The Honorable Heidi King

Deputy Administrator

National Highway Traffic Safety Administration

1200 New Jersey Avenue, SE

Washington, DC 20590

ZF's Comments to NHTSA's Advanced Notice of Proposed Rulemaking on Removing Regulatory Barriers for Vehicles with Automated Driving Systems

Docket No. NHTSA-2019-0036

Dear Deputy Administrator King:

ZF appreciates the opportunity to provide its perspective in response to NHTSA's Advanced Notice of Proposed Rulemaking on Removing Regulatory Barriers for Vehicles with Automated Driving Systems. ZF continues to support NHTSA's efforts to establish a national framework to guide the testing, development, and implementation of Highly Automated Vehicles (HAVs). ZF further supports NHTSA's initiative to identify any regulatory barriers in the existing Federal Motor Vehicle Safety Standards (FMVSS) to testing, compliance certification and verification of motor vehicles with Automated Driving Systems (ADSs) and certain unconventional interior designs. We have prepared remarks that comment on the near and long- term challenges of testing and verifying compliance with existing crash avoidance standards (100-series) within the FMVSS for vehicles equipped with Automated Driving Systems that lack traditional manual controls for human drivers to operate.

ZF North America ("ZF") is headquartered in Livonia, Michigan, and is a primary developer and producer of active and passive safety systems, serves all major vehicle manufacturers, and manufactures here in the United States and in more than 25 countries around the world. The convergence of active and passive safety systems, including driver assist and semi-automated functions such as adaptive cruise control, lane keeping assist and semi-automated functions such as adaptive cruise control, lane keeping assist and automatic emergency braking, provides the foundation for autonomous vehicle capability. It is estimated that over 94 percent of vehicle crashes are the result of human error. These technologies, when implemented at the SAE Level 3 and higher, have the potential to help significantly reduce deaths and injuries attributable to vehicle crashes.

This **Advanced Notice of Proposed Rulemaking for Removing Barriers for Vehicles with Automated Driving Systems** comes at a critical time for the auto industry. With the accelerated testing and deployment of vehicles with enhanced safety systems, including ADSs, it is important for NHTSA to set appropriate expectations, guidelines, or regulations for vehicle manufacturers, suppliers, and state and local government authorities. We believe it is appropriate to consider more defined or updated FMVSS-related standards.

Highlights of ZF's Comments:

- *A variety of test methods may be available to test ADS-DV compliance to the current FMVSS standards, depending on the specific test scenario, the performance capabilities of the vehicle, and its configuration – e.g. whether there is a suitable place on board for a human driver during testing.*
- *NHTSA could consider creating a dedicated FMVSS standard or set of standards for ADS-DVs, as with FMVSS 500 for low speed vehicles, to be able to tailor safety requirements explicitly to meet the needs of ADS-DVs without impacting the current FMVSS, and avoiding any unintended consequences for conventional vehicles after making those changes.*
- *Due to the difficulty of reproducing some test scenarios in ADS-DV vehicles without human driving controls, NHTSA could adapt existing tests to require specific levels of performance measured at the vehicle level, rather than at the sub-system or component level (e.g. maximum vehicle stopping distance permitted vs. maximum brake pedal force).*
- *Using a dedicated, hard-wired controller to provide manual control of an ADS-DV under test may provide a convenient, flexible interface to perform a range of validation tests, while minimizing the impact to a production vehicle and maintaining a cyber-secure environment.*
- *Simulations may be used to evaluate compliance in cases where it is not possible to manually control a vehicle, for example because there is no driver compartment or driver's seat available, or a maneuver may be risky for a human driver or difficult to replicate. Simulations may also be used to find edge cases for real-world verification and accelerate or increase the robustness of certain tests by allowing multiple scenarios to be run in parallel.*

ZF's full comments to specific NHTSA questions are provided on the following pages. We look forward to continuing this discussion with NHTSA and we welcome any questions you may have regarding our comments.

Best regards,

Dr. Franz Kleiner

Member of the Board of Management of ZF

Head of Americas Region

ZF Response to NHTSA ANPR Request for Comments

ZF provides comments in response to the following requests from NHTSA:

The agency requests comment on the following approaches: (1) Normal ADS-DV operation; (2) Test Mode with Pre-Programmed Execution (TMPE); (3) Test Mode with External Control (TMEC); (4) Simulation; (5) Technical Documentation for System Design and/or Performance Approach; and (6) Use of Surrogate Vehicle with Human Controls. The agency also requests comment on whether any additional alternatives are possible. In addition to answers to the questions that appear after the discussion of each approach, NHTSA requests that commenters answer these questions for each of the approaches:

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

- See summary tables below.

