SUBMITTED ELECTRONICALLY VIA REGULATIONS.GOV

August 27, 2019

Ms. Heidi King
Deputy Administrator
National Highway Traffic Safety Administration
1200 New Jersey Avenue S.E., West Building
Washington D.C. 20590-0001

Re: Advanced Notice of Proposed Rulemaking (ANPRM)*: Removing Regulatory Barriers for Vehicles with Automated Driving Systems*, NHTSA Docket No. 2019-0036, 84 Fed. Reg. 24433 (May 28, 2019)

Dear Ms. King:

The Alliance of Automobile Manufacturers ("Auto Alliance" or "Alliance")[1] appreciates this opportunity to provide comments supporting NHTSA efforts to address regulatory barriers for vehicles equipped with automated driving systems through the subject ANPRM.

Vehicles operated by an Automated Driving System (ADS) have the potential to significantly improve overall safety on our nation's roadways. In 2017 alone, 37,133 fatalities occurred as a result of vehicle crashes in the United States. ADS-operated vehicles have the potential to reduce this number by using advanced sensing technologies combined with artificial intelligence programming to avoid crashes. Unlike conventional human drivers, the ADS can't get distracted, drive impaired, or fall asleep at the wheel. In addition to safety benefits, ADS-operated vehicles hold promise to provide numerous social and economic benefits, including less congestion, lower fuel consumption, and increased mobility for the elderly and people with disabilities.

We appreciate that NHTSA has issued the subject ANPRM, which is a key step forward toward addressing and resolving the subject regulatory barriers for vehicles equipped with automated driving systems.

[1] The Auto Alliance is the leading advocacy group for the auto industry. Its members include BMW Group, FCA US LLC, Ford Motor Company, General Motors Company, Jaguar Land Rover, Mazda, Mercedes-Benz USA, Mitsubishi Motors, Porsche, Toyota, Volkswagen Group of America and Volvo Cars North America, and represent approximately 70 percent of all car and light truck sales in the United States. For further details, see http://www.autoalliance.org/

Parallel Phased Approach

The Alliance emphasizes that the task of amending the FMVSS to remove barriers to the introduction of ADS-operated vehicles, especially those without manual controls, needs to be completed using a parallel and phased approach that focuses on the near-term in order to realize the corresponding societal benefits associated with these vehicles as soon as possible, but to also include longer-term rulemaking to make the FMVSS requirements and test procedures fully compatible with ADS operation.

Rulemaking of this magnitude will take many years to complete. However, the potentially immediate benefits of ADS-equipped vehicles, combined with the extraordinary pace of technical progress in increasing the safety and security of these vehicles, calls for a different paradigm that acknowledges the fundamental difference between ADS-operated vehicles and conventional, human-driven vehicles, while maintaining the safety intent for the FMVSS.

Development of Fully-ADS Appropriate FMVSS Requirements

While we recognize NHTSA is addressing a very specific regulatory challenge for a specific design or use-case, we believe NHTSA is inadvertently delaying the widespread introduction of ADS-operated vehicles (that may have manual controls) to interstate commerce by not addressing the broader regulatory and compliance hurdles outlined below.

NHTSA should define "Automated Driving System (ADS)-operated vehicle"[2] in Part 571.3 as an ADS-equipped vehicle in which the ADS is engaged to perform the complete dynamic driving task (DDT), and then refer to various FMVSSs and provisions within them that do not or should not apply to such a vehicle as being inapplicable to it. [3] ADS-operated vehicles subsume (through automation) the functions previously performed by an autonomous human driver. This seismic development establishes a new paradigm for personal mobility – as profound a change as when a motorized engine replaced the horse more than a century ago. As such, we believe the appropriate object and scope of the changes under consideration in this ANPRM should apply to all ADS-operated vehicles, and not just to certain types of ADS-operated vehicles, such as an ADS-dedicated or dual-mode vehicle, given that the 'make inoperative' provision, as well as the long-standing policy that a vehicle must meet FMVSS requirements in any operating mode of which the vehicle is capable, both still apply. For example, even a conventional vehicle equipped with a Level 3 or 4 ADS sub-trip feature that is designed for high-speed operation on fully access-controlled highways may be designed so that the exterior mirrors automatically fold away during the ADS-operated portion of each trip to improve fuel economy and reduce road noise.

[2] The point to defining "ADS-operated vehicle," rather than "ADS-equipped vehicle," is to address the fact that a vehicle may support both human and ADS operation, and that different rules apply depending on whether the vehicle is operated by a human or by an ADS. For example, a dual-mode vehicle may be designed so that driver controls fold away while the ADS is operating the vehicle.

[3] In addition to coining and defining an "ADS-operated vehicle," the Alliance recommends that NHTSA adopt the levels, terms and definitions provided in the ISO-SAE version of J3016, which will be published later this year. The ISO-SAE version of J3016 is quite consistent with the Jun2018 version of J3016, but adds several terms and definitions and resolves the open points in the previous version. (Please see also our response to Question 6, below.)

Current FMVSS requirements designed specifically for human drivers, and that are unsuitable for ADS-operated vehicles, should not apply to them. For FMVSSs that are designed to supplement a human driver's ability to safely operate a vehicle (e.g. FMVSS 103, 104, 111, and visibility aspects of FMVSS 205, etc.), no safety benefit comes from enforcing compliance for such requirements while under ADS operation because the ADS does not use these for its perception or visibility capabilities. For telltales/indicators/warnings that are required by existing FMVSS language, these are in place to provide information to the human driver on the state and condition of vehicle systems so the human driver can appropriately operate the vehicle in a safe manner. The ADS will receive this information directly from the systems and control units, making these visible telltales/indicators/warnings of no use for the safe operation of the vehicle.

In the "AV Pilot" ANPRM, the agency mentioned that there was a potential that disabling controls for an ADS-operated vehicle could run afoul of the 'make inoperative' prohibition. The Alliance recommends that NHTSA consider rulemaking to allow an exemption from the 'make inoperative' prohibition to accommodate all ADS-operated vehicles (ADS-dedicated, dual-mode, and conventional vehicles equipped with an ADS feature). While conventional vehicles equipped with Level 3 or Level 4 ADS sub-trip features that require a licensed driver to operate the vehicle for at least part of every trip are designed to meet all existing FMVSS requirements while the ADS feature is _*not*_ engaged, the same may not be true when the ADS feature *is* engaged. NHTSA has long held that vehicles must meet FMVSS requirements in any mode of which the vehicle is capable. As such, it is important that the rules being written to accommodate ADS technology cover all ADS-operated vehicles, and not just certain types of ADS-operated vehicles.

Fortunately, there are near-term solutions that do not require extensive research or immediate rulemaking (e.g. compliance test procedure modification if there is not alignment with the corresponding regulatory text, legal interpretations/guidance, Part 555 exemptions and technical documentation). However, the above suite of actions should be conducted in parallel with foundational rulemaking to fully codify any technical interpretations or significant revisions to the compliance test procedures.

