ADVOCATES
FOR HIGHWAY
& AUTO SAFETY

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Request for Comment on "Federal Automated Vehicles Policy"
Notice and Request for Comments
81 Federal Register 65703, September 23, 2016

Advocates for Highway and Auto Safety (Advocates) files these comments in response to the National Highway and Traffic Safety Administration (NHTSA) notice and request for public comment on the "Federal Automated Vehicle Policy."[1] (NHTSA AV Policy). Simply because AV technology has the potential to evolve rapidly over time does not justify NHTSA abdicating its statutory mission of regulating motor vehicles to ensure public safety.[2]

Fifty years ago, Congress passed the National Traffic and Motor Vehicle Safety Act of 1966 because of concerns about the death and injury toll on our highways. The law required the federal government to establish federal motor vehicle safety standards (FMVSS) to protect the public against "unreasonable risk of accidents occurring as a result of the design, construction or performance of motor vehicles."[3] While cars have changed dramatically and will continue to do so in the future, the underlying premise of this prescient law and the NHTSA's safety mission has not.

Advocates has always enthusiastically championed technology and for good reason. It is one of the most effective strategies for reducing deaths and injuries. NHTSA has estimated that since 1960, hundreds of thousands of lives have been saved by motor vehicle safety technologies.[4]

In 1991, Advocates led the coalition that succeeded in having the airbag mandate included in the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991.[5] As a result, by 1997, every new car sold in the United States was equipped with a front seat airbag and the lives saved have

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[1] Request for Comment on "Federal Automated Vehicles Policy," 81 FR 65703 (Sept. 23, 2016).
[2] In general the term AV refers to all autonomous vehicles including those vehicles that NHTSA refers to as highly autonomous vehicles (HAVs) except as noted.
[3] Title 49, U.S.C. Sec. 30102.
[4] Lives Saved by Vehicle Safety Technologies and Associated Federal Motor Vehicle Safety Standards, 1960 to 2012, DOT HS 812 069 (NHTSA, 2015); See also, NHTSA AV Policy, *Executive Summary*, p. 5 endnote 1.
[5] Pub. L. 102-240 (Dec. 18, 1991).

been significant. In fact, airbags save over 2,000 lives annually.[6] Advocates continued to build on our success by pushing lifesaving technologies in other bills and regulatory proposals. These efforts included tire pressure monitoring systems,[7] rear outboard 3-point seat belts,[8] electronic stability control,[9] seat belt reminder systems,[10] rear video cameras,[11] brake transmission interlock,[12] seat belts on motorcoaches,[13] electronic logging devices[14] as well as other important safety improvements such as rollover crash avoidance and automatic emergency braking. These safety advances have saved countless lives.

According to the latest statistics from the National Highway Traffic Safety Administration (NHTSA), 35,092 people were killed on our nation's roads in 2015.[15] This represents a 7.2-percent increase from 2014 and is the largest percentage increase in nearly fifty years.[16] Injuries resulting from crashes also increased to 2.44 million from 2.34 million in 2014.[17] Advocates is hopeful that automated vehicle technology has the potential to significantly reduce this carnage. However, the safety benefits of AVs will be realized gradually as the widespread adoption of the technology will take years.

Introduction/Overview[18]

The NHTSA AV Policy points out that under current law and regulation, vehicle and equipment manufacturers are under no legal duty to provide information to the agency about a new technology, in advance of production and sale into the U.S. market, unless it fails to comply with an applicable FMVSS or raises a compliance question regarding existing regulations.[19] The NHTSA AV Policy does nothing to change the legal responsibility or duty that vehicle and equipment manufacturers owe to NHTSA or the public. The NHTSA has the authority, however, to require motor vehicle manufacturers, and other entities supplying auto equipment, parts and electronic systems for AVs, to conduct tests and perform analyses to document and

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[6] National Center for Statistics and Analysis, *Lives Saved in 2015 by Restraint Use and Minimum-Drinking-Age Laws*, National Highway Traffic Safety Administration, Report No. DOT HS 812 319 (Aug. 2016).
[7] Transportation Recall Enhancement, Accountability, and Documentation (TREAD) Act, Pub. L. 106-414 (Nov. 1, 2000)
[8] Anton's Law, Pub. L. 107-318 (Dec. 4, 2002).
[9] Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), Pub. L. 109-59 (Aug. 10, 2005)
[10] *Id.*
[11] Cameron Gulbransen Kids Transportation Safety Act of 2007, Pub. L. 110-189 (Feb. 28, 2008).
[12] *Id.*
[13] Moving Ahead for Progress in the 21st Century (MAP-21) Act, Pub. L. 112-141 (Jan. 3, 2012).
[14] *Id.*
[15] National Center for Statistics and Analysis, *2015 motor vehicle crashes: Overview*, Report No. DOT HS 812 318, National Highway Traffic Safety Administration (Aug. 2016).
[16] *Id.*
[17] *Id.*
[18] Due to the complexity of the issues involved and the length of the NHTSA AV policy, Advocates' comments exceed the 15 page limit pursuant to Title 49, C.F.R. § 553.21.
[19] Federal Automated Vehicles Policy: Accelerating the Next Revolution in Roadway Safety, 12507-091216-v9, p. 48 (NHTSA, Sept. 2015) (NHTSA AV Policy), available at http://www.nhtsa.gov/nhtsa/av/index.html.

verify that an AV system performs safely and as designed. That type of documentation should be required by rule rather than as part of the voluntary safety assessment letter that the agency now requests manufacturers to voluntarily submit to the agency.

Furthermore, the development and deployment of automated vehicles as well as the agency's role in regulating this technology must be open and transparent. Therefore, all communications and responses between NHTSA and a manufacturer as it relates to any issues involving automated vehicles must be made available for public review and scholarly research. In addition, all data generated from the testing and deployment of AVs, except for trade secrets and private individual information must be made public. In the past few years, automakers have hidden from regulators and the American public safety defects that have led to unnecessary deaths and injuries as well as the recall of millions of vehicles. This troubling lack of transparency should not be allowed to infect the development of driverless vehicles. Lack of transparency will severely undermine the public's confidence in this new technology and inhibit its adoption by the public regardless of its perceived benefits.