Table 1a: Possible Approaches to Revising Crash Avoidance Test Procedures

	Normal ADS operation	Test Mode with Pre-Programmed Execution (TMPE)	Test Mode with External Control (TMEC)
ADVANTAGES	*Ability to test system as designed, with real sensor feedback*	*No operator required for normal testing operation (but may be required for override if necessary, etc.)*	*No on-board operator required; external control removes need for (in-vehicle) operator, but still allows for override if necessary.*
	Simplest approach if vehicle ODD permits replication of test scenarios	*Better suited for testing specific and dedicated functions, as it provides consistent repeatability of test maneuvers.*	*Provides flexibility to easily modify / adapt test procedures as required.*
DISADVANTAGES	*Vehicle performance may vary based on conditional inputs, and other variables*	*May result in a system "designed to pass test" but not optimal for "out of test parameter" conditions*	*Difficult to record and document how performance in test is measured (should be easy to record / document, etc.)*
	Vehicle may not be capable of performing required test procedures in standard configuration	*Complexity of modifying / adding new test scenarios if required*	*Ability to consistently repeat test with a human (not robot) driver, especially if human "driver" is off-board; requires real world tests to verify connection/ latency issues.*
		Variations in test conditions may result in differences in performance	

Table 1b: Possible Approaches to Revising Crash Avoidance Test Procedures

	Simulation	***Technical Documentation for System Design and/or Performance Approach***	***Use of Surrogate Vehicle with Human Controls***
ADVANTAGES	*Able to evaluate many different dynamic scenarios / conditions - allows many variations and tests to be conducted more quickly / in parallel, including those edge cases that may be risky for an onboard driver (e.g. severe system failures) or difficult to repeat / replicate in vehicle testing*	*These should be required to denote what the system has; base listing without details may be sufficient; as well as verification from developer on performance of the system from internal tests, to demonstrate "readiness".*	*This may be a good method with / without human controls where early prototype modules could be tested & validated; early ADS-DVs may be retrofitted production vehicles, so can give representative performance results for vehicle dynamics and a human-drivable platform.*
		Suitable for non-dynamic performance validation.	
DISADVANTAGES	*Requires development of simulation models, and need for correlation testing as is can be difficult to precisely replicate the actual vehicle's control and dynamics in simulation*	*Limited applicability*	*The surrogate vehicle may not have same characteristics as the actual ADS-DV; so, this may not satisfy how an actual vehicle performs: * Mass differences * Handling differences * Braking perf. differences*
	May require separate vehicle to model validations or "envelopes" to compensate for other variables.		
	May still require "subset" of actual hardware (system / vehicle) tests to provide final validations		

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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.

- *See Tables 1a and 1b, above, and Table 2, below:*

Table 2: Feasibility of Possible Approaches

Normal ADS Operation	*Test Mode with Pre-Programmed Execution (TMPE)*	*Test Mode with External Control (TMEC)*
"Real World" vehicle level testing is feasible and practical for some test scenarios; may augment other test conditions to demonstrate response in altered cases, etc.	*Feasibility will depend on the extent / allowance of pre-programmed execution and how the vehicle reacts to variables.*	*Feasibility will depend on extent / allowance of what the external controller is able to do, and the performance / latency of the interface. Generally, "test mode" conditions may be non-preferable due to how that behavior is controlled / executed.*

Simulation	*Technical Documentation for System Design and/or Performance Approach*	*Use of Surrogate Vehicle with Human Controls*
Simulation could be used to extend the test scenario coverage and may be used to cover some of the "edge case" scenarios that are difficult or risky to replicate with an actual vehicle or other road users (e.g. pedestrians). *Simulation may be best suited for testing software functions.*	*Technical documentation review may be suitable for non-dynamic vehicle performance validation, and if ADS-DVs and conventional surrogate vehicles are functionally equivalent.*	*This may be possible but depends on capability of surrogate vehicle and how closely it resembles the ADS-DV (e.g. retrofitted production vehicle, or just common vehicle platform). Concerns noted in advantages/ disadvantages above.*

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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.

