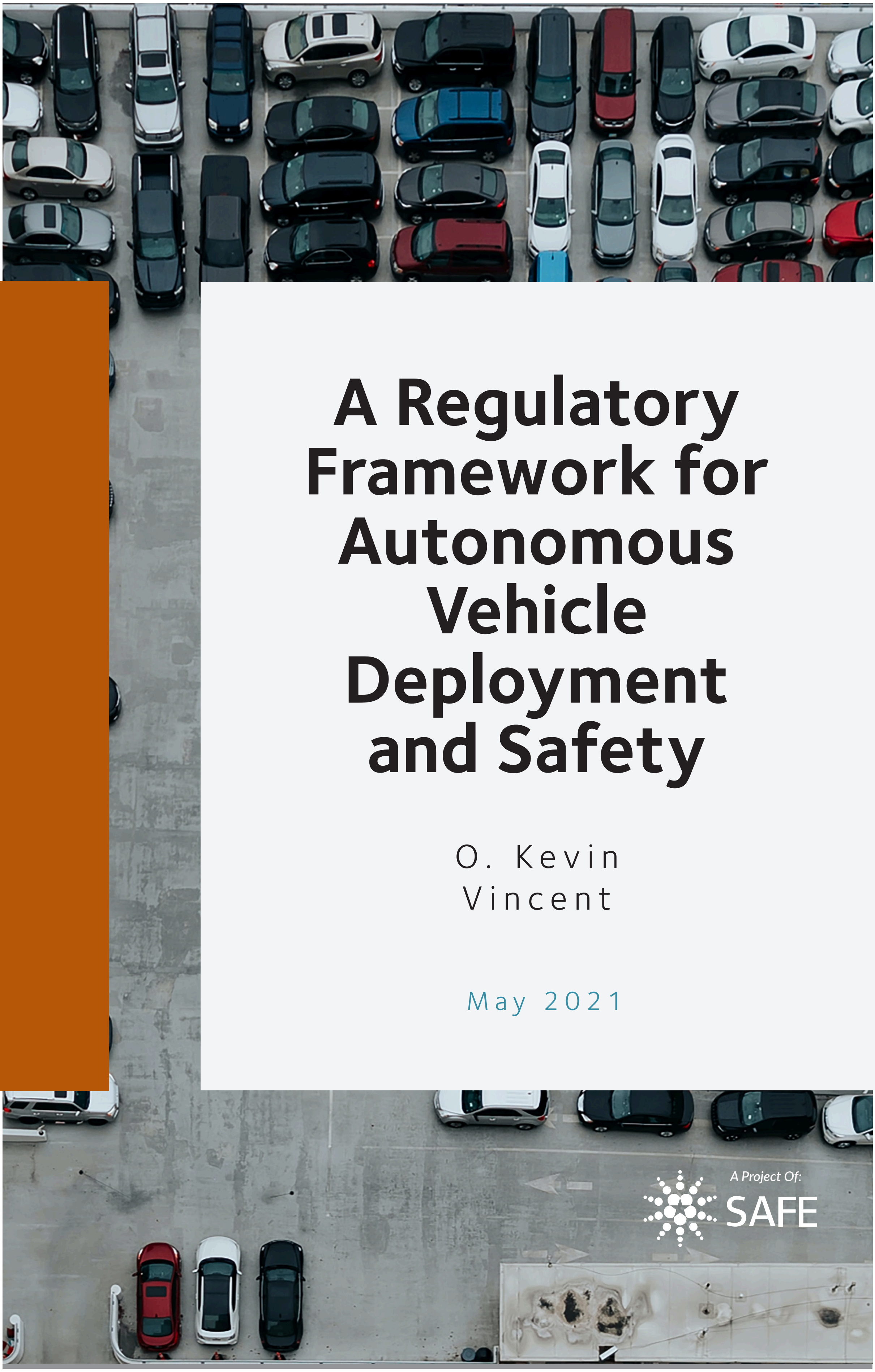

A Regulatory Framework for Autonomous Vehicle Deployment and Safety

O. Kevin Vincent

May 2021

A Project Of: SAFE

About the Author

O. Kevin Vincent is the Associate General Counsel for Regulatory issues at Lucid. Prior to joining Lucid, he advised companies in the electric vehicle and automated vehicle industries on legal and regulatory issues. Mr. Vincent held in-house positions with two EV manufacturers, and more recently had his own practice advising multiple clients on EV and AV issues. Mr. Vincent's background includes serving as the Chief Counsel for the National Highway Traffic Safety Administration (NHTSA), Department of Transportation, in Washington, D.C. In that role, Mr. Vincent provided legal advice to the NHTSA Administrator and other DOT officials, including the General Counsel and Secretary of Transportation, on transportation safety and fuel economy issues. While at NHTSA, Mr. Vincent accelerated adoption by the automobile industry of "green" technologies, having managed the drafting of the Corporate Average Fuel Economy (CAFE) greenhouse gas reduction regulations jointly issued by NHTSA and the EPA, leading to adoption of new technologies to improve fuel efficiency. Mr. Vincent's efforts helped result in the historic CAFE/CHG standards for Model Years 2017-2025 light duty vehicles that doubled the fuel efficiency of our nation's vehicles.

About SAFE

Founded in 2005, SAFE is a non-partisan organization that enhances the nation's energy security and supports our economic resurgence and resiliency by advancing transformative transportation and mobility technologies and ensuring that the United States secures key aspects of the technology supply chain to achieve and maintain our strategic advantage.

SAFE's sister organization, the Electrification Coalition works with consumers, businesses, and policymakers, to launch award-winning "real-world" programs and advocate for polices to accelerate transportation electrification around the country to reduce our nation's dependence on oil.

SAFE succeeds through an action-oriented approach. SAFE is not constrained by party or ideology. It is not a trade association, nor is it narrowed to one policy or technology. Instead, it identifies the problem and uses high-quality, fact-based analysis to develop the best policy solutions. Armed with a lucid understanding of the issues and expert policy recommendations, SAFE's network of advocates work to deliver results that benefit the nation. SAFE consciously maintains a strategic ability to adapt to rapidly evolving developments - including emerging technologies such as self-driving vehicles and economic and geopolitical trends such as Middle East instability and China's advancing ambitions to control the next generation of transportation - connected, shared, autonomous and electric vehicles - including the batteries that power them and the 5G technology that connects them.

The views expressed in this paper are solely the views of the author.

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Letter to the Reader

Promising step-changes in productivity for economic growth, an ability to maintain leadership in the transportation sector by competing with China, saving lives on our roads, and increases in efficiency and the acceleration of electric vehicle adoption, autonomous vehicles (AVs) hold the potential for U.S. economic and societal advancement on a scale unseen since the invention of the automobile itself. AVs can follow in the footsteps of the Interstate Highway System and the Internet as the next catalyzing technology to realize dramatic economic growth across all sectors.

The promise of affordable, point-to-point autonomous transportation, with novel vehicles redesigned from the ground up, also portends significant benefits for underserved communities. Improvements in emissions through a widespread deployment of electric, autonomous vehicles would positively impact public health and the environment. Moreover, AVs stand to greatly increase economic opportunities and provide upward economic mobility, as low-income communities can access low-cost transportation that plugs the systemic gaps in today's mass transit systems. For the disability and senior citizen communities, often unable to either access conventional mass transit or afford private or paratransit alternatives, AV transportation allows them the opportunity of greater participation in American public life.

Most importantly of all, however, is the tremendous potential of AVs to dramatically improve safety on our nation's roads. Deaths on American roadways are rising: The National Safety Council estimates that more than 42,000 people died on U.S. roads in 2020 - an 8 percent increase on the figures from 2019, despite fewer miles driven during the pandemic. As 94 percent of U.S. road accidents are due either wholly or in part to human error, an automated driver - unable to drive drunk, tired, or distracted - promises meaningful, lasting reductions road deaths and injuries, with the potential for continued improvement over time.

Safety is therefore a critical metric of AV regulation and deployment, but in the absence of a federal framework for AVs industry has faced uncertainty as a patchwork of state regulatory approaches fill the vacuum. SAFE, with the support of Intel Corporation, asked O. Kevin Vincent, former Chief Counsel of the National Highway Traffic Safety Administration, to provide an overview of the existing framework for the regulation of AVs in the United States and offer recommendations for a federal safety framework. The paper recommends a three-pronged framework focused on performance standards and the capacity of the AV to make safe decisions, process standards and the capacity of the AV to make the decisions its manufacturer says it will make, and the capacity for prompt corrective action if necessary.

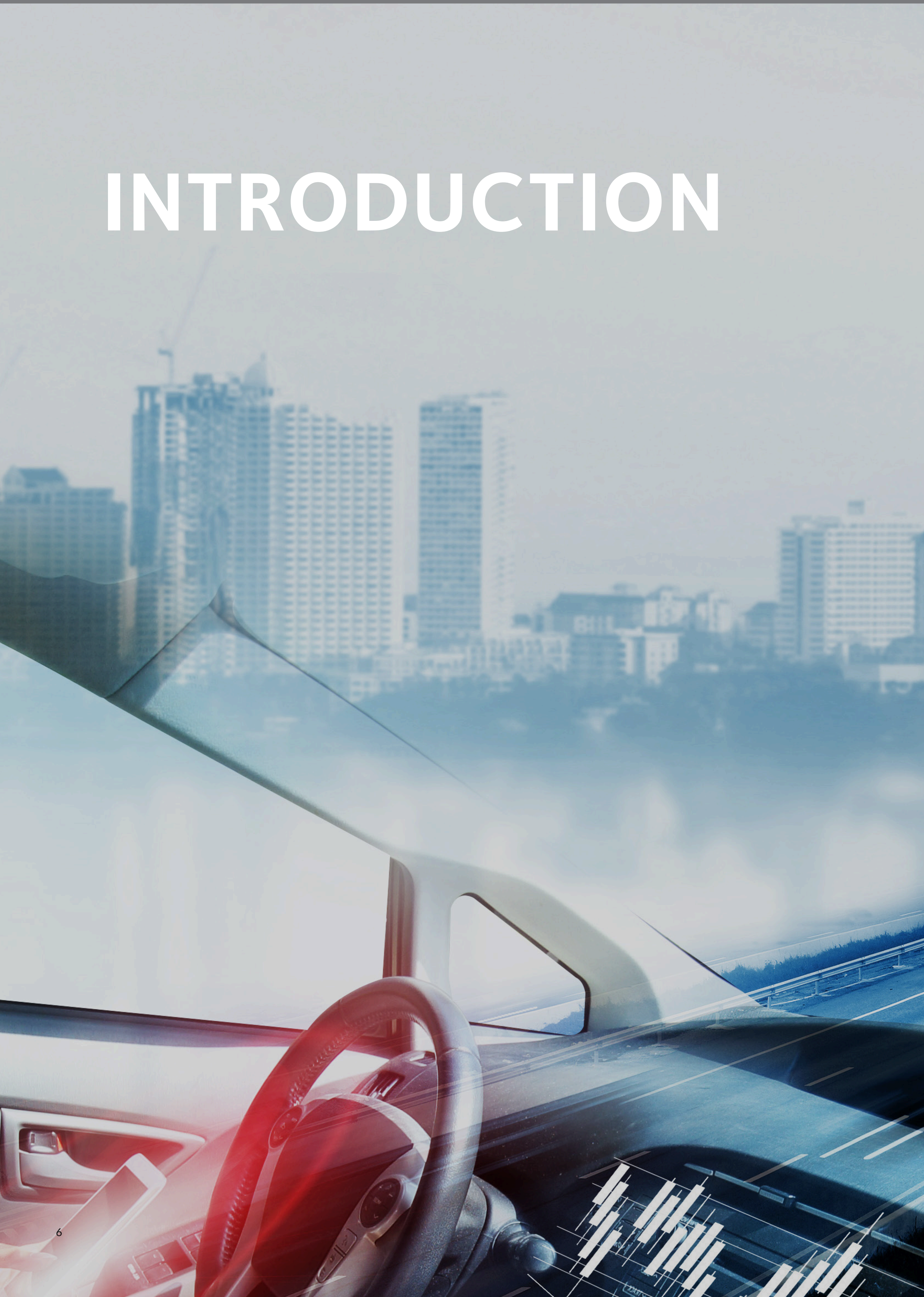
The paper asserts that regulatory certainty balanced with the ability to innovate is critical for the responsible, expeditious deployment of AVs. This AV deployment will not just create a vehicle fleet that enhances safety, promotes equity, protects the planet, and improves public health, but also ensures that the United States maintains global leadership in transportation technology for the movement of people and goods.

