

Beyond Telltales And Indicators Discussed Previously, Ford's 2021 Exemption Petition Includes FMVSS Regulating Controls And The Rearview Image

AV Exemption Petition Discussion: Rearview Image

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FMVSS 111 – Rear Visibility

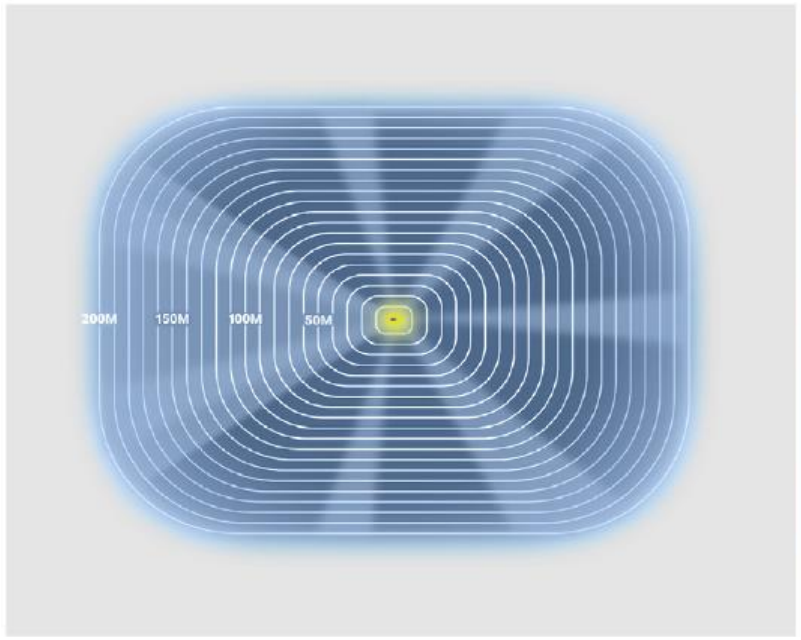
FMVSS 111 Purpose: The purpose of this standard is to ensure "clear and reasonably unobstructed view to the rear" of a vehicle

Exemption Elements:	**Equivalent Safety Rationale:**
• *S6.2(b) Final requirements. Each multipurpose passenger vehicle, low-speed vehicle, truck…shall display a rearview image meeting the requirements of S6.2.1 through S6.2.7.* • *S6.2.4 Linger time. The rearview image meeting the requirements of S6.2.1 and S6.2.2* ***shall not be displayed after the backing event has ended****.* • *S6.2.5 Deactivation. The rearview image…****shall remain visible during the backing event until either, the driver modifies the view, or the vehicle direction selector is removed from the reverse position****.*	Manual Mode: • Regulated image will be available to the human driver during backing events. AV Mode: • The regulated rearview image will not be displayed to occupants since they are not a part of the driving task • A situational awareness screen is available to illustrate ADS perception and provide contextual information to the riders throughout the ride • The ADS sensor suite will perceive and communicate a 360-degree view of the environment around the vehicle to the ADS over the vehicle network, including the rearview image field of view • The sensor suite will provide input to the ADS continuously during AV mode, including during forward operation

A Traditional Rearview Image Will Not Be Displayed To Occupants During AV Operation, But The ADS Will Continuously Sense The Environment Around The Vehicle, Providing Equivalent Safety To That Of A Non-exempt Vehicle.