- *Yes; this is covered in response to item 1, above, but may depend on the content and level of testing and validation the system supplier has performed (as noted in the table).*

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?

- *The agency should consider the capability and effort required to reproduce the required test procedure and results when selecting a test approach; in particular the feasibility of having a human driver control the vehicle during the testing period.*
- *The approach selected may also depend on the sensor suite utilized, as well as the central processing unit. These may drive some of the test considerations for compliance, etc.*

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?

- *It may be possible to have common performance standards that all conventional and ADS-DV road vehicles are required to meet, but in the case of ADS-DVs designed for low speed operation only, some vehicles may have insufficient dynamic performance to meet the normal FMVSS test requirements. In those cases, modifications to FMVSS 500 may be sufficient to address the impacted requirements.*
    - *The test requirements should be transparent to the make / model equipment, etc. so that equivalent validations may be performed; unless a tiered test method will be used such that tests may be modified depending on how they are outfitted.*

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 vehicles?

- *In addition to "driver," "[vehicle] operator" is another term that could be used to address ADS-DVs operating in autonomous or remotely piloted modes. This definition is used for drone operators - who pilot remotely.*
    - *An operator may also be an autonomous function or AI built into the system to evaluate data and make decisions. The operator may then also refer to the program that created the decision matrices, etc.*

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

- *NHTSA could consider creating a dedicated FMVSS standard or set of standards for ADS-DVs, as with FMVSS 500 for low speed vehicles, to be able to tailor safety requirements explicitly to meet the needs of ADS-DVs, without impacting the current FMVSS standards for human-driven vehicles and avoiding any unintended consequences after making those changes.*
- *This may be subject to change in the future, but presently, the definitions and testing items should be made such that either manual or ADS-DVs can be tested, and methods to evaluate performance can be made. As noted in prior items, clarification of definitions (or alternate definitions of methods) may be preferred to allow for various methods of monitoring, while obtaining "equivalent" information and thereby providing for a similar method to validate performance to a common standard.*

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?

- *NHTSA could fit a dedicated sensor package to the ADS-DV (e.g. gyros, accelerometers) to confirm that vehicle performance during testing is consistent with vehicle operation during normal use. Alternatively, sensor data from an onboard ESC system could be compared during normal and test operation to confirm similar vehicle performance.*
- *Simulation may also be a suitable method to demonstrate compliance, and a certification test may be applicable regardless to show vehicle compliance.*

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?

- *In general, the public expectation seems to be that ADS-DVs should provide at least equivalent safety protection levels as human-driven vehicles. Due to the difficulty of reproducing some test scenarios in vehicles without human driving controls, NHTSA could adapt the tests to require specific minimum levels of performance measured at the vehicle level, rather than at the sub-system or component level (e.g. maximum vehicle stopping distance permitted vs. maximum brake pedal force).*

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?

- *See item 1. above.*
- *Supplier of system may show certification tests and validation method (i.e. internal events) or NHTSA may require a subset of test to validate and show compliance via simulation / etc.*

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?

- *NHTSA may be able to run real-world tests at the component- or vehicle sub-system level to validate a simulation or presented documentation, without needing (or being able to) test the compliance of an ADS-DV at the vehicle level.*

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?

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?

- *In some cases, modifications could be made to allow for cases with ADS-DV systems for the test, but overall vehicle performance requirements should be same. In these cases, the items identified in Table 1 herein may still apply.*

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?

- *Yes; modifications could be made to allow for cases with ADS-DV systems for testing, but the overall requirements should be same. In these cases, the items identified in Table 1 herein may still apply.*
    - *References to specifics many not be required but could be noted as part of the "simulation case," where the ADS system supplier demonstrates capabilities via simulation and verifies with the actual test.*

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?

- *Relevant data should be supplied by the specific system supplier / OEM for the test cases noted. Platform test cases may generally be grouped when the same systems are employed.*

A. Normal ADS-DV Operation

To better understand the "Normal ADS-DV Operation" approach and its possible applications, the agency asks the following questions.

Questions specific to this testing method (general questions precede this section):

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.

- *Design concepts for vehicle routing can include:*
    - *Passengers request destination via a touch-screen selection of destination from a menu.*
    - *Voice recognition / audible verification for impaired passengers unable to use a touch screen input.*
    - *Pre-defined route with no passenger input available for vehicle destination.*

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.