Sincerely,

Robbie Diamond

Robbie Diamond
Founder, President and CEO
SAFE

INTRODUCTION



Introduction

Autonomous vehicles (AVs) have the potential to substantially reduce the estimated 94 percent of collisions that are caused by human error or choice. These collisions - the majority of which are caused by speeding, driving under the influence, or distraction - take the lives of 38,000 Americans annually, and injure millions more. The economic and social harm of these collisions adds up to nearly $1 trillion per year, which is an immense financial cost in addition to the devastating toll on the families of victims.[1]

Despite the safety benefits that AVs can bring, developers assert that regulatory uncertainty is holding back deployment of AVs in the United States. Conversely, safety advocates insist that AVs need to be subject to stringent regulation before they are allowed to operate on public roadways. This paper proposes a three-pronged Framework for Autonomous Vehicle Safety that can help to accelerate the deployment of AVs while making sure they improve safety for the American public.

The countries that lead in the development and integration of AVs will significantly influence the global automotive industry, and reap the benefits resulting from a new mobility paradigm. While the United States leads in AV technology, China is looking to close the gap. Beijing has launched a government-led AV development strategy. Central to this strategy is establishing a clear set of rules and regulations at the national level, which can eliminate regulatory uncertainties and may help the industry develop in a more standardized fashion relative to the United States. It is imperative that the United States act swiftly to ensure that regulatory uncertainty does not hold back the deployment of AVs in the United States.

The three prongs of the approach we propose are: (i) Performance Standards; (ii) Process Standards; and (iii) Prompt Corrective Action. These three elements address the fundamental questions that the public raises about the safety of AVs.[2] Performance Standards answer the question of "How do we know that a driverless vehicle will make decisions that will keep people safe?" Process Standards answer the question, "How can we trust that autonomous vehicles will make the decisions that the manufacturers say they will?". The Prompt Corrective Action prong of our approach answers the ultimate question, "How can we be kept safe if notwithstanding these Performance Standards and Process Standards, something still goes wrong?" This article explains the existing framework for regulation of AVs in the United States and each prong of our proposed approach.

The Existing Regulatory Framework in the United States

The United States does not currently have national regulations that apply specifically to AVs. Instead, AVs are subject to the same Federal Motor Vehicle Safety Standards (FMVSS) that all other new automobiles in the United States must meet (with only very limited exceptions).[3] The FMVSS do not regulate everything on a car, but only certain vehicle components. Most of the mechanical components of vehicles that can create a risk to safety (for example brakes and tires) are subject to the FMVSS, but with few exceptions, a vehicle's electronics are not covered by the FMVSS.[4] The FMVSS were all written with the natural assumption that a human being would be the driver of the vehicle. That assumption, of course, is incorrect with regard to self-driving vehicles, and as a consequence, it is difficult or even impossible to determine whether an AV complies with many of the FMVSS.

As written today, the FMVSS do not regulate the control unit for the vehicle - the decision-maker that decides whether and when the vehicle accelerates and brakes, turns, honks its horn or takes any other action that affects safety. That is because until the advent of AVs, the decision maker who controls the vehicle has been a human driver. Federal law does not regulate human drivers. Instead that has been left to the states. The states regulate drivers through driving tests as a condition of drivers' licenses, and through the enactment and enforcement of state and local traffic laws that govern the decisions that drivers make as they operate their vehicles. Although the states are allowed and expected to regulate human drivers who control vehicles,

1 SAFE, *America's Workforce and the Self-Driving Future: Realizing Productivity Gains and Spurring Economic Growth*, June 2018.

2 85 Fed. Reg. 17624; and Note: The United States Department of Transportation (DOT) uses the term "automated driving system" or "ADS" to describe Levels 3 through 5 automation in vehicles. DOT has begun using the term "ADS-Dedicated Vehicle" or "ADS-DV" for vehicles with Levels 4 and 5 automation that do not require a human operator in the vehicle. Rather than the cumbersome term ADS-DV, we use the terms "self-driving vehicle" and "autonomous vehicle" in this proposed framework for driverless vehicles that operate as Level 4 or Level 5 automated vehicles.

3 49 C.F.R. § 571.7(c); 49 U.S.C. § 30102(a)(7); and Note: The FMVSS are found in 49 C.F.R § 571. Off-road vehicles, military vehicles and vehicles propelled by human power without a motor (primarily bicycles) are not subject to the FMVSS.

4 49 C.F.R, § 571.126; 49 C.F.R. § 571.138; and Note: Most vehicle components include electronics in modern cars, but the applicable FMVSS for each component was written for a mechanical device, and electronics are not necessary for compliance. Among the few exceptions are FMVSS 126 (electronic stability control systems) and FMVSS 138 (tire pressure monitoring systems).

federal law preempts the states from regulating the design or manufacturing of the vehicle itself if the state regulation would conflict with the FMVSS.[5]

NHTSA's Clarification of the FMVSS to Allow AVs

A few years ago, the National Highway Traffic Safety Administration (NHTSA)[6] embarked upon a process to "modernize" the FMVSS so that the standards make sense when applied to autonomous vehicles. NHTSA has explained that its approach "is to clarify the *unintentional* barriers to innovation" with automated vehicles that result from the assumptions about a human driver in the FMVSS.[7] The agency began this process in March 2016 by publishing a report with the Volpe National Transportation Systems Center.[8] It then retained the Virginia Tech Transportation Institute (VTTI) in 2017 to conduct a still-ongoing study,[9] released a Request for Comment,[10] held public meetings,[11] announced that it was initiating eight separate rulemakings by assigning a Regulatory Information Number (RIN) to each rulemaking, published three Advance Notices of Proposed Rulemaking (ANPRMs), and issued the Notice of Proposed Rulemaking for Occupant Protection for Automated Driving Systems (the Occupant Protection NPRM). [12]

Only nine days before the end of the Trump administration, the U.S. Department of Transportation (DOT) issued an "Automated Vehicles Comprehensive Plan."[13] This plan lays out DOT's claimed accomplishments over the last four years, as well as the additional work that the Department needs to do, to advance the development of AVs. The plan summarizes NHTSA's rulemakings discussed above, as well as work by other DOT modes such as the Federal Motor Carrier Safety Administration (FMCSA) related to AVs, and identifies specific NHTSA rulemakings that need to be completed. The Biden administration has not set forth any clear policies for AVs, however, so it remains to be seen which, if any, of the rulemakings initiated by NHTSA under the Trump administration will be completed.

Table 1 on page 12 lays out the rulemakings that NHTSA has so far initiated as part of updating the FMVSS for vehicles with automated driving systems (ADS). However, NHTSA's work to update the FMVSS so that the standards apply to self-driving vehicles is far from complete. Each of the rulemakings listed in the table requires additional steps before there can be a final rule. NHTSA finished work on the NPRM updating the Occupant Protection standards - the rulemaking that is farthest along - before the end of the Trump administration, but the new Biden administration may make changes before the final rule is issued, or it may put the rulemaking on hold indefinitely, or even cancel it altogether.[14] For many of these rulemakings, the agency still needs to issue an ANPRM, an NPRM, and then a final rule. Each of these rulemakings will take months to complete, and it is unlikely that the process to update the current FMVSS to apply to AVs will be finished within the next couple of years.

In addition to using the rulemaking process to issue new standards and to revise the existing standards in the FMVSS, NHTSA has authority to provide official interpretations of the FMVSS as they are presently written. While NHTSA's laborious process to update the FMVSS to make them compatible with self-driving vehicles is underway, the agency is also slowly rolling out guidance on how to interpret the existing FMVSS in a way that will allow the development of AVs. In 2016, NHTSA issued a formal interpretation in response to a request from Google (now Waymo) for clarification on how the term "driver" in the FMVSS should be interpreted with reference to driverless vehicles.[15] More recently, on May 20, 2020, NHTSA published *FMVSS Considerations for Vehicles with Automated Driving Systems*, Volume I, to "translate" the

5 49 U.S.C. § 30103(b)(1).

6 NHTSA is an agency of the United States Department of Transportation (DOT).

7 85 Fed. Reg. 17624, at p. 14.

8 Anita Kim et al., Review of Federal Motor Vehicle Safety Standards (FMVSS) for Automated Vehicles, Preliminary Report, March 2016.

9 U.S. Department of Transportation, Occupant Protection NPRM, at p. 12.

10 83 Fed. Reg. 2607.

11 85 Fed. Reg. 17624, at p. 14.

12 Note: This NPRM covers some of the Occupant Protection standards in the 200 Series of the FMVSS.

13 See, e.g., U.S. Department of Transportation, *Automated Vehicles Comprehensive Plan*, January 2021.

14 Green Car Congress, "NHTSA issues final rule to modernize autonomous vehicle safety standards," January 15, 2021; and Note: On January 13, 2021, with only one week left in the Trump administration, NHTSA's Deputy Administrator signed a Final Rule in this rulemaking, but it will only go into effect when published in the Federal Register. Washington Post, "Biden Signs Executive Orders as Democrats Take Control of Senate," January 20, 2021; and Note: On the afternoon of President Biden's Inauguration on January 20, 2021, the President's Chief of Staff directed agencies to withdraw from the Federal Register all notices issued by the Trump administration that were waiting for publication.