As a general framework for progress, the Alliance suggests the following approach:

- Near-Term Action (Current - 2020)

  Address existing FMVSS and Part regulations via modifications to the requirements, compliance test procedures, or legal interpretation, that can be accomplished without undermining the safety goals of the FMVSS or Motor Vehicle Safety Act, in order to remove impediments to the deployment of FMVSS-compliant ADS-operated vehicles, including, but not limited to, ADS-dedicated vehicles (ADS-DVs) without conventional human-operated controls and displays (i.e. steering wheel, pedals, gear shifter, instrument cluster, etc.). We also note that, while it may be relatively easy to adapt certain existing FMVSS requirements that are unsuitable for ADS-operated vehicles in ways that would make it possible to nevertheless demonstrate "compliance," these adaptations are not appropriate, since they would serve no safety purpose, but could create potential stop-sale and recall liability for affected manufacturers.

- Intermediate Rulemaking (2020 – 2025)

Refine and further update the existing FMVSS and Part regulations to both codify prior compliance test procedure modifications or legal interpretations, as well as to incorporate new learnings (e.g. based on early deployment experience), NHTSA contractor research and testing, input from other stakeholders and lessons-learned globally. This intermediate phase of rulemaking should also accommodate non-conventional seating configurations and consider global regulatory approaches with the aim of harmonization.

- Longer-Term Rulemaking (Beyond 2025)

  Consider new rulemaking specific to ADS-operated vehicles based on in-use experience and data, and work within WP.29 to foster international regulatory harmonization when possible.

While this is an ambitious timetable, we are confident that it can be achieved with a leadership commitment to do so by also leveraging global efforts and working toward globally-harmonized regulations for ADS-operated vehicles.

All Proposed Approaches Are Valid for Certain Systems and FMVSS Requirements

As detailed in our Appendix 1 comments, each of the currently proposed approaches has merits as well as deficiencies and lends itself to application for different ADS-system/vehicle characteristics and FMVSS requirements. In addition, some may be immediately available for use as a near-term approach while others will require longer-term research and rulemaking effort to fully develop.

Given the diversity of potential ADS-operated vehicle sizes, architectures, use cases, and operational design domain (ODDs), there is no "one best approach" applicable to all vehicle types and architectures, for all FMVSS requirements. Each approach has its own advantages and disadvantages that might be appropriate for application to one vehicle but not another. In addition, technical documentation would likely be combined with many of the other approaches in order to provide the agency with more robust assurance that the subject vehicle does meet the intended performance of each FMVSS.

Each of the approaches, including appropriate documentation where necessary, would be functionally equivalent to each other. Where multiple approaches are feasible for a subject vehicle, manufacturers should have the flexibility to select the approach they deem most suitable for certifying their particular ADS-operated vehicle.

Cybersecurity

Vehicle manufacturers are responsible for maintaining the cybersecurity of their vehicles both when new and during service (subject to consumer consent). As a result, there are concerns that some of the proposed certification method options could introduce additional cyber "attack vectors" if they were implemented on production vehicles. Manufacturers are concerned that it may be impossible to sufficiently "harden" remote controllers and testing programs from malicious actions and thus are extremely reluctant to provide such ability on production vehicles – particularly for the incrementally low benefit of demonstrating compliance with minimum safety standards, which have a historically very low rate of recall risk. To address this concern, we recommend direct discussions with NHTSA compliance personnel to develop an approach that permits some testing with non-production-hardened vehicles/hardware.

Simulation

Simulation is currently a very powerful vehicle development tool and as such will find significant use as part of any technical documentation package. However, at this point additional work needs to be conducted before adequate processes are in place to permit NHTSA to be able to certify aspects of vehicle performance based **solely** on simulation (in lieu of a physical test). Significant efforts are being conducted through the UNECE GRVA/VMAD to explore and develop simulation based certification processes. In addition, we are aware that the SAE has also begun work on a standard for validating virtual test driving simulators. The Alliance is engaged in these development efforts and working to ensure that such processes are appropriate for both type-approval and self-certification processes.

****

Attached, please find the following Appendix 1 that provides specific responses to the potential approaches to revising crash avoidance test procedures and questions posed in the ANPRM.

The Alliance appreciates the opportunity to provide input to NHTSA on this important topic. We look forward to any follow up with the Agency to expand on these comments further.

Sincerely,

Scott Schmidt
Senior Director, Safety & Regulatory Affairs

cc: R. Posten

Appendix 1 – Comments and Response to Questions Regarding Possible Approaches to Revising Crash Avoidance Test Procedures

Potential Approaches Proposed:

- *Normal ADS-DV operation;*
- *Test Mode with Pre-Programmed Execution (TMPE);*
- *Test Mode with External Control (TMEC);*
- *Simulation;*
- *Technical Documentation for System Design and/or Performance Approach; and*
- *Use of Surrogate Vehicle with Human Controls.*

Each of the proposed approaches has merits as well as deficiencies, and lends itself to application for different ADS-system/vehicle characteristics and FMVSS requirements. In addition, some may be immediately available for use as a near-term approach, while others will require longer-term research and rulemaking effort to fully develop.

Given the diversity of potential ADS equipped vehicle sizes, architectures, use cases, and ODDs, there is no “one best approach” applicable to all vehicle types and architectures. Each approach has its own advantages and disadvantages that might be appropriate for application to one vehicle but not another. In addition, technical documentation would likely be combined with many of the other approaches in order to provide the agency with more robust assurance that the subject vehicle does meet the intended performance of each FMVSS.

Each of the approaches, with appropriate documentation where necessary, would essentially be functionally equivalent to each other. Where multiple approaches are feasible for a subject vehicle, manufacturers should have the flexibility to select the approach they deem most suitable for certifying their particular ADS feature or ADS-operated vehicle.

1) *What are the possible advantages and disadvantages of each approach?*

Normal ADS-DV Operation:

Advantages – The ability to test the vehicle in its “as delivered” state to FMVSS requirements directly provides sound test fidelity (little to no artificial manipulation of vehicle/test procedures) and thus best matches NHTSA’s historical approach of verifying compliance.

Disadvantages – Currently in the short-term there are not many FMVSS requirements that lend themselves to this approach. Not only are the ADS systems programmed to behave in ways that are not compatible with specific test requirements (e.g., for FMVSS 135 brake burnishing procedure, systems are not programmed with such functions), the test facilities where NHTSA contractors conduct testing are not within the vehicle’s ODD. Thus, even if the vehicle is capable of operating in a manner that would provide proof of compliance, getting the vehicle to do so on a test track would require digitally mapping the test facility and then adding that specific map to the specific vehicle under test, which would create an additional burden and cybersecurity challenge for this method.

In addition, other ODD features (e.g., signs, lane markings, roadway "furniture") might also be required to provide required vehicle localization.

The Alliance does not believe this is a practicable approach to compliance validation with *current* FMVSS requirements. We do, however, support the development of normal-operation, in-ODD test requirements for future, ADS-specific FMVSS requirements.

Test Mode with Pre-Programmed Execution

Advantages – For certain FMVSS requirements and vehicle/ADS characteristics preprogramming a "test mode" may offer an acceptable certification path that overcomes the limitations of performing a test procedure required by an FMVSS when there are no driver-operable controls present.

Disadvantages – By its nature, this option circumvents the programming that is in place during actual operation. The ADS normal operation may be programmed to avoid many of the scenarios prescribed in the FMVSS testing. As such for some standards (e.g., FMVSS 135) pre-programmed executions will only provide evidence that the vehicle has adequate hardware to comply with the FMVSS requirement.

To address this drawback, this option could be paired with a technical documentation requirement detailing the ability of the ADS system programming to satisfy the subject FMVSS requirements.