- *To be simple and safe for passengers to use, unmanned ADS-DVs may need to limit vehicle control options. For safety reasons, the consumer-accessible HMI should not allow operation of the vehicle at (or close to) its safety and vehicle dynamics limits. Therefore, a different or unique interface may be required for compliance and verification testing, which would not be available to regular passengers.*

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.

- *ADS-DVs without conventional driver controls will need to be able to be operated manually in a range of situations including initial manufacturing, maintenance and repair, low battery conditions, etc. and even maneuvering in very restricted spaces (e.g. for transportation) that would fall outside their normal ODD. This may be achieved with a temporary HMI controller connected via a wired or wireless interface (e.g. a gamepad-type controller).*

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?

- *NHTSA could temporarily install a sensor package to the ADS-DV (e.g. gyros, accelerometers) to confirm that vehicle performance during testing is consistent with vehicle operation during normal use. Alternatively, sensor data from an onboard ESC system could be compared during normal and test operation to confirm similar operation.*

B. Test Mode with Pre-Programmed Execution (TMPE)

Questions specific to this testing method (general questions precede this section):

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?

- *To maintain a cyber-secure environment, a dedicated interface ECU (or "dongle") could be required to access test libraries programmed into an ADS-DV.*
- *Alternatively, specific compliance testing software could be programmed into the ADS-DV solely for verification purposes, which includes the library of test procedures and scenarios. This software would then be removed afterwards.*

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

- *The FMVSS would need to specify the required test procedures to verify that the safety system is operating correctly, and the vehicle / ADS system manufacturers would need to create test programs to enable the vehicle to be tested to those procedures.*

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)?

- *It may be appropriate to fit a remotely operated "kill" switch to an ADS-DV test vehicle operated at a test track. A simple remote power-disable switch would not be able to influence the ADS-DV's test performance but would allow the vehicle to be safely stopped in the case of unexpected or dangerous operating conditions.*

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

- *The onboard gyro and accelerometer sensors used in Electronic Stability Control and other chassis systems are designed and manufactured to tight specifications. However, these sensor outputs are filtered and conditioned for their specific vehicle dynamic applications, and therefore may not be able to provide a suitable level of data to support NHTSA's verification testing or tolerance evaluations.*

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 could be some variability in ADS-DV test results between locations due to differing levels of road surface grip and ambient temperature, but similar variability may also be experienced with manually driven vehicles.*

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?

- *Yes, either geo-fencing restrictions could be disabled in "test mode" so that the vehicle does not know (or need to know) where it is operating, or specific test facilities could be added to the geo-fenced regions permitted for ADS-DV vehicle operation. These test facilities could be independent test facilities or NHTSA / DOT test facilities.*
- *For best testing flexibility and to prevent potential misuse of location information, it may be better to simply have a test mode that permits temporary operation outside the normal ODD.*
- *Vehicle manufacturers would probably develop this capability anyway to support their own development testing and validation activities, which could take place outside the commercial operating areas of an ADS-DV.*

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?

- *Managed test library access could be achieved via a hardware-based approach if vehicle manufacturers provided NHTSA with special "unlocked" controllers or interface ECUs to the ADS-DV's vehicle dynamics controller, such as a secure "dongle" or remote controller. If this interface is not present in the regular production vehicle, it would minimize the security and safety risk.*

- *Alternatively, dedicated software programmes or configuration (data) files with higher performance thresholds could be programmed into the ADS-DVs control ECU to add the FMVSS testing libraries for compliance testing purposes, and then erased afterwards. This approach could be more secure than having "hidden" files in all the production vehicles that could be unlocked for testing purposes by NHTSA.*

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?

- *The TMPE content would need to be updated by the ADS-DV vehicle / system manufacturers in parallel with FMVSS test requirement and vehicle performance changes; configuration management could be addressed by updating the specific hardware or software test tools used to access these test modes as required.*

C. Test Mode with External Control (TMEC)

Questions specific to this testing method (general questions precede this section):

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?