15 Paul Hemmersbaugh, "Compiled Response to November 12, 2015 Interpret Request," National Highway Traffic Safety Administration, U.S. Department of Transportation, February 20, 2016; National Highway Traffic Safety Administration, "Notice Regarding the Applicability of NHTSS FMVSS Test Procedures to Certify Manufacturers," U.S. Department of Transportation, December 21, 2020; and Note: On December 21, 2020, NHTSA issued a Notice modifying this Interpretation.

requirements for 12 of the standards in the current FMVSS and FMVSS test procedures so that they can be applied to AVs.[16] As indicated in the title, this "translation" task is incomplete and Volume II of the *FMVSS Considerations* is still to come.

Although NHTSA's interpretations and "translations" of the FMVSS will assist AV developers in the interim before NHTSA completes its rulemakings to modernize the FMVSS for automated vehicles, the current FMVSS may still present a roadblock to new designs of AVs. Until NHTSA completes its work modernizing the FMVSS for AVs, NHTSA and AV designers will need to resort to the FMVSS exemption process to address unconventional designs that lack traditional features used by human drivers such as steering wheels and mirrors.[17] NHTSA will consider exemption requests on a case-by-case basis to determine if compliance with particular FMVSS are unnecessary for a manufacturer's design of its AVs. The recent exemption from three of the FMVSS granted to Nuro,[18] as well as the request for an exemption filed by General Motors,[19] are illustrative of the approach that NHTSA will follow in processing requests by AV manufacturers for exemptions from the FMVSS.[20]

No Federal Regulation of the "Driver" of an AV

NHTSA's ongoing work to "modernize" the FMVSS will enable AV developers to prove that their vehicles can meet the same safety standards that other vehicles on the road have to meet, but the present FMVSS are based on the premise that a capable human driver is behind the wheel. There will be no human driver - capable or not - "behind the wheel" of a self-driving vehicle, and there will not even be a steering wheel in some AVs. In a self-driving car, an ADS takes the role formerly performed by a human driver to control the vehicle. NHTSA's modifications to the FMVSS do nothing to ensure that the automated driving systems will perform as safely as would human drivers. NHTSA acknowledges that its current regulations do not address this aspect of the safety of new ADS, including self-driving vehicles, and that "[o]nly existent FMVSS are covered as part of the scope of this effort. The development of future standards is considered outside of the project's scope."[21]

Autonomous vehicle developers proclaim that automation will improve safety on U.S. highways and eventually eliminate most crashes. NHTSA and the DOT clearly accept the premise that automated vehicles will improve vehicle safety, and NHTSA has issued multiple policy documents touting the potential for "improved safety and a reduction in roadway fatalities" from automated vehicles.[22] After all, most crashes are caused by drunk driving, distracted driving, drivers becoming drowsy or falling asleep at the wheel, or drivers violating speed limits or other traffic laws. Moreover, ADS do not drink or sleep, will not get drowsy or distracted, and can be programmed to obey all speed limits and traffic laws.[23] So, as a consequence, advocates of AVs assert that automation must improve safety and save lives. Yet, the public is well acquainted with the risk of computer failures in other contexts and reasonably expects that there will be backup systems that eliminate the risk of computer failures in AVs.[24] NHTSA has not proposed regulations to preclude the possibility of these risks in the computers that control AVs.

Safety advocates recognize the potential for improved safety from automated vehicle technologies, but many demand regulations to ensure that self-driving cars live up to their potential for improved safety. They contend that these regulations must be in place before AVs are allowed to

16 National Highway Traffic Safety Administration, *FMVSS Considerations for Vehicles with Automated Driving Systems: Volume 1*, U.S. Department of Transportation, April 2020.

17 U.S. Department of Transportation, *Preparing for the Future of Transportation: Automated Vehicles 3.0*, October 2018, at pp. 7-8.

18 National Highway Traffic Safety Administration, *Nuro, Inc., Grant of Temporary Exemption for a Low-Speed Vehicle with an Automated Driving System*, Dkt. No. NHTSA-2019-0017, U.S. Department of Transportation, February 11, 2020.

19 General Motors, *Safety Petition*, National Highway Traffic Safety Administration, U.S. Department of Transportation, January 11, 2018.

20 See e.g., National Highway Traffic Safety Administration, "Petitions to NHTSA," U.S. Department of Transportation, Webpage; National Highway Traffic Safety Administration, "NHTSA Grants Nuro Exemption Petition for Low-Speed Driverless Vehicle," U.S. Department of Transportation, February 5, 2020; Reuters, "Cruise, GM to Seek U.S. kay for Self-Driving Vehicle Without Pedal, Steering Wheel," October 21, 2020; and Note: They are also illustrative of how long the exemption process will take. Nuro submitted its request for an exemption on October 23, 2018 and NHTSA issued the notice granting the exemption on February 6, 2020. General Motors submitted its petition for an exemption on January 11, 2019 and announced in October 2020 that it would be withdrawing the petition, while it is still under consideration by NHTSA.

21 National Highway Traffic Safety Administration, *FMVSS Considerations for Vehicles with Automated Driving Systems: Volume 1*, U.S. Department of Transportation, April 2020, at p.2.

22 National Highway Traffic Safety Administration, *Automated Driving Systems 2.0: A Vision for Safety*, U.S. Department of Transportation, September 2017.

23 National Highway Traffic Safety Administration, "Risky Driving," U.S. Department of Transportation, Webpage.

24 Note: The public should not be concerned about this risk in connection with the vehicles being developed by responsible AV companies, because these companies are following ISO 26262 (discussed further below) and other industry standards that would eliminate this risk. But the point of this article is that these industry standards are not mandatory and an AV developer could choose to ignore them.

operate on public roads without a human driver.[25] Moreover, the public is naturally concerned about new risks that will arise when there is no longer a human in control of moving vehicles.

The 2018 crash in Arizona of an Uber vehicle operating in self-drive mode with backup safety driver sitting in the driving seat resulted from an error that a human would not make. Uber's AV in that crash recognized that an object was crossing the road in time to brake, but because the object was not crossing the road at a designated crosswalk, the AV "decided" that the object was not a human being and did not apply the brakes before it struck the pedestrian.[26] A car driven by a human might strike and kill a jaywalker because the driver was not paying attention, but no human driver would classify a jaywalker as an object that did not warrant braking.[27] NHTSA has not initiated rulemaking to address new risks that may occur when vehicles are designed to operate without a human driver, such as the risk revealed by Uber's automated vehicle.[28]

Instead, NHTSA and the DOT have made it clear that their policy is not to issue new regulations for self-driving vehicles, at least at the present time. NHTSA has issued four separate policy statements on automated vehicles, and each policy has emphasized that it is only guidance and not an enforceable regulation.[29] The "nonregulatory approach to automated vehicle technology safety" set forth in the AV 2.0 policy includes 12 principles that NHTSA recommends that automated vehicle companies follow in designing their vehicles, but as the Policy succinctly states, "[t]his Guidance is entirely voluntary, with no compliance requirement or enforcement mechanism."[30] Although detailed guidance documents issued by NHTSA - the agency with the expertise and responsibility for ensuring vehicle safety on America's highways - could create tort liability for vehicle manufacturers that choose to ignore the guidance, the 12 design principles recommended by NHTSA's policy statement are so general in nature that reputable AV manufacturers will have little difficulty in showing that they have followed the guidance.

There is a legitimate argument that regulations cannot or should not be proposed by NHTSA or other regulatory bodies before industry and government learn more from the various testing in real world conditions. It is a challenge to find the right balance between learning about and regulating a technology before we fully understand how it works and the risks its use creates. Nevertheless, most companies have been remarkably responsible in real world on road testing with public safety in mind.

A "Patchwork" of State Regulations Filling the Void

In the absence of regulation by NHTSA, various states have stepped in to try and regulate the safety of automated vehicles, including self-driving vehicles. The state laws and regulations range from the restrictive (e.g., California)[31] to the permissive (e.g., Florida).[32] Automated vehicle

25 Cathy Chase and Beth Osborne, "Without Regulation, Self-driving Cars Could Be a Hazard," Advocates for Highway and Auto Safety, May 3, 2020; and Insurance Institute for Highway Safety, "Lax U.S. Oversight of Industry Jeopardizes Public Safety," August 7, 2018.

26 National Transportation Safety Board, *Collision Between Vehicle Controlled by Developmental Automated Driving System and Pedestrian, Tempe, Arizona*, NTSB/HAR-19/03, November 19, 2019; and Note: This classification error by Uber's AV was one of several errors that NTSB identified as causing the fatal collision. In light of this collision, Uber ATG has certainly corrected the algorithms of its ADS to make sure this error will not be repeated and if the ADS of any other reputable AV developer was susceptible to the same error, that has certainly been corrected as well.

27 Note: In fact, human drivers might make such a decision, but there would be criminal consequences to any human making that decision.

28 James Owens, "Keynote Address at Automated Vehicles Symposium," July 29, 2020; Jonathan Morrison, "Speech at Chapter Event on Safety & Regulation," The Autonomous, July 9, 2020; and Note: In conferences in 2020, DOT had indicated that NHTSA's upcoming ANPRM for Safety Principles for ADS announced in RIN AM15 could seek comment on adding an FMVSS for ADS safety, but the Department's preferred approach was for the ADS Safety Principles to be "sub-regulatory." The ANPRM released in December 2020 by NHTSA (renamed as the "Framework for ADS Safety") clearly evinced a preference for a "sub-regulatory approach" to AV safety instead of enforceable standards in the FMVSS. See, e.g., National Highway Traffic Safety Administration, 49 C.F.R § 571 *Framework for Automated Driving System Safety*, U.S. Department of Transportation, November 19, 2020, at pp. 17-19; National Highway Traffic Safety Administration, "Framework for Automated Driving System Safety; Extension of Comment Period," U.S. Department of Transportation, January 29, 2021; and Note: After the Biden administration took office, NHTSA extended the due dates for comments in response to the ANPRM to April 1, 2021. Although this paper was written before NHTSA issued the ANPRM, it anticipated the questions in the ANPRM including the request for suggestions for a regulatory framework for ADS safety.

29 National Highway Traffic Safety Administration, *Federal Automated Vehicles Policy*, U.S. Department of Transportation, September 2016. ("AV 1.0", replaced by AV 2.0); National Highway Traffic Safety Administration, *Automated Driving Systems 2.0: A Vision for Safety*, U.S. Department of Transportation September 2017 (this Policy is referred to as "AV 2.0" and supersedes AV 1.0); U.S. Department of Transportation. *Preparing for the Future of Transportation: Automated Vehicles 3.0*, October 2018 (this Policy supplements rather than supersedes AV 2.0); U.S. Department of Transportation and National Science & Technology Council, *Ensuring American Leadership in Automated Vehicle Technologies: Automated Vehicles 4.0*, January 2020 (supplementing AV 2.0 & AV 3.0).