It should be noted, however, that there are safety concerns with having pre-programed routines (e.g., "sine with dwell") on production vehicles that could potentially be accessed/hacked by malicious entities. For this reason, vehicle manufacturers should be permitted to equip this functionally on a non-production vehicle for purposes of demonstrating compliance to existing FMVSS.

Finally, consideration should be given to whether the ODD and/or use case for the ADS-operated vehicle in question address a condition that could even occur. For example, high-speed braking requirements have no safety relevance for an ADS-operated vehicle that is designed exclusively for lower-speed operation.

Test Mode with External Control

Advantages – For certain FMVSS requirements and vehicle/ADS characteristics utilizing existing manual controls used to move vehicles for maintenance and transport may offer an acceptable certification path.

Disadvantages – By its nature, this option circumvents the programming that is in place during actual operation. As such without supplemental technical documentation, it will only provide evidence that the vehicle has adequate hardware to comply with the FMVSS requirement. Moreover, it is likely that such manual controls used to move vehicles for maintenance and transport purposes will be designed for very low-speed use, only, and will thus not be suitable for conducting the vast majority of whole vehicle dynamic test requirements contained in the 100-series FMVSSs.

To address this drawback, this option could be paired with a technical documentation requirement detailing the ability of the ADS system programming to satisfy the subject FMVSS requirements.

Another limitation is that, for some potential vehicle concepts, the vehicles ODD will not permit operation required to satisfy FMVSS requirements. In this case, rulemaking may be required to translate the safety intent of the FMVSS to the specific vehicle's ODD.

In addition, there are safety concerns with having manual controllers that may not be appropriate for general/untrained use that could be inappropriately used to operate the vehicle on-road. For this reason, the functionality to use these "special controllers" should not be required to be present on "production" vehicles. Instead, vehicle manufacturers should be permitted to equip this functionally on a non-production vehicle.

Simulation/Virtual Testing

Advantages – Simulation/virtual testing when appropriately conducted and validated can provide test fidelity equivalent to physical testing, without any of the safety/cybersecurity concerns present in other approaches, and using fewer and optimized resources than are otherwise required for physical testing. It would also allow an increased number of scenarios to be tested faster than physical testing. Currently, the UNECE is working to develop certification methods for ADS-operated vehicles using simulation as a part of a "multi-pillar" approach. This work should be able to inform NHTSA's consideration of simulation for both existing and future regulatory requirements.

ADS technology lends itself well to simulation, because, unlike a human driver, whose driving behaviors are variable and capricious, an ADS's driving behavior is quite stable and predictable.

Currently for crashworthiness assessments NHTSA already employs an analog simulation in the form of a crash test anthropomorphic test device (ATD). Such devices simulate the responses of the human to injury and are subject to Part 572 certification to ensure appropriate fidelity and repeatability/reproducibility. We envision that simulation programs/certification processes could be developed to be appropriately specified and subjected to a similar certification process as Part 572 to ensure appropriate fidelity and repeatability/reproducibility.

Disadvantages – Currently the main disadvantage to simulation is that currently there are no standardized methods for validating virtual test drive simulators, although work is on-going to develop this. Virtual test drive simulators also rely in large part on vehicle-specific programming to match the many subtleties of chassis dynamics and tire tuning. If simulation is to be used as a standalone certification method, it will need additional work to develop processes (similar to the certification of Crash Test ATDS) that will ensure adequate fidelity, repeatability/reproducibility and free of artifacts.

Technical Documentation

Advantages – Technical documentation is currently employed in a number of safety standards as well as in the Global Technical Regulations (GTR 20). Such technical documentation is currently used in performance aspects where the development of objective performance tests, including pass-fail criteria, has proven infeasible. The most recent example of its use pertains to Global Technical Regulation No. 20 (Electric Vehicle Safety (EVS)) [4] thermal propagation requirements[5].

In addition, as detailed earlier, technical documentation can be used in conjunction with the other methods, especially to provide information demonstrating that the ADS has programming appropriate to provide adequate performance for the specific FMVSS.

One of the key benefits to technical documentation as a compliance demonstration method is that it can be applied quickly (following regulatory changes to permit it), and does not require the development of new test properties, methods, and standards. It also avoids the risks explained

---

[4] http://www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29glob_registry.html

[5] Technical justification pages 49-51, Technical Requirements section 5.4.12, pages 78-79

above regarding cybersecurity, while providing regulatory flexibility and lower compliance costs. This is critical, because ADS technology is so complex and diverse and, as such, does not lend itself to classical regulatory approaches. This is similar to the issues encountered in the development of the EV Safety GTR #20 thermal propagation requirements where it was not possible to develop realistic and repeatable test procedures that would not significantly limit innovation. As a result, the agency felt that the technical documentation approach was the most appropriate method to address that aspect of battery performance.

Disadvantages – Since NHTSA's regulatory certification process utilizes self-certification, enforcement is predicated on the prescription of objective regulatory requirements. Currently, NHTSA can only directly enforce (other indirect means are available) the technical documentation requirement that the vehicle manufacturers submit the required technical documentation (i.e., in advance of NHTSA conducting its own compliance test); it does not have the authority to determine whether the system actually meets any specific performance requirements based solely on the manufacturer's documentation. In the case of FMVSS 126, it only ensures that the vehicle has hardware and programming to limit understeer, but does not ensure that any specific performance requirements for understeer control are met. However, experience indicates that since FMVSS 126 was instituted there have been no issues with respect to excessive vehicle understeer performance in this regard.

Use of Surrogate Vehicle with Manual Controls

Advantages – where appropriate surrogate vehicles exist, this method is an efficient method to verify that the base vehicle meets FMVSS. However, like some of the other methods, this option may be combined with technical documentation establishing that the ADS-equipped version of the vehicle under test has the same key components and would achieve the same level of performance within normal test-to-test variability.

Disadvantages - The key disadvantage with this approach is that there may not be a suitable surrogate vehicle available. Current FMVSSs largely regulate the capability of conventional vehicle systems and do not address ADS (or driver) behavior. As such, this method will be suitable in most cases because the behavior of the base vehicle will be the same, regardless of whether the vehicle is operated by a human driver or by an ADS. However, in certain rare cases, such as FMVSS 126, the ADS would in fact affect the performance of the vehicle – mainly by never (or nearly never) encountering situations that would trigger ESC intervention.

2) *Discuss whether each approach fits the requirements and criteria of the Safety Act and enables effective enforcement of the FMVSSs. Explain the basis for your answers.*

Each of the six approaches presents challenges for the traditional FMVSS enforcement model that NHTSA has employed for more than fifty years under the National Traffic and Motor Vehicle Safety Act. Under this traditional model, manufacturers self-certify compliance with the FMVSSs. After the vehicle has come to market, NHTSA purchases a motor vehicle randomly from a dealer, and tests it for FMVSS compliance. The vehicle manufacturer has no involvement in selecting the specific vehicle to be tested. While the manufacturer is often consulted by NHTSA in advance of the test to obtain certain information (for example, to determine the "nominal design riding position" of the driver's seat back for FMVSS No. 208 testing), the manufacturer does not otherwise participate in the testing itself. This arms-length testing model has worked well, and ensures a degree of independence for NHTSA's compliance verification program.