I. Vehicle Performance Guidance for Automated Vehicles

The Guidance

Advocates' two main objections to the proposed performance guidance are that the guidance is not mandatory and that there is a lack of specificity. In its current state, the non-mandatory guidance is such that any information willingly provided by industry in the safety assessment letters regarding compliance with the guidance may be incomplete, sparse, or at best so varied from letter to letter as to render the information collected useless in terms of agency review and developing future regulation. As detailed below, the guidance should be reconfigured around the concept of a functional safety approach to the design, development, and deployment of autonomous vehicles of all levels.[20] The guidance must be specific in terms of minimal reporting requirements and should establish those requirements based on a planned path toward future regulation. Failure to do this will only leave the federal agency charged with ensuring motor vehicle and public safety further behind the technology.

Scope

As indicated "all individuals and companies manufacturing, designing, testing, and/or planning to sell automated vehicle systems in the United States"[21] must consider the guidance. Similarly, the guidance must be applied to all AVs, including light-, medium-, and heavy-duty vehicles. The guidance must apply to both test- and production-level vehicles, specifically those which are

[20] Levels in this case refer to the levels of automation as defined by SAE J3016 and adopted by the NHTSA. Although the NHTSA distinguishes between SAE Level 0-2 and 3-5 AVs, the agency acknowledges that "this distinction does not change many of the areas in which the manufacturers . . . should apply elements of this Guidance during product development, testing, and deployment." NHTSA AV Policy, p. 31.

[21] NHTSA AV Policy, p. 11. These comments use the term "manufacturers" to represent all entities intended to be covered by the scope of the NHTSA AV Policy.

sharing the road with the general public.[22] The reality is that while testing of AVs on public roads is a necessity, to increase real-world data collection and improve development, AVs are sharing the road with other highway users who have not been informed of the testing, are unwitting participants to the testing, and may be exposed to crash risks without prior informed consent. AVs that are being tested as well as the routes they will travel should be conspicuously marked so that they are easily identifiable to the public. For these reasons, AVs used for research and testing on public roads, as well as AVs sold to the public, must all be subject to a rigorous functional safety process and requirements to ensure that the public will not be exposed to an unreasonable crash risk.

Overview: DOT's Vehicle Performance Guidance

In terms of content, the NHTSA AV Policy covers many of the important aspects necessary to achieve safety of AVs. However, the organization of the guidance appears disjointed and should be revised to conform more closely to a functional safety approach. In its present format, the guidance could be read as indicating that the individual guidance sections could be tackled as separate, independent issues when, in reality, a comprehensive and cohesive systems engineering approach must be taken in order to achieve the safe deployment of AVs.

Almost all portions of the guidance represent, to some degree, aspects of functional safety. Functional safety is a process by which a system is designed, developed and deployed to ensure that the system, as a whole, operates correctly and safely in response to inputs, errors, and failures. Functional safety is applied throughout the life-cycle of a system, from hazard analysis during design through auditing of performance after deployment. Only through ubiquitous adoption of a functional safety approach to the development of AVs can the safety and benefits of this technology be achieved. Advocates recommends that NHTSA reorganize the guidance into a framework focusing on a functional safety approach that identifies how each of the guidance components fit into the functional safety framework. The following is an example of how different sections of the guidance could be reorganized into a functional safety approach:

- System Design
  - Operational Design Domain[23]
  - Object and Event Detection and Response[24]
- Hazard Analysis
  - Mechanical

[22] The public must be given the opportunity to give meaningful informed consent to the testing of AVs on public roads. Among other things, AVs that are being tested as well as the routes they will travel should be conspicuously marked so that they are easily identifiable to the public. In addition, as required by federal regulation for research involving human subjects, cities and states that permit testing of AVs should have in place an Institutional Review Board to monitor that the testing of AVs to protect the rights all of the subjects involved in the testing. See: 45 CFR 46 (2009).

[23] Operational design domain (ODD) refers to how the AV system will detect and respond to the driving environment.

[24] Object and event detection and response (OEDR) refers to how the AV system will perform when a problem with the system itself is encountered.

  - User
    - Human Machine Interface (HMI)
    - Consumer Education and Training
  - External
    - Cybersecurity
    - Federal, State, Local Laws
    - Ethical Considerations
- Risk Reduction
  - Post-Crash Behavior
  - Fall Back (Minimal Risk Condition)
- Design Validation
  - Validation Methods (simulation, track, on-road testing)
- Performance Verification / Auditing
  - Data Recording and Sharing

Safety Assessment Letter to NHTSA

The NHTSA must make the reporting of AV information mandatory. Voluntary submission of information will not succeed because AV manufacturers are under no legal duty to report completely and fairly. While Advocates agrees with the underlying concept of the proposed Safety Assessment submission, there are three major problems with the Safety Assessment guidance as proposed in the NHTSA AV Policy. First, at the outset, the NHTSA undermines its effort by describing the Safety Assessment information to be provided as merely "outlining" how the manufacturer submitting the information is meeting the areas of concern in the NHTSA AV Policy guidance.[25] The agency then refers to the Safety Assessment submission as a "summary letter."[26] In fact, the agency guidance allows manufacturers to merely check-off a box for each area of requested information that indicates whether the manufacturer's AV system "Meets", "Does not meet", or "is not applicable" to each particular guidance area of the NHTSA AV Policy. In essence, if a manufacturer voluntarily responds at all, it could just check the appropriate response in each area without providing any substantive information or content whatsoever. Although the agency states that it expects responses to be "concise and complete[,]"[27] nothing in the guidance indicates that the agency is seeking detailed information in an initial response.

Second, as proposed, the request for the Safety Assessment submission lacks specificity as to what type of information the agency wants and that the manufacturer should submit. Requests for information contain only vague descriptions that may or may not receive accurate and complete responses. The agency approach to the Safety Assessment submission letter is to allow the manufacturer to provide as much or as little information as the manufacturer deems to be in its self-interest. In fact, the agency states that, after the initial submission, the agency "might

[25] NHTSA AV Policy, p. 15.
[26] NHTSA AV Policy, p. 16
[27] NHTSA AV Policy, p. 16.

request more detailed information on Guidance areas to better assess safety aspects of the HAV systems."[28] It is critical that the agency should try to obtain complete and detailed information from the outset. In its present non-mandatory form, the agency will have little recourse to compel manufacturers to provide additional information if the agency is not satisfied with the initial response. Follow-up requests may well extend beyond the four-month lead-time that the NHTSA AV Policy suggests is needed to review manufacturer submissions prior to testing on public roads.[29] In addition, such requests impose additional burdens on NHTSA's resources.