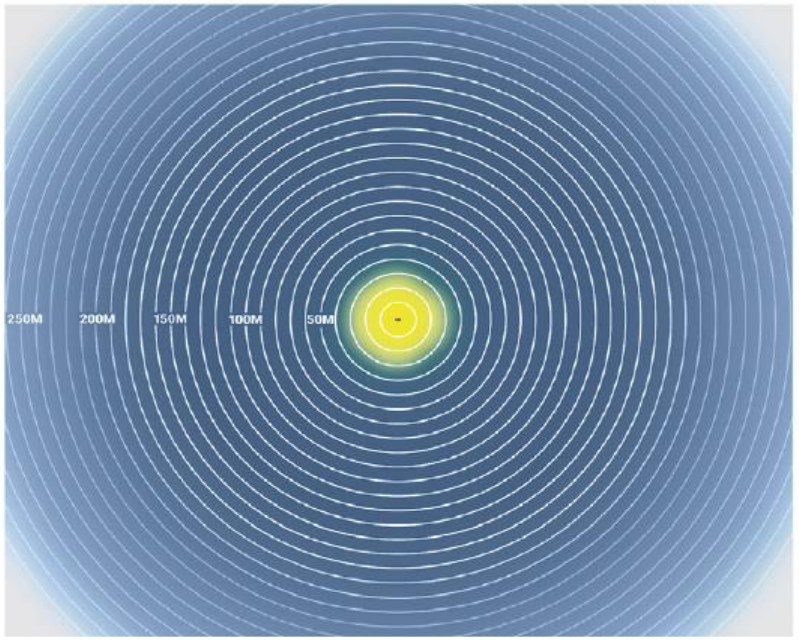
Ford's AV Sensing Capability

← Vehicle Direction



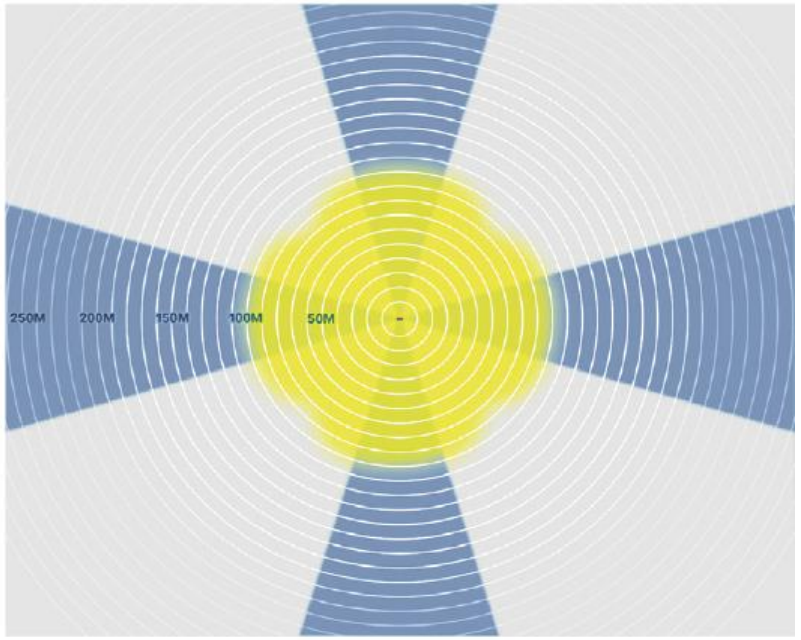
CAMERA COVERAGE - GROUND PLANE

- Near Field Cameras
- Far Field Cameras
- Vehicle



LIDAR COVERAGE - GROUND PLANE

- Short Range
- Mid Range & Long Range
- Vehicle



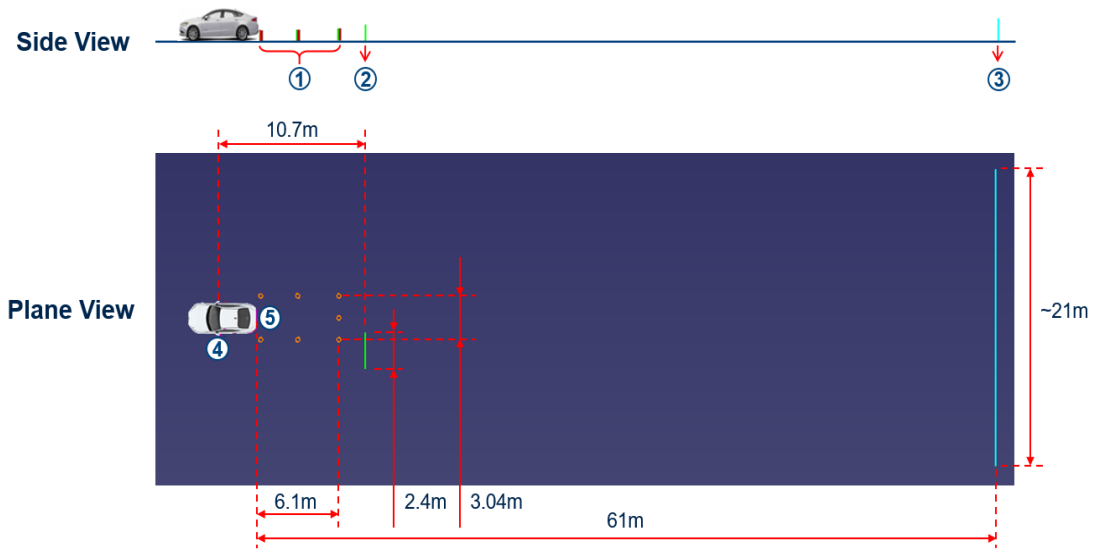
RADAR

- Mid Range
- Long Range
- Vehicle

SOURCE: ARGO AI

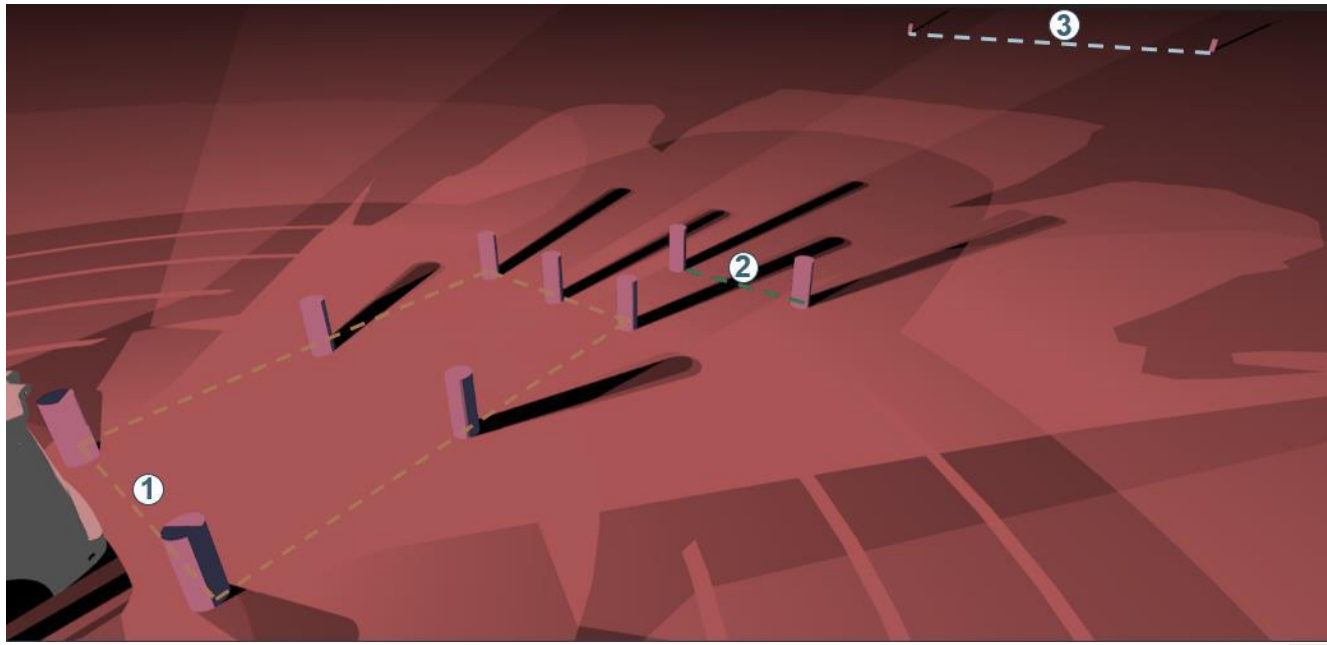
The ADS Is Continuously Sensing The Environment 360° Around The Vehicle With Three Different Sensors Types