Whatever the merits of the traditional program, however, it will not work without some accommodations for ADS-equipped vehicles without traditional controls, at least for a transition period until NHTSA writes new standards that fully account for ADS operation.

For background, it may be useful to summarize the requirements and criteria of the Safety Act for the adoption of FMVSSs. There are three core requirements: FMVSSs must be practicable; they must meet the need for motor vehicle safety; and they must be stated in objective terms. See 49 U.S.C. 30111(a). Here is a brief guide to these three criteria, for consideration in the context of ADS vehicles:

Practicability

A standard is "practicable" if it offers the regulated party a chance to demonstrate compliance. On the other hand, a standard may be "impracticable" if, for example, compliance with it imposes a prohibitive cost on a manufacturer or if it does not provide reasonably specific criteria or methods for a manufacturer to certify compliance. A primary objective of the ANPRM is to identify the best method(s) for testing ADS-operated vehicles to determine compliance. The NHTSA-proposed approaches should not result in less practicable methods than the ones in place today used to demonstrate compliance for traditional vehicles. The cost burden on the Agency and on the manufacturer should be considered in each case and the Agency should provide reasonably-specific criteria for determining a passing result. ADS manufacturers should have a fair opportunity to demonstrate compliance under any of the proposed approaches.

Meets the Need for Motor Vehicle Safety

A standard "meets a safety need" where NHTSA has identified a potential safety concern and develops the standard to address it. NHTSA has further stated that it "observes that its authority [under the Safety Act] is preventive in nature." NHTSA has identified on several occasions the number of traffic accidents and deaths that result from human operator errors every year, and has specifically pointed to the widespread integration of ADS-operated vehicles in the traffic system as a way to reduce those accidents. (See NHTSA's "AV 3.0" guidance document). As such, adopting safety standards applicable to ADS-operated vehicles would address a well-documented motor vehicle safety need.

Objectivity

Finally, a standard is "objective" if its testing procedures are capable of producing identical results when the test conditions are exactly duplicated, and provided that the compliance determination is based upon measurements or other objective data, as opposed to the subjective opinions of human beings. Regardless of which proposed approach is chosen, NHTSA should focus on ensuring the objectivity of the standards. As long as the Agency provides sufficiently precise and objective instructions for how the vehicles should be tested/simulated/documented, and details the specific information the Agency is seeking, manufacturers should be able to produce the same data as NHTSA under the same test conditions and should achieve the same outcome as a result.

As applied to each of the six approaches, the Alliance's thoughts are as follows:

- Normal ADS-DV operation
  - As noted above, this model presents the fewest opportunities for vehicle "manipulation" in the compliance verification process; however, "normal" operation is restricted to a limited ODD, which does not include the NHTSA test facilities. Mapping of the NHTSA's test facility would be required, at a minimum. Additional ODD feature replication may be also be required (e.g., specific roadside furniture, time-of-day, weather conditions, etc.). Few, if any, FMVSS requirements lend themselves to this type of testing.
- Test Mode with Pre-Programmed Execution (TMPE)
  - This model may work to demonstrate that adequate hardware is available to comply, but may not demonstrate FMVSS compliance per se. As such, this approach might require a combination with technical documentation of compliance.
- Test Mode with External Control (TMEC)
  - Similar to TMPE, this model may work to demonstrate that adequate hardware is available to comply, but may not demonstrate FMVSS compliance per se. As such, this approach might require a combination with technical documentation of compliance.
- Simulation
  - This model holds great promise for compliance confirmation; however, it depends entirely on the fidelity of the simulated model to the reality of ADS driving, and that model does not yet exist.
- Technical Documentation for System Design and/or Performance Approach
  - This approach is the closest to the status quo, because NHTSA has already accepted this as a compliance demonstration for the understeer control portion of FMVSS 126 and has promoted its use in the recently finalized Electric Vehicle Safety GTR #20 for thermal propagation requirements.
  - NHTSA agreed in the FMVSS 126 rulemaking that review of a company's technical documentation of compliance was adequate to confirm compliance with the understeer requirements in the standard.
  - This precedent should allow demonstration of compliance with other standards by means of technical documentation, for the same reasons that NHTSA found adequate for FMVSS 126.
- Use of Surrogate Vehicle with Human Controls
  - This approach is feasible, but may not produce what NHTSA needs, which is a compliance result on the vehicle that is actually being certified.

3) *Can more than one of these approaches be specified by the agency as alternative ways for the agency to determine compliance with the same requirement in the same FMVSS? If so, please describe how this could be done consistent with the Vehicle Safety Act, using one or more specific FMVSS requirements as illustrative examples. If more than one approach could be specified for the same requirement in the same FMVSS, do commenters believe that the agency, in assessing compliance with the same requirement in the same FMVSS, choose one approach for one vehicle model, but another approach for a different model? If so, explain why.*

   Given the diversity of potential ADS-equipped vehicle sizes, architectures, use cases, and ODDs, there is unlikely to be a single, best approach in the near term. As indicated earlier, each approach has advantages and disadvantages that might make it more appropriate for application to one ADS architecture type but not another. In addition, technical documentation would likely be combined with many of the other approaches in order to provide the agency with more robust assurance that the subject vehicle does meet the intended performance of each FMVSS.

   We believe that each of the approaches, with appropriate documentation where necessary, would essentially be functionally equivalent to each other. Where multiple approaches are feasible for a subject vehicle, manufacturers should have the ability to select which approach they want to certify using.

4) *If only one of these approaches can be used to enforce a particular FMVSS requirement, what factors should be considered in selecting that approach? What policy or other considerations should guide the agency in choosing one alternative approach versus another for determining the compliance of a particular vehicle or item of equipment?*

   Each of the approaches should be functionally equivalent and thus equally available for a vehicle manufacturer to certify to. Selection of specific approaches should be made by individual vehicle manufactures based on the specific vehicle's intended function, architecture, operating use case and ODD which will guide them in terms of which approach to select. Once selected, that compliance approach would apply for purposes of compliance demonstration to that FMVSS and ADS-operated vehicle throughout its useful life. Specific factors regarding the requirements will dictate which approach is most appropriate for compliance demonstration and repeatability. The cost for the manufacturer should also be a factor in determining the most appropriate method.

5) *With respect to any single approach or combination of approaches, could it be ensured that the compliance of all makes and models across the industry is measured by the same yard stick, i.e., that all vehicles are held to the same standard of performance, in meeting the same FMVSS requirement?*

   The standard of performance that needs to be met is the performance requirements currently in place for each FMVSS, and is the same for each approach (i.e., functionally equivalent). As a result, each approach simply provides manufacturers with the necessary flexibility in demonstrating compliance as efficiently as possible given the specific attributes of the subject vehicle.