Third, the NHTSA does not seek any uniformity of the substantive content for the Safety Assessment information. Responses from manufacturers can take many forms and use distinctive nomenclature that will slow down if not stymie the agency's evaluation of the information. The agency should categorize the types of information it seeks in each guidance area in order to better be able to compare implementations of industry standards, guidance, best practices, testing, protocols, and analyses.[30] Doing so will make the information gathered more useful to the public, industry, and government alike.

Finally, regarding the timeline for Safety Assessment responses, four months is excessive to develop a Safety Assessment letter for products already on the road, and for which all documentation should readily be available. This is particularly important as the initial response may not be sufficiently detailed and may require the agency to make an additional follow up request for more information. Likewise the demand that letters be provided four months prior to testing should be evaluated to ensure that the agency and the public have ample time to review the documents, especially if a vehicle is to be tested on public roads. For similar reasons, Advocates concurs that updates to the Safety Assessments are needed, and should be required, when updates are made to AV systems. However, the process and requirements for updating Safety Assessments should be specific and uniform to ensure that the information gathered is beneficial to the public, industry and regulators.

Cross-Cutting Areas of Guidance

Data Recording and Sharing

The collection and sharing of data with the public, the NHTSA, and within the industry will be critical to achieving the highest levels of safe AV performance. Similar to the way in which current crash databases are used to inform current safety regulation and vehicle design, an AV performance database would benefit all parties. NHTSA should maintain a public database that details any and all crashes involving an AV. The sharing of both incident (crash) and near

[28] NHTSA AV Policy, p. 16.
[29] NHTSA AV Policy, p. 16.
[30] The lack of specificity with the Early Warning Reporting (EWR) perfectly illustrates what can happen when the agency fails to provide proper specification for the information it seeks. The vague categories of the EWR have enabled the industry to hide questionable performance and dangerous defects. (EWR: Elective Warning Reports – When Manufacturers Don't Report Claims, Safety Research & Strategies, Inc., Apr. 8, 2014, available at http://www.safetyresearch.net/blog/articles/ewr-elective-warning-reports-when-manufacturers-dont-report-claims)

incident (near-miss) data would enable the industry to review performance of other AV systems and improve their own performance, especially for edge cases.[31] Likewise, the agency should use the data to develop specific sets of scenarios which AV systems must be able to address as part of future guidance and eventual regulation. The data to be collected and shared must be more specific than "all information relevant to the event and performance of the system."[32] This vague description leaves too much room for interpretation which could result in disjointed and unusable information from which limited insights could be gained. Importantly, specification of data to be recorded and shared should address industry concerns around intellectual property. For example, making sure that the data from an incident where an AV fails to see the side of a white truck crossing its path is of critical importance to the development of all AV systems as it identifies a scenario which could cause problems and lead to risks. This sharing of data or feedback loop, must be done to ensure that each AV system does not have to learn only from its individual failures but can be improved based on the failures or successes experienced by other AV systems.

Essential to gathering accurate and reliable technical data on AV system performance and failure is the need to require all such data to be captured and collected. While each manufacturer may voluntarily provide information that is collected for internal use, information about AV system performance on public roads must be provided to the NHTSA on a real time basis and made available to the public. In the meantime, the NHTSA must also require that Event Data Recorders (EDR) or other systems are able to collect and record all essential data on AV systems so that in the event of a crash or other failure the vehicle systems status data will be available to the agency, crash investigators, researchers and the vehicle owner. Advocates recommends that the agency complete the rulemaking to mandate EDRs in all passenger vehicles, and revise the current requirements in the EDR rule, 49 C.F.R. §563, to require additional data collection on all AV systems.

Privacy

Privacy will be a key factor in ensuring acceptance of AVs by the public. As noted above, the recording and sharing of data will be critical to achieving the safest performance of AVs as quickly as possible. Keeping the public informed as to the importance of sharing data and ensuring their privacy will be similarly critical to ensure participation. The industry and regulators must guarantee that data is protected and only used for the purposes of improving safety, and not for other commercial uses which could turn the public against data sharing.

System Safety

Functional safety should provide the framework for the overall approach to the guidance and future regulation. In almost all areas of the guidance, it will benefit all parties involved if the

[31] Edge Cases are those problems or situations that occur very infrequently or at the operational boundary. These are cases each manufacturer's vehicles may only see once, but the information about that situation would benefit all systems because of its rarity.
[32] NHTSA AV Policy, p. 18.

requirements of the safety assessment were more specific in terms of standards, guidance, best practices, and design principles about which the agency would like information. The industry could then respond as to whether and how they have implemented any of those practices. Requiring the specific and uniform reporting of data by manufacturers will enable the agency to understand how each of the guidance areas, practices, standards, etc., are being implemented across the industry. It will also allow the agency to work towards establishing regulation to require their implementation.

Vehicle Cybersecurity

Cybersecurity is an important aspect of AV development which must be addressed as part of functional safety. Again, the guidance is vague on the information it would like to receive from the industry. Specificity and uniformity will be the keys to evaluation of AV system information by the NHTSA and to informing the public. The agency should identify problems areas and require specific responses from manufacturers on how those are being addressed. Problem areas could include subjects such as GPS signal loss / degradation / spoofing, and off-line and real time hacking of single vehicles or fleets of vehicles. As with all other performance data, the sharing of data in terms of cybersecurity will improve overall safety and ensure that all vehicles, regardless of manufacturer, are afforded the same level of security. This is even more important when the aspect of connected vehicles is concerned as any weak link in the chain could leave many more vehicles vulnerable to programming errors or hacking. The potential risk of a single software error, or malevolent computer hack impacting hundreds or thousands of AVs, perhaps whole model runs, makes appropriate cybersecurity a crucial and indispensable element of AV design.

Human Machine Interface

The user interface is an essential aspect of the development and deployment of AVs. In the functional safety approach, the human/machine interface (HMI) presents both a source for and means of addressing hazards stemming from the user. As some products currently on the road have demonstrated, poor HMI design can lead to dangerous and deadly situations. For example, if an AV requires a human occupant to participate in the driving process, it must be designed to ensure that the human occupant is engaged, aware, and informed of the operational status of the vehicle particularly in time critical settings. Simply informing drivers that they must remain engaged or placing information in the owner's manual as to the limitations of the AV system are not a sufficient or acceptable substitute for engineering solutions that are effective in maintaining the engagement of the human operator. This is true even if the operator signs a statement indicating that they have read the manual. In a functional safety approach the hazard of driver engagement should be managed through monitoring and warning systems to ensure drivers are engaged to the level necessary for the system to operate safely. A system which fails to account for all sources of risk and hazard, especially the transition from or to a human operator, would not be functionally safe and should be evaluated by the agency before the AV system is certified by the manufacturer for use on public roads.