30 AV 2.0, at pp. ii & 2.

31 State of California Department of Motor Vehicles, "Autonomous Vehicles," Webpage.

32 FL Stat. § 316.85; National Conference of State Legislatures, "Autonomous Vehicles: Self-Driving Vehicles Enacted Legislation," February 18, 2020; and Note: The National Conference of State Legislators maintains a database tracking state laws and executive orders on autonomous vehicles in all U.S. states and territories.

developers have complained that California's regulations are overly burdensome and of doubtful safety value, and in particular object to the "disengagement" reporting required by California law and regulation.[33] In contrast, Florida, Texas and other states have enacted laws that are designed to invite manufacturers to test and deploy AVs in their states.[34] Arizona's regulations present an interesting case in that the National Transportation Safety Board (NTSB) concluded that the absence of regulatory oversight of Uber's testing of AVs by the State of Arizona was a contributing factor to the fatal collision with a pedestrian[35] and the State subsequently suspended Uber from further testing.[36] In addition to their objections to overly burdensome state regulations, the AV industry also contends that the hodgepodge of differing regulatory requirements in different states is hindering the development of autonomous vehicles.[37]

The present regulatory environment for AVs in the United States, with nationwide regulations by NHTSA many years away, if they are ever coming, and a "patchwork" of state regulations in the meantime, is less than ideal. This regulatory framework fails to satisfy the safety advocates who want rigorous safety standards for autonomous vehicles or the developers of autonomous vehicles who want regulatory certainty before they put AVs on America's roadways.[38] This paper outlines a new regulatory framework that NHTSA can adopt in order to provide the safety and enhanced mobility benefits of AVs to the American public at the earliest opportunity.

33 Andrew Hawkins, "Everyone Hates California's Self-Driving Car Reports," The Verge, February 26, 2020.

34 John Nelander, "Florida Wants to Lead In Autonomous Vehicles Implementation," Governing, November 20, 2019; and FL Stat. § 316.85.

35 National Transportation Safety Board, *Collision Between Vehicle Controlled by Developmental Automated Driving System and Pedestrian, Tempe, Arizona*, NTSB/HAR-19/03, November 19, 2019.

36 Ryan Randazzo, "Arizona Gov. Doug Ducey Suspends Testing of Uber Self-Driving Cars," AzCentral, March 26, 2018.

37 Josh Fisher, "Patchwork of Self-Driving Laws Limiting Autonomous Truck Innovations," FleetOwner, February 3, 2020; Kaveh Waddell and Kia Kokalitcheva, "States Are Sewing a Patchwork of AV Regulations," Axios, October 27, 2018; and Nathan Greenblatt, "Self-Driving Cars Will Be Ready Before Our Laws Are," IEEE Spectrum, January 19, 2016.

38 Aurora Team, "State Road Rules: A Troubling Patchwork of Regulations," Medium, August 28, 2019.

Table 1 – NHTSA AV Rulemakings

ANPRM	Pilot Program for Collaborative Research on Motor Vehicles With High or Full Driving Automation, 83 Fed. Reg. 50872	Sep. 28, 2018
ANPRM	Removing Regulatory Barriers for Vehicles with ADS (Crash Avoidance Standards), 84 Fed. Reg. 24433[1]	May 28, 2019
NPRM	Occupant Protection for ADS, 85 Fed. Reg. 17624	Mar. 30, 2020
ANPRM	Framework for ADS Safety, 85 Fed. Reg. 78058	Dec. 3, 2020
RIN	Passenger-Less Delivery Vehicles Equipped With ADS	ANPRM pending
RIN	Removing Regulatory Barriers for Innovative Motor Vehicle Technologies	ANPRM pending
RIN	Considerations for Telltales, Indicators and Warnings for ADSs	ANPRM pending
RIN	Specialized Motor Vehicles With ADS	ANPRM pending[2]

1 Note: This notice proposes changes to the Crash Avoidance standards found in the "100 Series" of the FMVSS.

2 See, e.g., U.S. Department of Transportation, *Report on DOT Significant Rulemakings*, February 2020; U.S. Department of Transportation, *Automated Vehicles Comprehensive Plan*, January 2021, at pp. 11-12; and Note: The most recent Report on DOT Significant Rulemakings includes projected dates for issuance of these ANPRMs but the projected dates have passed. DOT's AV Comprehensive Plan asserts that work on all four of these ANPRMs remains underway.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1

PERFORMANCE STANDARDS

New Framework Prong 1: Performance Standards

Safety regulations for AVs must address the fundamental question that the public, safety advocates and state and local governments have been asking - how do we know that driverless cars will make safe decisions? NHTSA and the auto industry need to answer this question, and they can do it by adopting standards to ensure that the decision-maker that replaces a human as the "driver" in an AV - the ADS - makes safe decisions. Standards are needed that require the ADS in self-driving vehicles to perform safely. In this article we call such standards "safety performance standards."

Safety performance standards need to be objective, repeatable, and transparent.[39] They must also be understandable by the public. Public concerns about the safety of self-driving cars will not be assuaged if companies maintain as trade secrets the criteria they use to determine if their vehicles are safe enough to release to the public. If the government is to require AV companies to adhere to standards, those standards must apply equally to all companies. These standards must also be available to the public, allowing the public the opportunity to criticize deficiencies in the standards and to recommend improvements.

As discussed above, it is unclear if DOT and NHTSA are ever planning to develop enforceable performance standards for AVs. If NHTSA is on the path of developing performance standards for automated vehicles, it is a very slow path.[40] Before that happens, NHTSA is recommending that the developers of AVs "adopt voluntary guidance, best practices, design principles, and standards developed by established and accredited standards-developing organizations...such as the International Standards Organization (ISO) and SAE International."[41] However, voluntary adherence to industry standards is not the only option for the AV industry and NHTSA.

Under the National Technology Transfer and Advancement Act of 1995 (NTTAA), "all Federal agencies and departments shall use technical standards that are developed or adopted by voluntary consensus standards bodies, using such technical standards as a means to carry out policy objectives or activities determined by the agencies and departments."[42] Voluntary consensus standards are technical standards (e.g., specifications, test methods) that are developed or adopted by voluntary consensus standards bodies, such as SAE, ISO and the Institute of Electrical and Electronics Engineers (IEEE). Pursuant to the NTTAA, NHTSA can and should adopt voluntary consensus standards for AVs into the FMVSS. By adopting industry standards in the FMVSS, NHTSA will assure the public that the government is requiring AVs to operate safely before they are deployed on the road at scale beyond testing, provide the AV industry the regulatory certainty it needs to deploy the vehicles, and do both on a timetable that will not stretch on interminably.

Multiple standards bodies are now developing industry standards for autonomous vehicles. Some of the industry standards under development are in the nature of process standards discussed in the next section of this paper, but other standards will address the fundamental question of how the automated driving system will make decisions to avoid or reduce the risk of death or injury from collisions. When the industry reaches consensus on these standards and they are published as final standards, they can be adopted by NHTSA in the FMVSS as safety performance standards for AVs.

IEEE P2846

One of the most promising approaches for development of a performance standard for AVs is in the final stages of development by IEEE. The IEEE P2846 working group is preparing "A Formal Model for Safety Considerations in Automated Vehicle Decision Making."[43] Mobileye (now a part of Intel) has contributed its Responsibility-Sensitive Safety (RSS) model,[44] and technical experts from 30 other companies and organizations in the AV industry (AMD, ARM, Aurora, Baidu, Denso, Edge Case Research, Exponent, Fiat Chrysler (FCA), Foretellix, Honda, Horizon Robotics, Huawei, Infineon, John Deere Intelligent Solutions Group, Kontrol, Motional, National Institute of Standards and Technology (NIST), National Taiwan University, Nuro, NVIDIA, NXP, Prover Technology, Qualcomm, Rivian, SAE, Uber ATG, University

39 49 U.S.C. § 30111(a); and AV 3.0, at p. 7.

40 National Highway Traffic Safety Administration, 49 C.F.R § 571 Framework for Automated Driving System Safety, U.S. Department of Transportation, November 19, 2020, at p. 54; and Note: NHTSA's recent Framework for ADS Safety ANPRM opines that it is "premature" for NHTSA to issue performance standards and indicates that they are "years away."

41 AVS 2.0 at p. 5.

42 Pub. L. 104-113.

43 IEEE Standards Association, "WG: VT/ITS/AV Decision Making" Webpage.

44 Shai Shalev-Shwartz et al., *On a Formal Model of Safe and Scalable Self-Driving Cars*, Mobileye, 2017.

of Michigan Transportation Research Institute, Valeo, Volkswagen and Waymo) have joined and are participating in IEEE P2846.

RSS uses mathematical equations and logic to express five common-sense rules of road safety: (i) Do not hit the car in front (maintaining longitudinal distance); (ii) Do not cut in recklessly (maintaining lateral distance); (iii) Right of way is given, not taken (a succinct statement of the principle that if another vehicle disobeys a rule of the road, the AV still must yield the right of way to the other vehicle to avoid a collision); (iv) Be cautious in areas with limited visibility; and (v) If the vehicle can avoid a crash without causing another one, it must.[45] Studies have shown that the RSS analysis addresses each of the Pre-Crash Scenarios that NHTSA has identified in its research.[46] These scenarios represent 99.4 percent of crashes of light-duty vehicles. [47]

Mobileye has proposed that AVs should never cause a crash and should significantly reduce the number of crashes caused by other vehicles, but they need not avoid every possible crash. Mobileye reasoned that AVs will not be of any practical use if they are designed to achieve that goal (after all, keeping a vehicle completely safe from crashing "amounts to staying in the parking lot").[48] Instead, Mobileye proposed that the RSS allow the ADS to make "reasonable assumptions" about the "worst case" actions of other drivers even though the human drivers in other vehicles may sometimes make unreasonable decisions that cause collisions with the AV.[49] For example, Mobileye points out that there may be no way for an AV moving in crowded traffic on a multi-lane highway with vehicles in lanes on both sides as well as in front and back to avoid a collision if one of the surrounding drivers intentionally or negligently steers into the AV. The only way for the AV to avoid that scenario altogether is for the AV to never enter multi-lane highways. Instead, the RSS model allows the AV to make the reasonable assumption that other vehicles will stay in their lanes.

Mobileye recognized that the "RSS model contains parameters whose values need to be determined through discussion with regulatory bodies and it would serve everyone if this discussion happens early in the process of developing autonomous vehicles solutions."[50] Essentially, Mobileye's RSS proposal begs the question whether NHTSA and other regulatory bodies will reach agreement on the values for the parameters to be used in the RSS, including the "reasonable assumptions" about other drivers' behavior.

IEEE P2846 is an open working group, meaning any member can contribute its own ideas for consideration in the development of the standard. While NHTSA has not chosen to join IEEE P2846, the agency was invited to send a guest speaker to present its Model Predictive Instantaneous Safety Metric (MPrISM).[51] The MPrISM provides a mathematical methodology to calculate the "unavoidable space" that can lead to a collision between vehicles, and a performance standard could use the MPrISM to prohibit AVs from allowing an unavoidable space with other vehicles. NVIDIA has contributed its Safety Force Field, which is a similar concept to the MPrISM,[52] and Aptiv has contributed the "Rulebooks" approach.[53] All of these proposed methodologies for making safe driving decisions are informing the IEEE P2846 working group and may be incorporated to some extent in the final standard issued by IEEE.

The IEEE P2846 working group is planning to release its draft standard in the second quarter of 2021.[54] IEEE will then need to vote whether to approve the draft and the final IEEE standard may come before the end of 2021.