6) *What other potential revisions or additions to terms, in addition to 'driver', are necessary for crash avoidance standards that NHTSA should consider defining or modifying to better communicate how the agency intends to conduct compliance verification of ADS vehicle.*

In addition to coining and defining an ADS-operated vehicle as recommended in the cover letter to this comment, the Alliance recommends that NHTSA adopts the levels, terms and definitions in the ISO-SAE version of J3016, which will be published later this year. J3016 is widely recognized and referenced as the global standard for driving automation taxonomy and vocabulary and provides the basis for clear and consistent communication on the topic of driving automation at all levels. For purposes of this ANPRM, which is focused on ADS-operated vehicles capable of driverless operation, the following terms are particularly important to define and use consistently:

- Automated Driving System (ADS)
- dispatch [in driverless operation]
- full-trip feature
- driverless operation [of an ADS-equipped vehicle]
- dynamic driving task (DDT)
- [dynamic driving task (DDT)] fallback
- minimal risk condition
- [DDT performance-relevant] system failure
- operational design domain (odd)
- remote assistance
- remote driving
- request to intervene
- routine/normal [ads] operation
- supervise [driving automation system performance]
- [human] user
- [human] driver
- in-vehicle driver
- remote driver
- passenger
- [DDT] fallback-ready user
- in-vehicle fallback-ready user
- remote fallback-ready user
- driverless operation dispatcher
- [motor] vehicle
- conventional vehicle
- [ADS-equipped] dual-mode vehicle
- ADS-dedicated vehicle (ADS-DV)

7) *Should NHTSA consider an approach to establish new definitions that apply only to ADS- DVs without traditional manual controls?*

As noted in the cover letter and in response to Question 6, the Alliance recommends that NHTSA defines "ADS-operated vehicle" to distinguish any type of ADS-equipped vehicle from a non-ADS-equipped vehicle, and to allow for different rules to apply to (or not apply to) an ADS-equipped vehicle when it is being operated by a human vs when it is being operated by an ADS. If NHTSA were only to define an ADS-DV, and ignore conventional vehicles equipped with sub-trip ADS features and dual-mode vehicles, it would fail to address numerous compliance-related issues that are problematical for these latter types of ADS-equipped vehicles, many of which are the same as the compliance problems faced by ADS-DVs. The Alliance believes the agency's resources are better spent addressing ADS-operated vehicles holistically, rather than focusing on a particular type of ADS-operated vehicle, or on specific aspects of its design (such as removal of human driver controls). We note, however, that this is not to say that there won't be any need to differentiate requirements in some cases among different types of ADS-operated vehicles - there will be - but, these types of differences will be fewer than those that would emerge in an effort to try to re-draft existing FMVSS requirements for each of the ADS-equipped vehicle types, let alone trying to do so at the feature level.

8) *For compliance testing methods involving adjusting current test procedures to allow alternative methods of controlling the test vehicle during the test (normal ADS-DV function, TMPE, TMEC), or to allow the use of a surrogate vehicle:*

   a) *How could NHTSA ensure that the test vehicle's performance using the compliance method is an accurate proxy for the ADS-DV's performance during normal operation?*

      Because ADS-operated vehicles have capabilities that are different from human-operated vehicles, the aspects of performance or the limitations thereof that are being tested by FMVSS may not be directly comparable. Some FMVSS requirements that are based on "normal" operation by human drivers with human capabilities and deficiencies might not be fully relevant to vehicles that are being operated by an ADS. For instance, brake pedal force requirements are meaningless for vehicles operated by an ADS. In addition, the requirements of most, if not all, FMVSSs require operation outside of the vehicle's ODD.

      The important point is that the different approaches provide adequate safety assurances as applied to the subject vehicle operating within its ODD. For TMPE, TMEC, or Surrogate Vehicle testing, this can be accomplished by requiring appropriate supplemental technical documentation detailing how the ADS programming meets the safety objective of the specific FMVSS.

   b) *If NHTSA were to incorporate the test method into its test procedures, would NHTSA need to adjust the performance requirements for each standard (in addition to the test procedures) to adequately maintain the focus on safety for an ADS-DV?*

      Performance requirements would need be adapted to account for ODD limits. Future ADS-specific FMVSS requirements that permit the use of the vehicle's normal ADS functions within the product's ODD are desirable.

9) *For compliance testing methods that replace physical tests with non-physical requirements (simulation, documentation):*

   a) *If the test method is used to determine compliance with a real-world test, how can NHTSA validate the accuracy of a simulation or documentation?*

      Simulation should include a validation analysis, which, in the case of virtual test drive simulators, typically involves periodically replicating simulated scenarios on a test track to verify that the same results obtain (within normal test-to-test variability). Similarly, documentation may include engineering analysis, physical testing (including component-level testing) and simulations.

b) *If NHTSA must run real-world tests to validate a simulation or documentation, what is the advantage of non-physical requirements over these other compliance methods?*

If NHTSA could run all currently-prescribed FMVSS physical tests on production ADS-operated vehicles at NHTSA contractor facilities, then there would be no need to consider alternative approaches. However, the track tests conducted by manufacturers to validate their virtual test drive simulators are conducted on their own private test facilities using non cyber-hardened prototype vehicles and, in some cases, external controllers – none of which are available for FMVSS testing and validation purposes today.

In the future, NHTSA might consider ways in which alternative physical tests might be performed in a manner, and in the ADS-appropriate ODD, for purposes of validating a "universal" simulation for compliance purposes, which could be used to demonstrate compliance to FMVSS requirements that can't be directly tested.

This is a similar approach to how manufacturers certify to certain requirements today, such as occupant protection. Crash sensor algorithms are developed and occupant injury values are confirmed with specific physical testing, although not every physical test covered by FMVSS is physically conducted. This allows for testing and certification to be completed within a reasonable time, with reasonable cost and flexibility. The addition of other compliance methods allows for an increased number of "tests" and scenarios to be evaluated without overburdening the manufacturer or NHTSA to run a physical test for compliance to every scenario.

10) *Would non-physical requirements simply replicate the existing physical tests in a virtual world? If not, what would be the nature of the non-physical requirements (that is, what performance metrics would these requirements use, and how would NHTSA measure them)? Are there ways that NHTSA could amend the FMVSSs to remove barriers to ADS-DVs that would not require using the compliance test methods described in below?*

In general, it is envisioned that non-physical requirements would mirror/replicate the existing tests in a virtual world. Where applied, non-physical requirements (simulation/virtual test drive/documentation) could be supported by validation tests that may include full-scale testing in conditions appropriate for ADS-operated vehicles, as well as component testing if applicable.

There are FMVSS requirements, such as brake pedal application force limits, that have no relevance for ADS-operated vehicles. Such test requirements should simply not apply to ADS-operated vehicles. In the near-term it would make sense to replicate the "relevant" physical tests with virtual testing where appropriate. In the long-term NHTSA could consider rulemaking to examine which existing tests are still meaningful for ADS vehicles and if so, consider the development of ADS-compatible test procedures.

a) *Are there any barriers in the FMVSS or NHTSA's test procedures that could be addressed by altering or removing references to manual controls in the test procedures without substantively changing the FMVSS performance requirement?*

One example of this is FMVSS 135, which requires the vehicle to be accelerated to 100 kph before the test driver is instructed to apply 500 N force to activate the brake pedal. The input force represents the likely force that a 5th percentile female would apply to the pedal in a hard-braking situation, and as such represents the 'minimal brake input force' end of the spectrum of human drivers. However, in an ADS-operated vehicle, the ADS is the driver and, as such, the standard should reflect the force that an ADS can command, which is more than can be reasonably expected from a 5th percentile female driver. In this example, the standard can be revised to reflect, instead of 500 N foot force, the maximum brake application that the ADS under test can be expected to command.

b) *Are there any changes that NHTSA could make to the FMVSS test procedures that could incorporate basic ADS capabilities to demonstrate performance, such as using an ADS-DV's capability to recognize and obey a stop sign to test service brake performance? What research or data exists to show that the compliance test method would adequately maintain the focus on ADS-DV safety? What modifications of the safety standards would be necessary to enable the use of the test method?*

It is possible to develop ADS-specific test procedures that evaluate the vehicle's nominal performance within the limitations of its ODD. However, such ADS-specific test procedures will take time to develop and are more relevant to the publication of new requirements versus the evaluation of compliance/granting exemptions to existing requirements. There remains the need to adopt short-term approaches while this longer-term research and rulemaking is occurring.

