GENERAL MOTORS LLC
Global Vehicle Safety

August 22, 2019
USG 4862

Ms. Heidi Renate King
Deputy Administrator
National Highway Traffic Safety Administration
1200 New Jersey Avenue, SE
Washington, D.C. 20590

RE: Removing Regulatory Barriers for Vehicles With Automated Driving Systems, Advance Notice of Proposed Rulemaking, NHTSA Docket 2019-0036, 84 Fed. Reg. 24433 (May 28, 2019)

Dear Deputy Administrator King:

General Motors Company and GM Cruise Holdings LLC (jointly, "GM/Cruise") appreciate the opportunity to provide comments addressing NHTSA's Advance Notice of Proposed Rulemaking ("ANPRM") on the topic of Removing Regulatory Barriers For Vehicles With Automated Driving Systems.

The ANPRM addresses a number of themes that will require significant and critical thought as NHTSA, industry, and the public continue to assess how a compliance model premised on traditional automotive engineering principles and historic Vehicle Safety Act interpretations might be reformed to reflect the nearing reality of commercially available autonomous vehicles. In that regard, it is imperative that NHTSA continue to drive this critical dialogue with a sense of urgency so that the necessary regulatory evolution keeps pace with advancing technology. Ultimately, the regulatory framework forged through this ANPRM, and NHTSA's subsequent rulemaking activities, will create a path for larger deployments of ADS-DV that will be the key to allowing the safety benefits of autonomous vehicles to be realized on a nationwide scale.

The enclosed Attachment contains GM/Cruise's complete responses to each of the questions included in the Request for Comment ("RFC") accompanying the ANPRM. To provide context to your review of those responses, GM/Cruise provides herewith an overview of its assessment of the six methodological approaches around which the RFC is organized, and some summary suggestions as to how those approaches might be deployed in short-, mid- and long-term horizons.

Turning to the six approaches themselves, GM/Cruise offers the following observations:

Technical Documentation for System Design and/or Performance Approach ("Technical Documentation"). Of the six approaches outlined in the ANPRM, this is the only one that is immediately available that will provide NHTSA the opportunity to conduct a comprehensive and substantive review of manufacturer data and information demonstrating ADS-DV compliance. Of

course, it will be incumbent upon manufacturers utilizing this approach to demonstrate that the information provided is representative of the particular ADS-DV under review. However, GM/Cruise notes that a similar compliance model currently exists in many of the European jurisdictions that rely on Type Approval-based compliance systems. While GM/Cruise is not advocating for Type Approval compliance in the United States, and believes that the current system of self-certification offers a number of advantages, Type Approval processes can provide a useful primer on an acceptable short-term approach to ADS-DV compliance. For example, GM/Cruise envisions that NHTSA's Office of Vehicle Safety Compliance (OVSC) could review manufacturer documentation submissions, which would be similar in content and nature to Type Approval submissions, much in the same manner that Office of Defect Investigations personnel review information provided by manufacturers in response to defect investigations. Because of its availability as a reliable approach that can be quickly and universally implemented pending development of alternative testing approaches, Technical Documentation is GM/Cruise's preferred short-term method.

Use of Surrogate Vehicle with Human Controls ("Vehicle Surrogacy"). While Vehicle surrogacy is conceptually a viable solution that, like Technical Documentation, could be immediately implemented, it depends entirely on the availability of a substantially similar traditional vehicle. Though suitable surrogates may be available early in autonomous vehicle development, GM/Cruise expects that this will become less likely as manufacturers increasingly design specifically for autonomous vehicle platforms. For that reason, investment in the development of this approach may not be viable long-term. Still, given its availability, GM/Cruise suggests that NHTSA permit surrogacy as an optional methodology.

Test Mode with Pre-Programmed Execution (TMPE). TMPE is conceptually feasible but will require additional time and effort before it can be employed. As GM/Cruise envisions preprogramming, the OEM would equip the tested vehicle with preprogrammed test subroutines. Since autonomous vehicles require mapped areas to operate properly, these subroutines would need to be constructed to take NHTSA's various test facilities into account, ensuring that each such test facility is accurately and appropriately mapped. There is no universal mapping—each OEM will be required to map the test facilities individually. Because that process is expected to be time-intensive, GM/Cruise recommends that the number of test facilities utilized by NHTSA for testing be managed in close cooperation with manufacturers/developers. All of this will require close collaboration between NHTSA and the OEMs.

NHTSA and the manufacturer community likewise will need to agree upon appropriate test parameters. GM/Cruise expects that this, too, may be an involved process, as many of those parameters currently are premised on human input and will need to be revised accordingly.

Finally, this approach entails significant and obvious competitive and cybersecurity implications. To maintain the security of each manufacturer's proprietary ADS technology, GM/Cruise suggests

access to the pre-programming be limited only to authorized GM/Cruise personnel, who also would support NHTSA performing any FMVSS testing.

Test Mode with External Control (TMEC). As GM/Cruise envisions this approach, the external controller would be a plug-in or remote device that over-rides the normal ADS operation and allows the vehicle to be operated remotely in a traditional (non-autonomous) mode. GM/Cruise recommends avoiding remote external controller devices if possible because of the increased cybersecurity concerns they entail. To GM/Cruise's knowledge, some manufacturers already are developing external controllers to maneuver vehicles in certain low-risk situations: i.e., at the assembly plants and for shipping. However, the external controllers developed to date have limited abilities that would not allow most FMVSS testing. It is conceivable—perhaps even likely—that certain OEMs will develop more sophisticated external controllers to allow some testing, including FMVSS testing, though that is not imminent.

It is worth noting that, to date, OEMs have developed external controllers operable for their vehicles only. Due to the unique coding and configurations used in any particular vehicle, it is unlikely that a universal external controller will be developed in the foreseeable future. Moreover, from a security standpoint, a universal external controller could pose significant vulnerabilities. Therefore, if NHTSA chooses this testing approach, GM/Cruise recommends that each manufacturer supply, if available, a specialized external controller for NHTSA to conduct the FMVSS verification testing of its vehicles. There is some precedent for this sort of manufacturer support of NHTSA testing. For example, NHTSA routinely requests test fixtures that allow it to mount headlamps in normal position to facilitate FMVSS 108 verification testing. Particularly early in autonomous vehicle deployment, GM/Cruise anticipates that external controllers will require specially trained operators to run more complex tasks and, as such, we recommend that the OEM also supply an operator to facilitate NHTSA testing.

Simulation. GM/Cruise submits that a simulation approach should be the ultimate goal for NHTSA and industry for compliance verification testing of ADS-DVs. Once developed, simulation will allow for efficient and effective compliance verification on an industry-wide basis. However, significant work remains before this becomes a reality. The variety of simulation models that might be employed will need to be validated, and that process will require additional time and effort by industry and NHTSA, working together. Given the potential efficiencies to be gained, this work can and should begin now. But the more immediate efforts that are necessary to remove regulatory roadblocks cannot be held in suspension while the necessary work to make simulation testing viable takes place. Instead, simulation should be pursued on an entirely distinct development path from the other methodologies NHTSA is studying as a means to move compliance verification testing of ADS-DVs forward.