Other Safety Performance Standards Under Development

Besides IEEE, there are other standards organizations developing safety performance standards for AVs. ISO Technology Report (TR) 4804, Road vehicles - Safety and

45 Mobileye, "Responsibility-Sensitive Safety," Webpage.

46 Mobileye, *Implementing the RSS Model on NHTSA Pre-Crash Scenarios*, 2017.

47 National Highway Traffic Safety Administration, *Pre-Crash Scenario Typology for Crash Avoidance*, U.S. Department of Transportation, April 2007.

48 Shai Shalev-Shwartz et al., *On a Formal Model of Safe and Scalable Self-Driving Cars*, Mobileye, 201, at p. 6.

49 Ibid., at p. 5.

50 Ibid, at p. 3.

51 National Highway Traffic Safety Administration, *Instantaneous Safety Metric*, U.S. Department of Transportation, June 25, 2019; and Bowen Weng et al., *Model Predictive Instantaneous Safety Metric for Evaluation of Automated Driving Systems*, May 20, 2020.

52 NVIDIA, "Self-Driving Cars: Planning a Safer Path," Webpage.

53 Andrea Censi et al., *Liability, Ethics an Culture-Aware Behavior Specification Using Rulebooks*, 2019; Motional, "Introducing Motional: The Hyundai Motor Group and Aptiv Autonomous Driving Joint Venture Unveils New Identity," PR Newswire, August 11, 2020; and Aptiv is participating in the IEEE working group as part of the Motional joint venture with Hyundai.

54 Junko Yoshida, "AV: Come Together, Right Now, Over Safety," EE Times, April 20, 2020; and IEEE, *IEEE P2846: Assumptions for Models in Safety-Related Automated Vehicle Behavior, July-December 2020 Status Report*, February 5, 2021.

cybersecurity for automated driving systems - Design, verification and validation methods,[55] follows up the paper on Safety First for Automated Driving (SAFAD) that was published in July 2019 by Daimler and 10 other companies (Aptiv, Audi, Baidu, BMW, Continental, FCA, HERE, Infineon, Intel and Volkswagen).[56] Many of the companies participating in the development of ISO TR 4804 are also participating in IEEE P2846, so the resulting standards will likely be complementary rather than conflicting. Although the SAFAD concept would incorporate RSS and includes certain requirements for how AVs should operate safely that would effectively constitute safety performance standards that would supplement RSS,[57] SAFAD is both broader and more general than RSS. For the most part, SAFAD would establish process standards and is discussed further in the next section of this article.

SAE is also working through the Automated Vehicle Safety Consortium (AVSC), whose other members are Daimler, Ford, GM, Honda, Lyft, Toyota, Uber ATG, and Volkswagen, to develop best practices for AVs. To date, the AVSC has been focused on writing best practices for the testing and development of AVs, but AVSC is beginning work on best practices to govern the performance of AVs after they go into operation. As mentioned with ISO TR 4804, there is overlap among the industry members of the standards-setting organizations, so any SAE safety performance standards that result from the AVSC are likely to be complementary to IEEE P2846.

In addition to the standards work that the AV industry now has underway with the voluntary consensus standards organizations, the AV industry is also participating in the drafting of the UNECE Global Technical Regulation (GTR) on Functional Requirements for Automated and Autonomous Vehicles (FRAV). The United Nations Economic Commission for Europe (UNECE) is the UN body that prepares the standards that all manufacturers must meet to secure "type approval" to sell their cars in Europe and in much of the rest of the world outside of North America. Although the United States does not use type approval and follows the fundamentally different process of "self-certification" for auto manufacturers to comply with vehicle regulations, the United States participates in the GTR process. A recent meeting of the UNECE's FRAV working group had been scheduled to occur in Santa Clara, California in September 2020 but was instead held as a virtual meeting. Subsequent meetings have been held online, including most recently on February 15, 2021.[58] The FRAV working group's efforts are on track to produce safety performance standards for AVs by 2024, if not sooner.[59]

In recognition of the lengthy time that it will take to complete the UNECE and U.S. standards, an organization called "The Autonomous" was established by TTTech Auto, a developer of software and hardware for automated driving systems. The Autonomous has convened representatives from "car manufacturers and technology suppliers" as well as "governmental, academic, regulatory and standardization institutions" to develop a "Global Safety Reference" for autonomous vehicles. The premise of The Autonomous is that their approach will lead to an expedited consensus of industry and government on safety regulations for AVs. The Global Safety Reference would serve as the basis for standards issued by regulatory bodies across the world. The project kicked off in 2019, with meetings ongoing throughout 2020 (including a virtual meeting focusing on "safety & regulation" that was held on July 9, 2020) that will culminate with a report scheduled for release in September 2021.[60] The details of the Global Safety Reference are still to be determined but they will undoubtedly address the decision-making of AVs and could serve as part of the basis for a safety performance standard for AVs in the FMVSS. Similarly to the ISO effort, the plan for the Global Safety Reference is to complement rather than conflict with the standards being developed in IEEE P2846. However, it remains to be seen whether governmental, regulatory and standardization institutions take up the invitation to endorse The Autonomous project and its Global Safety Reference.

How Should NHTSA Adopt an Industry Consensus Performance Standard for AV Safety

At the present time, IEEE P2846 seems to be on the fastest track for reaching an industry consensus on a performance standard for AV safety, although The Autonomous effort

55 International Organization for Standardization, "ISO/TR 4804:2020," December 2020.

56 Matthew Wood et al., *Safety First for Automated Driving*, Daimler, 2019.

57 Note: For example, SAFAD posits that "[a]ll automated vehicles should comply with the traffic rules in the ODDs that they operate in." SAFAD, Section 2.2.2.10, at p.56. RSS does not include this as one of its "common-sense rules".

58 Martin Dagan and Francois Guichard, "Functional Requirements for Automated and Autonomous Vehicles (FRAV)," U.N. Economic Commission for Europe, August 20, 2019.

59 Armin Greater et al., "Webinar: Automated Vehicle Technology, Public Policy, and BMW s Level 3 AV System," Eno Center for Transportation, July 14, 2020.

60 The Autonomous, *Chapter Event on Safety & Regulation*, July 9, 2020.

may accelerate that track. NHTSA should be participating in the development of IEEE P2846 as well as the ISO, AVSC and UNECE efforts to develop consensus standards for AVs. NHTSA should also use the ANPRM it just issued for a Framework for ADS Safety[61] to begin the rulemaking process to add an industry consensus standard such as IEEE P2846 to the FMVSS.[62] Although it would be premature to propose IEEE P2846 or any other industry consensus standard as the basis of a standard in the FMVSS until the industry standard is final, NHTSA can be evaluating the adequacy of each industry standard for inclusion in the FMVSS while NHTSA is participating in the standard setting process. NHTSA can then make plans to issue an NPRM proposing the industry standard as a new FMVSS when the industry standard goes final.

Of course, NHTSA need not be bound by the specific terms set by an industry consensus standard in preparing its NPRM, and NHTSA can rely upon the technical expertise of its own staff to propose changes to the standard that will improve safety when the agency issues an NPRM for a new safety performance standard for AVs. NHTSA may also need to use the NPRM to fill in gaps in an industry consensus standard. If, for example, an industry standard sets a range of acceptable values for different safety metrics, NHTSA could propose a single value within the range in the NPRM. As another example, if the industry standard does not require AVs to adhere to speed limits or other traffic laws, NHTSA could propose a maximum speed limit for AVs and/or a requirement that the AV obey all local traffic laws.

NHTSA can also use the rulemaking process to confirm that there is a consensus within the AV industry on the technical merits of the proposed standard. If some of the companies in the AV industry raise technical objections to the standard in their comments in response to an NPRM, NHTSA will have to reconsider whether the industry standard truly represents a voluntary industry consensus that can serve as the basis for a rulemaking under the NTTAA, notwithstanding its issuance by a voluntary consensus standards body. The agency will also have to consider carefully all comments in response to an NPRM that suggest changes to the proposed standard, and make changes that would improve the safety of AVs.

However, NHTSA should reject the objections of companies and other commenters that ask for delay of the issuance of an FMVSS for AV safety until a "better" industry standard emerges. And NHTSA must reject the objections of AV companies who want no enforceable safety standard for AVs at all but instead want NHTSA to continue its policy of unenforceable voluntary standards. After an industry consensus standard emerges there may be consequences for any company that ignores the industry standard and puts its AVs into operation anyway. The industry standard will create a "standard of due care" and the AV company could be held liable for anyone injured because of the company's failure to follow the standard. Since the AV industry will need to follow the industry standard to avoid the risk of tort liability, NHTSA should ignore companies who are only seeking to escape the risk of NHTSA enforcement liability rather than raising technical objections to the industry standard.

In the meantime, before an industry consensus safety performance standard emerges, NHTSA should proceed with final rulemakings to modernize the existing FMVSS for AVs, as it is already planning to do. After an industry consensus performance standard is finalized, however, NHTSA should not delay issuance of a new FMVSS for AVs until NHTSA completes its modernization of the existing FMVSS. The modernization effort should be expedited, and if necessary, NHTSA should continue to use its authority to interpret and translate the existing FMVSS for AVs until the modernization is complete. But NHTSA must avoid the temptation to launch a research project for the agency to study the efficacy of a final industry consensus standard, or to identify ways that the standard can be improved. The agency should not hold back from the public the improvements to safety that will come from the deployment of AVs while NHTSA conducts further research. NHTSA excels at research, but its process is lengthy; the agency can conduct research after a new FMVSS for AV safety is adopted and revise the new FMVSS as warranted by its research.

Nor should NHTSA wait for issuance of standards from other voluntary consensus standards bodies to emerge after the first voluntary consensus performance standard goes final. Safety standards for autonomous vehicles will undoubtedly continue to evolve and the wait for the perfect

61 National Highway Traffic Safety Administration, 49 C.F.R § 571 Framework for Automated Driving System Safety, U.S. Department of Transportation, November 19, 2020.

62 Note: Although it was largely written months before the ANPRM was issued, this article anticipates and answers the first question - "Describe your conception of a Federal safety framework for ADS that encompasses the process and engineering measures described in this notice and explain your rationale for its design." - and many of the other questions raised in the ANPRM.

standard will likely never end. NHTSA needs to plan on frequent updates to the FMVSS as new industry consensus standards are issued and existing standards are improved, but NHTSA does not need to resort to the lengthy rulemaking process to address every potential risk with AVs that is revealed after an AV performance standard is added to the FMVSS. NHTSA can take prompt action to assure the safety of the public if and when new risks to safety are identified through the use of a dynamic defects investigation process as discussed in the final section of this paper.

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PROCESS STANDARDS

New Framework Prong 2: Process Standards

A new safety performance standard can address the fundamental questions of whether self-driving vehicles will make safe decisions. But separate process standards are necessary to assure safety advocates and the public that self-driving vehicles will in fact perform safely as claimed by manufacturers.[63] Process standards apply to the processes that manufacturers use to develop, maintain and update their vehicles rather than governing the ultimate performance of the vehicle in operation. Adherence to rigorous process standards can ensure that AVs are designed to be safe, that they are tested to ensure safety, and that they are manufactured in a way that maintains safety.