FMVSS 111 – Rearview Image Approach



❶ Rearview Image Target
❷ Driver Side Mirror Target
❸ Interior Rear View Mirror Target
❹ Driver's Eye Point
❺ Rear of the Vehicle

Simulated rear environment rendering



The ADS Sensor Suite Perceives The Environment Around The Vehicle Continuously, Including The Field Of View Required Of The Rearview Image

AV Exemption Petition Discussion: Controls

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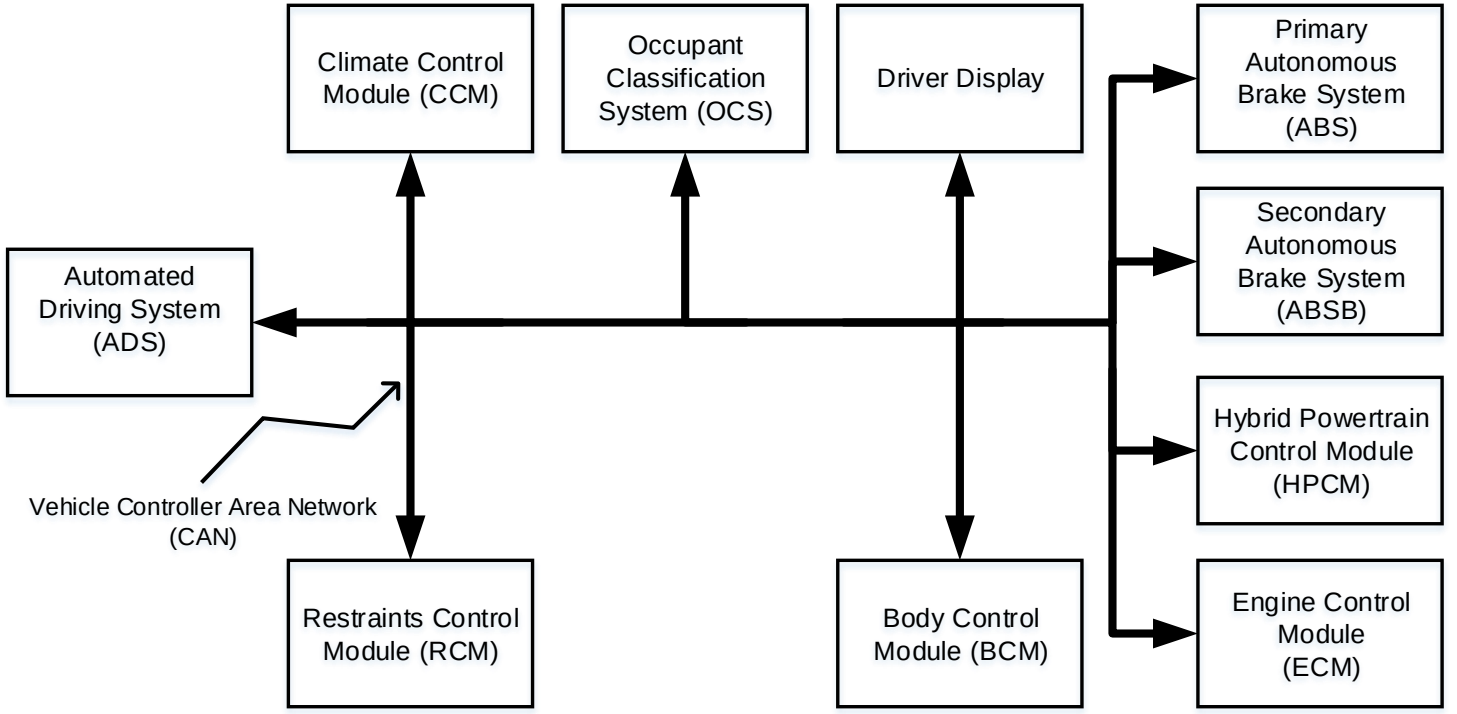
Driver Controls and Information – Ford's AV Design