Normal ADS-DV Operation. GM/Cruise views this as the least viable option for ADS-DV compliance testing for most FMVSS. This may be more viable for autonomous vehicles with manual controls, where testing is done in traditional mode. ADS-DVs do not provide for the

nuanced manual input required for most FMVSS. Moreover, during normal operation, geofencing is likely to prohibit any testing done outside of the ADS-DV's Operational Design Domain, which almost certainly will not include testing scenarios. As such, GM/Cruise submits that development efforts and resources should be directed towards the other approaches discussed in the ANPRM.

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As the description above makes clear, timing will be critical as NHTSA decides how this important aspect of regulatory reform takes shape. GM/Cruise believes that NHTSA should consider taking a flexible, multipronged approach that simultaneously allows NHTSA to fulfill its charge while promoting continued growth in this exciting and critical area. In the short term, a Technical Documentation approach will provide NHTSA an immediate option to verify FMVSS compliance through testing and design information until other testing methodologies can be developed. Surrogacy is another viable short-term option provided that an appropriate surrogate vehicle can be identified.

In the mid-term, NHTSA and industry could jointly pursue approaches based on pre-programming or external controllers. As stated above, both of these approaches require additional development and, as such, certification of ADS-DVs should not be delayed if the appropriate parameters cannot be provided in a timely manner.

From a long-term perspective, and independent of other efforts to remove regulatory roadblocks, NHTSA and industry should begin working on the viability and development of a simulation approach. This has the greatest potential benefit for both NHTSA and industry and, further, its efficiencies could be expanded to traditional vehicles as well.

Ultimately, GM/Cruise advocates for a flexible approach that offers the possibility of incorporating multiple methodologies. Indeed, it is conceivable that one method might work on one vehicle configuration, but not another. Or some manufacturers may not be able to utilize all methods (i.e., if they are unable to provide a viable external controller) and therefore will need to use another method. Each of the methodologies discussed in the ANPRM deviate from traditional FMVSS testing in a variety of ways. And though these differences are important, there is at least one commonality that all of the methodologies share: NHTSA will need to coordinate any testing efforts with manufacturers. This underscores a point that NHTSA no doubt already appreciates: namely, that cooperation between NHTSA and the manufacturing community will be a cornerstone of any future testing regime.

Finally, GM/Cruise acknowledges that a number of independent, third party organizations and for-profit entities (e.g., the American Automobile Association, the Insurance Institute for Highway Safety, Consumer Reports) are likely to submit comments in response to the ANPRM. GM/Cruise views the primary object of the ANPRM as addressing NHTSA's needs—not those of

these interested third parties. Testing undertaken by these organizations routinely differs from FMVSS testing. GM/Cruise will consider opportunities to work with these organizations independently to address the specific and unique needs and viewpoints expressed in their comments.

We close by reiterating our deep appreciation for providing GM/Cruise the opportunity to share its thoughts on these important issues. As always, GM/Cruise remains willing to meet with you and/or your staff to discuss in greater detail the contents of this letter, the enclosed responses to the RFC, or any of the subjects raised in the ANPRM. Please contact Matthew Jerinsky (202) 775-5065 of our Washington, D.C. office with any questions you might have.

Sincerely,

Maryann L Combs

Maryann L. Combs
Vice President
Global Vehicle Safety

Enclosure:
Attachment: Responses to ANPRM Questions

ATTACHMENT: Response to ANPRM Questions

QUESTIONS 1-11:

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:

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

RESPONSE:
GM/Cruise addresses the advantages and disadvantages of the six approaches enumerated in the ANPRM in turn below. Ultimately, as discussed more fully below, GM/Cruise believes that NHTSA will need to embrace various approaches to FMVSS testing if the regulatory roadblocks discussed in the ANPRM are to be removed, thereby allowing the potential safety benefits of AVs to be brought to market.

1. Normal ADS-DV operation
In the near term, GM/Cruise plans to operate ADS-DVs with a level 4 ADS within a given Operational Design Domain (ODD). It's our understanding that many other ADS-DV developers/manufactures will do the same. To ensure that such vehicles stay within their preprogrammed ODD, GM/Cruise will impose a virtual perimeter, or geofence, that, if violated, will trigger the vehicles to enter into a Minimal Risk Condition. In short, imposition of a geofence is a part of GM/Cruise's safety-by-design approach. Additionally, GM/Cruise intends to operate its ADS-DVs in certain driving environments - urban centers, highways, etc., - and only on pre-mapped and labelled roads within those environments; therefore, normal ADS-DV operation at a test center or some locale outside of its ODD that has not been mapped would pose a substantial challenge that would need to be overcome prior to any testing by NHTSA. And, at least at this time, normal operation of ADS-DV outside of its preprogrammed ODD is not feasible.

Furthermore, even if the FMVSS tests required the ADS-DV only to follow a prescribed path—i.e., not in nominal point-to-point routing mode—an L4 ADS-DV, in order to perform accordingly, must still rely on highly specific, detailed maps and must be able to localize itself (i.e., determine the vehicles precise position on that map); otherwise, the vehicle will be unable to follow a prescribed path for failure to understand where it is in relation to the path, the map, or the world. In such a scenario, once the ADS-DV recognizes its failure to localize, it will force the ADS-DV to assume a Minimal Risk Condition, a low-risk operating condition pursuant to which the self-driving system will operate the vehicle at a reduced speed or pull to the side of the road and execute a safe stop, as appropriate.

To the extent that NHTSA proceeds with an approach premised on normal ADS-DV operation, GM/Cruise believes the best solution would be to map the specific test facility NHTSA intends to use. In selecting the

test facility, however, care must be taken to ensure that the test facility environment is not so artificial as to introduce issues with the ADS operation, such as an inability to localize/operate.

Normal ADS-DV operations would entail additional limitations on NHTSA's ability to conduct verification testing of FMVSS compliance. For instance, when operating in normal ADS-DV mode, NHTSA would not have any method to introduce specific test instructions or parameters because certain command inputs may exceed the ODD of the ADS-DV. As such, it would not be possible for NHTSA to carry out required steps of certain FMVSS test procedures.

For example, for an ADS-DV whose ODD is limited to operating at speeds below 65 km/hr, it would be impossible to conduct FMVSS 135 testing, which requires snub braking, followed by acceleration up to 100 km/h, followed by a full application of the service brakes. While it may be possible to perform certain of the less complicated FMVSS testing in normal ADS-DV operation (e.g., FMVSS 138), as a general matter, it is unlikely that a normally operated ADS-DV could be used for more complicated FMVSS testing unless the vehicle also is equipped with human controls.