Crashworthiness

Compliance with the FMVSS is mandatory and should remain so. In the future, as new seating configurations are proposed, the NHTSA may be required to adapt the FMVSS to ensure that occupants are provided the same minimal levels of crashworthiness protection currently afforded by all vehicles. Leaving occupant safety in AVs to the "due care" of the industry is a step backward that is fraught with problems and opens the door for making trade-offs with safety. Furthermore, concerning AV compatibility, the agency should establish regulatory requirements rather than relying on voluntary agreements. In the end, it is foreseeable that AVs will share the road with traditionally operated vehicles with human drivers for an extended time and, despite any AV advances, will likely still be involved in crashes which will require the vehicle design to ensure that it protects occupants and crash partners alike.

Consumer Education and Training

Consumer education and training are imperative to ensure safe deployment of AVs. Failure to fully familiarize consumers with needed operational and safety information, or to properly train vehicle owners who may have to take over operation of the AV at some point, could result in rejection of AVs by the public and more importantly lead to crashes. As end users of the product, even if they are not involved in the driving task at all, consumers will ultimately decide the fate of AVs. Consumer education and training in all aspects of AV operation are critical to success.

Advocates agrees with the NHTSA's statements and observations in the guidance that manufacturers develop education and training programs for employees, dealers, distributors and consumers.[33] This is especially necessary for Level 3 (and lower) AVs in which the driver may need to take over control of the vehicle when the operational limits of the AV system have been reached. The suggestion in the NHTSA AV Policy that consumers who purchase AVs should receive training on the operational capabilities and limitations of the AV system they purchase, along with an on-the-road demonstration prior to taking possession of the AV would be beneficial. However, the agency should take the next step and offer specific solutions and develop prototype program materials to guide manufacturers in this effort.

The agency must also consider the need for standardizing the operation of AVs or their functions, and requiring training and education / information from the manufacturers or as part of the state policy for licensing to ensure that, until such time as drivers are no longer required, that lack of education or training do not undermine the safety benefits of AVs.

Furthermore, while all relevant information must be included in the vehicle owners' manual, there is a clear need, especially for vehicles that may require the intervention of a driver or which can have their operational capabilities updated significantly, for important features of the AV

[33] Advocates is aware of instances in which dealership sales personnel were unfamiliar with the capabilities of the AV systems they were demonstrating to customers.

system operation to be delivered to consumers in other ways. The agency should consider requiring instrument panel instructions / notifications that must be read and accepted before the AV can begin operating, and a separate AV system tutorial that can be viewed on board the AV when not in operation or on other personal data devices. A comprehensive approach to AV education and training is essential for the success of AV adoption.

Certification

Manufacturers will still be responsible to self-certify that their AV meets all federal and state requirements as well as operates safely and as designed. Manufacturers and other responsible entities will need to keep both the NHTSA and consumers aware of the operation, capabilities, and limitations of AV systems that are on the road. With the possibility of over the air (wireless) updates which could change the operation of AVs overnight, it will be essential for manufacturers to provide updated Safety Assessments to the NHTSA regarding any changes that affect the certification of the vehicle. Clear instructions regarding any changes must also be conveyed to the vehicle owner and operators.

Post-Crash Behavior

As part of functional safety, AVs must be able to recognize failures and address them or enter a failsafe mode. Controlling post-crash behavior to prevent the operation of AVs systems after damage to sensors is part of addressing a crash which is a known hazard. Similarly, it is important for the repair and re-certification of AV systems to be well established to ensure only safe AV systems are allowed back onto public roads.

Federal, State and Local Laws

In terms of functional safety, complying with Federal, State, and local laws is a known aspect of an AV systems design and expected operation. Variation in laws between jurisdictions is another known operational parameter that must be considered and addressed by AV manufacturers. It would appear that compliance with Federal, State, and local laws would be part of the operational design domain (ODD) and the object and event detection and response (OEDR), rather than a stand-alone topic of the guidance. Additionally, the NHTSA should consider the impact of the variation in transportation laws, road designs, lane marking, signage, etc. on the implementation of AVs and the benefits which could be derived from seeing uniformity across the country.

Ethical Considerations

Conflicts between the objectives of safety, mobility, and legality could occur in the operation of AVs; however, the guidance is vague on the specific means by which these conflicts will be resolved. Merely stating that solutions to these issues "should be developed transparently using

input from Federal and State regulators, drivers, passengers and vulnerable road users…"[34] is not sufficient to ensure that dangerous products are not placed on the road now. Until such time as these "algorithms" are developed and proven, the safety objective should guide decisions. It is for this reason that the collection and sharing of data on vehicle operation will be important. The NHTSA must be more forthcoming with regard to how it will approach AV designs in which the manufacturers have opted to make different decisions in balancing these ethical considerations.

Automation Function

Specification of the conditions under which an AV system will operate (ODD), how the AV system will detect and respond to the driving environment (OEDR), and how the AV system will perform when a problem with the system itself is encountered (fall back (minimal risk conditions)), are all part of the design aspect of a functional safety approach. For each system and the system overall, specifying which conditions a system can operate within, what the expected response is, and what happens when all else fails are essential parts of the design, hazard analysis, and hazard mitigation / elimination aspects of functional safety. The NHTSA must ensure that it collects sufficient information and test data/results to confirm that the manufacturer has done its safety due diligence and to validate that these aspects of the AV system are operating safely and as designed.

Operational Design Domain

Defining an ODD and translating that information to the NHTSA and specifically the consumer will be important to ensure that user error is reduced and that limitations in the operation of AV systems both within and outside of the ODD can be identified. Specificity and uniformity in reporting will improve the ability for this information to be used to develop future regulation and inform the public. It is also important that manufacturers consider specifying not only the ODD (where the system will work) but to clearly define the operational boundaries for the consumer. As discussed in previous sections, simply informing the consumer is not adequate from a functional safety stand point and should be supplemented with engineering solutions, including properly designed HMI, to ensure that opportunities for error or misunderstanding that could pose a crash risk are eliminated.

