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Robert Bosch LLC
38000 Hills Tech Dr.
Farmington Hills, MI 48331

www.bosch.us

The Honorable Heidi King
Deputy Administrator
National Highway Traffic Safety Administration
US Department of Transportation
1200 New Jersey Avenue, S.E.
Washington, DC 20590

Re: Advanced Notice of Proposed Rulemaking - Removing Regulatory Barriers for Vehicles with Automated Driving Systems
Docket No. NHTSA-2019-0036

Dear Deputy Administrator King,

Robert Bosch LLC (Bosch) appreciates the ongoing efforts of the National Highway Traffic Safety Administration (NHTSA) to identify and address regulatory barriers to Automated Driving System (ADS) technologies.

In accordance with NHTSA's stated positions on the issue, Bosch also anticipates that ADS can serve a vital safety role on US roads, considering that more than 90% of all accidents[1] are attributable to human error. ADS technologies have the potential to decrease the number of accidents on US roads, ultimately reducing fatalities and injuries as well as the amount of property damage. Bosch supports the agency's goal to use this ANPRM to develop a proposal to amend Federal Motor Vehicle Safety Standards (FMVSS) in order to address possible compliance challenges while maintaining a strong emphasis on safety.

Bosch further supports NHTSA's targeted approach to FMVSS revision, considering each FMVSS on a case-by-case basis while focusing on the original safety intent of each individual standard. It is an appropriate first step to review existing requirements prior to creating additional ADS-specific standards.

[1] NHTSA 2015 Traffic Safety Facts, DOT HS 812 116

When selecting approaches that can be used to enforce a particular FMVSS requirement, Bosch believes NHTSA should consider the following factors: the repeatability of results, compliance with specification intent, correlation with a conventional vehicle, the feasibility of methods, cost and effort to produce acceptable results, minimizing adaptation of vehicle for test execution and the principle of technology neutrality.

General approaches to amend existing 100-series FMVSS requirements and test procedures

The comments offered by Bosch below are primarily focused on FMVSS 126 (Electronic Stability Control Systems for Light Vehicles) and FMVSS 135 (Light Vehicle Brake Systems). However, our discussion will address several other standards requiring a further review in light of emerging technologies.

Normal ADS-DV Operation:

Bosch does not view **Normal ADS-DV operation** as an appropriate approach for FMVSS 126 and FMVSS 135 validation. Bosch believes there are several challenges with this approach preventing consistent and repeatable results. Presented as an example is the vehicle preparation requirements outlined in the brake burnish procedure of FMVSS 135. The absence of these preparation procedures will result in the inability to produce consistent and repeatable results due to real-world brake lining material variability. Moreover, there would be a lack of control of the test surface such that it would comply with the guidelines within the regulation.

Additionally, some of the maneuvers require intentional system failures, such as a failed brake circuit. Bosch feels it may be problematic to induce these types of system failures to an ADS-DV on public roads. Consequently, Bosch would caution NHTSA against the adoption of normal ADS-DV operation as a means of validation for FMVSS 126 or FMVSS 135.

Test Mode with Pre-Programmed Execution (TMPE):

Regarding FMVSS 126, an automated sine with dwell maneuver provides more consistent results than the same maneuver executed by a human driver. Therefore, Bosch believes that a pre-programmed test script will be necessary for any method of physical testing. However, Bosch has concerns regarding the exclusive use of **Test Mode with Pre-Programmed Execution** (TMPE) as an approach for FMVSS validation. There are inherent risks and cybersecurity concerns that would have to be considered to protect against unauthorized use. These concerns may be more challenging in the case that the functional logic which allows the vehicle to operate in a regulation validation mode is onboard

the vehicle at the time of sale. NHTSA should seek confirmation from the vehicle manufacturers who must handle the vehicle cybersecurity protection strategy as to whether the TMPE method is feasible within an acceptable risk tolerance.