Although a final consensus performance standard for AVs has yet to emerge, there are multiple voluntary industry consensus standards that apply to the processes of designing, manufacturing and testing of vehicles that would help to ensure the safety of AVs. Some of these process standards are already in existence and in wide use within the automotive industry; other standards are newly emerging.

Table 2 (on page 26) is an illustration of some of the process standards that the AV industry will be, or is already, following in developing self-driving vehicles. This list is not exhaustive. SAE reported at the Automated Vehicles Symposium earlier this year that it is compiling a Roadmap of AV standards and that it had already identified over 40 different standards under development. DOT included in its recent AV Comprehensive Plan a list of 20 relevant voluntary consensus standards for the development of AVs that largely overlaps with Table 2, but the plan does include industry standards not listed in the table.[64]

Design and Manufacturing Standards

Compliance with the existing ISO Functional Safety Standard - ISO 26262 - is widely acknowledged within the automotive industry as essential for the design of ADS.[65] Likewise, ISO 21448 on the Safety of the Intended Functionality (SOTIF) is considered essential for autonomous vehicles although the standard was drafted for use in vehicles with Levels 1 and 2 automation. ISO cautions that ISO 21448 "can be considered for higher levels of automation, however additional measures might be necessary."[66] Among other things, ISO TR 4804 takes up the task of extending SOTIF to Levels 3-5 automation and is expected to be published this year, but the final standard will take two to three years.[67] As shown in Table 2, several other ISO and IEEE standards are under development that will help to ensure safety in the process of designing AVs.

Voluntary industry consensus standards can also ensure that AV companies follow state-of-the-art practices in manufacturing to achieve the highest quality in their vehicles. Most automotive defects actually result from flaws in materials or parts rather than from fundamental flaws in vehicle designs. Accreditation to the well-known ISO 9001 standard, or its counterpart for the automotive industry, ISO 16949, will minimize the risk that traditional hardware defects occur in AVs.

Each of these design and manufacturing process standards establishes a systematic approach to avoid safety risks that could occur in the design or manufacture of AVs. ISO 26262, for example, helps to make sure that if one element of a vehicle's electronics fails, the vehicle is designed so that another element can compensate for the failure. So if, for example, a camera sensor goes out on an AV, the vehicle needs to be designed to use input from another sensor to keep the AV from going "blind". Each process standard applies to different aspects of vehicle safety, but adherence to all of these standards will enhance overall vehicle safety for AVs.

Taxonomy Standards

To give meaning to the results of safety testing, and to provide descriptions to the public and NHTSA of the Operational Design Domain (ODD) - the road type, weather, geographic and other conditions in which each AV can safely operate - as well as other aspects of the safety performance of AVs, the AV industry needs a common understanding with NHTSA as to the terminology applicable to automated vehicles and automated vehicle technologies.

Development of new standards defining the terms and taxonomy for AVs has now been largely completed although some work remains. In April, the SAE Autonomous Vehicle

63 Note: Our use of the term "process standards" is inconsistent with the use of this term by many of the participants in the AV industry, but it provides a convenient dichotomy for the two types of standards we recommend in this article.

64 U.S. Department of Transportation, *Automated Vehicles Comprehensive Plan*, January 2021, at p. 13.

65 Kurt Shuler, "Taking Self-Driving Safety Standards Beyond ISO 26262," Semiconductor Engineering, December 5, 2019.

66 International Organization for Standardization, "ISO/PAS 21448: 2019," January 2019.

67 Junko Yoshida, "BMW Unveils AV Safety Platform Architecture," EET Asia, May 7, 2020.

Safety Consortium released the *Best Practice for Describing an ODD*.[68] Earlier this year, UL 4600 was released to define the elements of a safety case that manufacturers should address to prove automated vehicle safety (while expressly leaving it to manufacturers or regulators to determine the values for each metric that they determine will achieve safety).[69] NHTSA has already endorsed the taxonomy created by SAE for the different levels of automated driving systems in SAE J3016.

NHTSA can make sure that all the participants in the AV industry are talking to NHTSA from the same page, and that all the AV companies in the industry are adhering to rigorous standards in designing and manufacturing their vehicles, by incorporating final consensus industry process standards for the design, manufacture and taxonomy of AVs in the FMVSS.

Testing

Autonomous vehicles will need to be tested in accordance with rigorous testing standards to assure the public of their safety. Because of the absence of a human driver in AVs, traditional methods for testing vehicles that rely on test drivers are largely irrelevant for the testing of AVs. The AV industry has responded to these circumstances by developing new standards for testing AVs in SAE J3018,[70] and the UNECE is continuing the development of testing standards.[71] The most critical requirement for AV safety testing has been the identification of the many scenarios that need to be tested, but new processes for the validation and verification of test procedures and scenarios are also being developed.

Multiple projects around the world have been compiling scenarios for testing of AV safety. NHTSA's *Framework for Automated Driving System Testable Cases and Scenarios* is the example closest to home.[72] Two recent projects out of Europe have developed scenarios that could be included in consensus standards for testing AVs. Project Pegasus is a German consortium that created a library of scenarios as part of its overall project developing standards for AVs,[73] and Streetwise from the Netherlands has also developed a database of scenarios to test AVs against.[74] A recent study by the Institute of Automated Mobility in Arizona identified different safety metrics for testing and evaluation of the safety performance of AVs, again without specifying safety values for those metrics.[75] When an industry consensus performance standard emerges and is incorporated into the FMVSS, NHTSA should simultaneously give its imprimatur to final consensus industry testing standards by likewise incorporating them into the FMVSS.

Numerous reports have concluded that computer simulation testing will be necessary to determine compliance with performance standards for AVs.[76] The sheer number of different scenarios that need to be tested to achieve confidence in test results makes computer simulation testing essential. SAE has compiled a list of the various computer simulations available for testing AVs.[77] NHTSA's *Framework for Automated Driving System Testable Cases and Scenarios* is NHTSA's natural starting point for requiring AV manufacturers to conduct simulation testing for compliance with performance standards,[78] but it will need to be augmented with scenarios developed by other organizations. Without designating a single preferred simulation test, NHTSA should identify which of the available simulation tests provide adequate assurances of safety and then require AV manufacturers to conduct computer simulation testing to verify a proper response for each pre-crash scenario identified by NHTSA. NHTSA then should include in

68 Automated Vehicle Safety Consortium, "Best Practice for Describing an Operational Design Domain: Conceptual Framework and Lexicon," SAE ITC, Webpage.

69 Underwriter Laboratories, "Presenting the Standard for Safety for the Evaluation of Autonomous Vehicles and Other Products," Webpage; Edge Case Research, "Uber ATG Collaborates with Edge Case Research to Advance Self-Driving Vehicle Safety," June 16, 2020; and Note: Uber ATG was the leading proponent of UL 4600 and has developed its Safety Case to be consistent with UL 4600.

70 SAE International, "SAE International Releases Updated J3018 Standard for On-Road Testing of SAE Level 3, 4 and 5 Prototype Automated Driving System (ADS)," September 26, 2019.

71 Martin Dagan and Francois Guichard, "Validation Method for Automated Driving (VMAD)," U.N. Economic Commission for Europe, January 18, 2021.

72 National Highway Traffic Safety Administration, *A Framework for Automated Driving System Testable Cases and Scenarios,* U.S. Department of Transportation, September 2018.

73 Pegasus, *Pegasus Method: An Overview*, 2019.

74 Olaf Op Den Camp, "Scenario-Based Safety Validation for Connected and Automated Driving," TNO, Webpage.

75 Wishart Como et al., "Driving Safety Performance Assessment Metrics for ADS Equipped Vehicles," SAE International Journal of Advanced and Current Practices in Mobility 2(5):2881-2899, February 14, 2020.

76 Nidhi Kalra and Susan Paddock, *Driving to Safety: How Many Miles of Driving Would It Take to Demonstrate Autonomous Vehicle Reliability?*, Rand Corporation, 2016.

77 Rahul Razdan, *Unsettled Technology Areas in Autonomous Vehicle Test and Validation*, SAE EDGE, 2019, at pp. 14-16.

78 National Highway Traffic Safety Administration, *A Framework for Automated Driving System Testable Cases and Scenarios,* U.S. Department of Transportation, September 2018.

Table 2 - Process Standards		
Type	*Title of Standard*	*Status*
Design	ISO 26262 - Functional Safety Standard[1]	In effect
Design	ISO/PAS 21448 - Safety of the Intended Functionality (SOTIF)[2]	In effect
Design+	ISO TR 4804[3]	Under development
Design	ISO/SAE 21434 (ADS cybersecurity)[4]	Under development
Design	IEEE P1228 (software safety for safety-critical systems)[5]	Under development
Design	IEEE P2851 (Internet protocol ("system on a chip"))[6]	Under development
Design	SAE AVSC, *Best Practice for Data Collection for ADS-Dedicated Vehicles to Support Event Analysis*[7]	In effect
Manufacturing	ISO 9001 (Quality Management Systems)[8]	In effect
Manufacturing	ISO 16949 (Automotive Quality Management Systems)[9]	In effect
Taxonomy	SAE AVSC, *Best Practice for Describing an ODD*[10]	In effect
Taxonomy	SAE J3016 (*Taxonomy And Definitions For Terms Related To Driving Automation Systems For On-Road Motor Vehicles*)[11]	In effect
Taxonomy+	UL 4600[12]	In effect
Testing	SAE J3018[13]	In effect
Testing	UNECE Validation Method for Autonomous Driving (VMAD)[14]	Under development
Testing	NHTSA, *Framework for Automated Driving System Testable Cases and Scenarios*[15]	In effect
Testing	Project Pegasus[16]	In effect
Testing	TNO Streetwise[17]	In effect
Testing	Association for Standardization for Automation and Measuring Systems (ASAM) OpenSCENARIO 1.0.0[18]	In effect
Testing	SAE, *Driving Safety Performance Assignment Metrics for ADS-Equipped Vehicles*[19]	In effect

1 International Organization for Standardization, "ISO 26262-1:2018," December 2018.

2 International Organization for Standardization, "ISO/PAS 21448:2019," January 2019.

3 International Organization for Standardization, "ISO/TR 4804:2020," December 2020.

4 International Organization for Standardization, "ISO/SAE FDIS 21434,: Webpage.

5 IEEE Standards Association, "P1228 - Standard for Software Safety," November 7, 2019.

6 IEEE Standards Association, "P2851 - Standard for Exchange/Interoperability Format for Functional Safety Analysis and Functional Safety Verification of IP, SoC and Mixed Signal ICs," November 7, 2019.

7 SAE International, "AVC Best Practice for Data Collection for Automated Driving System-Dedicated Vehicles (ADS-DVs) to Support Event Analysis," September 23, 2020.

8 International Organization for Standardization, "ISO 9001:2015," September 2015.

9 International Organization for Standardization, "ISO/TS 16949:2009," June 2009.

10 Automated Vehicle Safety Consortium, "Best Practice for Describing an Operational Design Domain: Conceptual Framework and Lexicon," SAE ITC, Webpage.