Object and Event Detection and Response

Within its ODD, each AV system must be expected to detect and respond to all scenarios which could affect safe operation. This includes interactions with other vehicles, pedestrians, cyclists, animals, and other objects. The NHTSA provides a limited list of behavioral competencies for normal driving and references a number of scenarios for crash avoidance and other hazards (construction, disabled vehicles, etc.). Advocates believes that this type of specific listing of scenarios which all AVs, as appropriate based on each particular AV system ODD, should be addressed as part of the safety assessment. With sufficient, uniform data sharing, manufacturers

[34] NHTSA AV Policy, p. 26.

should be aware of all scenarios that AVs should address as part of their safety assessment. The agency should work towards a functional safety requirement which would include specifications of scenarios which must be addressed by an AV system, depending on the ODD, and which could be tested to ensure compliance.

Fall Back (Minimal Risk Condition)

As noted above in the discussion of post-crash behavior and in other sections, establishing fail safe conditions and operation is yet another part of functional safety. Once hazards and risks are identified and then eliminated, mitigated, or guarded against, and warnings are provided, the final step is to ensure that a system can recognize a failure or when it is operating outside of its ODD and return the system to a failsafe operation. However, having a failsafe design should not just be a recommendation. As with nearly all other parts of the guidance, AVs must be functionally safe, including having failsafe modes. These modes will be especially important in the early rollout of AVs when unknown risks have not yet been adequately identified through data collection and sharing.

Validation Methods

Performance validation is another step in the functional safety process. The NHTSA Safety Assessment must include specific tests and validation methods which the AV manufacturers must confirm have or have not been used, with a description and documentation of the methods the manufacturer did use to validate its AV system. Manufacturers should be required to provide information on all methods beyond those listed by the agency which will inform and enable the agency so it can update future versions of the list. Again, data collection and sharing will also be critical to performance validation to ensure that performance on the road and in the hand of the public is matching the performance predicted by the design.

Guidance for Lower Levels of Automated Vehicle Systems

All manufacturers of AV systems should be required to meet functional safety requirements for the design, development, and deployment of AVs. Almost all of the current guidance fits into what should be required in a comprehensive functional safety approach. Lower levels of automation should not be exempt from having to thoroughly apply the process.

Advocates supports ODD, OEDR, and minimal risk conditions applying to lower level AV systems. Every AV system has conditions under which it is designed to operate and its operation is specified. While the details may not be as extensive as that of a higher level (3-5) system, this is not an exception but rather a modification. Finally, a failsafe mode is still necessary even if it is not as drastic as those for higher level AVs. Uniformity in application of the functional safety process across all levels of AVs is necessary to ensure safety and inform the agency and the public.

Next Steps: Activities to Improve, Expand and Oversee the Guidance

It is critical that the NHTSA move swiftly towards effective regulation before the technology becomes ubiquitous. Abandoning the regulatory process is not a solution. A concerted and coordinated effort between agencies, branches of government, industry and the public will be necessary to achieve the goals of bringing AVs to market and doing so safely.

II. Model State Policy

The stated purpose of the model state policy is to "create a consistent, unified, national framework" for AV regulation, yet the framework is so loose it is difficult to envision consistent outcomes.[35] In fact, this framework, because it lacks so many necessary details, will create a patchwork of state standards which stands in stark contrast to the stated goals of the model policy. The NHTSA fails to include a timeline for suggested evaluations and actions that states need to complete. While the model policy acknowledges that states must undertake changes and improvements to transportation infrastructure in order to ensure the safe operation of AVs, it fails to instruct the states on what specific upgrades are needed. In addition, the model policy does not set any standard for crash reporting deadlines or data requirements which will be crucial to state regulation of the testing and deployment of AVs. Not only are the paucity of details contained in the model policy of great concern, the proposal also contains several critical shortcomings on its face that must be rectified.

Introduction

Advocates agrees with the statutory mission of NHTSA to regulate the design and performance of motor vehicles including AV technology and vehicles to ensure public safety. However, so long as the agency chooses to issue merely voluntary guidance to address safety and regulatory issues on emerging AV technology, states have every legal right to fill the regulatory vacuum with state developed solutions. NHTSA, by issuing only guidelines, has left open the field of AV safety that can and must be filled by the states. As such, each state can currently dictate (and some already are) what tests it deems acceptable and what constitutes an acceptable or successful result. This decentralized process leaves an incredible amount of variability in standards and interpretation. Advocates urges the agency to issue regulations to govern the safety assessment process and other regulatory appropriate aspects of AVs that the agency has exercised with respect to the safety of non-automated motor vehicles.

NHTSA should partner with states to properly train and educate drivers on the proper use of AV systems; however, specific focus should be placed on training dealership sales personnel and vehicle buyers and drivers on the capabilities and limits of AVs including when a driver must retake control of an AV after disengagement of the autonomous system.

[35] NHTSA AV Policy, p. 37.

NHTSA should take a leadership role and work with the states to ensure enhanced requirements for AVs. The inadequate maintenance of an AV, particularly out of date software, could have disastrous consequences on its operation and public safety. These concerns merit that AVs receive a heightened standard of care from state regulators tasked with ensuring that all vehicles registered in a state are properly maintained.

Model State Policy

The NHTSA must require, and recommend that state law reinforce, the need for AVs to be designed to comply with all aspects of state motor vehicle and traffic laws. Furthermore, NHTSA should work with the Federal Highway Administration, the Federal Motor Carrier Safety Administration and the states to ensure that AVs are compliant with all highway and traffic requirements. Mandating this uniformity will greatly reduce the opportunity for errors by AVs when dealing with the current patchwork of state requirements or guidelines such as lane widths, road markings, and signage.

In terms of defining who the "driver" of an AV is the NHTSA AV Policy contains an apparent inconsistency. For level 3 AV systems, where the human driver has to be able to take over control of the vehicle, states should define the "driver" of the vehicle as the human operator of the vehicle not the AV system as proposed in the model state policy. NHTSA asserts that States should generally deem the AV system to be the "driver" of the vehicle for SAE Levels 3-5.[36] Later in the guidance, however, the NHTSA indicates that States should continue to regulate the "human" driver for AV "technologies that are less than fully automated, SAE levels 3 and lower."[37] For a level 3 vehicle where a driver is still tasked at various times with the operation of the vehicle, when the vehicle reaches its operational limits, the driver of such a vehicle must continue to be defined as the human operator.

