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July 28, 2021

Dr. Steven Cliff
Acting Administrator
National Highway Traffic Safety Administration
1200 New Jersey Avenue, S.E.
Washington, D.C. 20590

Dear Acting Administrator Cliff:

RE: Petition under 49 C.F.R Part 555.6(d) to facilitate the deployment of a vehicle whose overall level of safety or impact protection is at least equal to that of a nonexempted vehicle

Ford Motor Company (Ford), the largest producer of vehicles assembled and sold in the United States, with offices at One American Road, Dearborn, Michigan 48126-2798, files this application, pursuant to 49 C.F.R. 555.6(d), for a two-year temporary exemption [**Confidential Business Information (CBI)**] to further develop, evaluate, and deploy its Society of Automotive Engineers (SAE) Level 4 Automated Driving System (ADS) feature equipped vehicle.

We have announced our intent to deploy a vehicle with an SAE Level 4[1]- ADS-equipped feature for commercial applications that include ride hailing and package delivery early in this decade. As we do not plan to equip these vehicles with certain conventional manual controls and communications required for compliance to portions of the FMVSS, we request NHTSA's approval to achieve the safety purpose of such Federal Motor Vehicle Safety Standards (FMVSS) through alternative and equivalent means.

At Ford, the safety of our customers and the integrity of our products are a primary focus. The approval of this petition will help us further our collective goal of improving and shaping the future of safe, smart mobility.

We thank the agency for its consideration of this petition. If you have any questions regarding the petition, please contact Anthony Smith (email: asmit685@ford.com or phone: 313-845-2408).

Sincerely,

Desi Ujkashevic

[1] Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles J3016_202104 (https://www.sae.org/standards/content/j3016_202104/)

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I. Background:

a. Introduction

Ford Motor Company hereby files this application, pursuant to 49 C.F.R. 555.6(d), for a two-year temporary exemption [**Confidential Business Information**] in order to deploy a vehicle whose overall level of safety or impact protection is at least equal to that of a nonexempted vehicle. Ford is seeking the exemption in order to further develop and evaluate its SAE level 4 Automated Driving System (ADS) feature, which will be equipped on vehicles that are fleet owned and operated. The exemption is requested to enable controlled deployment and usage of the ADS-equipped vehicles on tested, proven roadways during appropriate weather conditions. When engaged, the ADS assumes the driving role and performs the entire Dynamic Driving Task (DDT) as defined in SAE J3016[2]. In addition, some driving controls and features designed for human drivers will be not be available to occupants of the ADS-equipped vehicles.

Ford is seeking exemptions from sections in specific FMVSS that have requirements written with controls required for the human driver to operate vehicle features, telltales, indicators, and warnings required to notify the human driver of a feature's status or malfunction.

The FMVSS and the sections for which exemptions are requested are summarized below:

Table 1 - Summary of FMVSS Exemptions

Regulation	Description	Sections
101	Controls and Displays	S5.1 – S5.4, S5.6
102	Transmission Shift Position Sequence, Starter Interlock, and Transmission Braking Effect	S3.1.4.1
108	Lamps, Reflective Devices, and Associated Equipment	S6.6.1, S6.6.2, S9.1.1, S9.3 – S9.8
111	Rear Visibility	S6.2.3 – S6.2.5
126	Electronic Stability Control Systems	S5.3
135	Light Vehicle Brake Systems	S5.5, S5.3.1
138	Tire Pressure Monitoring	S4.3, S4.4

Ford intends to comply via self-certification to all other applicable FMVSS regulations and sections.

[2] Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles J3016_202104 (https://www.sae.org/standards/content/j3016_202104/)

b. Description of the Ford ADS-equipped Vehicle

Ford Motor Company's purpose is to help build a better world, where every person is free to move and pursue their dreams. Ford was built on the belief that freedom of movement drives human progress, and that belief has fueled its passion to create great cars and trucks. Ford envisions that the future of transportation will be increasingly electric, connected, and autonomous. Today, it drives our aspiration to become the world's most trusted company, designing smart vehicles for a smart world that help people move more safely, confidently and freely while reducing the carbon footprint.

We recognize that just inserting new mobility technologies and services into a city or neighborhood won't solve its existing challenges and may even make them worse. That is why we are committed to collaborating with city leaders where we operate. We are learning how each city works, what its needs are, and how our technology can help adapt and support each city's unique transportation system. If applied correctly, new technologies can enable solutions to help improve the quality of life for everyone by providing additional access to transportation. We're developing a portfolio of solutions that can help a city improve its transportation system and the ever-growing mobility options emerging every day.

Granting this petition will allow a progressive deployment to realize the potential of self-driving technology. Prior to the COVID-19 pandemic, the United Nations had identified increasing urbanization as one of the defining trends of the 21st Century[3], which was causing a shift from individual vehicle ownership to the use of shared mobility options such as ride-hailing services. Due to the pandemic, we have seen a shift in consumer behavior, including a dramatic shift in people's willingness to embrace home delivery of goods and services. In a June 2020 report[4], consulting firm Accenture found an increase of consumers using home delivery services with 45% saying they expect to continue to do so. Self-driving vehicles are one of the solutions to help enable the future of mobility.

We are developing our ADS-equipped vehicles to operate as a safe, productive and valuable part of a city transportation system to help make people's lives better. For example, self-driving services could be hailed as a last-mile solution, to avoid parking costs and reduce traffic frustrations, or to provide a solution for people who may not be able to drive themselves. In the realm of goods delivery, we see an opportunity to help with the increasing demand generated by the convenience of efficient delivery from retailers or supporting a business to provide additional ways to move their goods. As they reach scale, self-driving vehicles have the potential to transform society in through enhanced safety, improved congestion and improved mobility for everyone (including underserved populations such as the elderly and people with disabilities). We believe that people and packages can move more safely, efficiently and affordably in the self-driving future.

For a self-driving system to perform the entire driving task, ADS-equipped vehicles are equipped with the latest in cutting-edge sensing and compute technology. The components that make up the vehicle itself such as the suspension, brakes and electrical system are also critical to self-driving vehicles. These components must be designed and developed as an integrated system

[3] United Nations - World Urbanization Prospects 2018: https://www.un.org/development/desa/pd/news/world-urbanization-prospects-2018

[4] https://www.accenture.com/us-en/insights/consumer-goods-services/coronavirus-consumer-trends-impacting-cpgs

working in unison to enhance capability, reliability and performance. We believe the end result needs to be a high-quality, energy-efficient vehicle, that people trust to serve their needs.

Our ADS-equipped vehicle uses a hybrid-electric vehicle (HEV) platform that has been specifically designed and tailored to support mobility services such as ride sharing, ride hailing and package delivery. Each vehicle will be modified with the components that make up the ADS and are responsible for the core capabilities of perception, motion planning and execution, which together enable the vehicle to drive itself.

When equipped with the ADS, our vehicles can be operated in either a human-driven mode (Manual Mode), or in an ADS-driven mode (AV Mode). Transitioning between modes can only be performed by a trained operator while the vehicle is stationary. When the ADS is active, it performs the entire DDT, and removes the need for a human driver.

The Operational Design Domain (ODD) describes where, when, and under what conditions an ADS-equipped vehicle will operate. The intended ODD represents a convergence of the vehicles' expected capabilities and the projected business model, which includes ride-hailing and goods delivery along urban streets. We expect these vehicles to operate day and night, and from clear conditions up to light rain.