In addition, the UNECE is developing ADS-specific requirements for safety that will address key performance aspects such as braking, lane control and stability. The Alliance encourages NHTSA to remain engaged in this process and consider harmonization with any guidelines, requirements, or test methods that are developed in this process.

11) *What research or data exists to show that the compliance test method would adequately maintain the focus on ADS-DV safety? What modifications of the safety standards would be necessary to enable the use of the test method?*

When considering future ADS-specific performance/test requirements, there is significant research being conducted internationally (e.g., SAE, AMP, Pegasus, etc.). As such, NHTSA should remain engaged in the international regulatory discussions being conducted by WP29 and GRVA and consider harmonization with any guidelines, requirements or test methods which might be developed.

Normal ADS-DV Operation;

As described above, the Alliance contends that compliance testing of ADS-DVs in normal operation, as described in the ANPRM, is not a feasible means of addressing existing FMVSS requirements that entail whole-vehicle testing for the reasons described in the ANPRM. In the longer-term, such an approach for ADS-operated vehicles is feasible and desirable, but will require substantial research and new rulemaking.

The Alliance disagrees with the example provided by the agency in discussing the pros and cons of this approach, namely, FMVSS 138. The agency suggested that an ADS-DV whose ODD includes the type of on-road driving required by FMVSS 138 to trigger a low pressure warning following such an induced condition. As previously explained, these types of requirements, which are designed specifically for human drivers and serve no safety purpose for an ADS-operated vehicle, should apply to them, because, unlike a truly autonomous human driver, an ADS must monitor and address any and all vehicle malfunction conditions <u>by design</u> – including low tire pressure. We recognize that FMVSS 138 is a special case, as it was specifically authorized by the TREAD Act, rather than by the Safety Act, but the Safety Act principle that mandated safety requirements should only be imposed in response to a demonstrable safety need is still valid, and is absent in this case for ADS-operated vehicles.

12) *What design concepts are vehicle manufacturers considering relating to how an ADS-DV passenger/operator will interface with, or command (e.g., via verbal or manual input), the ADS to accomplish any driving task within its ODD? Please explain each design concept and exactly how each would be commanded to execute on-road trips.*

    The interfaces passengers use to direct an ADS-DV where to drive will vary from vehicle to vehicle. However, it is unlikely that ADS-DVs will include interfaces that allow passengers to direct vehicle motion control (i.e., command/response control), as this is the responsibility of the ADS. Based on current pilot vehicles and published reports, it is expected that passengers will have interfaces that allow them to specify a destination (including payment), interact with a fleet operator, and execute a "passenger-initiated emergency stop." For example, they would not have the ability to cause the vehicle to drive up a 10 percent grade and engage the "Park" position in order to verify that the vehicle does not roll.

13) *Are there specific challenges that will be encountered with this kind of approach for vehicle compliance verification? Please be specific and explain each challenge.*

    We agree with the list of challenges listed by the agency in the ANPRM. ODD restrictions in many cases not only make it impossible to test an ADS-operated vehicle to the extant requirements, but they also obviate the safety need for such requirements and validation testing. For example, an ADS-DV that operates exclusively on urban roadways (at lower speeds) in fair weather conditions, and which is programmed to drive defensively in all conditions, is extremely unlikely to encounter conditions that would trigger ESC engagement, or to benefit significantly from such engagement in the extremely rare circumstances of its occurrence (e.g., during or immediately following a relatively high-speed impact).

14) *Will all ADS-DVs without traditional manual controls be capable of receiving and acting upon simple commands not consisting of a street address based destination, such as "drive forward or backwards a distance of 10 feet and stop"; "shift from park to drive and accelerate to 25 mph"; "drive up onto a car hauler truck trailer"; etc.? Please explain projected challenges for ADS-DVs without traditional manual controls to complete discrete driving commands and tasks.*

    Such command/response capability is unlikely to be provided to customers of ADS-DV ride-hailing services for safety reasons. For ADS-DV package delivery vehicles, such command/response capability might be provided in limited circumstances, such as maneuvering the vehicle at very low speeds in or around a loading dock or within a marshalling yard. However, such command/response capability as designed for business purposes is unlikely to meet the multivariate needs of test contractors attempting to perform FMVSS testing of ADS-DVs. Moreover, there would still be the problems associated with conducting tests outside of the vehicle's ODD.

15) *How would NHTSA ensure that the performance of the ADS-DV during testing is consistent with how the vehicle would perform during actual normal use?*

The premise of this proposed method is to make the measurement of the FMVSS performance compatible with how the vehicle is designed to actually operate in the real-world. As such, the test conditions would need to be developed for compatibility with the vehicle's ODD and operating modes as designed for real-world operation. As previously noted, such an approach would require research and future rulemaking.

Test Mode with Pre-Programmed Execution (TMPE);

The Test Mode with Pre-Programmed Execution method affords NHTSA the ability to overcome the limitations of performing a test procedure required by an FMVSS when there are no controls. Test procedures currently evaluate the performance of a component or subsystem and establish pass/fail criteria based on whole-vehicle performance. ADS-operated vehicles are expected to operate conservatively and provide a smooth ride, and thus are unlikely to reach the steering and braking thresholds required by the test procedure under normal driving conditions. This method can meet the intent of the FMVSS to test the component of system level safety but will not be able to test additional ADS operational capability.

A TMPE allows the agency to conduct the test within the constraints described above, but ADS developers need to exercise appropriate care to address challenges, some of which are listed below. Potential approaches to address the issues are listed below for ADS developers to incorporate into their designs, should they choose to use this test method.

Creation of a "test" mode: For this test mode to be operational, the checks for the ADS and other safety systems may need to be emulated or even bypassed. The developer has to create a test mode interface to accept steering, brake and throttle requests that would need to be sent to the corresponding steering and propulsion systems directly.

Cybersecurity: For the foreseeable future, testing late-stage prototype vehicles, rather than production vehicles, should be permitted for this method, since providing the test mode, along with the ability to load an HD proving ground map into the ADS, poses significant cybersecurity risk.

In addition, ADS developers need to demonstrate transparency to the agency that the TMPE mode can address any gaming concerns. At this time, we believe that the agency will need to work closely with the ADS developer to switch from automated driving mode to the TMPE mode.

16) *How could engineers responsible for performing FMVSS compliance assessments of an ADS-DV without manual controls be expected to access and interface with the compliance test library menu?*

Since the ADS is expected to complete the entire DDT while engaged, the TMPE mode would only be allowed with appropriate authorization to mitigate cybersecurity concerns. ADS developers would need to provide the agency or the test engineer with appropriate test hardware/encryption code and information for the applicable test procedures that are compatible with this approach.
A test mode can be used to emulate the ADS steering and torque requests during testing. A laptop interface could enable the selection of individual tests from a test library menu.