Bosch sees additional concerns with the use of TMPE as an approach to validation specifically when considering FMVSS 126 and FMVSS 135. Regarding FMVSS 135, Bosch would like to make reference to the brake burnish sequence in S7.1 and the sequence of maneuvers from S7.13 to 7.16. These are structured sequences of multiple brake stops with narrowly defined conditions that must be conducted in succession. These sequences will always require some need for the vehicle to be reoriented between stops. Likewise, FMVSS 126 requires complex brake and tire conditioning procedures in S7.4 and S7.5. As such, both regulations would require test facility-specific programming to the vehicle for the execution of the maneuvers to allow for full TMPE execution.

Furthermore, these procedures would also require outside input to be provided to the ADS-DV via an external signal, for example, to check on the brake temperature for FMVSS 135. Additionally, the regulation calls for the vehicle to remain within a 3.5-meter lane through the duration of the stop in S6.5.4.2, of which, a steering correction from the test driver in a conventional vehicle is permitted via S6.5.3.3. Maneuvers such as the hydraulic circuit failure test in S7.10 for a vehicle with a diagonal split brake system would also require steering correction to successfully perform the test.

Additionally, considering FMVSS 126, the tire conditioning in S7.5 would require a lane following mechanism to follow the 30-meter circle. This will require an input such as cameras, while disabling other ADS functions. Bosch feels that it would be extremely difficult to create such a detailed catalog for these types of maneuvers via TMPE, while ensuring customization for a vehicle to each test track to enable successful testing. In summary, Bosch believes that the use of TPME may require additional functionality that is necessary to perform tests per FMVSS 126 and FMVSS 135.

Test Mode with External Control (TMEC):

On the other hand, it may be feasible to embed a pre-programmed test script into an external controller rather than into the vehicle software. Via this method, the **Test Mode with External Control (TMEC)** approach would address some of the barriers associated with TMPE validation. While there may be cybersecurity concerns with having an access for an external interface, in the

case of FMVSS 126 and FMVSS 135, Bosch believes TMEC presents fewer barriers for validation of an ADS-DV.

It is likely that each vehicle would be required to have a unique structure of internal signals that could be used to inject specific maneuver request details. It could be possible to develop a common front end test driver interface, with a unique back end that is specific to the vehicle being tested. It would require cooperation from the vehicle manufactures to develop proper signal interfaces for each vehicle, which would enable the normal Operation Design Domain (ODD) to be overridden.

Lastly, validation via TMEC would allow for certain aspects of the maneuvers that are dependent on the actions of a test driver to remain, for example, keeping the vehicle within the boundaries of a lane during the execution of a hydraulic brake failure test.

Simulation:

Bosch feels that **simulation** alone cannot fully address the inherent challenges of FMVSS 126 and FMVSS 135 as an appropriate approach for FMVSS validation. A simulation model can only be considered valid once all of the inputs to the model can be demonstrated to correlate well with real world results specific to the use case. The integrity of the simulation must be verified in every critical aspect. Specifically for FMVSS 126, Bosch has concerns with the system model correlation with substantial lateral slip at the tire and road interface. Bosch has not yet seen a simulation model of which the accuracy of the tire road model can extend to a 100% slip scenario. It should be further noted that single wheel vertical separation of the tire from the test surface is possible during the execution of the sine with dwell maneuver.

Likewise, FMVSS 135 will present substantial challenges to a simulation approach. Challenging factors will include:

- The braking force capacity between the tire and road as the tire reaches 100% slip.
- The variability of brake friction behavior with temperature and pressure variation.
- Brake thermal capacity and cooling behavior to properly simulate fade performance.
- Suspension stiffness and the weight transfer response of the vehicle during brake application.

Bosch believes that it will be challenging for simulation models to accurately predict detailed aspects of different test scenarios, for example, the ability to maintain a lane considering that the test driver may counter steer against brake steering tendencies. Overall, the challenges of simulation alone will limit feasibility as an approach for FMVSS validation. A successful approach to simulation would require an intense degree of cooperation between NHTSA and the vehicle manufacturers.