Self-driving vehicles have the potential to create safer streets for everyone, including cyclists and pedestrians, not just those utilizing a vehicle. The ADS must constantly survey its surroundings and consider pedestrians, cyclists and other road users to predict how to best react. The ADS consists of computing hardware, software, sensors and map data. A 360º multi-modal sensing strategy includes:

- **Near field and far field cameras** – high-resolution video image captures for detection, tracking and classification of static and dynamic objects
- **Mid and long range radars** – sensors that transmit radio waves to detect objects and help determine their range and velocity
- **Short and long range LiDARs** – high-precision sensors that measure distances to objects using pulses of laser light to visualize the space around it with 360º coverage
- **Inertial Measurement Unit (IMU) and wheel speed sensors** – sensors for determination of orientation and position of the vehicle over time

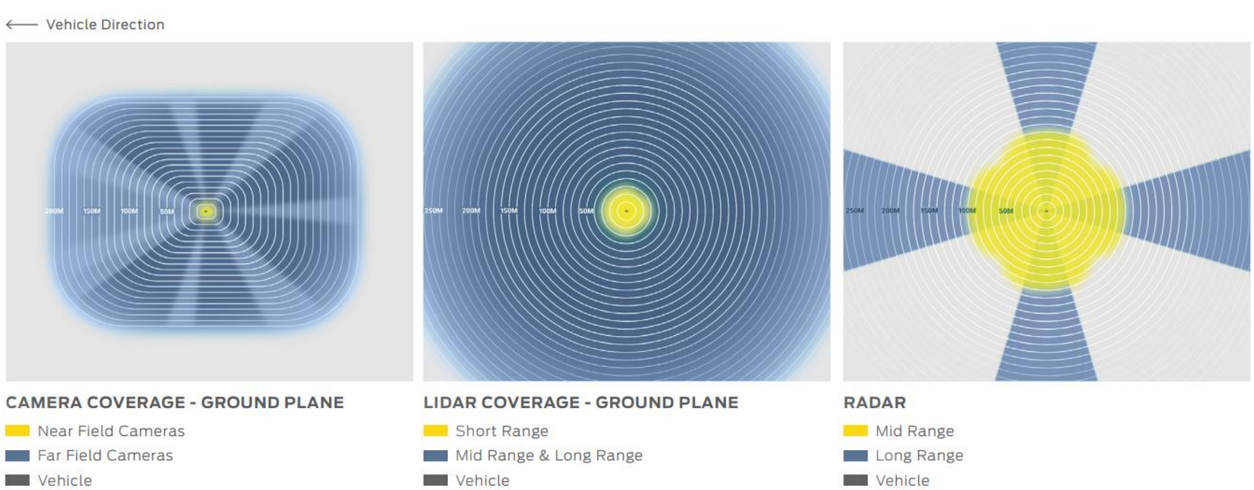

Figure 1 - Ford's AV sensor coverage (Source: Argo AI)

The ADS uses a high definition map of the road network and surrounding environment. This, when combined with real time sensing, allows the vehicle to determine its location within a lane, dynamically route to a destination, and interpret local rules of the road, such as speed limits and traffic controls. Software analyzes the sensor data to locate vehicles, pedestrians and other obstacles, predict their future motion, and plan an appropriate vehicle path through the environment. Once a path is determined, motion commands are calculated and then communicated to the vehicle's actuators, such as the engine, transmission, steering, braking, and exterior lighting.

c. Designing for Safety

At Ford, we place safety at the heart of the process and build the entire system – vehicle, software, testing and training–around it. Along with Argo.AI, our Automated Driving System developer, systems engineering drives our safety strategy throughout the development process, which helps overall safety even in the unlikely event a component fails or the vehicle suffers a problem. At every stage of design and testing, our engineers use systems engineering tools and processes and supplement them with lessons from the aerospace industry's long history of automation and safety.

We use a proven three-step method for validation: simulation, closed-track testing and real-world testing. Simulation techniques include Hardware-in-the-Loop (HIL) and Software-in-the-Loop (SIL) to create virtual sandboxes for component and sub-system testing. We are currently testing ADS-equipped vehicles with safety operators on city streets, but they will not be in commercial operation without safety operators in the vehicle until we achieve specific milestones in our development process that indicate we are ready to do so. As we test our system, we will continually improve our software through our engineering processes. These include machine learning and testing the software against our safety and performance requirements to complete driving tasks in a manner expected of human drivers operating within the ODD.

The System Safety approach includes the application of engineering tools and processes, and supplements them with industry standards and best practices (such as ISO 26262 – Road vehicles – Functional Safety) and lessons learned in the field. Using this approach, safety-critical system functionality is designed to be robust, with redundancy and fallback responses as a part of the System Safety protocols. The AV is designed to fail safely or fail-operational[5] depending on the type of malfunction. Fail-operational systems include braking, steering, electrical systems, and the virtual driver system. Ford's AV implements system redundancies that are able to function independently of their counterpart system, yet in parallel, to support the ADS in its driving task. In addition to diagnostics, the vehicle is monitored to determine its readiness, such as verifying all doors are closed prior to initializing a trip.

Cybersecurity is a fundamental element of our System Safety process, and our cybersecurity strategy extends well beyond the vehicles' electronics, sensors, and the ADS. We are addressing cyber risks throughout the entire vehicle lifecycle from concept and design, to supply chain and production, to operation and maintenance.

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[5] Fail-operational systems continue to operate when any single component fails. Fail-safe systems go to a safe state when they cannot operate.

We also look forward to continuing our work with our industry partners in efforts such as the SAE Automated Vehicle Safety Consortium (AVSC) and the Crash Avoidance Metrics Partnership (CAMP), as well as with NHTSA, to define common, industry-wide safety assurance test methods related to ADS development and operational deployment. Since this work is ongoing and we are constantly learning during development, we plan to update our Voluntary Safety Self-Assessment with information on our production AV vehicles and test methods, when applicable.

We are not in a race to be first to offer self-driving vehicles to the public. Our focus is on bringing ADS-equipped vehicles to market in a safe and responsible manner. In addition to state-of-the-art hardware and software, we are also incorporating a sophisticated vehicle health monitoring strategy, redundancies, and fallback strategies as described below to improve overall safety.

As learned from the aerospace industry, the ADS has complementary computing systems. These two computers function simultaneously while sharing information and operating on separate power distribution networks. Should a failure occur in the primary system, the complementary system will bring the vehicle to a controlled stop.