17) *Would the FMVSS need to specify the libraries available to NHTSA to test the vehicle?*

In the near term, the manufacturer is expected to provide the information, modes and the equipment to complete the required testing. This will allow each manufacturer to develop the test interface specific to their ADS program(s) while remaining encrypted and manufacturer-controlled. We expect the manufacturer will be present during testing, to protect data and system integrity.
In the longer term, the industry could work with standards development organizations, such as SAE, to develop a scripting protocol for specifying the test procedure actions, which ADS developers could use to develop a test mode interface for translating the script into specific requests for steering, braking and throttle control purposes.

18) *Is it practical to expect that an ADS-DV without any traditional manually-operated controls can be safely and efficiently operated within the confines of a test track with only a pre-programmed test menu (i.e., without some form of external controller or other means of vehicle control input)?*

The manufacturer would still need to be engaged with the third party testing team. Additional precautions of identifying the test start and end points would need to be established. The TMPE method allows the ability to conduct the tests on the track. A standardized means to abort the test could provide additional safety for testing personnel.

19) *Can an ADS-DV be expected to perform within tight tolerance levels using the regular on-board sensors?*

Although the ADS-operated vehicles will have an advanced sensor suite, the TMPE method is expected to only utilize steering, braking and throttle inputs to complete the test and is expected to perform within the tolerance levels observed in the existing test procedure.

20) *How much variation in test results across various test locations (i.e., proving grounds) is expected to result from testing an ADS-DV equipped with the same FMVSS compliance library at different locations? Could the ability to satisfy FMVSS performance requirements depend on the location the tests are performed?*

There are already standards to control test surfaces for friction, lane markings and other test equipment. Since the conventional testing results do not vary between locations, the TMPE test results should remain compliant with FMVSS standards at all locations.

21) *Is it reasonable to assume any geofence-based operating restrictions could be suspended while the ADS-DV is operating in a "test mode" intended to assess FMVSS compliance?*

Manufacturers could provide prototype vehicles that have the test mode capability, as well as the ability to receive the requisite HD map for the proving ground. Providing these capabilities on production vehicles is not recommended for cybersecurity reasons.

22) *How could vehicle-based electronically accessible libraries for conducting FMVSS testing be developed in a way that would allow NHTSA to access the system for compliance testing but not allow unauthorized access that could present a security or safety risk to an ADS-DV?*

Manufacturers would provide late-stage prototype vehicles that have these programs. Providing such capability on production vehicles would expose them to increased risk of being hacked to obtain access to the hard-braking/sine-with-dwell programs.

As mentioned in question 17, the scripts for executing the tests could be developed in consultation with standards bodies.

The manufacturer would need to develop security protocols to prevent unauthorized access to the test mode by providing a temporary authorization to engage the test mode in specified test locations, through a representative of the ADS developer. Restricting the test mode to a prototype vehicle addresses the security concerns associated both with providing the test mode capabilities and the proving ground-specific HD map to enable the vehicle to operate outside of its ODD.

23) *Are there other considerations NHTSA should be aware of when contemplating the viability of programmed execution-based vehicle compliance verification?*

The key considerations have been addressed in the previous responses.

24) *When changes or updates are made to the ADS, how will the TMPE content be updated to reflect the changes and how often would it be updated?*

As updates are made to the ADS the manufacturer should consider the impact to the TMPE procedure through its internal safety review process as part of the self-certification approach. As this type of testing should be conducted on prototype vehicles, rather than on production vehicles, it should be easier and more efficient to make changes as needed to update the test mode hardware and/or software.

Manufacturers must vet all changes for their effect on compliance and changes to the ADS will need to be included in the vetting process. Though software will likely be updated frequently, most changes to the ADS will not affect the TMPE. Therefore, required TMPE updates should be infrequent.

Test Mode with External Control (TMEC);

For certain FMVSS requirements and vehicle/ADS characteristics, utilizing an external controller with a special interface to the ADS that enables command/response vehicle motion control could offer an acceptable certification path. However, as previously explained, the Alliance believes such an approach could only be safely enabled on prototype vehicles, given the cybersecurity risk it could pose for production vehicles. The cybersecurity risk associated with the attempt to apply this approach to production vehicles could be further exacerbated by the concomitant need to inject an HD map of the NHTSA-contractor test facility into a particular production vehicle just for compliance testing purposes.

For these reasons, the functionality to use these "special controllers" should not be required to be present on "production" vehicles. Instead, vehicle manufacturers should be permitted to equip this functionally on a late-stage prototype vehicle. If manufacturers choose to provide such controllers for production vehicles, appropriate cybersecurity measures (e.g., hardware/software encryption) must be implemented.

25) *Is it reasonable to assume a common (universal) interface, translator, and/or communication protocol between an external controller and any ADS-DV will be developed?*

    External controllers will be developed by each OEM for their specific use in testing prototype vehicles. The varying configurations of ADS-operated vehicles (passenger, passenger-less cargo, etc.) make it difficult to develop a universal controller.

    As explained above, the Alliance does not believe that developing such a universal controller for use in testing <u>production</u> ADS-operated vehicles makes sense, as it significantly increases cybersecurity risk. A plug-in or remote universal controller would require a level of standardization which could make it even more attractive as a cyber-attack vector.

    The idea of a universal controller should be investigated by the SAE, or other industry consortium. However, even if it proves to be practicable to develop such a universal external controller, it will take considerable research and new rulemaking to adopt such an approach. In the interim, NHTSA should rely on OEM supplied external controllers and prototype vehicles to conduct such testing.

26) *What is the most viable method for securely interfacing an external controller with the ADS-DV (e.g., wireless or physical access)?*

    Both methods are subject to cybersecurity risk. As previously noted, it is not sensible to take on additional cybersecurity risk simply for the sake of demonstrating compliance to minimum safety standards. For this reason, we believe that both the TMPE and TMEC methods should allow testing using late-stage prototype vehicles.

27) *Could a means of manual control be developed that would allow NHTSA to access the system for compliance testing but not allow unauthorized access that could present a security or safety risk to an ADS-DV?*

Not reliably, given the attractiveness of such a device to potential malicious actors. Even if one develops well-designed protocols for protecting the use of the devices by a well-meaning manufacturer, NHTSA and NHTSA contractor employees, this could allow such controllers to be developed by other, malicious actors.

28) *Is it reasonable to assume any geofence-based operating restrictions could be suspended while an external controller intended to assess FMVSS compliance is connected to the ADS-DV?*

On late-stage prototype vehicles, yes.

29) *Are there other considerations NHTSA should be aware of when contemplating the viability of using an external controller-based vehicle certification?*

Allowing external controllers as an optional methodology for testing prototype ADS-operated vehicles is a viable interim approach, but it is not necessary to develop a universal external controller (i.e., the TPME approach provides the same interim testing capability with less effort and expense).

In the longer term, NHTSA should develop ADS-specific safety standards and protocols that do not require external intervention into hardened vehicle control and mapping software on production vehicles.

Simulation;

Simulation/virtual testing when appropriately conducted and validated can provide test fidelity equivalent to physical testing, without many of the safety/cybersecurity concerns present in other approaches, and at a small fraction of the cost and resources otherwise required for physical testing. It also facilitates much more robust testing, since it can include permutations of a scenario. Currently, the UNECE is working to develop certification methods for ADS-operated vehicles using simulation as a part of a “multi-pillar” approach. This work, should be able to inform NHTSA’s consideration of simulation for both existing and future regulatory requirements.