Technical Documentation for System Design and/or Performance Approach and Use of Surrogate Vehicle with Human Controls:

Bosch acknowledges the current precedent of **technical documentation** surrounding FMVSS 126; however, validation of an ADS-DV via technical documentation would serve as a topic to be addressed between the vehicle manufacturers and NHTSA. The criteria determining an appropriate **surrogate vehicle** for validation of an ADS-DV would have to be defined. Again, Bosch views this as a topic for discussion amongst vehicle manufacturers and NHTSA. If an agreement can be reached to determine an appropriate surrogate vehicle for validation of an ADS-DV, the technical barriers for this approach may not be as significant as some of the other proposed validation methods.

FMVSS 135 and FMVSS 105 (Hydraulic and Electric Brake Systems):

Bosch would also like to highlight the inherent similarities between FMVSS 135 and FMVSS 105. Although the procedures and performance criteria of each requirement differ in several ways, the barriers for the validation of an ADS-DV are substantially similar. Each of the comments provided in this response concerning the validation of FMVSS 135 will apply to vehicles subjected to FMVSS 105.

Additional considerations for FMVSS 135

- Force to the brake control
    - It should be considered that in most cases the limitation of wheel slip is the strictest test criteria and the 500 N pedal force limitation does not affect the stopping distance result (maneuvers S7.5, S7.6, S7.7, S7.8, S7.9, S7.10). In these cases, removing the pedal force limitation will have little impact to vehicle performance results
    - Maneuvers S7.13-7.16 procedures are dependent upon the pedal force achieved in S7.5, so in this case NHTSA must define a new target application level not dependent upon pedal force
    - Maneuver S7.11 is generally restricted by pedal force on certain conventional vehicles in the case that they lack a source of secondary brake power / power support. It should be expected

that the human limitation on pedal force no longer exists, an ADS-DV will generally be more capable than certain conventional vehicles in maneuver 7.11 because of the presence of power brake redundancy

- NHTSA may need to consider the methods by which failures are induced in an ADS-DV and whether the failure induction method maintains the goals of the test maneuver. ADS-DVs will generally be designed to detect error conditions and either compensate performance or restrict the operational envelope

Maneuver details that may need to be considered for FMVSS 135

- S6.31b: May require a provision from the manufacturer to disable the RBS system for validation testing if there is no user interface available to do so
- S6.5.2: Changes are required in the test vehicle to override ADS system operational design domain rules
- S6.5.3.2: Changes are required in the test vehicle to override ADS system operational design domain rules
- S6.5.4.1: Counter steer input discussed within text above
- S6.5.5: If requirements will still remain for the vehicle to be placed in a "neutral gear", it will be necessary for the manufacturer to provide some interfacing control to allow the test operator to make this gear selection, presuming the vehicle intended for public sale has no such transmission control mechanism
- S7.1.2 Burnish: Limitations to automated operation discussed above and include considerations for braking to a deceleration target, which may require a special control in the TPME method
- S7.2; S7.4: These sections are likely irrelevant for an ADS-DV, as such a vehicle should always be equipped with ABS

Maneuver details that may need to be considered for FMVSS 126

- S7.5: Maximum time between laps/passes of the maneuver is 5 minutes, which places an additional constraint on requirements to automate the test execution
- S7.6: Scripting the slowly increasing steering request appears feasible. An additional constraint which the test driver performs today is to keep the vehicle within the defined speed tolerance as the lateral acceleration increases
- S7.11: The requirement to measure, zero and filter the actual steering wheel angle may become irrelevant when the steering angle becomes an externally injected signal

FMVSS 114 (Theft Protection and Rollaway Prevention):

As a manufacturer of Passive Entry / Passive Start (PEPS) systems for passenger vehicles, Bosch respectfully requests that NHTSA consider aspects of FMVSS 114 which may serve as a barrier to the adoption of such keyless systems for future ADS-DVs. The automotive industry is transitioning away from traditional key systems and key cylinders and increasingly incorporating the use of new access technologies. In most cases, a physical key may longer be used and may be replaced by a device such as the vehicle owner's mobile phone.