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

While GM/Cruise believes that a TMPE approach could be viable, it raises some cybersecurity challenges. Quite simply, GM/Cruise anticipates that there would be reluctance by many developers and manufacturers to allow access to the codebase by outside sources—a reluctance that GM/Cruise would share.

In light of the cybersecurity concerns, if a TMPE approach were to be used, the particular tests would need to be installed into the ADS-DV by GM/Cruise as part of the base programming. Additional security features would likely need to be added to access the preprogrammed tests, as well as to ensure that such preprogrammed tests could not be accessed by anyone else during times when the vehicle is not being used for testing purposes. This is particularly worrisome given that preprogramming may include requiring the vehicle to operate outside its given ODD. Designing and programming such possibility into the base code of each vehicle raises concern for GM/Cruise. Ideally, from a security perspective, if TPME is to be used, the manufacturer would control access to the preprogrammed tests and could provide one of its technicians to assist NHTSA by accessing the tests.

In addition, there are a myriad of test-specific nuances that would need to be addressed and agreed-upon. FMVSS 135 testing is a useful case in point. Under FMVSS 135, following the initial vehicle positioning, the vehicle brakes must be snubbed. This would be required in various test environments, which would need to be incorporated into the programmed procedure. Following that, the vehicle is brought back to its initial location, from which a testing brake run is done, after which the vehicle again returns to its initial position. Because each manufacturer's ADS-DV will operate differently and because it is likely that NHTSA will need to provide input while conducting the test, GM/Cruise recommends each manufacturer provide a technician to help facilitate NHTSA testing.

This above sequence of events with respect to running an FMVSS 135 test raises many questions that would need to be addressed through programming. For example, how much time would NHTSA require before beginning another brake test run? Would NHTSA require time to input data from the prior test run? Following the required test runs, the brake system must be disabled. This, in turn, raises questions of whether that task would need to be integrated into the vehicle's programming. Or does NHTSA assume that the vehicle would be towed to any post-test garage? These questions, and many others like them, would

need to be addressed in a TMPE scenario. Ultimately, NHTSA would need to work with industry to agree on standardized programming for test procedures.

In addition, the programming must be secured to prevent cyber attacks and other potential security threats. GM/Cruise recommend only the manufacturer/developer be able to access to preprogramming. Therefore, GM/Cruise recommends that the manufacturer/developer supply a technician to access the programming and provide any required input during the testing.

Moreover, as with the normal operation approach, a TMPE approach likewise would require that any test facility NHTSA uses will need to be mapped. As there is no universal mapping used industry-wide for ADS-DV operations, each manufacturer would have to map any test facility independently. As such, if this approach were used, GM/Cruise would recommend that NHTSA limit the number of facilities it uses to conduct the tests.

In addition to the need to map test facilities, manufacturers would need to assess whether the test facility sufficiently represents the ODD of the ADS-DV. If not, the performance during the tests would not necessarily represent the vehicle's real-world performance.

To summarize, the potential cybersecurity concerns that TMPE would likely raise would necessitate manufacturer involvement in NHTSA's testing. For example, GM/Cruise envisions working with NHTSA to develop the preprogrammed testing. This testing would be loaded into the vehicle's base programming. Access to the test programs would be limited to GM/Cruise personnel. The test facility that NHTSA intends to use would also need to be mapped prior to any testing. GM/Cruise recommends that manufactures supply a technician who would access the relevant test programs and who would also facilitate any input required.

As these concerns make clear, a TMPE approach necessarily will entail significant dedicated manufacturer support to interface with the vehicle prior to and potentially during NHTSA's testing.

3. Test Mode with External Control (TMEC)

While a TMEC approach may have some theoretical appeal—e.g., it could allow NHTSA to manually operate and test a manufacturer's ADS-DV—there are several practical problems that could limit its utility. Most importantly, a TMEC scenario would likely require yet-to-be-developed manufacturer-specific controllers, which would necessarily require either extensive training for NHTSA operators or manufacturer-supplied technicians to facilitate NHTSA testing.

The external controller allows manual operation of an ADS-DV vehicle. It is possible that this type of controller could be used to run FMVSS verification testing. If an external controller were used, the following issues would need to be addressed:

- ADS-DVs from different manufacturers will have unique configurations and specific programming. This will require manufacturers to develop their own external controller. Since each manufacturer will have a unique external controller, it will necessitate each manufacturer supplying an external controller to NHTSA to conduct verification testing. It may be unrealistic to expect NHTSA personnel to learn each controller. It may be necessary that along with the controller, each manufacturer provide technician support to facilitate NHTSA testing.

- Some ADS-DV configurations may require remote external controllers, such as ADS-DVs used solely for cargo transportation. These configurations may not provide for passenger transportation; and therefore, may require the external controller to operate remotely.

- At least in the near-term, a universal controller is unlikely and is not recommended. The myriad of expected AV configurations and software architectures would make it difficult to develop a universal controller. In addition, a universal controller would introduce security challenges. Instead of attempting to develop a universal external controller, GM/Cruise would suggest that manufacturers provide a controller for NHTSA's use on an as-needed basis.

4. Simulation

While GM/Cruise believes that simulation may ultimately be the best long-term testing objective, it will be difficult to achieve in the short-term because it is the most technically challenging to implement, as explained more below.

First, as a technical matter, a simulation approach necessarily will involve more than simply executing the test. Specifically, GM/Cruise envisions that obtaining the data to demonstrate the validity of the simulation model will be a complex and challenging task.

Second, a simulation approach necessarily will require agreement by NHTSA and the industry on an appropriate simulation model. This encompasses not only the simulated testing environment, but how testing controls will be applied to that environment; for example, how vehicles perform at certain tuning specifications. The requirement for a generic testing baseline in a simulated environment will be difficult to achieve in the short term given the multitude of specific inputs required for any particular vehicle. It may be possible to start with a less sophisticated model, if NHTSA is willing to accept less fidelity. For example, an Adams model currently exists for stopping distance. If the fidelity of a model like this is sufficient, it may reduce the time to implement some FMVSS verification by simulation.

Third, a simulation approach will likely raise confidentiality concerns, since the simulation models will require input by manufacturers of highly sensitive vehicle, software, hardware, and other proprietary information. Though NHTSA has a process for the protection of certain Confidential Business Information, that process must be strictly applied to safeguard manufacturer confidences. Moreover, that process would need to encompass not only information submitted to NHTSA, but also any information necessarily provided to or obtained by third-party testing facilities. These confidentiality concerns should be assessed in light of the U.S. Supreme Court's recent opinion in *Food Marketing Institute v. Argus Leader Media*, 588 U.S. ____ (2019).

GM/Cruise supports working on this methodology but believes it is a long-term solution. Consequently, we believe it should be developed independently from the current effort to reduce regulatory roadblocks. NHTSA should instead focus on other methodologies in the short term until, or if, a standardized simulation model can be achieved.

