August 28th, 2019

National Highway Traffic Safety Administration
Docket Management Facility
U.S. Department of Transportation
Room W12-140
1200 New Jersey Avenue S.E.
Washington, D.C. 20590-0001

Subject: NHTSA Docket No. 2019-0036, "Removing Regulatory Barriers for Vehicles With Automated Driving Systems" from Federal Register Volume 84, No. 102, Tuesday, May 28, 2019

Dear Gentlemen:

Haldex Brake Products, Inc. (Haldex), a global manufacturer of air brake system components for commercial vehicles including Disc Brakes, Antilock Braking Systems (ABS), Electronic Braking Systems (EBS), Electro-Mechanical Braking Systems (EMB), actuators, brake adjusters, brake block and disc brake pads supports the Agency's efforts to remove regulatory barriers and modernize regulations for the purpose of advancing technologies to improve the safety of drivers and passengers on public roads.

Please find attached Haldex responses to some of the agency's questions provided in the ANPRM.

Regards,

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Once vehicles no longer have traditional manual controls, how will NHTSA be able to test them to ensure that they meet the revised standards?

The vehicles need to have an override function, where an external device "controller" plug into the vehicle such as a USB port or diagnostic port allowing a person to manually control the vehicle. This controller could be a standard device per an SAE standard that is provided from the manufacturer. Standardize the controller and its interface per an SAE standard.

How does NHTSA get a vehicle it purchases for compliance testing to the test facility?

Have the ADS-DV towed to the test facility such as on a flat bed truck. Contact the ADS-AV manufacturer regarding how to transport the ADS-DV to the test facility.

How does NHTSA direct the vehicle to perform the required test procedure?

Contact the manufacturer of the ADS-DV for information. If agency desires to have a standard method for directing the ADS-DV to perform a required test procedure, have SAE develop an industry recommended practice for ADS-DV manufacturers to follow. Have SAE develop a set of standardize test maneuvers that are implemented at various speeds and random sequence of maneuvers.

How does NHTSA deal with a vehicle whose ODD does not include a test facility?

Have SAE develop a standard method for directing the ADS-DV to perform a required test procedure, have SAE develop an industry recommended practice for ADS-DV manufacturers to follow. Have SAE develop a set of standardize test maneuvers that are implemented at various speeds in a random sequence of maneuvers. Standardized track maneuvers. SAE standard for a series of maneuvers to perform.

The following are comments on the following approaches:

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

a. Normal ADS-DV operation
b. Test Mode with Preprogrammed Execution (TMPE)
c. Test Mode with External Control (TMEC) allows separation of software enable mechanical issues using a remote driver.
d. Simulation.
e. Technical documentation for System Design and/or Performance Approach
f. Use of Surrogate Vehicle with Human Controls
g. Any additional possible alternatives? **Do not modify the vehicle but modify the environment it is driven in considering both weather, traffic and road conditions.**

There should be tests that are standard, but not standard in their approach. Will there be FMVSS requirements for autonomous defensive driving?

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.**

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.**

   A combination of the above is the more likely an approach in conducting the testing safely, efficiently and cost effectively using a combination of a, d & e when driver manual controls are available. All the approaches above need to be taken into consideration when the ADS-DV does not provide the driver with manual control.

4. **If only one of these approaches can be used to enforce a 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 vehicle or item of equipment?**

   Normal ADS-DV operation approach should be used to enforce a FMVSS requirement if only one of these approached can be used and that is with available manual controls for the driver. How the ADS-DV operates under various road, traffic and weather conditions should guide the agency in choosing other alternatives. A combination of the above is the more likely approach in conducting the testing safely, efficiently and cost effectively.

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 will be difficult to ensure that the compliance of all makes, types and models of ADS-DV across the industry are measured by the same yard stick. Today there are different FMVSS standards for vehicles with different performance requirements based on vehicle type, weight and equipment installed. How ADS-DV hardware is installed on various vehicle makes, types and models will have some impact on how the vehicles will perform in meeting the performance requirements.

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?**

Combustion vehicles refer to "engine". Electrical vehicles refer to "motors".

ADS-DV equipped with Electro-Mechanical Braking - FMVSS 105, 121, and 136

Electro-Mechanical Braking utilizes electrical motors for brake actuation. TP-136 references brake chambers when it may be electrical motors. FMVSS may need to reference as actuation devices versus brake chambers.

TP-136: The ESC system applies service brake pressure at any wheel for a continuous duration of at least 0.5 second of at least 34 kPa (5 psi) for air braked systems and at least 172 kPa (25 psi) for hydraulic-braked systems. Electro-Mechanical Brakes there will be a force applied, but no fluid pressure measurement available.

With an ADS-DV equipped with Electro-Mechanical Brakes there may be no pressure signal, but an electrical signal or force output.

Energy Storage Devices. Pneumatic braking system utilizes reservoirs for storing pressurized air. Electro-Mechanical braking utilizes a battery for storage of electrical power.