- In Manual Mode, all regulated controls and related communications will be available to the human driver
- In AV Mode, functionality typically accessed through traditional controls and information may be accessed by the ADS to the vehicle's modules directly over the CAN-bus or vehicle network
- The ADS is programmed to take appropriate fallback measures based on the information communicated by the modules in the presence of faults



AV Mode Rationale and Responsibility for Safety

- Customers are not expected to participate in the driving task or mitigate vehicle faults
  - The majority of controls found in a vehicle are specifically related to performing the dynamic driving task
  - Providing customers access to these controls may inadvertently lead them to believe that they are responsible for the safe operation of the vehicle, or potentially interfere with the ADS performing the driving task

- We will use the vehicle HMI to offer customers comfort and convenience features
  - Certain controls that are not supporting the ADS in performing the driving task will be provided to customers for comfort and convenience (climate and visibility)

- The ADS receives information related to vehicle faults, constantly assesses its ability to perform the DDT, and will execute a fallback maneuver if it determines its capability is degraded

AV Mode Regulated Controls Summary

Regulated Control	Exemption requested	Available to occupants
Turn signals	X	
Headlamp beam switching device	X	
Hazard warning signal	X	
Marker lamps	X	
Windshield wiping system		X
Windshield washing system		X
Windshield defrosting/defogging system		X
Heating / AC system		X
Heating / AC fan		X
Brake Pedal	X	

Select Controls That Do Not Interfere With The ADS Performing The Driving Task Will Be Offered To Occupants During AV Mode For Comfort and Convenience

FMVSS 101 – Controls and displays

FMVSS 101 Purpose: The purpose of this standard is to ensure the accessibility, visibility and recognition of motor vehicle controls, telltales and indicators, and to facilitate the proper selection of controls under daylight and nighttime conditions, in order to reduce the safety hazards caused by the diversion of the driver's attention from the driving task, and by mistakes in selecting controls.

Exemption Elements:	**Equivalent Safety Rationale:**
• *S5.1.1 The controls listed in Table 1 and in Table 2* ***must be located so they are operable by the driver*** *under the conditions of S5.6.2.* • *S5.2* ***Identification*** • *S5.3* ***Illumination*** • *S5.4* ***Color*** • *S5.6.1 The driver has adapted to the ambient light roadway conditions.* • *S5.6.2* ***The driver is restrained by the seat belts*** *installed in accordance with 49 CFR 571.208 and adjusted in accordance with the vehicle manufacturer's instructions.*	Manual Mode: • All regulated controls will be available to the human driver. AV Mode: • Driving task controls will not be offered to occupants to prevent interference and confusion about DDT responsibility • Select controls related to occupant comfort and convenience will be provided via the HMI (wipe, wash, and climate with defrost) • Driving task controls and associated status information will be accessed by the ADS over the vehicle network

Traditional Driving Task Controls Will Not Be Offered to Occupants And Are Not Required To Support The ADS When They Are Commanded Over The Vehicle Network

FMVSS 108 – Lamps, reflective devices, and associated equipment

FMVSS 108 Purpose: *"to reduce traffic accidents and deaths and injuries resulting from traffic accidents, by providing adequate illumination of the roadway, and by enhancing the conspicuity of motor vehicles on the public roads so that their presence is perceived and their signals understood, both in daylight and in darkness or other conditions of reduced visibility"*

Exemption Elements:	**Equivalent Safety Rationale:**
• *S6.6.1-2 All vehicles…must be equipped with a turn signal operating unit, a turn signal flasher, a turn signal pilot indicator, a headlamp beam switching device, and an upper beam headlamp indicator…a vehicular hazard warning operating unit, a vehicular hazard warning signal flasher, and a vehicular hazard warning signal pilot indicator meeting the requirements of S9.* • *S9.1.1* ***The turn signal operating unit…must be self-canceling by steering wheel rotation and capable of cancellation by a manually operated control****.* • *S9.4 Headlamp beam switching device. Each vehicle must have a means of switching between lower and upper beams…****by a simple movement of the driver's hand or foot****…* • *S9.6.2* (Hazard Warning) *Operating unit switch. The unit* ***must operate independently of the ignition or equivalent switch****…*	Manual Mode: • All regulated controls are available to the driver AV Mode: • Exterior lighting related controls will not be offered to occupants to prevent interference and confusion about DDT responsibility • For the ADS, how the controls must be operated by the driver's hand or foot are no longer necessary since it is capable of commanding the regulated lighting elements and receiving their status over the vehicle network • The ADS provides equivalent safety to the self-canceling turn signal requirement by commanding deactivation upon completion of the driving action, and the ADS is not subject to distraction

Lighting Controls Are Commanded By The ADS Over The Vehicle Network, Negating The Need For Actuation By A Human Driver's Hand Or Foot And Self-Cancellation Performance Requirements