ADS technology lends itself well to simulation, because, unlike a human driver, whose driving behaviors are notoriously variable and capricious, an ADS’s driving behavior is quite stable and predictable.

Currently for crashworthiness assessments NHTSA already employs an analog simulation in the form of a crash test anthropomorphic test device (ATD). Such devices simulate the responses of the human to injury and are subject to Part 572 certification to ensure appropriate fidelity and repeatability/reproducibility. We envision, that simulation programs/certification processes could be developed to be appropriately specified and subjected to a similar certification process as Part 572 to ensure appropriate fidelity and repeatability/reproducibility.

The main disadvantage to simulation is that currently there are no standardized methods for validating virtual test drive simulators, although work is on-going to develop this. Virtual test drive simulators also rely in large part on vehicle-specific programming to match the many subtleties of chassis dynamics and tire tuning.

If simulation is to be used as a standalone certification method, it will need additional work to develop processes (similar to the certification of Crash Test ATDS) that will ensure adequate fidelity, repeatability/reproducibility.

30) *How can simulations be used to assess FMVSS compliance?*

    Standardized virtual test drive simulation tools have already been developed in support of international projects, such as Pegasus. These tools enable a proprietary vehicle model to interface with the standardized elements of the virtual test drive simulation tool. We expect that, once standardized validation methods are developed, it will be possible to demonstrate the fidelity of the simulation tool sufficient for FMVSS compliance demonstration purposes.

31) *Are there objective, practicable ways for the agency to validate simulation models to ensure their accuracy and repeatability?*

    Please see response to Question 30.

32) *Is it feasible to perform hardware-in-the-loop simulations to conduct FMVSS compliance verification testing for current FMVSS?*

    Yes, HIL and SIL simulation tools are widely used in development and may be suitable for testing certain requirements under FMVSS. As with ATDs and virtual test drive software, any simulation that has been adequately standardized and validated should be eligible for FMVSS demonstration purposes, if applicable.

33) *Is it feasible to perform software-in-the-loop simulations to conduct FMVSS compliance verification testing?*

    Please see response to Question 32.

Technical Documentation for System Design and/or Performance Approach; and

Existing vehicles contain multiple subsystems and control modules that interact with each other to achieve the desired function to fulfill FMVSS (as well as internal-often stricter) requirements. An ADS-operated vehicle is an evolution of existing vehicle technology that, in the context of this discussion, should be deemed as an extension of existing processes. The functions of an ADS that are specifically governed by applicable 100 series FMVSS requirements could be certified using technical documentation showing the technical logic and interaction of modules used to implement the regulated functions, perhaps supplemented by testing and/or simulation data providing evidence that the technical documentation accurately describes the vehicle's performance characteristics.

34) *How can the documentation-focused approach ensure compliance with FMVSS, considering it neither verifies that the vehicles on the road match the documentation nor confirms that the vehicles on the road comply with the FMVSSs?*

As noted above, technical documentation could be supplemented with testing and/or simulation documentation that provides evidence of its fidelity to the ADS-operated vehicle in question.

35) *If technical documentation were acceptable for compliance verification, how would the manufacturer assure the agency that the documentation accurately represents the ADS-DV and that the system is safe?*

Please see response to Question 34.

36) *Exactly what kind of documentation could be submitted for each kind of FMVSS requirement? Provide specific examples with detailed explanation of the documentation required.*

Technical documentation may be appropriate as support for specific regulations/regulatory provisions, but more than one method may be required for verification. This would be similar to the current process for providing information regarding the existing technical documentation provisions in FMVSS 135 or 126. In addition, such documentation will likely contain significant proprietary information and thus would require confidentiality protection by the agency.

The types of technical documentation could be binned into the following categories:

a) Documentation of hardware(part numbers, drawings) and software(versions) to demonstrate equivalency of systems between ADS-DV and surrogate vehicle

b) A combination of electrical architecture, information flow and network diagrams to highlight communication of messages between ADS and vehicle systems

c) System/subsystem and component testing used to validate simulation models

Use of Surrogate Vehicle with Human Controls.

Where appropriate surrogate vehicles exist, this method is an efficient method to verify that the base vehicle meets FMVSSs. However, like some of the other methods, this option may be combined with technical documentation establishing that the ADS-equipped version of the vehicle under test has the same key components and would achieve the same level of performance within normal test-to-test variability.

The key disadvantage with this approach is that there may not be a suitable surrogate vehicle available. Current FMVSS regulate the capabilities of conventional, human-operated vehicles and do not address ADS (or driver) behavior. As such, this method will be suitable in most cases because the behavior of the base vehicle will be the same, regardless of whether the vehicle is operated by a human driver or by an ADS. However, in certain rare cases, such as FMVSS 126, the ADS would in fact affect the performance of the vehicle – mainly by never (or nearly never) encountering situations that would trigger ESC intervention.

37) *To what extent could equivalence of the vehicle components used for conventional and ADS-DVs be demonstrated to assure that surrogate vehicle performance would be indicative of that of a surrogate ADS-DV?*

This approach could be used for test procedures that require the use of manual controls. For example, the purpose of FMVSS No. 126 is to prevent driver loss of directional control, including loss of control resulting in vehicle rollover and requires the steering wheel angle as a validation metric. It is possible for a manufacturer to demonstrate through supplemental documentation (part numbers, software versions etc.) that an ADS-operated vehicle has an Electronic Stability Control (ESC) system that is functionally equivalent to that of a conventional vehicle that has shown compliance with the standard test procedure that references the Steering Wheel Angle.

38) *How can the agency confirm that the maneuver severity performed by a surrogate manually-drivable vehicle, during FMVSS compliance tests, is equal to that of the subject ADS-DV? For example, how can the characterization maneuvers and subsequent scaling factors in the FMVSS No. 126 ESC test on the surrogate vehicle be confirmed as equivalent on the ADS-DV?*

Please see response to Question 37.

In addition, as noted in response to question 13, the use case and ODD for certain types of ADS-operated vehicles may also effectively obviate the need for ESC. For example, an ADS-DV that operates exclusively on urban roadways (at lower speeds) in fair weather conditions, and which is programmed to drive defensively in all conditions, is extremely unlikely to encounter conditions that would trigger ESC engagement, or to benefit significantly from such engagement in the extremely rare circumstance of its occurrence (e.g., during or immediately following a relatively high-speed impact).

39) *If results from FMVSS compliance tests of a conventional vehicle performed by its manufacturer differ from the results of NHTSA tests of an equivalent ADS-DV (particularly if the conventional vehicle complies with the agency's standards, but the ADS-DV does not), can the conflicting results be reconciled? If so, how?*

NHTSA should use the same test type as per the manufacturer's suggestion. If the manufacturer is using a surrogate test, but NHTSA is using an alternative form, differences between the different testing methods will need to be identified and reconciled before any determination of non-compliance can be made.

If the manufacturer choses to prove compliance using a conventional vehicle, the manufacturer should show through technical documentation that the vehicle components and systems under test are virtually[6] identical to those in the ADS-DV.

[6] Non-functional differences may exist to account for the fact that the same component on an ADS-operated vehicle may lack a feature needed solely to support human generated inputs to the component.