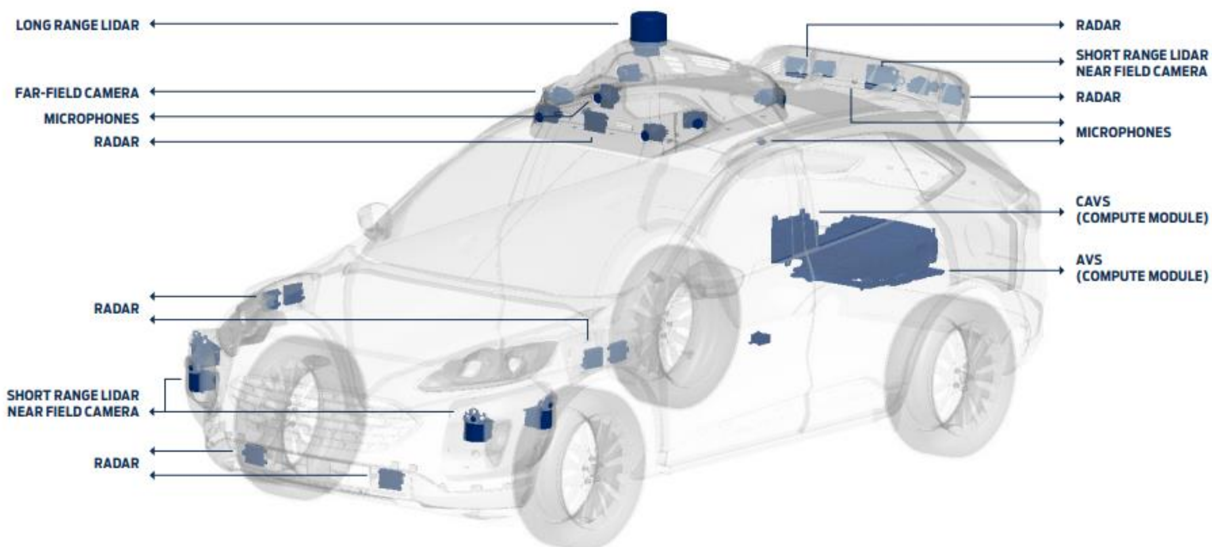


Figure 2 - Ford's Autonomous Vehicle Platform

While the main power to the vehicle is provided by the high voltage battery, complementary electrical power sources and distribution to several critical components are also present. In the case of a power failure on one network, the complementary power network is able to provide power to the computers, sensors, braking and steering systems on its network to bring the vehicle to a controlled stop. Should a failure occur in the primary system, the vehicle is still able to operate through the secondary system. More specifically, should a sensor, controller, actuator, etc. within the steering system fail or lose communication, the steering system is designed to maintain control of the vehicle. The same is true of the brake system, such that it is able to maintain safe operation of the vehicle in the event of a single point failure.

When the ADS detects a malfunction affecting the system's ability to perform the DDT, it will perform a fallback maneuver. These maneuvers are categorized into three levels, as shown in Table 2. Each subsystem conducts its own onboard diagnostics (no offboard connectivity required). Safety critical subsystems also monitor the status of other subsystems they interface with. Depending on the severity of a detected malfunction, the vehicle will transition to an appropriate minimal risk condition, ranging from diagnostic reporting back to the operations terminal to stopping as soon as possible. The Fallback Level can be escalated if other faults occur, driving conditions warrant it, or if time thresholds to complete the vehicle response are not met.

Table 2 - Ford AV Fallback Levels

Fallback Level	Vehicle Behavior
1	Vehicle completes trip and is scheduled for service
2	Vehicle finds a suitable parking location or pulls over to the shoulder
3	Vehicle comes to a controlled stop in path

d. Fleet operations

The ADS-equipped vehicles will be fleet owned and operated to allow for a controlled deployment and usage on tested, proven roadways in appropriate weather. Two variants of the ADS-equipped vehicle platform are highlighted in Table 3 below. The self-certified AV will be a fully compliant version of the vehicle used for continuous improvement and mapping purposes. It will be outfitted with traditional controls, and may only be manually driven by specially trained operators. The exempted AV will feature non-traditional controls that are only available in a dedicated Manual Mode intended for service purposes, while AV Mode operation does not offer controls to occupants since there is no expectation for human input during the DDT.

Table 3 - AV Variant Differences

	Exempted AV	Self-Certified AV
Steering Device	Active in Manual Mode only [**CBI**]	Always active (Steering Wheel)
Gas & Brake Pedals	Active in Manual Mode only [**CBI**]	Always active
Other Regulated Controls &Telltales	Manual Mode only[6]	Always active
ADS Equipped?	Yes	Yes
Authorized Human Drivers	Manual Mode available to trained operators only	Specially trained safety operators only
Use Case	Ride-sharing / Goods Delivery	Mapping / Development Ride-sharing / Goods Delivery
NHTSA Compliance	Petitioning for exemptions	Self-certification compliance

[6] In AV Mode, select telltales, indicators, and controls will be presented to occupants, including those related to restraints and occupant protection. Those related to the DDT will not be provided when the ADS is active.

Within the service depots (and the assembly plant environment), trained operators are expected to help with the logistics of fueling and maintenance. The exempted AV vehicles will have a Manual Mode to simplify these tasks. Manual Mode is enabled only for authorized users [**Confidential Business Information**]

Confidential Business Information

At the end of daily operation, the AVs will be fueled, cleaned and serviced at a central service depot. During this down time, there will also be an opportunity to complete data downloads and make necessary software updates to ensure smooth operations. This approach ensures the vehicles are adequately maintained and serviced.

II. Establishing an Overall Level of Safety at Least Equal to a Nonexempted Vehicle

This section demonstrates how our AV meets the safety purpose of affected FMVSS and provides safety at least equal to that of a nonexempted vehicle.

The specific requirements that we seek to address via exemption are attributed to requirements within the FMVSS where a human driver is expected to execute or recognize elements of the safety task. We believe these FMVSS exist due to a human driver's need to operate regulated controls and receive regulated information, and as prescribed, no longer support the safety purpose when an ADS is performing the DDT. Most traditional controls and information are not available during the vehicle's AV mode to prevent occupants from interfering with the driving task when being executed by the ADS.

In the Manual Mode available to trained operators only, the vehicle will comply with all applicable FMVSS. For AV Mode operation, Ford seeks to accomplish the regulated safety performance through alternative means, as the ADS and vehicle are made capable of receiving the regulated information and controlling the regulated elements of the applicable FMVSS. As the vehicles have not yet been produced, results of tests conducted to demonstrate failure to meet the standards or exceed conformity to the standards are not included. The expected regulatory performance of our exempted AVs will be maintained, and potentially improved upon in some cases, as outlined in the sections that follow.

FMVSS 101: Controls and displays

Requirement

FMVSS 101's stated purpose 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*."[7] Sections S5.1, S5.2, S5.3, S5.4, and S5.6 specify the location, identification (symbol, word, etc.), illumination, color, and evaluation conditions of the regulated controls, telltales, and indicators, respectively.

The safety needs of FMVSS 101 differ between the human-driven Manual Mode and when the ADS performs the DDT in AV Mode. In AV Mode, the ADS is not receptive to optical telltales and indicators and will not utilize physical control interfaces typically offered to humans. The ADS receives the regulated information and has the ability to command the regulated controls needed for the driving task electronically through the vehicle communication network.

Ford's Approach

In Manual Mode, our AV can be operated by a trained, human-driver. All required controls, telltales and indicators will operate as required by regulation. Modules within the vehicle communicate with each other and broadcast the regulated information over the vehicle communication network

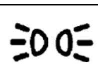
[7] 49 C.F.R. § 571.101 - S2

(e.g. controller area network buses, or CAN), the driver display module receives the information and displays telltales and indicators when triggered. For example, the Body Control Module (BCM) is an electronic control unit responsible for monitoring, controlling, and arbitrating between various modules and accessories such as the power windows, mirrors, and lighting through the vehicle communication network.

In AV Mode, a few select telltales, indicators, and controls will be presented to occupants, including those related to restraints and occupant protection, as described below. However, the ADS does not need the location, identification, illumination, and color prescribed within FMVSS 101 when the ADS is performing the driving task, so the majority will not be provided to occupants. The controls and the conditions which would normally trigger the regulated telltales and indicators, will be accessed by the ADS via the vehicle communication network. By utilizing the vehicle communication network, the ADS directly receives the information these regulated features were meant to communicate to human drivers, and often in greater detail. The ADS is immediately capable of responding to that information, which may include an appropriate fallback maneuver. Additionally, fault information may be communicated from the AV to the fleet management system to schedule vehicles for return to the AV terminal for service or servicing on road.