FMVSS 135 – Light Vehicle Brake Systems

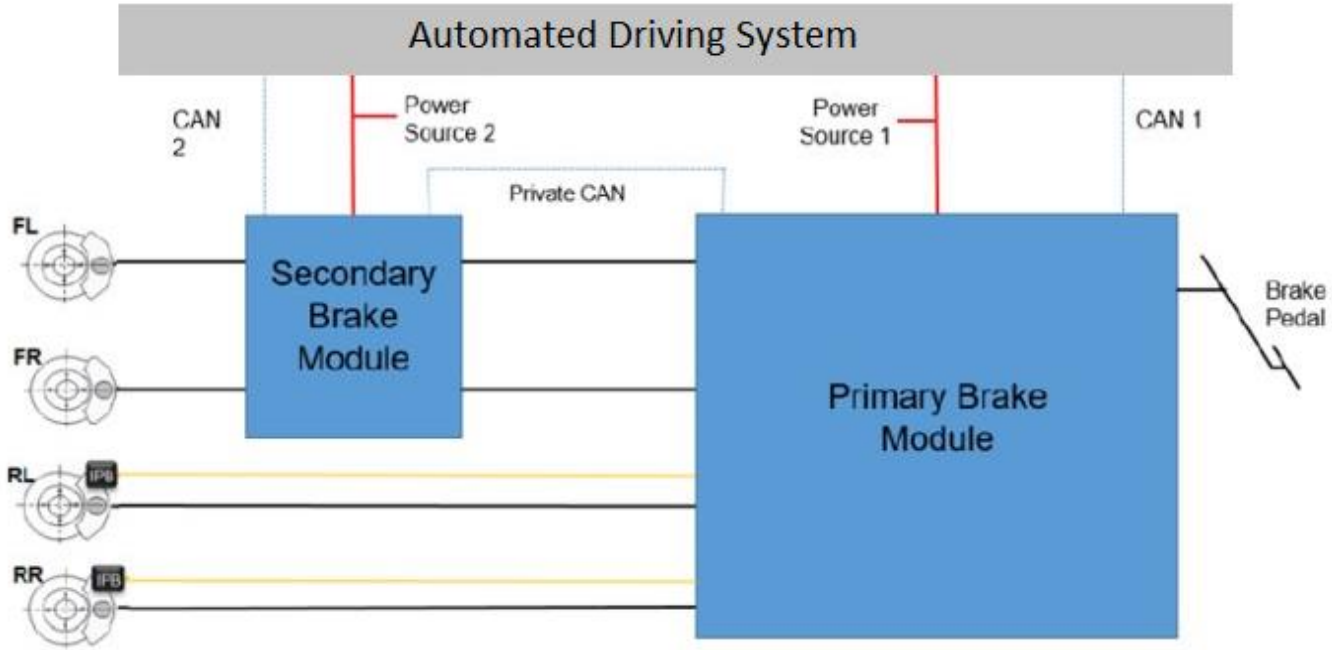
FMVSS 135 Purpose: *"to ensure safe braking performance under normal and emergency driving conditions"*

Exemption Elements:	**Equivalent Safety Rationale:**
• *S5.3.1. The service brakes shall be **activated by means of a foot control**. The control of the parking brake shall be independent of the service brake control, and **may be either a hand or foot control**.*	Manual Mode: • Regulated brake controls will be available to the human driver AV Mode: [CONFIDENTIAL BUSINESS INFORMATION] • The ADS will control the service brake and parking brake over the vehicle communication network

The Regulated Brake Controls Are Commanded By The ADS Over The Vehicle Network, Negating The Need For Actuation By A Human Driver's Hand Or Foot.

Ford AV Brake Controls

- Foot operated service brake control and foot/hand actuated parking brake control are available during Manual mode
- Ford's AV has a brake architecture that allows the ADS and a human driver to retain control of the vehicles brake system during nominal and faulted conditions



The AV Has A Braking System That Allows the ADS To Operate The Service Brakes In A Manner Equally As Safe As A Compliant Vehicle

Summary

- Why is Ford seeking an exemption for the rearview image linger time and deactivation requirements?
  - Ford believes providing 360 degree sensing to the ADS (including coverage of the regulated field of view) at all times improves safety
- Why isn't Ford displaying the rearview image to occupants in AV mode?
  - Displaying the rearview image to occupants does not support the driving task, but providing the situational awareness display enables occupants to understand how the ADS perceives the environment
  - Situational awareness will be provided regardless of the direction of travel
- How did Ford decide what controls would be offered to occupants in AV Mode?
  - Ford assessed each control for the responsibility of the passenger to take action to address the driving task and their ability to support customer comfort and convenience
- Why isn't Ford providing certain controls to the occupants in AV mode?
  - Customers are not expected to participate in the driving task, and Ford believes presenting driving task controls would create confusion regarding responsibility for the dynamic driving task and potentially interfere in the driving task
- What controls will be provided to occupants in AV Mode?
  - Included in the user interface will be wipe, wash, and climate control (including defrost) as comfort and convenience features

The ADS Accessing Controls And Receiving Rearview Image information Over The Vehicle Network Provides Equivalent Overall Safety To That Of A Non-exempt Vehicle

Discussion

AV Exemption & Safety Assurance

NHTSA Discussion

October 25, 2021

Redacted Version

NHTSA / Ford - Chat about FMVSS 108 & 111 and Safety Assurance

Monday, October 25, 2021
10:00 a.m. – 11:00 a.m.

Meeting Purpose:

- To review Ford's FMVSS 111 rearview image and 108 controls safety strategy as related to the AV exemption petition contents.