Administrative

Advocates supports the establishment of a jurisdictional automated safety technology committee in each state as outlined in the model policy. However, the committees should be balanced and include strong representation from safety and consumer representatives as permanent official members. Placing these representatives on the committee will foster public confidence in the testing and deployment of AVs in their state and will encourage acceptance of the technology as it becomes more prevalent. In addition, these representatives can provide a unique and invaluable perspective to the committee as they consider numerous issues affecting consumers and public safety.

[36] NHTSA AV Policy, p. 39.
[37] NHTSA AV Policy, p. 43.

Jurisdiction Permission to Test

The lead state agency tasked with regulating AVs should prohibit the testing of AVs in safety sensitive areas such as school and construction zones as outlined in the model state policy. The malfunction of an AV while testing in such areas would be catastrophic. In addition, authorizations given for testing should be renewed on an annual basis due to the number of issues that could evolve during the course of a year involving experimental vehicles using such rapidly developing technology that could receive and require programming changes and updates at any time. Moreover, any authorization should immediately be reviewed after a notice of a crash involving an AV covered by the permit.

Testing by the Manufacturer or Other Entity

As outlined in the model state policy, not only should all crashes involving test vehicles be reported to the applicable state regulatory body, but any and all safety critical events such as near misses or operational malfunctions should also be disclosed to state regulators and the public. State regulatory bodies cannot accurately assess the progress of AVs and their ability to operate on public roads without this full and accurate picture of the performance of AVs during testing.

Law Enforcement Considerations

Advocates concurs with NHTSA's statement that "[f]or vehicles that offer less than full automated capabilities, there is potential for increased distracted driving."[38] Despite these obvious concerns, the agency continues to merely issue guidelines rather than regulations to govern in-vehicle and nomadic electronic devices that contribute to distracted driving, an issue that has long been identified by the safety community and the agency and supported by numerous research studies as a major public health epidemic.[39] For AVs that are less than fully automated, states must be encouraged to enact robust laws to govern any and all in vehicle distractions.

III. NHTSA's Current Regulatory Tools

Rulemaking Authority

The NHTSA's most broad-ranging authority to influence and govern motor vehicle safety, and to eliminate unreasonable risks to the public, is through proposing a standard to govern conduct and performance through a public rulemaking process. This is, and has been since the inception of the agency, the approach used to "adopt new standards, modify existing standards, or repeal an existing standard."[40] The establishment through regulation of safety standards for motor vehicle safety and related technology performance requirements is the standard and established agency

[38] NHTSA AV Policy, p. 45.
[39] Distraction.gov, NHTSA.
[40] NHTSA AV Policy, p. 49.

procedure. The current body of lifesaving federal motor vehicle safety standards (FMVSS) has been constituted through this process and procedure.

Public notice-and-comment rulemaking provides a number of important benefits. The regulated industry and the public receive a concise, detailed statement of agency plans and proposed rules, including testing procedures and performance requirements. It requires the agency to master detailed technical issues and to organize the analysis of benefits and costs of a proposed rule. The regulated entities and the public are afforded an opportunity to evaluate and analyze the proposal and provide focused feedback to the agency, including posing questions regarding matters that may require greater clarity as well as critical feedback on technical aspects of the rule. Rulemaking affords all stakeholders, including the public and the regulated industry, the platform for making broad, general philosophical statements regarding the agency proposal, as well as the avenue to address narrow, technical issues. The regulatory process clarifies the agency's intent as to what will be subject to a particular regulation and how the agency intends to regulate an aspect of motor vehicle equipment or operation. This is important to reach a general agreed understanding of the issue and assure only sound, well-reasoned requirements are imposed on the regulated industry. While rulemaking may, by its nature, take longer than other existing regulatory tools (e.g., interpretation letters or exemption petitions), rulemaking according to the agency "enables the Agency to make the broadest and most thorough changes to governing regulations, and gives the public the greatest opportunity to participate in the Agency's decision-making process."[41] In fact, the NHTSA states that rulemaking may be the best approach to address "a motor vehicle or equipment design [that is] substantially different from anything currently on the road [for which] compliance with standards may be very difficult or complicated. . ."[42] This description directly applies to the development and installation of AVs.

The future reliability and public acceptance of AVs would benefit greatly from regulatory action that sets a fair and level playing field for industry and, at the same time, provides transparency and oversight for the introduction of AVs into the motor vehicle fleet. While the NHTSA has not regulated every aspect of motor vehicles, crucial safety and operating systems have been regulated as part of the FMVSS or other pertinent regulations for decades. There is no clear and compelling reason why AV technology should be treated any differently or given greater leeway than previous mechanical or electronic technological innovations. Furthermore, there is no reason to believe that AV technology differs in any meaningful degree from the developments and improvements that have been routinely regulated over the past 50 years of automotive development. The agency cannot evade its statutory duty simply because the new technology seems complicated or highly technical.

The NHTSA has expressed its view that "only after new technology is developed and proven does the Agency establish new safety standards. * * * Strong safety regulations and standards are a vital piece of NHTSA's safety mission and the Agency will engage in rulemaking related to

[41] NHTSA AV Policy, p. 50.
[42] NHTSA AV Policy, p. 49.

automated safety technologies in the future."[43] While Advocates understands that, at present, there may not be sufficient information and data to establish minimum performance requirements for some aspects of AV systems, that does not mean that the agency should defer from regulating those aspects of AV performance that are already known but which are not yet regulated, such as autonomous emergency braking (AEB) systems. Moreover, NHTSA is not precluded from requiring manufacturers to adopt a functional safety process that will ensure appropriate testing of AV systems will be conducted to prove the systems' safe performance within the design parameters of the particular AV system.

The NHTSA has an obligation to the public to ensure that new, highly complex AV systems will perform safely. At this time the NHTSA should require each vehicle manufacturer, or other company producing the computer logic and software, to adopt a functional safety process that requires comprehensive testing of AV systems that the agency can review. This would ensure that the manufacturers are under a legal obligation to perform appropriate due diligence to disclose the results to the agency prior to motor vehicles equipped with AV system's being placed in the stream of commerce.