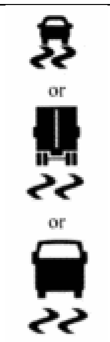
Table 4 combines the regulated expectations from FMVSS 101's Table 1[8] and Table 2[9]. In the vehicle's Manual Mode, we are able to demonstrate compliance to the regulated elements, where applicable and as required. Table 4 also includes our approach to each regulated element during AV Mode operation, summarizing how the information is communicated or controls are available to the ADS, vehicle, and occupants (when applicable).

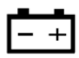
Table 4 - FMVSS 101 Regulated Telltales, Indicators, and Controls

	Manual mode					**AV Mode**
ITEM	**SYMBOL**	**WORDS OR ABBREVIATIONS**	**FUNCTION**	**ILLUMIN -ATION**	**COLOR**	**Approach**
High beam		-	Telltale	-	Blue or Green	The vehicle uses Automatic high beams by default. The ADS may command beam switching beams and receives feedback on the status via the vehicle communication network as required while performing the DDT.
Turn signals		-	Control	-	-	The ADS commands turn signals and receives feedback on their status via the vehicle communication network as required when performing the DDT.
			Telltale	-	Green	
Hazard warning signal		**Hazard**	Control	Yes	-	The ADS commands the hazard warning signal and receives feedback on the status via the vehicle communication network as required when performing the DDT.
		-	Telltale	-	-	
Position, side marker, end-outline		**Marker Lamps or MK Lps**	Control	Yes	-	The ADS commands marker lamps and receives feedback on the status via the vehicle

[8] 49 C.F.R. § 571.101 – Table 1, Controls, Telltales, and Indicators With Illumination or Color Requirements
[9] 49 C.F.R. § 571.101 – Table 2, Identifiers for Controls, Telltales, and Indicators with No Color or Illumination Requirements

	Manual mode					AV Mode
ITEM	**SYMBOL**	**WORDS OR ABBREVIATIONS**	**FUNCTION**	**ILLUMIN -ATION**	**COLOR**	**Approach**
marker, identification, or clearance lamps						communication network as required when performing the DDT.
Windshield wiping system		**Wiper or Wipe**	Control	Yes	-	Vehicle windshield clarity is not required to safely navigate the vehicle, but the ADS uses the rain-sensing wiper feature from the base vehicle by default. Riders have the option to control wipers through the user interface.
Windshield washing system		**Washer or Wash**	Control	Yes	-	Riders have the option to control wash through the user interface.
Windshield washing and wiping system combined		**Washer-Wiper or Wash-Wipe**	Control	Yes	-	N/A
Windshield defrosting and defogging system		**Defrost, Defog, or Def.**	Control	Yes	-	Riders have the option to control climate through the user interface. Between rides, the ADS may command the Climate Control Module (CCM) via the CAN network to improve the vehicle comfort and/or visibility prior to riders entering the vehicle.
Rear window defrosting and defogging system		**Rear Defrost, Rear Defog, Rear Def., or R-Def.**	Control	Yes	-	N/A
Brake system malfunction	-	**Brake**	Telltale	-	Red	The ADS receives feedback on the status via the vehicle communication network.
Antilock brake system malfunction for vehicles subject to FMVSS 105 or 135	-	**Antilock, Anti-lock, or ABS**	Telltale	-	Yellow	The ADS receives feedback on the status via the vehicle communication network.
Malfunction of Variable Brake Proportioning system	-	**Brake Proportioning**	Telltale	-	Yellow	The ADS receives feedback on the status via the vehicle communication network.
Regenerative brake system malfunction	-	**RBS or ABS/RBS**	Telltale	-	Yellow	N/A
Malfunction in antilock system for vehicles other than trailers subject to FMVSS 121	-	**ABS or Antilock**	Telltale	-	Yellow	-
Antilock brake system trailer fault for vehicles subject to FMVSS 121		**Trailer ABS or Trailer Antilock**	Telltale	-	Yellow	-
Brake pressure (for vehicles	-	**Brake Pressure**	Telltale	-	Red	The ADS receives feedback on the status via the vehicle communication network.

	Manual mode					AV Mode
ITEM	**SYMBOL**	**WORDS OR ABBREVIATIONS**	**FUNCTION**	**ILLUMIN -ATION**	**COLOR**	**Approach**
subject to FMVSS 105 or 135)						
Low brake fluid condition (for vehicles subject to 105 or 135)	-	**Brake Fluid**	Telltale	-	Red	The ADS receives feedback on the status via the vehicle communication network.
Parking brake applied (for vehicles subject to FMVSS 105 or 135)	-	**Park or Parking Brake**	Telltale	-	Red	The ADS receives feedback on the parking brake status via the vehicle communication network.
Brake lining wear-out condition (for vehicles subject to FMVSS 135)	-	**Brake Wear**	Telltale	-	Red	N/A Vehicle will have means of visually checking brake lining wear.
Electronic Stability Control System Malfunction (for vehicles subject to FMVSS 126)		**ESC**	Telltale	-	Yellow	The ADS receives feedback on the status via the vehicle communication network.
Electronic Stability Control System "Off" (for vehicles subject to FMVSS 126)		**ESC OFF**	Control	Yes	-	ESC Off is not featured on the ADS-equipped vehicle
			Telltale	-	Yellow	
Electronic Stability Control System Malfunction (for vehicles subject to FMVSS 136)		**ESC**	Telltale	-	Yellow	-
Fuel Level		**Fuel**	Telltale	-	-	Engine Control Module (ECM) fuel level sensor circuit communicates range and performance to the ADS over CAN. The ADS ensures sufficient fuel remains to complete scheduled trip and returns for refueling.
			Indicator	Yes	-	
Engine oil pressure		**Oil**	Telltale	-	-	ECM communicates engine oil pressure powertrain degradation signal and relays condition to fleet management to schedule service. If pressure is outside of range, the vehicle takes appropriate action to minimize safety risks.
			Indicator	Yes	-	

	Manual mode					AV Mode
ITEM	**SYMBOL**	**WORDS OR ABBREVIATIONS**	**FUNCTION**	**ILLUMIN-ATION**	**COLOR**	**Approach**
Engine coolant temperature		**Temp**	Telltale	-	-	ECM communicates engine coolant temperature sensor range and the powertrain capability degradation signal to ADS. If over temperature conditions are met, the vehicle communicates the condition to fleet management to schedule service and takes appropriate action to minimize safety risks.
			Indicator	Yes	-	
Electrical charge		**Volts or Charge or Amp**	Telltale	-	-	Status, system faults or loss of power are communicated to the ADS by the appropriate module.
			Indicator	Yes	-	
Engine stop	-	**Engine Stop**	Control	Yes	-	N/A
Automatic vehicle speed (cruise control)	-	**-**	Control	Yes	-	The ADS does not use cruise control.
Speedometer	-	**MPH, or MPH and km/h**	Indicator	Yes	-	Vehicle speed is a part of the user interface for passengers. Vehicle speed is constantly monitored by the ADS.
Heating and Air conditioning system	-	**-**	Control	Yes	-	Riders have the option to control climate through the user interface. Between rides, the ADS may command the CCM via CAN to improve the vehicle comfort and/or visibility prior to riders entering the vehicle.
Automatic transmission control position (park) (reverse) (neutral) (drive)	-	**P R N D**	Indicator	Yes	-	The ADS receives feedback on the status via the vehicle communication network.
Heating and/or air conditioning fan		**Fan**	Control	Yes	-	Riders have the option to control climate settings through the user interface. Between rides, the ADS may command the CCM via CAN to improve the vehicle comfort and/or visibility prior to riders entering the vehicle.
Low Tire Pressure (including malfunction) (See FMVSS 138)		**Low Tire**	Telltale	-	Yellow	The ADS is made aware of this status via the vehicle communication network.
Low Tire Pressure (including malfunction that identifies involved tire) (See FMVSS 138)		**Low Tire**	Telltale	-	Yellow	-
Tire Pressure Monitoring System Malfunction	-	**TPMS**	Telltale	-	Yellow	The ADS is made aware of this status via the vehicle communication network.