11 SAE International, "SAE J3016-2018," June 2018.

12 Underwriter Laboratories, "Presenting the Standard for Safety for the Evaluation of Autonomous Vehicles and Other Products," Webpage.

13 SAE International, "SAE International Releases Updated J3018 Standard for On-Road Testing of SAE Level 3, 4 and 5 Prototype Automated Driving System (ADS)," September 26, 2019.

14 Martin Dagan and Francois Guichard, "Validation Method for Automated Driving (VMAD)," U.N. Economic Commission for Europe, January 18, 2021.

15 National Highway Traffic Safety Administration, *A Framework for Automated Driving System Testable Cases and Scenarios*, U.S. Department of Transportation, September 2018.

16 Pegasus, *Pegasus Method: An Overview*, 2019.

17 Olaf Op Den Camp, "Scenario-Based Safety Validation for Connected and Automated Driving," TNO, Webpage.

18 ASAM, "ASAM OpenSCENARIO," March 19, 2021.

19 Wishart Como et al., "Driving Safety Performance Assessment Metrics for ADS Equipped Vehicles," SAE International Journal of Advanced and Current Practices in Mobility 2(5):2881-2899, February 14, 2020.

the FMVSS a requirement that AV manufacturers conduct simulation testing using one (or better - more than one) of the approved simulation tests.

Although computer simulation testing is essential to provide meaningful results, it will also be useful for AV manufacturers to conduct physical testing of their vehicles before they are released on public roadways. Physical testing is useful for certain conditions that are difficult to simulate. Even more importantly, physical testing provides concrete proof to the public and to safety advocates of the safety of AVs.

Several states have invited AV manufacturers to conduct testing on their public roadways if their autonomous vehicles can be controlled by a backup safety driver, and a few states allow testing even without a backup safety driver. AV manufacturers should take advantage of the opportunity to test in jurisdictions that encourage use of their roadways for testing AVs. Because of public concerns with testing of self-driving vehicles without a human who can take control as a safety backup, NHTSA should not encourage testing of self-driving vehicles on public roads without a safety backup so long as industry bodies like SAE are recommending safety backup drivers and then must assess for itself if that changes. However, NHTSA should require all AV manufacturers to demonstrate the safety of their self-driving vehicles by also testing them using industry consensus test procedures on test tracks.

SAE has identified 35 different test centers in the United States that have some capability to test autonomous vehicles.[79] In 2017, NHTSA designated 10 of these test centers as official proving grounds for autonomous vehicle testing.[80] The next year, however, NHTSA rescinded the designation of the 10 proving grounds and declared that DOT was not going to pick winners and losers among the test centers.[81] NHTSA needs to reverse course yet again, however, and redesignate a list of centers approved for the testing of AVs. The list of approved test centers should not be limited to the 10 centers previously approved, but all test centers located in the United States should be invited to apply for designation, and NHTSA should approve any center that establishes it has adequate facilities for the testing of AVs. The centers approved by NHTSA must be available for testing by all manufacturers, and they must open to allow public viewing of AV compliance testing (the facilities can be closed to the public at other times while conducting proprietary testing for customers). NHTSA should also designate repeatable and publicly-available test procedures for determining compliance with AV performance standards that can be performed at each designated AV test center.

NHTSA will require additional resources to conduct evaluations of the many simulation tests, and the multiple AV test centers, that would be candidates for inclusion in the FMVSS. The AV industry and safety advocates should unite in supporting the increases to NHTSA s budget that will be necessary for the agency to accomplish these essential tasks.

Pursuant to the Federal Motor Vehicle Safety Act, NHTSA requires auto manufacturers to certify the compliance of the vehicles they manufacture with the FMVSS. The United States Self-Certification practice is in stark contrast with the Type Approval procedure followed in Europe and China and most of the rest of the world, where manufacturers must obtain approval from government regulators that each type of vehicle they sell complies with safety standards. NHTSA should adhere to its longstanding process of self-certification for AVs. AV manufacturers need to submit certifications that their autonomous vehicles comply with new performance and process standards incorporated into the FMVSS but advance authorization from NHTSA should not be required. AV manufacturers may want to obtain independent certification of their compliance with some standards to bolster the credibility of their self-certifications of compliance, but ultimately, each manufacturer will have to self-certify their own vehicles as compliant with each applicable standard incorporated in the FMVSS.

79 Rahul Razdan, *Unsettled Technology Areas in Autonomous Vehicle Test and Validation*, SAE EDGE, 2019, at p. 10.

80 U.S. Department of Transportation, "U.S. Department of Transportation Designate 10 Automated Vehicle Proving Grounds to Encourage Testing of New Technologies," January 19, 2017.

81 AV 3.0 at 17.


3

PROMPT CORRECTIVE ACTION

New Framework Prong 3: Prompt Corrective Action

Autonomous vehicles offer the promise that they will be safer than human-driven vehicles. AVs will be safer because they will never have a human in control who is drunk or drowsy or distracted and because they will always obey speed limits and other traffic laws.[82] NHTSA should accelerate all of its FMVSS rulemakings for AVs in order to get these safer vehicles on the road sooner rather than later. But is it enough to say that AVs need only to be as safe as a human driver who is sober, awake, and alert and obeys all traffic laws? Instead we have to ask the question - are AVs as safe as we can reasonably make them? By making industry consensus standards enforceable through the FMVSS, NHTSA can go part of the way in giving a positive response to this question. But to answer it fully, NHTSA needs to fully use its authority to investigate potential defects in AVs, and AV manufacturers need to embrace NHTSA's recall authority as an opportunity for the industry to work cooperatively with NHTSA to identify and remedy risks to safety in AVs.

Under the Federal Motor Vehicle Safety Act, NHTSA has the authority to order auto manufacturers to remedy defects in the vehicles they sell or lease to the public in the United States.[83] NHTSA has repeatedly made it clear that the agency will "not hesitate to exercise its defect authority" in connection with AVs.[84] NHTSA's primary policy statement on automated vehicles explains that "NHTSA's enforcement authority concerning safety-related defects in motor vehicles and motor vehicle equipment extends and applies equally to current and emerging ADSs."[85] Although the Trump administration has made dramatic changes to enforcement practices at all federal agencies including NHTSA and the rest of the DOT, NHTSA's *Enforcement Guidance Bulletin on Safety-Related Defects and Automated Safety Technologies* issued at the end of the Obama administration has not been rescinded.[86] This Enforcement Guidance Bulletin states unequivocally that:

> "Where a fully automated (self-driving) vehicle or other automated safety technology causes crashes or injuries, or poses other safety risks, the Agency will evaluate such technology through its investigative authority to determine whether the technology presents an unreasonable risk to safety. Similarly, should the Agency determine that a fully automated (self-driving) vehicle or other automated safety technology has manifested a safety-related defect, and a manufacturer fails to act, NHTSA will exercise its enforcement authority to the fullest extent."[87]

The legal test that NHTSA has to apply to order a recall is very simple to recite: the agency can order a manufacturer to recall any vehicle that presents an "unreasonable risk to safety."[88] In practice, however, NHTSA never actually orders recalls; if the agency has reasons to suspect that there is a defect, NHTSA opens a public investigation that puts pressure (or in NHTSA's parlance - "influences") a manufacturer to order a "voluntary" recall.[89] The traditional process followed by NHTSA's Office of Defects Investigation (ODI) does not involve investigators appearing at the scene of a crash to inspect the wreckage and interview witnesses.[90] Instead, ODI usually tries to calculate a failure rate for the vehicle model under investigation and then compare that rate to the failure rate of peer vehicles.[91] If the failure rate is "unreasonable" compared to peer vehicles, then NHTSA will open its public defect investigation.

Calculating failure rates for traditional vehicles - which have all been driven by humans - is not a trivial task. Almost by definition, it requires NHTSA to wait for multiple failures to occur before it can calculate a failure rate, since a single incident will likely yield a statistically invalid failure

82 Note: This assumes of course that AV manufacturers either choose to, or are required to, program their vehicles to obey all traffic laws.

83 49 U.S.C. 30101 *et seq.*

84 National Highway Traffic Safety Administration, *Nuro, Inc., Grant of Temporary Exemption for a Low-Speed Vehicle with an Automated Driving System*, Dkt. No. NHTSA-2019-0017, U.S. Department of Transportation, February 11, 2020,at pp. 36, 47 & 53.

85 AV 2.0 at p.3.

86 81 Fed. Reg. 65705; National Highway Traffic Safety Administration, "Automated Driving Systems," U.S. Department of Transportation, Webpage; and Note: The Enforcement Guidance Bulletin is posted on NHTSA's website as a Supporting Document to NHTSA's current Policies on Automated Driving Systems.

87 81 Fed. Reg. at 65708.

88 49 U.S.C. 30102(a)(8).

89 Note: Most recalls are in fact purely voluntary in that that are announced by manufacturers without any "influence" from a NHTSA investigation. National Highway Traffic Safety Administration, Motor Vehicle Safety Defects and Recalls: What Every Vehicle Owner Should Know, U.S. Department of Transportation, August 2017, at p. 10.

90 Note: The similarly named but entirely separate National Transportation Safety Board (NTSB) does follow that approach to investigate crashes, and the NTSB's practices understandably create confusion in the public about the nature of NHTSA's investigations.

91 National Highway Traffic Safety Administration, *Motor Vehicle Safety Defects and Recalls: What Every Vehicle Owner Should Know*, U.S. Department of Transportation, August 2017, at p. 8.

rate. Moreover, determining what actually "failed" for any given crash is a very complex task. NHTSA has to rely upon complaints from vehicle drivers and drivers are notoriously inconsistent in describing what occurred in a crash or other alleged vehicle failure in their complaints.[92] Drivers' complaints are also notorious for blaming a vehicle failure for what is more likely to be human error (drivers complaining of sudden unintended acceleration when the more logical explanation is that the driver mistakenly pressed the accelerator instead of the brake being a prime example). Parsing out the meaningful data to calculate a valid failure rate is a laborious task that will drag out defect investigations for months or years.

In contrast, AVs present a far simpler task to determine what went wrong for any given crash. AVs are outfitted with an array of sensors (cameras, and often lidar and other types of sensors) that record all the details of a crash. Accident reconstruction in a crash of an AV does not need to rely much, if at all, on the vagaries of human testimony. Review of the sensor data and other data recorded by the AV should reveal in almost every crash a definitive answer to the question whether the autonomous vehicle caused the crash, or a human driver of the other vehicle (or a human pedestrian) was at fault. For every crash where fault lies with the AV, by definition the AV has presented an unreasonable risk to safety. NHTSA does not need to wait for multiple crashes to reach the conclusion the vehicle is defective. As a matter of policy and practice, NHTSA should force a recall when it finds an AV presents an unreasonable risk to safety.