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

   Yes. With the introduction of any new technology there will be new terms, definitions and methods that will not necessarily be covered by existing and established methods and practices. Attempting to fit a square peg into a round hole may hinder the benefits of the new technology, by not allowing the technology to provide all the benefits it may offer to society. Example: Electric vehicles utilize regenerative braking, which ends up doing most of the braking compared to the foundation brakes on the vehicle. The foundation brakes on an electric vehicle today must meet the requirements of a vehicle with a combustion engine. Aircraft utilizes reverse thruster to perform most of the task in slowing the aircraft to a stop. Can the aircraft approach to braking be applied electric vehicle braking?

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?**

      Conduct field tests by monitoring the vehicle(s) on defined approved public roads and where the ADS-DV OEM has validated the operation of the ADS-DV on approved public roads and road conditions (weather & traffic congestion conditions) for safe operation.

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?

Yes.

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?

The documentation that is submitted to NHTSA to validate the accuracy of the simulation must contain some actual vehicle test results to provide the agency confidence that the simulation is valid and representative of the vehicle performance. The model to be validated may be required to be performed across several vehicle combinations. The validation of the model would be provided in an appendix of the simulation too test report. Any limiting factors regarding the use of the model also needs to be addressed in the report. Haldex uses hardware in the loop for Type Approvals per ECE-Regulation No. 13, Annex21, Appendix 3 of vehicle stability and braking. An example of a Vehicle Stability Test Report using Haldex HIL rig simulation tool for test can be provided from Haldex to the agency upon request.

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?

Overall there will be fewer tests to be performed based upon various vehicle configurations saving test time and money. Test reports verifying the vehicle performance can be generated faster than performing all the actual tests required for the various vehicle configurations.

ADS-DV vehicle utilize cameras in the system, which also can be utilized as Dash CAMs for monitoring and recording traffic conditions. Every autonomous car has the added benefit of having cameras onboard for documenting the traffic condition prior to traffic events. Will there be FMVSS requirements for autonomous defensive driving? ADS-DV with Dash CAMs provides the DOT with mobile monitoring of traffic and road conditions.

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?

Yes, some such as FMVSS 105, 121 and 136.

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, some examples are congested traffic conditions, rough road / pot-hole test, road debris (tire scraps) and weather (sun glare).

How does an ADS-DV respond to a test where five objects such as a child, adult, dog, cat and bike are induced into the test at once? How does the vehicle decide? Does the vehicle put itself in danger at the expense of not hitting an object or objects? How do you verify FMVSS 136 performance? Cannot respond, not an ADS-DVs OEM provider.

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?**

A. NORMAL ADS-DV OPERATION

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.**

Not an ADS-DVs OEM. Smart phone through blue tooth or text messages where you enter a code into the ADS-DV vehicle command interface, which will direct the vehicle where to go.

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.**

Yes. May not perform the task requested. It will not meet compliance if it does not perform the requested task. The challenges are the test track within the vehicle ODD when the ABS is trigger. Meeting specific requirements within FMVSS 121 and 136 where the vehicle needs to be at a speed to perform the test.

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.**

The vehicle may be preprogrammed and not able to do something unsafe thus unable to perform some of the tests of FMVSS 136.

You have a test where five objects such as a child, adult, dog, cat and bike are induced into the test to see how the vehicle responds. How does the vehicle decide? Does the vehicle put itself in danger at the expense of not hitting an object or objects? How do you verify FMVSS 136 performance? Cannot respond, not an ADS-DVs OEM provider.

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?**

Conduct field tests by monitoring the vehicle(s) on defined approved public roads and for a period where the ADS-DV manufacturer has validated the operation of the ADS-DV on approved public roads and weather conditions for safe operation.

B. TEST MODE WITH PRE-PROGRAMMED EXECUTION (TMPE)

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?**

Cannot respond, not an ADS-DVs system provider. ADS-DVs manufacturer's provide access by sending engineers an email or smart phone app and code to access the compliance test menu for performing the compliance assessment. SAE working with members from ADS-DV manufacturers can develop a standard method for accessing the compliance test library menu.

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

Yes, the FMVSS needs to generally define and specify the tests contained in the library. The test procedures and methods within the library needs to be a living library where the test maneuvers and procedures can be revised frequently and quickly because of the advancements in technology. The specific test applicable to run for that vehicle would be selected from a living library, a library that is constantly updated or revised for the ADS-DVs vehicles.

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)?**

No. The ADS-DV vehicle may be preprogrammed not to do something unsafe and thus be unable to perform a maneuver such as an FMVSS 136 test .

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

AD-DV can be expected to perform within tight tolerances levels compare to a driver. Tight tolerance is not possible under all conditions or circumstances. The performance will be affected by how the vehicle is equipped, software and hardware level of the vehicle equipment, who performs the test, how the test is conducted, weather conditions during the test, when (time & day) and where (track location and surface) the test was performed. SAE developing a recommended test practice for ADS-DV vehicles can help ensure the uniformity between tests by having the necessary information documented prior and during the test, eliminating gaps of information or data when test results are compared.

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?

The variation of ADS-DV equipped will be the same or better than manually operated vehicles.