	Manual mode					AV Mode
ITEM	**SYMBOL**	**WORDS OR ABBREVIATIONS**	**FUNCTION**	**ILLUMIN -ATION**	**COLOR**	**Approach**
(See FMVSS 138)						
Hand Throttle Control	-	**Throttle**	-	-	-	-
Engine Start Control	-	**Engine Start**	-	-	-	N/A
Manual Choke Control	-	**Choke**	-	-	-	-
Odometer	-	**Kilometers or km, if kilometers are shown. Otherwise, no identifier is required.**	-	-	-	N/A
Horn		**Horn**	-	-	-	The ADS is able to command the horn via the vehicle communication network.
Master Lighting Switch		**Lights**	-	-	-	N/A
Headlamps and Taillamps Control	-	**-**	-	-	-	The ADS utilizes the auto headlamp feature by default, and is capable of commanding lighting via the vehicle communication network as required to perform the DDT.
Low Brake Air Pressure Telltale (for vehicles subject to FMVSS 121)	-	**Brake Air**	-	-	-	-
Seat Belt Unfastened Telltale		**Fasten Belts or Fasten Seat Belts**	-	-	-	The AV will monitor the seatbelt status of each seat and notify/warn occupants via the HMI when their seat belt is unbuckled.

Statement of Overall Safety

FMVSS 101 is intended to meet the challenge "*to ensure the accessibility, visibility and recognition*" of controls and important safety information to drivers, and this purpose is met in both Manual and AV Modes. The vehicle is compliant in Manual Mode, offering the controls, telltales, and indicators to the human driver as regulated. By using the vehicle communication network in AV Mode, the ADS is able to command vehicle features related to the DDT when the regulated controls are not present. In addition, regulated information is communicated over the network, ensuring the information is immediately available and the ADS can respond accordingly. Certain controls, telltales, indicators, and warnings will also be provided to occupants in AV Mode, including those related to occupant protection. This approach ensures the AV's overall level of safety at least equal to that of a nonexempted vehicle.

FMVSS 102: Transmission shift position sequence, starter interlock, and transmission braking effect

Requirement

The purpose of this requirement is "to reduce the likelihood of shifting errors."[10] S3.1.4 of FMVSS 102 requires, "identification of shift positions, including the positions in relation to each other and the position selected, shall be displayed in view of the driver."[11] Because the ADS is not receptive to optical telltales and we will not provide this information to occupants, we are requesting an exemption to this requirement. While the ADS is operational, the ADS performs the DDT and receives information about the transmission shift positions electronically through the vehicle communication network.

Ford's Approach

In Manual Mode, the vehicle will comply with S3.1.4. In AV Mode, the ADS requests a gear shift via redundant CAN messages to the powertrain control module (PCM). It also continually receives two separate CAN messages from the PCM regarding gear state, from which it can determine the actual gear position. Details on these two CAN messages are shown in Table 5 below. In both manual and AV modes, the PCM controls solenoids to select the desired gear.

Table 5 - Gear State Selection and Feedback CAN Messages

Message	Contents
Transmission Park State	Indicates the current state of the park system (e.g. Park, Out of Park, Transition to/from Park, etc.)
Gear Position	Indicates the achieved gear position of the automatic transmission (e.g. R, N, 1st, 2nd, etc.)

Statement of Overall Safety

The purpose of FMVSS 102 S3.1.4 is to "reduce the likelihood of shifting errors" by providing a standard means of communicating transmission shift positions to drivers. In AV Mode, the ADS will receive continuous communication from the PCM about the transmission shift position, so it will be provided with the same information about the transmission shift position as the driver in a nonexempted vehicle, providing an equivalent level of overall safety. In Manual Mode, the requirements of S3.1.4 are met.

[10] 49 C.F.R. § 571.102 – S1
[11] 49 C.F.R. § 571.102-S3.1.4.1

FMVSS 108: Lamps, reflective devices, and associated equipment

Requirement

FMVSS 108's purpose 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."*[12] The vehicle's compliant Manual Mode provides the trained human driver with the required regulatory controls, indicators, and telltales. In AV Mode, lighting-related controls, indicators, and performance elements are no longer necessary to support the driving task in the absence of a human driver. Furthermore, should controls remain accessible to riders, the occupants may select a lighting feature that contradicts the ADS's driving action, causing confusion and reducing safety for other road users and/or the ADS-equipped vehicle.

Since the traditional lighting controls, indicators, and telltales are unavailable to occupants in AV Mode, an exemption is needed, as S6.6.1 stipulates the need for 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 that meet specific performance requirements within S9[13]. Among them is a requirement for the headlamp beam switching device to be "*operated conveniently by a simple movement of the driver's hand or foot*", which will not apply when the ADS is performing the DDT. In addition, S6.6.2 addresses the need for a vehicular hazard warning operating unit, a vehicular hazard warning signal flasher, and a vehicular hazard warning signal pilot indicator that meet the requirements of S9[13].

Ford's Approach

The vehicle uses some of the automated lighting features offered in the vehicle's Manual Mode in AV Mode as well. For example, the vehicle defaults to use the automatic headlamp feature that monitors ambient light conditions and activates the low-beam headlamps when conditions warrant. As with a human driver, the ADS is able to override the default lighting features in situations where headlamp activation or deactivation may be necessary within the ODD (e.g. when traveling through tunnels where the ambient lighting conditions may not activate headlamps). For lighting controls and associated communications, the ADS communicates with the body control module (BCM) over the vehicle communication network through the primary and secondary ADS.

In the case of the turn signal operating unit, the ADS is able to determine when turn signals are necessary based on the driving actions executed over the course of the active trip. The ADS may plan a turn or lane change, activate the turn signals in the desired direction using the appropriate command via the vehicle communication network, and perform the desired driving action, then

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[12] 49 C.F.R. § 571.108 – S2

[13] 49 C.F.R. § 571.108 – S9.1.1, S9.3 – S9.8

deactivate the signal with the appropriate command via the vehicle communication network. In this case, the vehicle communication network command sent between the modules addresses the ADS equivalent of a turn signal operating unit, and constant vehicle communication network communication provides the ADS the equivalent of a turn signal pilot indicator. This method addresses the expectation for steering wheel rotation to cancel the turn signals, or cancellation by a manually operated control, as prescribed in S9.1.1.

Similar to the low beam headlamps, the vehicle defaults to use the automated high beam feature that monitors oncoming lighting to determine when it is appropriate to engage the upper beams. The ADS is also able to send commands over the vehicle communication network to activate and deactivate upper beams as needed within the ODD, addressing the need for a headlamp beam switching device and its associated performance requirements. When the upper beams are active, the ADS receives constant feedback from the lighting module over the network, effectively addressing the need for the upper beam indicator.

The hazard warning signal is also commanded by the ADS to the lighting module over the vehicle communication network. Certain Fallback Levels trigger the hazard warning signal as the vehicle is coming to a stop, while others activate them after the vehicle is stopped. As with the other lighting features, the lighting module is in constant communication with the ADS over the network, preventing the need for a traditional hazard warning signal indicator.

In the event of a failure or loss of communication with lighting features, appropriate actions will be taken by the vehicle to alert the AV service team an issue requires attention.