The agency can and should require manufacturers, as part of the self-certification requirement, to certify that sufficient functional safety testing and analysis has been performed to establish that the AV system will perform safely and as designed. To accomplish this, the agency should require all AV system manufacturers, by regulation, to adopt a functional safety process to conduct state-of-the-art testing and analysis to establish that the AV system performs safely and meets or exceeds all aspects of the systems design parameters. Such a requirement is intended to allow the manufacturer to document that its AV system(s) has been fully and extensively tested and that all critical features, including the programming software, operate properly. There must be a modicum of regulatory oversight by NHTSA to ensure that the AV system manufacturers are acting responsibly and have not taken any short-cuts in the rush to market.

Advocates' call for a regulation to require functional safety testing and analysis is based on empirical evidence. The May 7, 2016 crash of a Tesla Model S equipped with the Autopilot AV system feature is a real world example of why such regulatory action is necessary as well as the timely notification to NHTSA is essential.[44] Tesla has stated that it required drivers to acknowledge that they would remain engaged in the driving task. A functional safety analysis would have required Tesla to evaluate what happens when the system fails to identify a road hazard, when the driver is not engaged in the driving task, or when both failures occur simultaneously all of which are foreseeable. Functional safety requires consideration of all foreseeable and feasible failure modes, as well as unlikely and low probability failure modes. Blaming the driver for failing to heed a warning, or for over reliance on the AV system, is

[43] NHTSA Enforcement Guidance Bulletin 2016-02: Safety-Related Defects and Automated Safety Technologies, Final Notice, NHTSA, 81 FR 65705, 65706 (Sept. 23, 2016).

[44] The Tesla Autopilot System has been the subject of investigation in other crashes, including another fatal crash in China in January of 2016, Neal Boudette, *Autopilot Cited in Death of Chinese Tesla Driver*, The New York Times (Sep. 14, 2016).

inexcusable when technological means of mitigating the risks of sensor failures and human behavior are available.

The risk classification for failures in this and similar systems being developed must be very stringent since failure of the Autopilot sensors or the detection algorithm while travelling would present an unreasonable crash risk. Such an analysis, likely, would have led to requirements that additional sensors be added to the vehicle to mitigate the sensor "blind spot" created by using visual data from a camera with limited input from additional technologies such as radar or lidar. Tesla subsequently announced that it had fixed the problem through a new software update to the Autopilot System.[45] This flaw would have and should have been detected by Tesla during a functional safety analysis of the Autopilot System. Without such a required analysis, there may be other instances where readily detectible and foreseeable problems were not identified until after a crash occurs.

The functional safety analysis might also have resulted in additional driver engagement requirements such as driver monitoring and warning systems, and stronger driver reengagement methods to ensure driver readiness to retake control of the vehicle. In the functional safety analysis, Tesla would have been required to research, test, and examine not just the Autopilot sensor array, but driver reengagement readiness to prove that the design enabled drivers to either remain engaged in the driving task (as Tesla stated was necessary) or that re-engagement could be successfully accomplished in a safe manner. In fact, after the fatal crash the company instituted more warnings to the driver to remain alert while the Autopilot System is engaged.[46] It is the NHTSA's responsibility to require functional safety certification to eliminate the types of system failures that resulted in a fatality and eliminate the need for "after the fact" improvements which should have been anticipated.

While the NHTSA's proposed voluntary submission of a letter (addressed above) has many of the hallmarks of what is needed to be reported to the agency, a regulation must, first and foremost, require manufacturers of AV systems for motor vehicles to adopt a functional safety process that will ensure that the manufacturer tests its AV system appropriately and comprehensively. Second, documentation of all test results, those that establish the functional safety of the system, as well as any information that indicates the failure of the AV system to fulfill functional safety parameters, must be provided to NHTSA in advance of placing the AV system or AV equipped vehicle in the stream of commerce. Finally, these aspects must be made mandatory, rather than voluntary, in order to ensure that the manufacturers are legally obligated to adopt an effective functional safety process and to supply all relevant information to the agency.

[45] Louis Hansen, *Tesla turns to radar in upgrade of Autopilot*, The Mercury News (Sept. 11, 2016). In fact, Tesla has not provided any evidence that the problem has been fixed.
[46] *Id.*

Enforcement Authority

In relation to the NHTSA's enforcement authority, the NHTSA AV Policy states that "when vulnerabilities of [automotive] technology or equipment pose an unreasonable risk to safety, those vulnerabilities constitute a safety-related defect"[47] that can spur the agency to investigate and take remedial action including ordering the manufacturer to conduct a safety recall.[48] Moreover, the agency's enforcement authority applies " 'notwithstanding the presence or absence of an FMVSS for any particular type of advanced technology.' "[49] Advocates strongly supports the NHTSA's enforcement efforts to investigate, identify and recall noncompliant or defective vehicles. Advocates views the enforcement role played by the agency as critical to ensuring that motor vehicles, once in use, perform safely. However, the agency position begs the question as to why the agency would forego issuing a prospective regulation to improve the safety performance of production models and eliminate safety flaws in AV systems before they are sold to the public. The NHTSA's enabling statute recognizes that the agency must act in a proactive manner to avoid and reduce crashes, injuries and deaths in the first place.[50] Rather than relying entirely on its enforcement authority, the agency should also be actively ensuring through regulatory, as opposed to only voluntary, action that AV systems are produced without production flaws before the AV systems are sold to the public, placed in the stream of commerce, and then subsequently have to be recalled.

The historic and well-founded approach of the NHTSA has been to require, in the first place, specific minimum performance requirements or standards that vehicle manufacturers must certify that each vehicle meets. These standards raise the quality and safety performance of motor vehicles before sale to the public. While its enforcement authority does permit the agency to investigate and recall vehicles for safety defects even if there is no underlying performance standard, the lack of an underlying performance standard may complicate the exercise of the agency's enforcement authority. This is a significant concern for electronically controlled systems and software where a specific flaw or malfunction may be more difficult to identify. If there is no underlying requirement or process, manufacturers will be far less cautious about ensuring the operating safety of the vehicle prior to sale.