#	Topic	Lead(s)	Purpose	Timing
1.	Welcome / Introduction	D. Ujkashevic	• Review meeting purpose, agenda topics and desired outcomes	5 min. (10:00 – 10:05 am)
2.	Ford's AV Highlights and Safety Assurance Overview	A. D'Amato A. Smith	• Review Ford's AV plans, key design elements, and safety assurance approach	15 min. (10:05 – 10:20 am)
3.	Ford's FMVSS 108 Controls Strategy		• Review Ford's approach to lighting controls in AV Mode	10 min. (10:20 – 10:30 am)
4.	Ford's FMVSS 111 Rearview Image Approach		• Review Ford's rearview image plan for AV Mode	10 min. (10:30 – 10:40 am)
5.	Next Steps	G. Vemulakonda	• Alignment on next steps	20 min. (10:40 – 11:00 am)

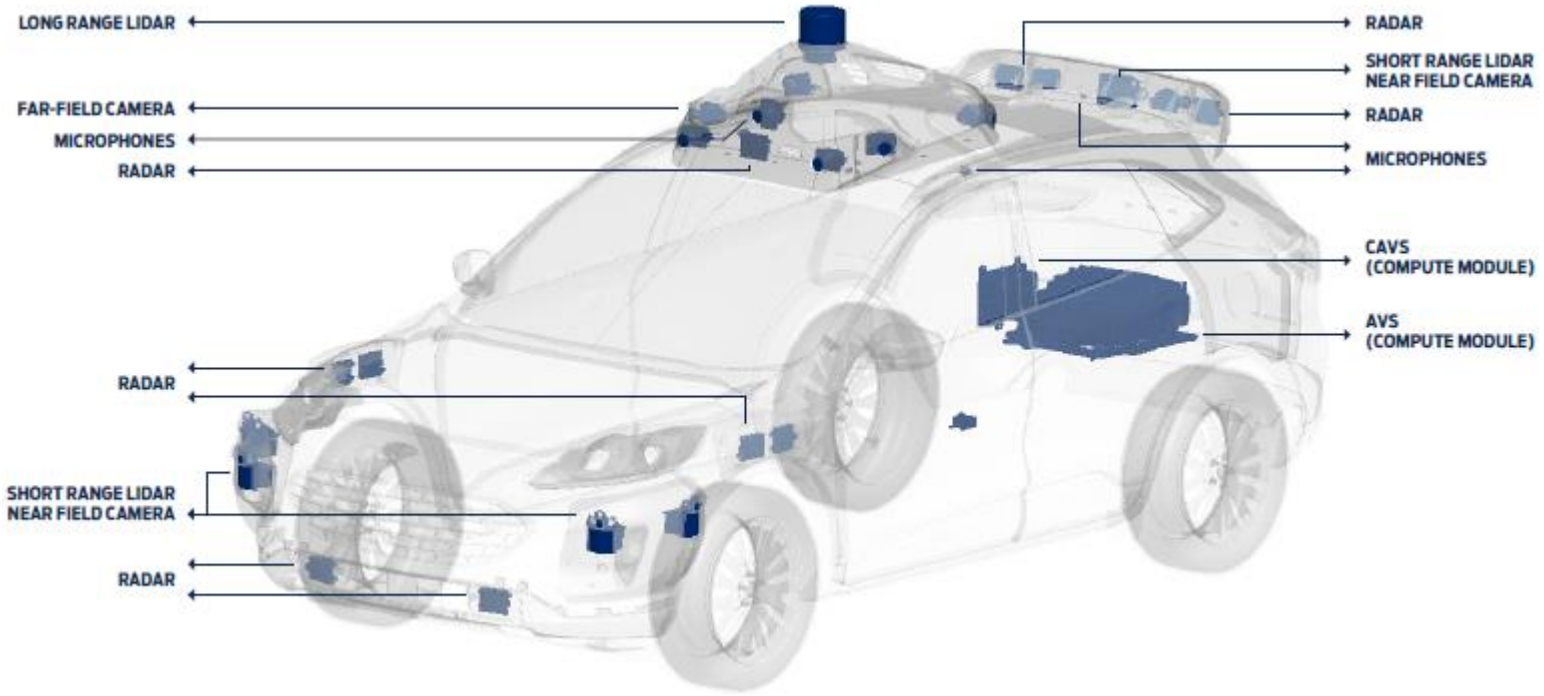
Ford's AV Highlights

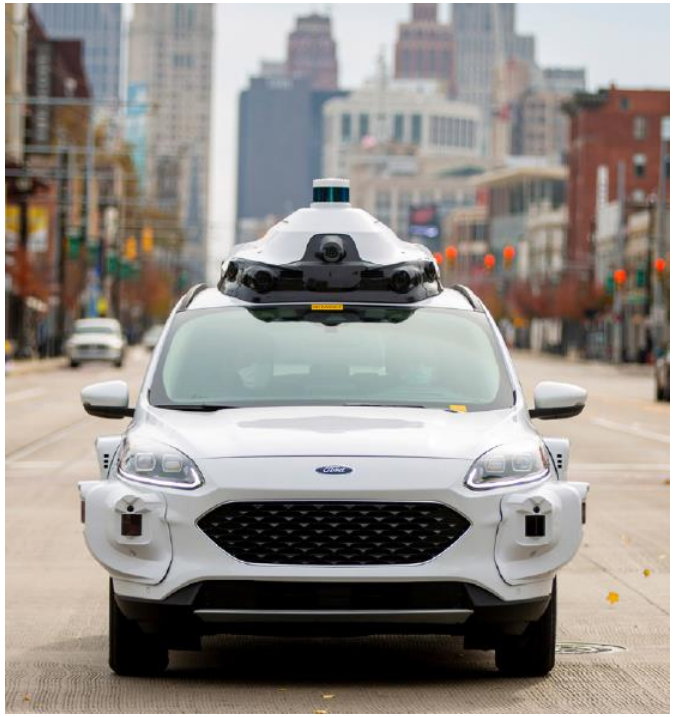
Ford's AV Plans

- Planned deployment for AV on an Escape Hybrid platform

- The Ford Escape AV adds sophisticated technology to enable the automated driving system (ADS) to perform the dynamic driving task (DDT) and ensure it is robust to failures

- Vehicle design does not have traditional manual controls and therefore faces regulatory barriers





2021 Ford AV Exemption Content

Exemption request is under the basis of Part 555.6(d), presenting an overall level of safety at least equal to that of nonexempted vehicles.