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

GM/Cruise believes technical documentation is likely the most efficient and effective near-term solution. With such an approach, manufacturers would submit, when requested, technical documentation that they would already possess that demonstrates compliance.

GM/Cruise supports utilizing this approach until alternative approaches, including the others referenced in this question, can be developed to enable NHTSA to perform independent testing. Of the enumerated approaches, this is the only one that can be implemented quickly, reliably, and universally across all manufacturers.

However, as discussed throughout this response, verification that ADS-DVs are FMVSS compliant under existing standards, regardless of the testing approach, will require closer cooperation between NHTSA and manufacturers and developers. Submissions of technical documentation could occur in much the same way as documents are currently submitted to ODI in connection with safety investigations.

This methodology is already proven. Europe has successfully used type approval for decades. Documentation similar to type approval submissions for a given standard could be supplied to NHTSA when requested.

To be clear, GM/Cruise is not suggesting that NHTSA change any aspects of today's self-certification process or even abandon it for type approval. Self-certification has worked successfully for half a century. We strongly believe that self-certification should continue. GM/Cruise is suggesting that a technical documentation approach can serve as an interim solution until alternative methodologies, like preprogramming and external controllers can be fully developed.

GM/Cruise further recommends that this technical documentation approach be considered as the primary solution, at least in the short-term, because it can easily be implemented, and it leverages much of the data that manufacturers are already collecting to demonstrate the safety, compliance, and validation of the vehicles. It allows a path forward until other methodologies can be fully developed.

6. Use of Surrogate Vehicle with Human Controls

Use of a surrogate vehicle with human controls would be a reasonable approach when the ADS-DV is built on a conventional vehicle platform. The standards of appropriate surrogacy, however, are unclear, and would necessitate an individualized showing by each manufacturer proposing to use a surrogate vehicle. It is unclear whether this approach could be viable for any AV developed specifically and solely as an ADS-DV—i.e., one not based on a conventional base vehicle. GM/Cruise believes that this model could become obsolete as AVs are increasingly developed solely as ADS-DVs.

Conclusion

GM/Cruise believes that, except for the "normal operation" approach, all of the proposed approaches to revising crash avoidance test procedures could be used for ADS-DV FMVSS compliance testing. Some of the approaches—technical documentation and surrogacy—could be implemented immediately. Others—preprogramming and external controllers—will require some development. And simulation, while desirable, will take substantial time, effort, and resources to bring to fruition.

GM/Cruise recommends that NHTSA consider approaches for both the short and long-term. NHTSA should allow testing approaches like surrogacy and technical documentation in the short-term. GM/Cruise's preferred approach is technical documentation until other testing approaches—e.g., preprogramming and external controllers—can be fully developed and implemented.

We also support simulation as a testing approach, but we feel this will take a concerted effort and cooperation by NHTSA and industry to develop and implement. Therefore, simulation is likely feasible

only as a long-term approach; as such, it should be developed independently of the efforts to create a near-term regulatory path for ADS-DV FMVSS compliance.

All of the viable methodologies will require NHTSA and manufacturers to work more closely. GM/Cruise believes NHTSA will need to embrace various methodologies if regulatory roadblocks are to be removed, thereby allowing the potential safety benefits of ADS-DVs to be brought to market more swiftly.

QUESTION 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.

RESPONSE:
While all of the approaches outlined in the ANPRM could allow for effective enforcement, as discussed above, each bring potential obstacles to NHTSA's ability to independently conduct verification testing:

- Normal Operation: For normal ADS-DV operation to work, geo-fencing and ODD limitations must be addressed. Moreover, there is currently no method with normal operation that would allow NHTSA to input specific commands far beyond normal ADS-DV operation.
- Preprogramming: TMPE will require some interface that must be developed and controlled by the tested manufacturer.
- External Controller: Setting aside cybersecurity questions, TMEC would require NHTSA to use a manufacturer-specific controller interface until a universal controller interface could be developed.
- Simulation: Assuming that NHTSA and industry agree upon reasonable simulation parameters, manufacturers still would be required to provide specific data to enable the simulation to work.
- Technical Documentation: NHTSA can confirm manufacturer's compliance with applicable FMVSS through technical documents. The technical documents that manufacturers will supply can sufficiently demonstrate FMVSS compliance. Upon request, manufacturers could supplement technical documents with targeted testing. GM/Cruise recommends that NHTSA OVSC collect and evaluate data in a manner similar to that currently used by ODI.
- Surrogacy: Even surrogacy, while most closely aligned with NHTSA's traditional testing, requires manufacturers to demonstrate that the surrogate vehicle is substantially similar to the ADS-DV that NHTSA is investigating.

As the limitations described above illustrate, it will be very difficult for NHTSA to independently conduct compliance testing on an ADS-DV using the traditional arms-length model that has defined NHTSA compliance testing over the years. Instead, each methodology requires that NHTSA and the individual manufacturers work together to provide a means for NHTSA to verify compliance with applicable standards. Until other approaches become more viable, GM/Cruise recommends that NHTSA leverage manufacturer testing by, in the first instance, allowing compliance verification to occur through a presentation of technical documentation.

QUESTION 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.

RESPONSE:
In light of its responses to Questions 1 and 2 above, GM/Cruise believes that multiple testing approaches likely can be used in conjunction with one another. For example, providing NHTSA with technical documentation—GM/Cruise's suggested approach at this time given its capability to be implemented immediately—is possible in virtually any scenario. The other proposed testing approaches could supplement technical documentation if necessary.

The compatibility of the various approaches has less to do with the specifics of the approach itself and more to do with the time required to develop the approach. As discussed above, use of a surrogate vehicle is a potentially immediate solution and could be implemented now if a suitable surrogate could be identified by the manufacturer. A manufacturer-specific TMEC approach also could be viable now if the manufacturers could quickly develop and supply the necessary external controller in a way that addresses the attendant cybersecurity risks.

In contrast to a manufacturer-specific TMEC approach, a universal external control scenario is likely to take much more time. To standardize a common system compatible with all ADS-DVs developed by all manufacturers will take considerable time to develop and will require the cooperation of all manufacturers. GM/Cruise suggests that an independent standards organization, like SAE International, be engaged to develop the required universal external controller.

Several of the approaches outlined in the ANPRM appear to GM/Cruise to have less certain paths to implementation, or ones that necessarily entail long-term timeframes. Normal ADS-DV is one of those. It is unlikely a normally operating ADS-DV can be tested by NHTSA unless it is equipped with manual controls. Without manual controls, unless some alternate method can be developed with the manufacturer's help, NHTSA will not have any method to input the necessary parameters to run the current FMVSS tests. GM/Cruise thus believes that NHTSA's development time and resources would be better spent on one of the other methods.