Statement of Overall Safety

Similar to FMVSS 101, the AV system design addresses the driver control and communication requirements found in FMVSS 108 S6.6.1, 6.6.2 and S9 by allowing the vehicle's ADS to communicate electronically over the vehicle communication network. The system design meets the regulatory purpose in communicating important safety information to the ADS and it allows the ADS to react immediately to provide safe lighting performance. In addition, should any error or loss of communication be detected, the appropriate actions are taken by the vehicle to minimize risks to safety. This approach addresses the regulatory purposes identified in FMVSS 108 S6.6.1, S6.6.2 and S9, providing equivalent safety for the vehicle's AV Mode of operation.

FMVSS 111: Rear visibility

Requirement

The purpose of 111 is *"to reduce the number of deaths and injuries that occur when the driver of a motor vehicle does not have a clear and reasonably unobstructed view to the rear."*[14] Sections

[14] 49 C.F.R. § 571.111 – S2

S6.2.3 – S6.2.5 provide response time, linger time, and deactivation requirements for the rearview image performance that must be perceived by the driver. Compliance for the rear visibility system can be demonstrated in the vehicle's Manual Mode when engaged by a trained operator. However, the displayed image doesn't provide the intended safety purpose to the ADS in AV Mode, and the ADS will not visually perceive the image typically provided to a human driver. Furthermore, the rearview image will not be displayed to human occupants during backing events, as the ADS is solely responsible for the DDT and the occupants have no responsibility to perform any driving actions.

Ford's Approach

In lieu of a traditional rearview image, in AV Mode the ADS utilizes a collection of sensors that meet the intended visibility requirements of FMVSS 111 (see Figure 7). Human drivers can potentially be distracted if a rearview "image" lingers beyond the length of time it takes for a backing maneuver, whereas the ADS will not be distracted by the rearview "image", so requiring the ADS to disable its rear sensing outside of backing events would decrease its ability to sense the environment around the vehicle. As a result, the safety intent of the response time and linger time requirements of S6.2.3 and S6.2.4, and the deactivation requirement of S6.2.5 is no longer necessary. In the case of our ADS, the near-field and far-field cameras, radars, and LiDARs (sensor suite) provide multiple modalities through which the vehicle can detect the environment around the vehicle during operation at all times, allowing operation in various environmental conditions, from low lighting to light precipitation. The sensor suite uses the strengths of each sensor type to provide the ADS with continuous, robust, real-time 360-degree coverage of its surroundings, regardless the direction of travel.

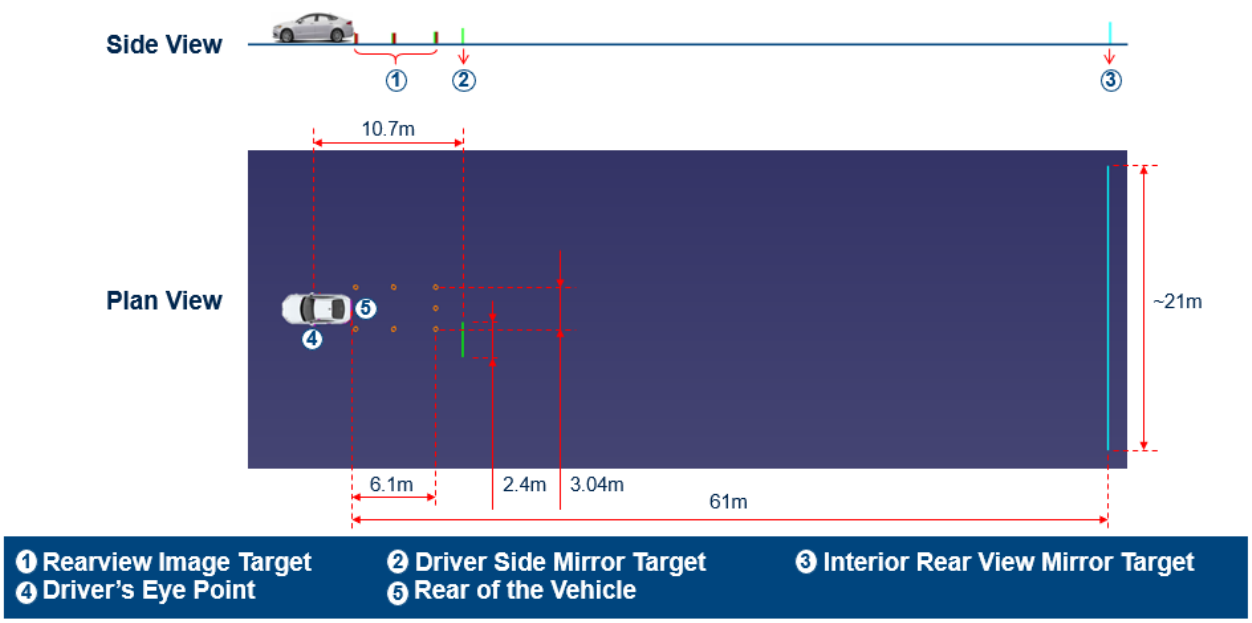

Figure 7 - Regulated FMVSS 111 Targets

The suite's ability to communicate the regulated field of view to the ADS can be demonstrated upon request via renderings of the regulated elements within the environment around the vehicle as they are collected by the sensor suite. Utilizing the test objects defined in S14.1.3 as the edges of the regulated field of views of Targets 1, 2, and 3, Figure 8 illustrates example sensing by the vehicle in accordance with FMVSS 111. The shades of red illustrate how different sensors sense the regulated environment.

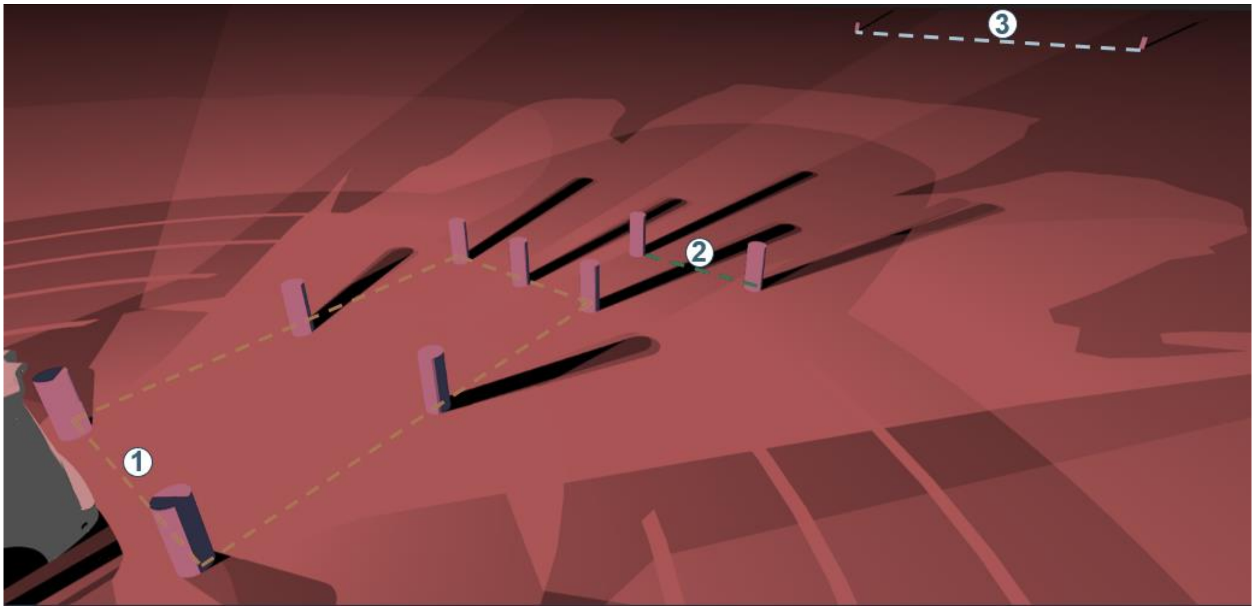

Figure 8 - Rendering of regulated environment sensed by the ADS

Statement of Overall Safety

Per the design described above, the ADS uses inputs from its multi-modal suite of sensors to constantly perceive the 360-degree environment around the vehicle in AV Mode, which includes the regulated field of views specified in FMVSS 111, while providing the regulated image and performance for a human driver in Manual Mode. This approach establishes overall safety performance at least equivalent to that of a nonexempted vehicle.