- *Industry standard interfaces such as OBD have been developed for defect reporting across vehicle manufacturers, with a common software and connector interface. A similar approach could be taken for ADS-DVs with a cyber-secure standardized interface, in the same way that the USB interface is used universally for PC gaming for HMI controls for example.*
- *However, OEMs or commercial fleets may prefer to develop proprietary interfaces, especially for test mode and control, for increased cybersecurity.*

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

- *Requiring a physical connection to the vehicle is probably more cyber-secure, as it could require user access to the vehicle interior and additional secured control panel to make the connection and could only be used to control one vehicle at a time.*
- *Wireless security may be increased under controlled conditions; i.e. if at a test ground, in test conditions, etc. A review of these wireless protocols would need to ensure that there is no override outside these test condition s/ parameters (i.e.no potential lockout scenario).*

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?

- *Secure and safe access could be achieved if vehicle manufacturers provided NHTSA with special "unlocked" control or interface ECUs to the ADS-DV's vehicle dynamics controller, such as a secure dongle or HMI controller to enable testing, or dedicated software and/ or configuration files that enable "test" modes.*

- *If these control interfaces and/or software are not present in the regular production vehicle, they would not be potential security / safety risks.*

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?

- *Yes, either geo-fencing restrictions could be disabled in "test mode" so that the vehicle does not know (or need to know) where it is operating, or specific test facilities could be added to the geo-fenced regions permitted for ADS-DV vehicle operation. Vehicle manufacturers would probably develop this capability anyway, to support their own development and validation activities.*

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

- *Yes, NHTSA should consider whether the ADS-DV has a suitable and safe location for the tester to ride onboard during the evaluation testing.*

D. Simulation

Questions specific to this testing method (general questions precede this section):

30. How can simulations be used to assess FMVSS compliance?

- *Simulations can be used to evaluate compliance in cases where it is not possible to manually control a vehicle, for example because there is no driver compartment or driver's seat available. Simulations may also be used to find edge cases for real-world verification and accelerate or increase the robustness of certain tests by allowing multiple scenarios to be run in parallel.*
- *Automated vehicles must be able to respond properly in an almost infinite number of driving scenarios, respond to an incredibly large number of obstacles and road users and in addition, perform in a variety of environmental conditions. There does not appear to be any feasible way to physically test vehicles in all these situations, nor is road or track testing sufficiently controllable, repeatable, exhaustive, fast or simply safe enough. The ability to test in a simulation environment to cover all known scenarios and conditions within an ODD is essential for the verification and certification of automated vehicles.*
- *Furthermore, items like the validation of the system's behavior under failure conditions can only be done via virtual methods (HIL / failure injection).*

E. Technical Documentation for System Design and/or Performance Approach

Questions specific to this testing method (general questions precede this section):

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?

- *Technical documentation could be used in specific cases to demonstrate that the components and functionality of a safety system in an ADS-DV are identical to those of an equivalent FMVSS-compliant surrogate vehicle and are being used for the same application (e.g. TPMS).*

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?

- *Self-certification is the standard approach taken for FMVSS compliance testing today, so the OEM would need to certify that the documentation is an accurate representation of the ADS-DV, and NHTSA has the ability to spot-check and confirm compliance.*
- *In addition, component-level or off-board test results could be used to demonstrate the correct function and operation of the safety system under evaluation.*

F. Use of Surrogate Vehicle with Human Controls

Questions specific to this testing method (general questions precede this section):

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?

- *Key design parameters directly impacting vehicle dynamics and safety could be compared and equalized for the manually driven surrogate vehicle and ADS-DV; e.g.*
    - *Vehicle weight, and front / rear weight distribution*
    - *Tire size, manufacturer and type*
    - *Braking system performance (e.g. pressure build rate, brake component sizing and type)*
    - *Steering motor power and maximum input rates*

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?

- *NHTSA could temporarily install a sensor package to the ADS-DV (e.g. gyros, accelerometers) and use the sensor data - e.g. yaw and lateral acceleration – to measure the dynamic responses of a manually driven vehicle, and then compare this with equivalent data generated by an ADS-DV reproducing the same test maneuver.*
- *Conventional and ADS-DV vehicle comparison test results could be harmonized using this data, as the programmed input to the ADS-DV could be modified until the vehicle response matches the conventional manually-driven vehicle.*

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?

- *See item 38, above: conventional and ADS-DV vehicle comparison test results could be harmonized using this data, as the programmed input to the ADS-DV could be modified until the vehicle response matches the conventional manually-driven vehicle.*
- *If the two vehicle responses can't be aligned this way, the missing functions or variables causing the difference would need to be identified and adapted for.*