While preprogramming is a possible solution, it also will require significant development time. This will include time spent by manufacturers mapping the test facility, loading the required preprogramming, and supplying technicians both to access the programming and facilitate NHTSA's testing.

Finally, from GM/Cruise's perspective, the optimal long-term solution is simulation. GM/Cruise believe, however, that simulation will require the longest lead time and that full development of a simulation approach will take far longer than the time required to modify the existing FMVSSs to accommodate ADS-DVs. Consequently, simulation should be developed independently of the other methodologies to allow a path for full compliance of ADS-DVs as quickly as possible.

QUESTION 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?

RESPONSE:
In response to Question 4, GM/Cruise incorporates its responses to Questions 1-3 above.

QUESTION 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?

RESPONSE:
In principle, the same standard of performance should apply to any vehicle within the specific ODD to which the manufacturer is claiming is in scope for commercial operation. However, there are specific requirements that do not apply to specific sub-groups of vehicles. For example, roof crush standards do not apply to convertibles. Similarly, the FMVSS contain different requirements for light vehicles and trucks.

In the same way, some requirements imposed by the current FMVSS may not apply to the specific design elements of ADS-DV. For example, requirements that prevent humans from over-driving vehicles (e.g., FMVSS 126 regulating electronic stability control systems) may not be needed if the goal can be achieved in a different way. Other requirements may need to change because the requirement, as written, does not apply. For example, if FMVSS 135 testing is conducted from a speed of 100 km/h, but the ADS-DV is limited to a speed of only 60 km/h there may be a need to exempt the vehicle from this requirement, or more likely modify the requirement based on the vehicle's maximum speed.

Additional consideration should be given to the development of unique testing approaches that require translation of the existing requirements into more easily tested methodologies. For example, a long-term development goal might be an accredited test course that incorporates many FMVSS requirements into the course. Completion of the course could allow ADS-DV certification of multiple FVMSS requirements

QUESTION 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.

RESPONSE:
GM/Cruise adheres to the belief that the fundamental objective of the FMVSS—to provide baseline automotive safety standards that are "practicable," "objective," and that "meet the need for safety," 84 FR 24435—is equally applicable to ADS-DVs. However, the methodologies and requirements within the FMVSS, particularly the 100 series, are almost exclusively aimed at the safety of a human-controlled

vehicle. For example, measuring stability control (FMVSS 126) does not make sense in isolation if the ADS-DV path generation could be proven to always generate a path within the limits of traction.

However, GM/Cruise believes that AVs must meet the intent of existing FMVSS requirements until or unless more appropriate requirements are found necessary and can be developed.

With respect to the potential revision to or additional of terminology in the existing FMVSS, any requirement that is specified in terms of human input needs to be revised to incorporate a more objective requirement. For example, FMVSS 135 requires the input of 500 N force upon the brake pedal. 500 N represents the likely force a 5th percentile female could apply to the pedal. This represents one extreme of the human population that might be driving. However, in an ADS-DV, the ADS is the dedicated driver and, as such, the standard should reflect the force that the ADS-DV can command. In this example, the standard can be revised to reflect, instead of 500 N foot force, the maximum brake application that the ADS-DV can be expected to command. The FMVSS are replete with a number of similar examples.

The immediate goal should be the revision of all applicable FMVSS requirements to allow for ADS-DV verification of certification. Of course, certain requirements that specifically involve human controls may not apply to a vehicle without human controls. For example, FMVSS 203 and 204 regulate steering wheel and stalk mounted controls in a crash. If there is no steering wheel or stalk mounted control, these presumably could not and would not apply.

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

RESPONSE:
In response to Question 7, GM/Cruise incorporates its response to Question 6 above.

In addition, GM/Cruise supports NHTSA establishing new definitions that apply only to ADS-DVs without manual controls. It would allow NHTSA to clearly delineate, where necessary, the requirements that apply to ADS-DV versus those that apply to traditional vehicles.

Expanding upon this approach, NHTSA may want to consider creating a new series of FMVSS requirements that apply to vehicles operated by an ADS-DV without traditional controls. NHTSA used a similar approach when it promulgated the 500 FMVSS series for low speed vehicles. It allowed NHTSA to choose the appropriate requirements for low speed vehicle without affecting the traditional requirements. So too, NHTSA could create a new series of requirements for vehicles using an ADS-DV without manual controls. It would allow NHTSA to:

- Point to traditional FMVSS requirements that would also apply to ADS-DV vehicles.
- Modify requirements, where necessary, specifically for vehicles operated with an ADS-DVs without manual controls without affecting the traditional requirements.
- Discard requirements that do not apply to vehicles operated with an ADS-DVs without manual controls.

GM/Cruise looks forward to working with NHTSA to establish new definitions and standards for ADS-DVs. We've developed a revised FMVSS for ADS-DVs that we would be willing to share and discuss with NHTSA; if appropriate, GM/Cruise could provide this revised FMVSS in a supplemental response.

QUESTION 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?***
>
> ***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?***

RESPONSE:
In responding to Question 8 generally, GM/Cruise reiterates its position that the initial rulemaking should be to revise existing FMVSS requirements, as appropriate, to reflect the reality of testing ADS-DVs. In this regard, GM/Cruise notes that there may be certain requirements that may need to be adjusted and others that may not apply.

In response to subpart a. of Question 8, GM/Cruise believes that NHTSA and the manufacturer will need to work closely and collaboratively to agree that the methodology being used is an accurate proxy. In general, GM/Cruise believes that all testing approaches, with the exception of normal operation, or a combination thereof, could be used for most FMVSS verification. Furthermore, GM/Cruise recommends that NHTSA allow multiple testing approaches.

In response to subpart b. of Question 8, GM/Cruise submits that it is more likely that NHTSA will need to adjust the input parameters to allow for ADS-DV testing. For example, FMVSS 135 requires brake pedal input of 500 N. This is in part to provide an appropriate input for smaller human drivers. In the case of an ADS-DV, the ADS will be the dedicated driver and, as such, the required brake input (to the extent that that remains a relevant metric in the ADS-DV design) should be calibrated to reflect the brake application capabilities of the ADS.

GM/Cruise nonetheless can envision scenarios where performance requirements may need to be adjusted. For example, FMVSS 126 and 135 testing is performed at specific speeds; if the ODD of the ADS-DV is limited to slower speeds, it may be necessary to adjust that parameter, which may in turn result in an adjustment of the performance requirements. Moreover, as stated above, there no doubt will be certain requirements that simply do not apply to certain ADS-DVs. For example, FMVSS 203 and FMVSS 204 should not apply to a vehicle without a steering wheel.

In general, GM/Cruise believes the initial rulemaking should be to modify the existing and applicable FMVSS requirements to ADS-DVs, but there may be certain requirements that may need to be adjusted and others that may not apply.