FMVSS 126: Electronic stability control systems for light vehicles

Requirement

The stated purpose of FMVSS 126 is 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*"[15]. Section S5.3 requires an electronic stability control (ESC) malfunction telltale,

[15] 49 C.F.R. § 571.126 – S2

that must be in front of and in clear view of the driver. While the ADS is operational, the ADS performs the DDT. Because the ADS is not receptive to optical telltales, it receives information about the ESC status electronically through the vehicle communication network.

Ford's Approach

Our ADS communicates directly with the autonomous braking module (ABM) through the vehicle's controller area network (CAN) buses to provide the same information that the telltale required in S5.3 provides to a human driver. The ESC logic is contained within the primary ABM. If ESC malfunctions while ADS is operational, the ADS will be made aware of this malfunction via communication from the ABM. During manual mode operation, the telltale will display this information to the trained operator.

Statement of Overall Safety

Our approach to use the CAN bus to communicate regulated telltales and indicators and control the applicable regulated features enables the ADS to recognize and respond to information typically provided to a human driver. This approach provides a level of safety equivalent to that of a nonexempted vehicle.

FMVSS 135: Light vehicle brake systems

Requirement

The stated purpose of FMVSS 135 is to "*ensure safe braking performance under normal and emergency driving conditions*"[16]. Section S5.3.1 requires a foot control for actuating the service brakes and a parking brake that is actuated by either a hand or foot. Section S5.5 requires a warning indicator that must be in front of and in clear view of the driver. While the ADS is operational, the ADS performs the DDT. Because the ADS is not receptive to optical telltales, it receives information about the brake system status electronically through the vehicle communication network.

Ford's Approach

Both of these FMVSS 135 compliance barriers result from the difference between how a human driver and the ADS interface with the underlying brake system. Our ADS communicates directly with the ABM through the vehicle's CAN buses to provide the same information that the telltale required in S5.5 provides to a human driver. If any brake system failure identified in FMVSS 135 occur during normal ADS operation, the ADS will be made aware of this malfunction via communication from the ABM. During brake system failures, the systems braking performance is maintained by one of the two redundant brake control modules as illustrated in Figure 9.

During Manual Mode, if the brake system experiences any of the fault modes identified in FMVSS 135, an indicator that is compliant with FMVSS 135 and FMVSS 101 will be displayed to the driver.

[16] 49 C.F.R. § 571.135 – S2

When ADS is active, there will not be a foot control for actuating the service brakes as required in S5.3.1. There will also not be a hand or foot control for actuating the parking brake as required in S5.3.1. The ADS will control both latitudinal and longitudinal motion of the vehicle. The brake control module receives electronic signals to activate either the service brakes or the Integrated Parking Brake (IPB) as shown in Figure 9. The corresponding physical controls are available to the trained operator during Manual Mode.

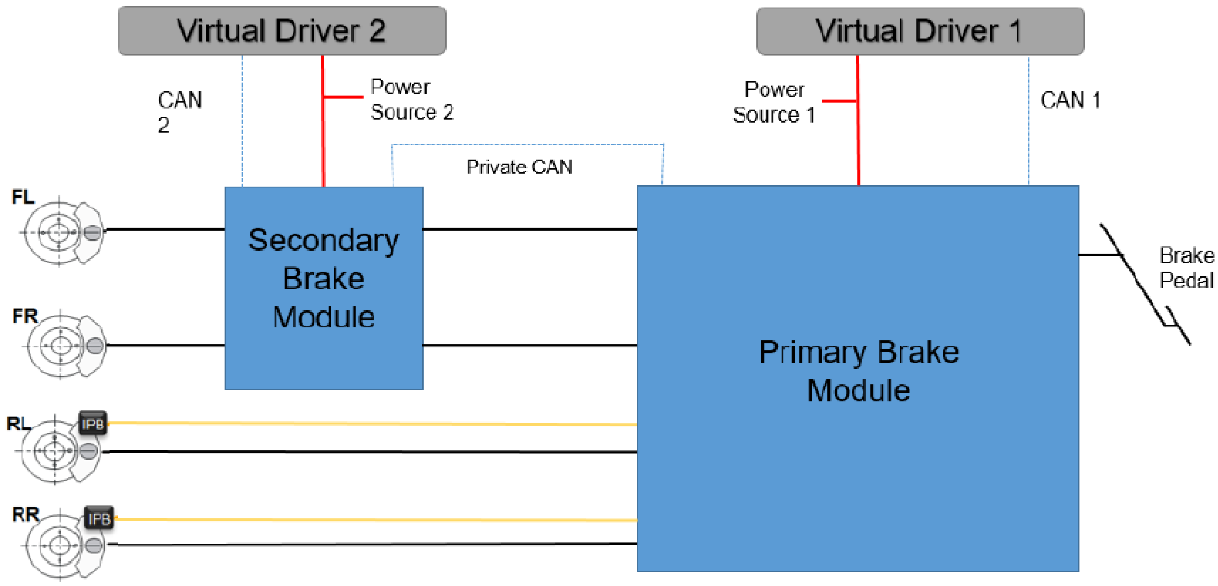

Figure 9 - Redundant Brake System Diagram

Statement of Overall Safety

The level of safety of the non-complaint AV is maintained, in the absence of a foot control for actuating the service brakes and a parking brake that is actuated by either a hand or foot during AV operation. Similar to a nonexempted vehicle, the brake system on the AV continues to meet the performance requirements of the standard.

Our approach to use the CAN bus to communicate regulated telltales and indicators and control the applicable regulated features enables the ADS to recognize and respond to information typically provided to a human driver. This approach provides a level of safety equivalent to that of a nonexempted vehicle.

FMVSS 138: Tire pressure monitoring systems

Requirement

FMVSS 138's purpose is to "warn drivers of significant under-inflation of tires and the resulting safety problems". S4.3 and S4.4 require tell-tales "mounted inside the occupant compartment in front of and in clear view of the driver."[17] We are requesting an exemption for these sections due to the ADS is not receptive to optical telltales and we do not intend to provide this information to occupants. While the ADS is operational, the ADS performs the DDT and receives tire pressure monitoring system (TPMS) information electronically through the vehicle communication network.

Ford's Approach

The TPMS on our AV consists of four tire pressure sensors, one located in each wheel, the radio transceiver module (RTM), the BCM, the ABM, the PCM and the instrument display. The tire pressure sensors measure the pressure of each tire and send the pressure information wirelessly to the RTM, which then sends it over a private wired network to the BCM. The PCM and ABM send additional data to the BCM over the vehicle's CAN buses. Using all this data, the BCM runs a TPMS algorithm that determines if the tire is significantly under-inflated (i.e. more than 25% below the placard pressure, as defined in S4.2(a)). Figure 10 illustrates the tire pressure monitoring system, including the sensors, electronic control units (ECUs) and the data sent between them.