The Bosch Perfectly Keyless system is one example of a new technology that is already being implemented in the passenger vehicle market. The Bosch technology works with a virtual key stored in the owner's smartphone. Sensors installed in the car recognize the owner's smartphone as securely as a fingerprint, then open and start the vehicle only for that individual. Digital key management links the app and the vehicle via the cloud. To open the door and start the engine, it communicates with the car using a radio signal across a wide range of frequencies and various types of radio technologies. i.e. BLE, UWB, etc. The new smartphone-based key can be used in cars, entire car-sharing fleets, and commercial vehicles.

Concerning the definitions included in S4, Bosch urges NHTSA to reconsider the "key" to include "any mechanical or electronic (digital key) means to provide access to a vehicle for the purpose of operating a specific vehicle."

The language in S5.1.1 will require modification to accommodate vehicles with PEPS_FOB, smartphone, and all electronic means of access. Once the "key" (defined for electronic access means) has authorized the vehicle for operation, these electronic key systems allow the key to be located outside of the vehicle without preventing normal activation of the vehicle until then end of the current drive cycle. In many cases, a warning for "no key" is issued to the authorized user. However, the motor remains active (ON) and the vehicle is drivable. There is currently debate over the various use cases that support the need to complete a drive cycle even if the electronic key is removed from the vehicle. However, there are arguments against this as well. It will be the decision of the vehicle manufacturer as to how this functionality will be defined.

One suggestion would be to add S5.1.1 (c), stating the following: "(c) continue with the current drive cycle and provide an instant notification informing the authorized user that the vehicle is active and the Key (defined for electronic access means) is no longer located within range for start of vehicle operation."

Bosch recommends that NHTSA consider removing or amending S5.1.2 which contains the following text: “The same combinations may be used for more than one vehicle type.” Bosch notes that, for keyless entry systems, the use of the same combinations may allow for Relay Station Attacks and potential theft of the vehicle, unless other protection measures are employed to protect against such attacks.

In S5.1.3(a), Bosch recommends that the use of the word “inserted” be replaced with “inserted or validated”, or “validated by the starting system.” In a Passive Entry / Passive Starts system a key is always validated for location and electronic code before the requested action is completed.

Bosch notes that the text in S5.2.1 is also designed to target a mechanical or physical key. Bosch would recommend that the wording be amended to reflect that this requirement refers specifically to a mechanical or physical key. No other change would be required as the statement is valid with PEPS_FOB or a smartphone being used as a key. When the FOB or phone are out of range, the vehicle is allowed to continue operation throughout the present drive cycle.

Bosch further urges NHTSA to address and re-evaluate the following portions of FMVSS 114 in light of present and future digital key technology.

- S5.2.3
- S5.2.4
- Test Procedure – S6.2.1(c)
- Test Procedure - S6.2.3(f)

Conclusion:

Bosch appreciates the opportunity to offer its feedback concerning the ANPRM for Removing Regulatory Barriers for Vehicles with Automated Driving Systems. We look forward to continuing to work with NHTSA and other stakeholders to increase road safety though innovative driving technology.

We would be pleased to address any questions or to provide additional information on our proposals. Please do not hesitate to contact Ana Meuwissen at 202/815-7645 or at Ana.Meuwissen@us.bosch.com with any inquiries.

Yours sincerely,

D. Scott Winchip
Regional President North America
Chassis Systems Control
Robert Bosch LLC

David Sziraki
Regional Business Unit Leader North America
Automotive Electronics
Robert Bosch LLC

Ana M. Meuwissen
Director, Federal Government Affairs
Robert Bosch LLC