QUESTION 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?***
>
> ***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?***

RESPONSE:
GM/Cruise notes at the outset that testing methods premised on non-physical requirements are beneficial because they can be performed over a much larger range of conditions, simulated or otherwise, and provide the ability to assess metrics that are difficult to measure in the physical world.
As to subpart a. of Question 9, if a manufacturer uses either the simulation or technical documentation approaches, there may not be a reasonable method for NHTSA to run an independent real-world test. As previously stated, GM/Cruise believes that cooperation will be required between NHTSA and a manufacturer regardless of the approach employed. In the case of simulation or technical documentation, the manufacturer will need to provide an appropriate explanation as to why the simulation or technical documentation is an appropriate and fair proxy for real-world testing.

Turning to subpart b. of Question 9, GM/Cruise disagrees with the premise of this question. While NHTSA must take steps to ensure that manufacturers are acting in good faith and meeting their compliance obligations, there is no requirement that NHTSA run "real-world" testing to validate either the simulation or documentation approach. "Real world" testing simply has been the historical tool that NHTSA has used to accomplish its goal of verifying compliance with the FMVSS. But, as the issuance of this ANPRM proves, technological advances have to some degree outpaced the current compliance regime. If we are to embrace those technologies, and the "possibility of associated reductions in the number of motor vehicle crashes, deaths, injuries, and associated economic costs," 84 FR 24434, NHTSA also must be willing to look beyond historical methods of assessing compliance. This necessarily entails acceptance of testing with non-physical requirements. Of course, as stated above, manufacturers must help NHTSA approach, accept and implement any alternate methodologies by providing data-driven proof that the non-physical documentation is representative of real-world parameters.

QUESTION 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?***

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?

RESPONSE:

GM/Cruise believes that, if NHTSA's short-term goal is to refine or modify existing FMVSS requirements to account for the design, layout and technologies incorporated into any ADS-DV, then an appropriately configured simulation should meet that need. Looking beyond the short-term, the use of a simulation approach may eventually expand to test other aspects of the ADS-DV operation, particularly where there is a noted safety need. However, this likely would constitute new rulemaking that goes beyond the scope of this effort to remove regulatory roadblocks.

In response to Subpart a., GM/Cruise notes that there is no need to rely on human controls in the FMVSS test procedure if the stated goal of that procedure can be achieved in a different manner. Returning to FMVSS 135 as an example, the test procedure might be to bring the ADS-DV to 100 km/h and then apply maximum brake. While this changes the test parameter, the requirement would remain unchanged. There are, however, other test parameters that may require adjustments to existing performance requirements—particularly in light of ODDs that define how the vehicle will operate and in what environment. As mentioned earlier, if a vehicle is incapable of achieving 100 km/h, then the vehicle should be brought to the maximum possible speed before the maximum brake force is applied. This would require an appropriate modification to the required stopping distance.

Subpart b. implicates validation of the ADS. This is a complex and challenging task—almost as challenging as AV development itself. There is no agreed approach to ADS validation yet. In the future, once the regulatory roadblocks have been removed and ADS-DVs are routinely being deployed, it may be possible to create an accredited test track that incorporates various safety parameters for testing. As NHTSA suggests, a stop sign could be one of test parameters to which the ADS-AV must recognize and react. Of course, to be a meaningful test under FMVSS 135, the speed at which the brakes are applied must be controlled. The application of the brakes themselves also must be controlled to ensure that the brake system is sufficient. These variables make it difficult, if not impossible, to meet the FMVSS parameters while simply driving the ADS-DV in a normal environment; FMVSS parameters often intentionally involve extreme circumstances, not experiences in a normal driving environment.

Therefore, GM/Cruise supports the exploration of alternative methodologies as a long-term goal; however, the pressing need for removing regulatory roadblocks requires shorter term solutions.

QUESTION 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?

RESPONSE:

Other than the ongoing work by VTTI, GM/Cruise is not currently aware of any data showing that "that the compliance test method would adequately maintain the focus on ADS-DV safety." However, many of the approaches enumerated in the ANPRM routinely have been used for verification of compliance in the past.

Any required modifications to the safety standards depend, in part, on which of the test methods is chosen, and which of the test parameters will be used. For example, surrogacy requires no modification if a traditional vehicle acts as the testing surrogate (assuming that it is an appropriate surrogate). Testing done through an external controller may not require much modification because the external controller interface would allow the vehicle to be run as a manual vehicle. Of course, other FMVSS may require more substantive modification if any of the test approaches were to be used. Generally, if the ADS-AV lacks any human interface, any FMVSS premised on input specified for human controls would need to be modified.

In basic terms, if a human can run the test, through surrogacy or an external controller, then few changes are required. If, however, simulation or preprogramming is being used, then parameters, specified in terms of human input, must be modified to non-human input.

A. NORMAL ADS-DV OPERATION (Questions 12-15)

QUESTIONS SPECIFIC TO THIS TESTING METHOD

QUESTION 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.

RESPONSE:
At present, GM/Cruise's intent for commercial deployment is that no part of the Dynamic Driving Task will be performed by a passenger. Passengers are allowed only to input the destination setting on the phone app or to request special assistance.

QUESTION 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.

RESPONSE:
Yes. Passengers will not be allowed to control speed, acceleration or braking, all of which must be controlled to conduct certain tests. In addition, as discussed above, geofencing will prohibit testing outside the ADS-DV's ODD. In addition, even if the test facility were mapped, the artificial nature of the test facility may interfere with the normal operation of the ADS-DV.

QUESTION 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.

RESPONSE:

No; GM/Cruise's ADS-DVs that lack traditional manual controls will not be able to react to the types of commands contained in Question 14, at least not for the foreseeable future. Currently, any discrete commands necessary for maneuvering the vehicle (e.g., maneuvering around the assembly plant, pulling onto a car hauler) will be accomplished using a special external controller.

It is conceivable that eventually, as ADS-DVs are personally owned, more discrete commands by the passenger may be possible. However, that possibility does not currently exist and is not envisioned in the immediate future. The inability to input discrete commands will make it impossible for most FMVSS testing to be conducted in an ADS-DV in normal operating mode. In addition, geofencing will prohibit operation of the first few generations of ADS-DVs outside of their ODD.

QUESTION 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?

RESPONSE:

The current FMVSS tests do not assess how a human driver will operate a vehicle during actual use. Rather, they test the capabilities of the vehicle's subsystems. The initial FMVSS testing of ADS-DVs should do the same. This would be comparable to the existing application of FMVSS testing to traditional vehicles.

If a prospective safety need is determined, future FMVSS rulemaking can concentrate on ensuring the ADS can safely operate the vehicle.

B. TEST MODE WITH PRE-PROGRAMMED EXECUTION (TMPE) (Questions 16-24)

QUESTIONS SPECIFIC TO THIS TESTING METHOD

QUESTION 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?