NHTSA's Enforcement Guidance Bulletin recognizes that there will often be no need to calculate a failure rate and that a single incident may be sufficient to trigger a recall of AVs. In fact, the bulletin states that even in the absence of a crash, NHTSA can initiate a recall of "software or other electronic systems... when the engineering or root cause of the hazard is known, [because] a defect exists regardless of whether there have been any actual performance failures."[93]

In order to take advantage of the inherent advantages that AVs provide for reconstructing crash events to identify causes for the crash, NHTSA needs to revamp entirely ODI's investigative process as applied to collisions that involve an AV. NHTSA should take *immediate* action to investigate each crash involving an AV and assess responsibility for the crash at least initially as the number of AVs on the roads is small. The agency should not wait to analyze data from multiple incidents before conducting a review of data from each AV crash. This would be a change of practice for NHTSA and require an approach more similar to that of the NTSB or NHTSA's own Office of Special Crash Investigations[94] than to ODI's normal defect investigations. However, ODI's investigation of each crash need not require a visit to the site of the crash. Instead, NHTSA should demand that the AV manufacturer provide to ODI data from the AV needed for reconstruction of the crash. In order to ensure that ODI staff acquire expertise in analyzing data from AVs, NHTSA will also need to create a special team within ODI dedicated to investigating AV crashes. This could change as the number of AVs on the roads increase when NHTSA can take an approach of picking and choosing investigations, particularly when it is something that runs into an AV as opposed to the AV running into something.

Using this revamped approach, NHTSA will be able to react quickly to each crash of an AV to determine if the AV was at fault in the crash and has to be recalled or reprogrammed. For many crashes that do not involve an injury, NHTSA's assessment of fault for the crash may be a relatively trivial matter. For example, there have already been many instances of rear-end collisions into AVs that were braking to comply with traffic laws or out of caution in the presence of pedestrians. ODI will likely be able to determine quickly that the AV was braking for good reason and that the following car driven by a human driver was at fault and no further investigation is needed. But if the rear end crash involves serious injury or death or if there is not a valid explanation for the AV braking, ODI would conduct an in-depth review of all the AV's relevant sensor and other data.

ODI is a small office. NHTSA's budget will need to be increased to allow ODI to take on the expanded role recommended in this Regulatory Safety Framework. ODI will need to hire more personnel with appropriate expertise in analyzing complex data from automated driving systems. The AV industry should advocate and support increased funding for the enhancement of NHTSA's capabilities in investigating the safety of the new vehicles introduced by the evolving AV industry. Close scrutiny by NHTSA of AV crashes in cooperation with AV manufacturers will assure the public that the government is committed to public safety as this new technology is introduced on America's roadways.

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92 National Highway Traffic Safety Administration, *Motor Vehicle Safety Defects and Recalls: What Every Vehicle Owner Should Know*, U.S. Department of Transportation, August 2017, at p. 4; and Note: ODI includes a "Vehicle Owner's Questionnaire" on its website and refers to the complaints submitted in response to the Questionnaire as "VOQs". The VOQs are the source of complaints for most of ODI's failure rate analysis, but ODI also uses additional sources for calculation of failure rates.

93 81 Fed. Reg. at 65708.

94 National Highway Traffic Safety Administration, "Special Crash Investigations (SCI)," U.S. Department of Transportation, Webpage.

Importantly, the analysis of the AV's data following the crash of an AV may reveal not only who was at fault in the crash, but also whether the AV could have avoided or mitigated the collision even though the human driver of another vehicle or a pedestrian was at fault. After all, the safety promise of AVs is that they will be safer than humans.

Although the determination of fault in the crash of an AV should be much simpler than the traditional determination of fault in crashes involving only human-driven vehicles, determining the remedy for crashes involving autonomous vehicles will likely involve complex engineering analysis of software or hardware or both. But another great promise of automated vehicles is that we are able to engineer solutions for faults in automated vehicles. In contrast, we cannot really fix humans. NHTSA can reduce the rate of drunk driving, and the rate of distracted driving, and the rate of drowsy driving, and the rate of speeding, and the agency has been pursuing programs to reduce these risks for many years, with some success, but we will never be able to completely stop humans from driving distracted, drowsy or drunk.[95] AVs, unlike humans, should not make the same mistakes repeatedly.

In the aftermath of a crash of an AV, the manufacturer and NHTSA may conclude that the crash, while not the fault of the AV, could have been avoided or mitigated by a reasonable change to the programming of the AV.[96] When that happens, the manufacturer should implement a design improvement to reduce the risk of future collisions. NHTSA's Enforcement Guidance Bulletin posits that "Manufacturers have a continuing obligation to proactively identify and mitigate . . . safety risks discovered after the vehicle and/or equipment has been in safe operation."[97] Furthermore, NHTSA contemplated that "if a manufacturer fails to provide secure updates to a software system and that failure results in a safety risk, NHTSA may consider such a safety risk to be a safety-related defect compelling a recall."[98] AV manufacturers must be prepared that if they learn how to avoid or mitigate a risk of a collision in an autonomous vehicle they are obligated to avoid or mitigate that risk. Failing to do so will allow an unreasonable risk to safety - a defect - to remain in their vehicles and subject the manufacturer to a recall and NHTSA enforcement action.

In essence, NHTSA and the AV industry can use this new enforcement strategy to create a continuous improvement program for autonomous vehicles, with vehicles always becoming safer. Recalls will be an especially effective tool for improving safety in AVs because, in stark contrast to most recalls to date, achieving 100 percent completion of recalls of AVs is a real possibility. Historically, recall completion rates lag, because recalls require the cooperation of vehicle owners, and even in the circumstance of defects that cause horrific and well-publicized injuries (such as exploding Takata air bags), it is impossible to convince some vehicle owners to bring their vehicles in for recall repairs. When AV defects can be remedied through software upgrades, however, many manufacturers may be able to accomplish those remedies through over-the-air upgrades, taking away the need for vehicle owners to bring their vehicles in for repair as well as the discretion to skip the repair.

The exemption that NHTSA granted to Nuro last year illustrates NHTSA's concern that AV manufacturers maintain control of their fleets in order to eliminate risk to the public when a defect in an AV is identified. NHTSA included a condition in the exemption that "Nuro must be capable of issuing a "stop order" that causes all deployed R2X vehicles to, as quickly as possible, cease operations in a safe manner, in the event that NHTSA or Nuro determines that the exempted vehicles present an unreasonable or unforeseen risk to safety."[99] Similarly, NHTSA should include as part of the new FMVSS for automated vehicles a requirement for manufacturers to be able to ground their fleets after deployment for purposes of effectuating recalls. Manufacturers operating as owners of their own AV fleets can of course ground them when needed, but manufacturers who sell or lease their AVs to third parties can include as a term in their contracts for sale or lease of an AV a condition that the vehicle owner allow the manufacturer access to the vehicle in the event of a recall or design improvement that enhances safety.

Using NHTSA's revamped defects investigation process, it will also be very straightforward to make sure that when an AV manufacturer identifies a mistake and a solution - that is, develops an engineering remedy for a safety risk - in an AV, other manufacturers do not make the same mistake with

95 "Driver Alcohol Detection System for Safety," Webpage; and Note: The Driver Alcohol Detection System for Safety (DADSS) Program does offer hope that someday drunk driving could be eliminated even if humans remain behind the wheel.

96 Note: Any crash could be avoided or mitigated by programming changes that impose unreasonable constraints on the operations of an AV, such as limiting the speed of the AV to less than 10 mph. But NHTSA and the public must recognize that such constraints would destroy the utility of AVs and therefore need not be implemented by AV manufacturers.

97 81 Fed. Reg. at 65706.

98 81 Fed. Reg. at 65709.

99 National Highway Traffic Safety Administration, *Nuro, Inc., Grant of Temporary Exemption for a Low-Speed Vehicle with an Automated Driving System*, Dkt. No. NHTSA-2019-0017, U.S. Department of Transportation, February 11, 2020, at p. 58.

their AVs. NHTSA s defects investigation process is an open process. In the event of a recall, NHTSA posts on its website the manufacturer's detailed description of the safety defect along with the remedy.[100] The same practice should hold true for AVs. All AV models, regardless of manufacturer, that are susceptible to the same defect should be remedied. But NHTSA and the AV industry should take this open process even further to build public trust in the safety of self-driving vehicles, although this should be done while protecting intellectual property rights..

In conjunction with NHTSA's enforcement process, AV manufacturers should commit that they will share design improvements that enhance safety with their competitors. Manufacturers should not treat safety solutions that can save lives and prevent injuries as proprietary information that protects only their own customers, and they should instead share that information with other manufacturers. AV manufacturers can do this through participation in an AV-Information Sharing and Analysis Center (ISAC) modeled on the existing Auto-ISAC for cybersecurity risks.[101] The AV-ISAC should share remedies for AV risks not covered by AV safety performance standards. Work within the AV-ISAC could also lead to modification of AV safety performance standards. As manufacturers identify solutions for "edge" cases that are not addressed in the standards, they can and should share those solutions with other manufacturers through the AV-ISAC.

If IEEE P2846 (or another industry standard incorporated into the FMVSS as a performance standard for AVs) ultimately excludes heavy-duty vehicles and does not address all types of light-duty vehicle crashes,[102] the AV-ISAC can share safety solutions in these categories. The AV-ISAC and NHTSA's enhanced enforcement focus on AVs should not be limited to light-duty vehicles. NHTSA and the AV industry should use these tools to ensure the safety of automated trucks and buses as well as self-driving cars.

100 National Highway Traffic Safety Administration, "Safety Issues & Recalls," U.S. Department of Transportation, Webpage.

101 "Automotive Information Sharing and Analysis Center," Webpage.

102 Note: We note that the RSS concept that underlies IEEE P2846 was limited to light-duty vehicles and did not address the 0.6% of crashes that fell outside of NHTSA's Pre-Crash Scenarios.

CONCLUSION

Conclusion

NHTSA should complete its rulemakings to modernize the FMVSS to accommodate autonomous vehicles. The agency should work with the AV industry and safety advocates in consensus standards development organizations to develop performance and process standards for AV safety and then add industry consensus safety performance and process standards for automated driving systems to the FMVSS. NHTSA should also adopt a new defects investigation and enforcement approach for autonomous vehicles to make sure that unreasonable risks to safety that are not eliminated by the new safety standards are promptly corrected by all AV manufacturers.

The AV industry and safety advocates should support additional funding for NHTSA to accelerate and expand its rulemaking process for AV safety. Companies within the AV industry should work cooperatively through consensus standards setting bodies and an AV-ISAC to improve the safety of their AVs, rather than competing on safety. The industry and safety advocates should also support a new emphasis by NHTSA on using its enforcement authority to ensure that all unreasonable risks identified with AVs are remedied swiftly, including by supporting increases in NHTSA s budget to allow NHTSA to fully exercise its enforcement authority.

Crashes involving AVs are inevitable. The utopian goal of zero crashes of autonomous vehicles can never be achieved so long as they have to interact with less-than-perfect humans. But we can fix autonomous vehicles over time to make them at least approach perfection, something that cannot be done with human drivers. Delaying AVs for the utopia of no crashes lets an unattainable perfect defeat an attainable good of reducing deaths and injuries on our nation's highways, through the deployment of AVs sooner rather than later.

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