21. Could the ability to satisfy FMVSS performance requirements depend on the location the tests are performed?

Yes, depending upon how much margin of compliance the ADS-DV vehicle has. There can be 20% variance in test results depending on the location of the test. The performance of the ADS-DV can be affected by how the vehicle is equipped such as sensors, tire tread, tire and brake pad compounds, software and hardware level of the vehicle equipment. Variation in test results can also be affected by who performs the test, how the test is conducted, weather conditions during the test, when (time, day and month) and where (track location and surface) the test is performed.

22. 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, if required to do so by FMVSS regulations.

23. 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?

Have ADS-DV manufacturers have a security check like the banks where a random code or key is text to a smart phone or emailed to a computer that allows access the system for compliance testing.

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

Getting out of test mode should have an option for reset or timeout (day or 12 hours) of the system.

25. **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 contents of TMPE online library is updated after the manufacturer of the ADS had validated the changes or updates. The frequency of the change is with each change or update.

C. TEST MODE WITH EXTERNAL CONTROL (TMEC)

26. **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?**

Yes. SAE working with members from ADS-DV manufacturers can develop a common protocol to be used.

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

Wireless is always going to be more susceptible to eavesdropping and skilled hackers to bypass than wired communications. A strong encryption is required to protect data transmitted over wireless. If wireless systems are used it is critical that WPA encryption be used. SAE working with members from ADS-DV manufacturers can develop a standard for securely interfacing an external controller.

28. **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?**

Yes. Similar methods being used by banks to verify a person's identity before allowing access into a bank account can also be deployed by ADS-DV vehicle manufacturers for allowing NHTSA access the system for compliance testing. SAE working with ADS-DV vehicle manufacturers can develop an SAE Standard Practice for accessing manual control of the vehicle.

29. 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. SAE working with ADS-DV vehicle manufacturers can develop an SAE Standard Practice for accessing manual control of the vehicle.

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

The human factors aspects of the external controller. Is the controller easy to use or does it require some thought to operate? Is the controller operation familiar to the individual performing the test? Is this a standardized controller or interface? What steps are involved in learning the operation of the controller? Does the controller impede the operator's responses compared to a vehicle with manual controls?

D. SIMMULATION

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

Simulations will benefit FMVSS compliance when there are multiple vehicle configurations and tests required to validate compliance.

a. Define all applicable test.
b. Have the tests program in a virtual environment.
c. Have each ADS-DV OEM send in their FMUs or model.
d. NHTSA test each FMUs with all defined applicable tests in the virtual environment.
e. Run actual tests to verify model.

32. Are there objective, practicable ways for the agency to validate simulation models to ensure their accuracy and repeatability?

The accuracy and repeatability are depended on inputs. Real world testing results is required at least once to validate to the model results.

33. Is it feasible to perform hardware- in-the-loop simulations to conduct FMVSS compliance verification testing for current FMVSS?

The full volume of items in FMVSS compliance test is impossible. Can be used on some performance requirements, providing one actual vehicle test is performed to verify. Better and more reliable than software in the loop. Haldex uses hardware in the loop for Type Approvals per ECE-Regulation No. 13, Annex21, Appendix 3 of vehicle stability function and braking

systems.

A HIL system is used at Haldex which contains the vehicle simulation software TruckMaker. The TruckMaker contains not only the dynamic model of a motor vehicle and its trailer, but also the environment such as driver, tire and road model, and user- and IO-interface which are needed for simulating real driving scenarios. Different motor vehicles and trailers are defined by different parameterisation of the simulation models without the need to change the simulation software. The software TruckMaker is connected using electronic hardware to the ECU in such a way that all inputs of the ECU are generated to represent the real vehicle and all outputs from the ECU lead to a realistic reaction of the vehicle model.

The TestManager as part of TruckMaker is used to automate the sequence of tests required, to configure the braking system as appropriate and to generate a subsequent report with characteristic values and diagrams.

The vehicle stability function is added to the simulation model by means of the electronic control box in a hardware-in-the-loop configuration.

34. Is it feasible to perform software-in-the-loop simulations to conduct FMVSS compliance verification testing?

The full volumes of FMVSS compliance verification testing is impossible. Can be used on some performance requirements, providing you can define the tests, but not as reliable as hardware in the loop.

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

35. 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?

36. 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?

Technical documentation by itself is not acceptable for FMVSS ADS-DV compliance. Technical documentation in combination with the other approaches needs to be a requirement for ADS-DV compliance.

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

An example of a Vehicle Stability Test Report using Haldex HIL rig simulation tool for test in combination with actual vehicle tests can be provided from Haldex to the agency upon request.

F. Use of Surrogate Vehicle with Human Controls

38. 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?

39. 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?

40. 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?

Yes, through continued dialogue by comparing each test regarding condition of the vehicle, how the vehicle was equipped, software and hardware level of the vehicle equipment, who performed the test, details how the test was conducted, when (time & day) and where (track location and surface) the test was performed. After the differences in the tests have been identified, retest the ADS-DV upon agreement between the agency and the ADS-DV manufacturer on how the retest is to be performed. SAE developing a recommended test practice can help ensure the necessary information is documented prior and during the test, so there are no gaps in the information or data after testing when test results are compared.