RESPONSE:

GM/Cruise envisions a dedicated testing mode that would be pre-programmed by the manufacturer to NHTSA specifications. As discussed in prior responses, this testing mode would be predicated on mapping the facility where the test would be run. Moreover, because accessing pre-programmed content poses obvious cyber-security concerns, the concept would need to be thoroughly vetted by cybersecurity experts. In order to secure the vehicle GM/Cruise recommends that the programming not be independently available to NHTSA. Instead, manufacturers would supply a technician to access the programming. This technician would also facilitate NHTSA testing

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

RESPONSE:

No. GM/Cruise envisions NHTSA permitting multiple test methodologies such that manufacturers could choose to make external controller, preprogramming, or surrogacy their primary method for NHTSA testing. Consequently, NHTSA should not specify the libraries within the FMVSS. If specific libraries are specified, it would likely impede flexibility.

QUESTION 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)?

RESPONSE:

In response to Question 18, GM/Cruise incorporates its response to Question 16 above.

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

RESPONSE:

Yes. If the issue of localization outside the ODD can be adequately addressed, the onboard sensors are sufficiently accurate to perform within the tolerance levels required to run FMVSS testing equal or better to human levels.

QUESTION 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?

RESPONSE:

As mentioned in GM/Cruise's prior responses, pre-programming will require mapping of the test facility. Variation between test facilities is dependent upon localization and the map accuracy. If these are consistent, performance will be consistent also. And while surface conditions vary across different testing locations, that variation is only a small contributing factor in the ultimate outcome of testing in any given location.

As mentioned in response to Question 16, NHTSA and the manufacturers will need to work together to develop pre-programming. That pre-programming may also need to comprehend the specific environment of the test facility. In addition, test locations will need to be mapped. As such, GM/Cruise recommends the number of test facilities be limited.

QUESTION 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?

RESPONSE:
No. As GM/Cruise plans to deploy ADS-DV, the proper operation of the vehicle is predicated on it operating within the ODD. Suspending the geo-fencing would not be sufficient to ensure proper operation. As previously mentioned, GM/Cruise believes mapping will be required along with addressing the environment of the test facility to ensure it is consistent with the ODD of the ADS-DV.

QUESTION 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?

RESPONSE:
This is very challenging from a cybersecurity standpoint. ADS-DVs will have dedicated maintenance and test modes, but current plans are only to make those available at dedicated locations and time windows to authorized personnel. In order to maintain the security level necessary for an ADS-DV, any kind of external access to the system must be viewed as a potential vulnerability. Therefore, GM/Cruise recommends that access be limited to authorized manufacturer personnel and that the manufacturer supply an authorized user to facilitate NHTSA testing.

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

RESPONSE:
GM/Cruise's responses to the preceding questions outlined a number of issues that will need to be addressed including: securing pre-programming by limiting access (*see* Response to Questions 1 & 16); limiting test facilities/pre-programming for specific facilities (*see* Response to Questions 1 & 20; and suspending geo-fencing through a specific test mode (*see* Response to Question 21).

This is a fairly comprehensive list. If GM/Cruise identifies other issues, we will share them with the Agency.

Ultimately, as with the other approaches raised in the ANPRM, NHTSA and industry will need to work together to make pre-programming a reality.

QUESTION 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?

RESPONSE:

Though software will be updated very frequently, GM/Cruise vets all changes for their effect on compliance. Changes to the ADS will need to be included in the vetting process. However, GM/Cruise does not believe most changes to the ADS will affect the TMPE. Therefore, we believe required TMPE updates would be infrequent.

C. TEST MODE WITH EXTERNAL CONTROL (TMEC) (Questions 25-29)

QUESTIONS SPECIFIC TO THIS TESTING

QUESTION 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?

RESPONSE:

GM/Cruise believes that most manufacturers are developing some type of external controller to maneuver vehicles around assembly plants and to load/unload during shipment. These controllers are generally limited to these logistical functions and may not provide sufficient functionality to conduct most FMVSS testing. We believe, however, that it is possible to develop an external controller with sufficient functionality to allow FMVSS verification testing.

While the development of a common (universal) control interface remains a possibility, there are a number of associated challenges. First, the varying configurations of ADS-DVs (passenger, passenger-less cargo, etc.) will make development difficult.

Second, there may be resistance due to cybersecurity concerns among the manufacturer community to the development of an external controller because a plug-in or remote universal controller would require a level of standardization that necessarily may make attacks easier.

The idea of a universal controller should be investigated more fully by SAE International or some alternative industry consortium or trade association. In any event, GM/Cruise anticipates development could involve a significant amount of time. In the interim, if a TMEC approach is adopted, NHTSA could rely on manufacturer-supplied external controllers to conduct testing.

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

RESPONSE:

There is no clear answer as to which method for interfacing an external controller is most easily secured. Whether wireless or physical, each method provides a port of entry that will need to be secured. Wireless methods would need to be secured from cyberattack, while physical access would need to be secured from physical tampering.

Ultimately, the various vehicle configurations (passenger-based, cargo-based, etc.) will likely drive both plug-in and wireless controllers. As previously mentioned, some ADS-DVs will be dedicated cargo vehicles without capacity for human passengers. These vehicles will likely require wireless controllers. Others will be more conducive to physical access. Manufacturers initially will design external controllers based on their particular needs—i.e., to more readily shuttle vehicles around manufacturing plants, or for testing, etc. The security of these controllers also will be addressed by the manufacturers during development.

Any effort to develop a universal remote may actually result in a family of remotes with variations designed for specific vehicle configurations. This effort will take time and, in the interim, NHTSA should rely on manufacturer supplied external remotes. There is precedent for this. When testing headlamps, NHTSA routinely requests fixtures to easily mount the lamps in design position. NHTSA could take a similar approach requesting an external controller from the manufacturer for testing.

QUESTION 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?

RESPONSE:

In principle this should be possible; however, it would require an industry-wide effort and time to develop. To date, no such effort has been initiated. A more feasible approach in the meantime may be to have manufacturers temporarily supply external controllers that allow NHTSA to conduct compliance verification testing. If necessary, the manufacturer could also provide an operator.

QUESTION 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?

RESPONSE:

Yes; if an external controller were used, the operation of the external controller would likely circumvent geofencing, allowing the vehicle to be controlled "manually."

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

RESPONSE:

GM/Cruise argues the most viable approach is to allow external controllers as an optional methodology for testing. As stated above, at least initially, these controllers will only be available from the manufacturers. Further, the manufacturers will need to supply the controller, and possibly an operator to NHTSA, to enable verification testing.

GM/Cruise reiterates its prior suggestion that the feasibility and development of a universal controller should be pursued by SAE International, or an alternative industry consortium or trade association. The first step of that effort might be to develop standardized control recommendations for manufacturer's external controllers, making any controller supplied by them easier for NHTSA to use.