Reg	Description	Sections	Categories		
			I	II	III
101	Controls and Displays	S5.1, S5.2, S5.3, S5.4	X	X	
102	Transmission Shift Position Sequence, Starter Interlock, and Transmission Braking Effect	S3.1.4.1	X		
108	Lamps, Reflective Devices, and Associated Equipment	S6.6.1, S6.6.2, S9.1.1, S9.3 – S9.8	X		
111	Rearview Visibility	S6.2.3 – S6.2.5			X
126	Electronic Stability Control Systems	S5.3	X		
135	Light Vehicle Brake Systems	S5.3.1, S5.5	X		
138	Tire Pressure Monitoring	S4.3.1, S4.4	X		

Categories:

I. Subsections related to driver controls and communications
II. Subsections related to a driver's seating position
III. Subsections related to driver's visibility

Ford's 2021 Exemption Petition Includes Regulated FMVSS 108 Controls And The FMVSS 111 Rearview Image

Redacted Version

Ford's AV Safety Assurance

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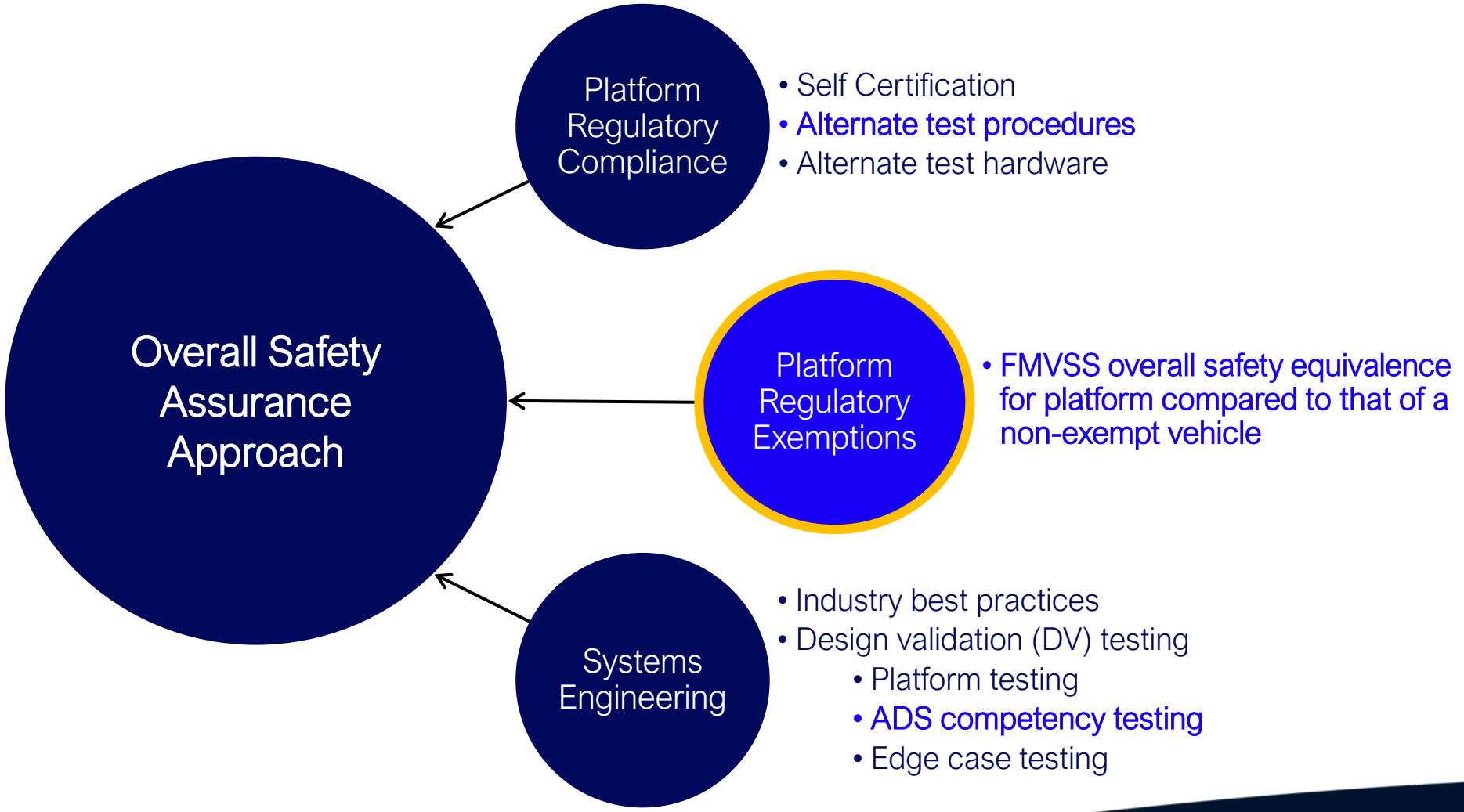
Discussion on Safety