Finally, although the NHTSA's enforcement authority is extensive, safety flaws may take years to identify and recall. This has been the situation with a number of safety recalls. In 2000, congressional hearings and the media revealed hundreds of needless deaths and injuries caused by the Firestone/Ford Explorer defective tire fiasco because of delayed agency action. Again, for the same reason, in 2009, families were put at unacceptable risk due to the Toyota sudden acceleration problem. In the past several years, the public has learned about the cover-ups and deception by General Motors which knowingly used faulty ignition switches that have been

[47] NHTSA AV Policy, p. 50.
[48] NHTSA AV Policy, p. 50.
[49] NHTSA AV Policy, p. 50, citing NHTSA Enforcement Guidance Bulletin 2016-02: Safety-Related Defects and Automated Safety Technologies, 81 FR 65705, 65707 (September 23, 2016).
[50] 49 U.S.C. § 30101.

linked to at least 169 deaths and many more injuries because of long delayed agency action.[51] Furthermore, the defective air bags manufactured by Takata have resulted in millions of vehicle recalls and have caused at least 11 deaths in the U.S. and numerous injuries because, in part, of delayed agency action.[52]

Although its enforcement powers are necessary, they are not executed immediately after a safety defect involved crash occurs. It may then take months or years to establish that a defect exists and what the defect is and then more time to convince the manufacturer that a recall is appropriate and, even then, further negotiation to ensure that the scope of the recall is adequate, and all that time assumes that a remedy is available. Thus, while the agency's enforcement authority is necessary and essential, to identify safety defects, it does not provide the prophylactic safety effect of standards and regulations.

Exemption Authority

Advocates is concerned with the NHTSA AV Policy's discussion of the use of exemption authority and proposed expansion of that authority. Compliance with safety standards must be maintained to ensure that all consumers are afforded a minimal level of safety. Advocates concurs with the agency statement that "[g]eneral exemptions do not excuse non-compliance with applicable standards simply because doing so would be inconvenient or inconsistent with the manufacturers' preferred vehicle design."[53] However the agency in its discussion regarding expanding its general exemption authority considers not only increasing the number of vehicles and duration of the exemptions, but also mentions the possibility of moving towards relaxed limitations or even eliminating numerical limits for exempt vehicles altogether.[54] Advocates strongly opposes this idea which will compromise safety.

As Advocates' comments on countless past general exemptions have shown, particularly from the FMVSS, the standard for proving that an alternative approach represents an equivalent level of safety to the existing regulatory requirement is murky.[55] Furthermore, Advocates is concerned that expansion of the exemption authority would lead to an alternative path around FMVSS compliance. Advocates concurs with the agency's expressed concern that "it would be important to guard against overuse of the exemption authority which might displace rulemaking as the ***de facto*** primary method of regulating motor vehicles and equipment."[56] For this reason alone, the expansion of exemption authority should be avoided. This is not the intent of the agency's organic statute, its current exemption authority, or the preferred means by which the agency should ensure public safety. Advocates recommends that the agency focus on efficiently

[51] Angelo Young, *General Motors Ignition Switch Flaw Death Toll Rises To 169 Following Personal Injury Settlement; Penalty Costs Top $2.1B*, International Business Times (Sept. 17, 2015)
[52] Ryan Beene, *11th U.S. death related to Takata airbags reported by Honda*, Automotive News (Oct. 20, 2016).
[53] NHTSA AV Policy, p. 55.
[54] NHTSA AV Policy, p. 76.
[55] Most exemption requests are supported by little or no substantive data that meets the equivalent level of safety legal standard.
[56] NHTSA AV Policy, p. 76 (emphasis added).

addressing current regulatory shortcomings and adapting current requirements through rulemaking rather than eviscerating the rules through exemptions.

IV. Modern Regulatory Tools

Safety Assurance

The discussion of Safety Assurance in the NHTSA AV Policy document confirms that the NHTSA could establish, by rule, a mandatory Safety Assurance requirement "to demonstrate that motor vehicle manufacturers' and other entities' design, manufacturing, and testing processes apply NHTSA performance guidance, industry best practices, and other performance criteria and standards to assure the safe operation of motor vehicles, before those vehicles are deployed on public roads."[57] This could apply to level 0-2 vehicles as well as level 3-5 AVs as well. The agency makes clear that "NHTSA could implement many safety assurance tools without additional statutory authority."[58] Advocates completely agrees and urges the agency to pursue this course of requiring manufacturers to establish a functional safety based assessment process to be reviewed by the agency. The adoption of a required safety assurance process for AVs would still be consistent with the manufacturer self-certification procedure required by existing law.[59] Manufacturers would have to comply with the safety assessment process and allow NHTSA an opportunity to review the AV documentation and request additional information. However, following the agency review the manufacturer would be able to self-certify the AVs as under current law. The agency would not itself pre-test prototype AVs to ensure that they conform to the FMVSS and the verifications contained in the manufacturer safety assessment.

Pre-Market Approval Authority

Pre-market approval would allow the agency to conduct testing on prototype vehicles and to ensure no AVs are marketed without approval. This may be particularly important for highly complex electronic aspects of vehicle control and to allow examination of computer programming and logic. However, it is an entirely different regulatory system that exists currently at the NHTSA. Regardless, the safety assessment aspect of the agency guidance could be put into place by rule, without the need for pre-market approval legislation.[60]

Cease and Desist Authority

Advocates strongly supports the enactment of legislation to afford the NHTSA cease and desist authority to immediately remediate imminent hazards. This authority, possessed by other

[57] NHTSA AV Policy, pp. 70-71.
[58] NHTSA AV Policy, p. 71.
[59] Title 49, U.S.C., § 30115.
[60] The NHTSA's discussion of a hybrid approval process that would combine self-certification of existing FMVSS and pre-market approval by the NHTSA, or a third party expert supervised by the agency, for AV features that are not subject to an FMVSS or regulation, still require Congress to pass pre-market legislation.

regulatory administrations, including the Federal Motor Carrier Safety Administration, would allow the agency to expedite taking action in the event that a serious problem or defect poses an immediate danger to public safety. In a number of previous and recent safety recalls, the agency might have invoked such authority to ground vehicles that pose a significant unreasonable risk to public safety. Imminent hazard authority would still require some measures of due process and court review to ensure that the agency does not act impetuously, but would allow a faster response to address a serious safety problem.

Post Sale Authority to Regulate Software Changes

Advocates agrees with the NHTSA that the agency currently has authority to regulate software changes that update vehicle programming and could affect the basis for the original vehicle certification. As the software governing an AV is part of the vehicle or vehicle equipment, the agency has authority to regulate changes that could affect vehicle safety systems and that could result in a defect or give rise to an unreasonable risk to safety. The agency should require by regulation any post sale software update be submitted to NHTSA and made available for public review with a summary of the changes that were implemented.

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