D. SIMULATION (Questions 30-33)

QUESTIONS SPECIFIC TO THIS TESTING METHOD

QUESTION 30:
How can simulations be used to assess FMVSS compliance?

RESPONSE:
While the effort needed to validate simulations is significant, if suitable infrastructure and Hardware-in-the-Loop (HIL) systems can be developed, GM/Cruise believes this ultimately could be a very effective and efficient testing approach. GM/Cruise anticipates that agreement to a universal simulator between all manufacturers and developers would be a challenging and, potentially, lengthy industry effort.

With that said, GM/Cruise, envisions NHTSA and industry jointly developing simulation models for specific FMVSS. Once the models have been verified to represent real-world testing, manufacturers would submit the necessary vehicle, software, sensor, and other parameters that NHTSA could then use to run the simulation. It is likely that the information submitted by manufacturers would be of a confidential nature and confidential treatment would need to be provided. This confidential treatment would need to be extended to any third-party test facilities that NHTSA uses during its verification. It is also possible, if proven successful, this approach could be extended to traditional vehicles, leading to a more streamlined and lower cost testing approach for NHTSA overall.

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

RESPONSE:
For any particular FMVSS, the determination of an acceptable simulation model necessarily must include an assessment of the accuracy and repeatability of that model. NHTSA and manufacturers will need to work together to identify this model and certify it as appropriate. This process will need to take place for each FMVSS identified as appropriate for simulation, and as such GM/Cruise expects that it will take time. GM/Cruise believes this to a worthwhile effort, however. Simulation eventually could obviate the need for physical testing, thereby accelerating the time it takes to perform NHTSA's vehicle testing. As such, GM/Cruise view the development and proliferation of simulation as a testing methodology as the ultimate goal towards which industry and NHTSA should drive, one that will benefit both ADS-DVs and traditional vehicles alike. Until that goal is achieved, it is likely other methodologies will need to be allowed and utilized.

In saying this, GM/Cruise appreciates that the complexities involved in creating an accurate model capable of application to all vehicles make development of this test methodology more difficult. Consequently, GM/Cruise posits that this effort should be undertaken by NHTSA and the industry as a long-term project, one that is independent of, and will be addressed in tandem with, the more immediate goal of removing regulatory road blocks.

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

RESPONSE:

Yes, it is feasible. However, as stated in our previous response, developing and validating an appropriate hardware-in-the-loop simulation will take considerable time. That project should be addressed independent of the primary goal of removing regulatory roadblocks.

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

RESPONSE:

As with its response to Question 32, GM/Cruise believes that software-in-the-loop simulations also are feasible, but likewise will take considerable time to develop, and should be addressed separately from the more immediate goal of removing regulatory roadblocks.

E. TECHNICAL DOCUMENTATION FOR SYSTEM DESIGN AND/OR PERFORMANCE APPROACH (Questions 34-36)

QUESTIONS SPECIFIC TO THIS TESTING METHOD

QUESTION 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?

RESPONSE:

The fundamental principle underlying technical documentation-focused approach has been successfully used for years in Europe as the basis for type approval. GM/Cruise understands that the United States regulatory regime is premised on self-certification and is not suggesting that NHTSA abandon that. But it is worthwhile to note that the concept of submitting, upon request, technical documentation demonstrating compliance has a proven track record in a robust regulatory regime.
In addition, NHTSA ODI routinely makes safety defect determinations based on technical documentation provided by manufacturers as part of its formal investigation process. A similar approach could be taken

by OVSC. To verify compliance, it could request technical documentation from the manufacturer. If the information is insufficient to assure OVSC of the vehicle's compliance, it could then open a formal investigation, just as ODI does in the defect context.
As NHTSA no doubt expects, all leading manufacturers in the AV space work extensively with internal test verification and validation approaches as part of the self-certification process. This testing and verification data and documentation produced through this process are extensive, extending far beyond the applicable FMVSS requirements. This safety information could form the basis of the technical documentation that would be supplied to NHTSA as part of the compliance process.

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?

RESPONSE:
The Safety Act imposes on manufacturers an obligation to provide information upon NHTSA's request or in compliance with NHTSA regulations. *See* 49 U.S.C. § 30166(e). As with all information submitted to a government agency, that information must be accurate, truthful and complete. In addition, the Safety Act prohibits manufacturers from certifying compliance if, "in exercising reasonable care, [they have] reason to know the certificate is false or misleading in a material respect." 49 U.S.C. § 30115(a). Through these requirements, manufacturers are required to provide NHTSA with accurate documentation and information.

While ultimately the onus will be on each manufacturer to ensure that the technical documentation it provides is accurate, complete and representative of the data regarding the ADS-DV at issue, GM/Cruise notes that confirmation that the documentation accurately represents the ADS-DV is likely to vary by manufacturer, depending on the testing regimen it employs. For instance, one manufacturer may rely on a combination of physical testing and engineering analysis, while another may rely more heavily on simulation that is based on real-world testing.

QUESTION 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.

RESPONSE:
GM/Cruise anticipates that the technical documentation that would be submitted by a manufacturer would be the internal testing documentation kept and relied on by the manufacturer to establish that its vehicle exceeded the FMVSS requirements. However, while the various FMVSS specify particular test methodologies for verifying compliance, manufacturers are not compelled to adhere to those test methodologies. In fact, manufacturers often employ methodologies that vary—sometimes dramatically—from the test methodologies NHTSA uses for verifying compliance. As such, GM/Cruise expects that the specific type of testing information reflected in any particular technical documentation submission will vary widely across manufacturers.

F. Use of Surrogate Vehicle With Human Controls (Questions 37-39)

QUESTIONS SPECIFIC TO THIS TESTING METHOD

QUESTION 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?

RESPONSE:

Ultimately, the manufacturer will need to make a compelling, case-specific argument that use of a surrogate is appropriate. However, if a traditional vehicle has been converted to an ADS-DV with no changes to base vehicle systems and little change to the GVWR or the center of gravity, then the traditional vehicle should serve as a viable surrogate for the ADS-DV.
As ADS-DVs begin to have specific designs, it will become increasingly difficult to justify the use surrogacy. However, if a traditional vehicle has substantially similar subsystem hardware, a similar configuration, a similar GVWR, and a similar center of gravity, it still may be possible to support the use of a traditional vehicle as a surrogate.
In addition, it may be possible for a manufacturer to create a surrogate from a vehicle test mule that operates in a traditional manner, but otherwise simulates the subsystems and vehicle configuration of the ADS-DV.

QUESTION 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?

RESPONSE:

It will be difficult for NHTSA to confirm independently that the surrogate accurately simulates the ADS-DV. Instead, the manufacturer will need to provide NHTSA with evidence that the surrogate accurately simulates the ADS-DV.

QUESTION 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?

RESPONSE:

If the results differ significantly, and compliance of the ADS-DV is in question, GM/Cruise believes this would be grounds for NHTSA to open a formal noncompliance investigation.