The Ford Exemption Petition Covers The Equivalent Safety For The Vehicle Platform As A Part Of The Overall Safety Assurance Approach

FMVSS 108 & 111: Compliance and Systems Engineering

Redacted Version

AV Mode Regulated Controls Summary

Regulated Control	Exemption requested	Available to occupants
Turn signals	X	
Headlamp beam switching device	X	
Hazard warning signal	X	
Marker lamps	X	
Windshield wiping system		X
Windshield washing system		X
Windshield defrosting/defogging system		X
Heating / AC system		X
Heating / AC fan		X
Brake Pedal	X	

Select Controls That Do Not Interfere With The ADS Performing The Driving Task Will Be Offered To Occupants During AV Mode For Comfort and Convenience

FMVSS 108 – Lamps, reflective devices, and associated equipment

FMVSS 108 Purpose: *"to reduce traffic accidents and deaths and injuries resulting from traffic accidents, by providing adequate illumination of the roadway, and by enhancing the conspicuity of motor vehicles on the public roads so that their presence is perceived and their signals understood, both in daylight and in darkness or other conditions of reduced visibility"*

Exemption Elements:	**Equivalent Safety Rationale:**
• *S6.6.1-2 All vehicles…must be equipped with a turn signal operating unit, a turn signal flasher, a turn signal pilot indicator, a headlamp beam switching device, and an upper beam headlamp indicator…a vehicular hazard warning operating unit, a vehicular hazard warning signal flasher, and a vehicular hazard warning signal pilot indicator meeting the requirements of S9.* • *S9.1.1* ***The turn signal operating unit…must be self-canceling by steering wheel rotation and capable of cancellation by a manually operated control****.* • *S9.4 Headlamp beam switching device. Each vehicle must have a means of switching between lower and upper beams…****by a simple movement of the driver's hand or foot****…* • *S9.6.2* (Hazard Warning) *Operating unit switch. The unit* ***must operate independently of the ignition or equivalent switch****…*	Manual Mode: • All regulated controls are available to the driver AV Mode: • Exterior lighting related controls will not be offered to occupants to prevent interference and confusion about DDT responsibility • For the ADS, how the controls must be operated by the driver's hand or foot are no longer necessary since it is capable of commanding the regulated lighting elements and receiving their status over the vehicle network • The ADS provides equivalent safety to the self-canceling turn signal requirement by commanding deactivation upon completion of the driving action, and the ADS is not subject to distraction

Lighting Controls Are Commanded By The ADS Over The Vehicle Network, Negating The Need For Actuation By A Human Driver's Hand Or Foot And Self-Cancellation Performance Requirements

FMVSS 108 Follow Up – Controls

- The vehicle platform will control primary lighting operation using the Automatic Headlamp and Automatic High Beam Control (AHBC) features
- The ADS commands turn signals over the vehicle network as required based on the driving actions the vehicle may take (lane changes, turns, etc.)
  - Design validation testing addresses the minimum state requirements such as:

State	Turn Signal Min. Activation Distance (ft)	Turn off High Beam Distance (ft)**	
		Approaching Oncoming	Approaching from Rear
California	100	500*	300*
District of Columbia	100	500*	300*
Florida	100	500	300
Michigan	100 @ < 35 mph* 300 @ > 35 mph*	500	300*
Pennsylvania	100 @ < 35 mph 300 @ > 35 mph	500	300
Texas	100	500	300

* Adopted from the worst case ODD

**high beams do not engage when the vehicle is on lighted roads

- Additionally, as required within the ODD, the ADS may command low and high beams or hazard warning lamps over the vehicle network (construction zones, tunnels, etc. may require activation of headlamps)

FMVSS 111 – Rear Visibility

FMVSS 111 Purpose: The purpose of this standard is to ensure "*clear and reasonably unobstructed view to the rear*" of a vehicle

Exemption Elements:	**Equivalent Safety Rationale:**
• *S6.2(b) Final requirements. Each multipurpose passenger vehicle, low-speed vehicle, truck…shall display a rearview image meeting the requirements of S6.2.1 through S6.2.7.* • *S6.2.4 Linger time. The rearview image meeting the requirements of S6.2.1 and S6.2.2* ***shall not be displayed after the backing event has ended****.* • *S6.2.5 Deactivation. The rearview image…****shall remain visible during the backing event until either, the driver modifies the view, or the vehicle direction selector is removed from the reverse position****.*	Manual Mode: • Regulated image will be available to the human driver during backing events. AV Mode: • The regulated rearview image will not be displayed to occupants since they are not a part of the driving task • A situational awareness screen is available to illustrate ADS perception and provide contextual information to the riders throughout the ride • The ADS sensor suite will perceive and communicate a 360-degree view of the environment around the vehicle to the ADS over the vehicle network, including the rearview image field of view • The sensor suite will provide input to the ADS continuously during AV mode, including during forward operation

A Traditional Rearview Image Will Not Be Displayed To Occupants During AV Operation, But The ADS Will Continuously Sense The Environment Around The Vehicle, Providing Equivalent Safety To That Of A Non-exempt Vehicle.

Discussion