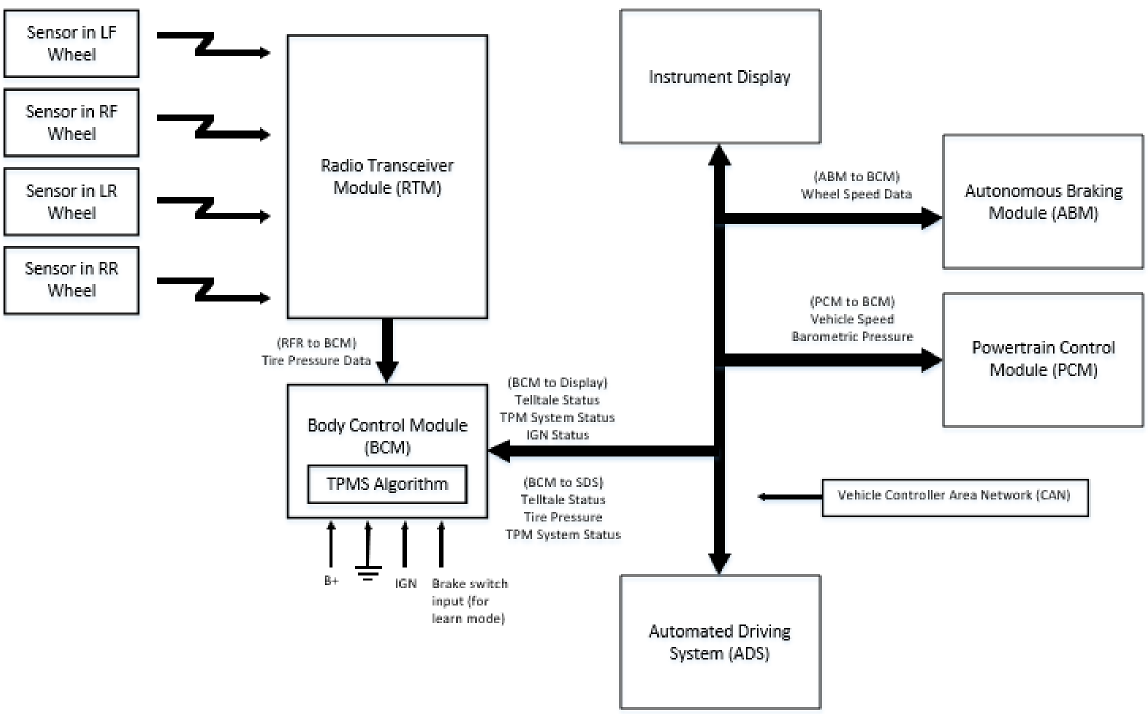

Figure 10 - TPMS Schematic

The BCM runs the TPMS algorithm and broadcasts two periodic messages over CAN to various modules, including the instrument display. These are outlined in Table 6 below:

[17] 49 C.F.R. § 571.138 – S4.3.1(a) and S4.4(b)(1)

Table 6 - Tire Pressure Communication to ADS

Message	Contents
Tire Pressure Status	State of each tire (e.g. normal, significantly under-inflated, fault)
Tire Pressure Data	Pressure in each tire in PSI

When in Manual Mode, tell-tales will be provided to the trained operator and the TPMS system will meet all the requirements of S4.

When in AV Mode, we do not plan to provide a telltale to warn vehicle occupants of low pressure or TPMS malfunction because such a warning would not accomplish the stated purpose of FMVSS 138, which is “to warn drivers of significant under-inflation of tires and the resulting safety problems.” While in AV Mode, none of the occupants are “drivers” or are capable of driving the vehicle. Instead, the ADS and other vehicle ECUs will receive the aforementioned CAN signals and together will execute the following response:

1) The ADS is continuously monitoring its ability to perform the DDT. If at any time, it detects a significant degradation of its lateral control of the vehicle, it will perform a minimum of a Fallback Level 2.
2) The vehicle will prevent entry into AV Mode if the pressure in any tire is significantly under-inflated or if there is a fault in the TPMS.
3) If a tire is significantly under-inflated or a TPMS fault is detected while in AV Mode, but the ADS has determined that there is not a significant degradation of lateral control, the vehicle will report the tire condition to Ford’s fleet management system and then execute a minimum of a Fallback Level 1.

This strategy is aligned with the required owner’s manual statement: “when the low tire pressure telltale illuminates, you should stop and check your tires as soon as possible, and inflate them to the proper pressure.”

S4.3.3(a) and S4.4(4)(i) require that the low tire pressure and TPMS malfunction telltales illuminate “as a check of lamp function.” This requirement is needed for optical telltales that could be subject to failed light bulbs. In AV Mode, the TPMS communicates to the ADS via the vehicle communication networks. The various electronic control modules, including ADS, continuously check to determine that the expected communications are received.

However, the TPMS functions the same in both modes, with the only difference being that tell-tales are not displayed in AV Mode. The BCM communicates the Tire Pressure Status and Tire Pressure Data CAN signals in both modes. Thus, verification that the system is functioning in Manual Mode is sufficient to confirm that the ADS is provided the required information in AV Mode.

Statement of Overall Safety

Our AV’s TPMS design satisfies the purposes of FMVSS 138 S4.3 and S4.4 by communicating the required information directly to the ADS system. Importantly, the AV has additional capabilities to react to the information about tire pressure to help prevent the vehicle from being driven for extended periods on significantly under-inflated tires. Since the ADS has the same information as the nonexempted vehicle, and the response to low tire pressure is the same in both vehicles, the level of safety of the two vehicles is equivalent.

III. Substantiation that compliance would prevent the sale of the vehicle

Our AV will not include controls during AV operation that would allow NHTSA to independently verify compliance to several FMVSS. In order to comply, controls such as a steering wheel, brake pedal, gear state controls, and others would need to be equipped on the vehicle and responsive to human input during AV operation. Given human occupants are not intended to participate in the driving task during AV Mode, Ford believes having active driving controls and communications would introduce an unacceptable risk to safety.

IV. Plans for further action at the end of the exemption period

a. If granted, we do not intend to sell the vehicles to individual customers; rather, the vehicles will be operated in a captive fleet for their full service life. No more than 2,500 exempted vehicles will be produced and introduced into commerce within a 12-month period during the 2-year exemption.
b. We will work with stakeholders across the industry on rulemaking efforts during the exemption period, with the intention of supporting NHTSA's updates to FMVSS and/or development of new regulations for governing ADS operation. If new rulemaking is not completed by the end of the exemption period, we intend to apply for an exemption renewal.

V. Statement Concerning Sales of Exempted Vehicles

We will not deploy more than 2,500 exempted vehicles into commerce in the United States in any 12-month period [**CBI**] If future changes to statute increase the exemption limit for ADS-equipped vehicles, we request that NHTSA change this limit to match the allowable limit under the new law.

Closing Remarks

We believe this document meets all of the requirements of 49 C.F.R. 555.6(d), in accordance with 49 U.S.C. 30113. Per NHTSA's statement of intent to help facilitate the safe deployment of autonomous vehicle technology, we seek NHTSA's approval through this petition to participate in shaping the future of safe and smart mobility. We request NHTSA to approve a two-year temporary exemption from the FMVSS provisions discussed in this petition.

We thank NHTSA for its consideration of this petition and the information contained herein. We also welcome any questions or comments related to the petition, regulatory barriers for AVs, the vision for the future of the AV mobility space, and beyond.