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April 1, 2021

Dr. Steven Cliff
Acting Administrator
National Highway Traffic Safety Administration
1200 New Jersey Avenue, SE
Washington, D.C. 20590

Docket Number NHTSA-2020-0106

Submitted via Federal eRulemaking Portal at http://www.regulations.gov

Dear Acting Administrator Cliff:

Nuro is pleased to comment on the National Highway Traffic Safety Administration's ("NHTSA" or "the Agency") advance notice of proposed rulemaking on a framework for automated driving system ("ADS") safety. Nuro shares the Agency's perspective that ADS technology has the potential to provide tremendous benefits for personal transportation, the movement of goods, economic growth, and decreasing auto-related injuries and fatalities. We support the Agency's efforts to create a framework to promote the safe development and deployment of ADS.

Nuro was founded with the mission to "accelerate the benefits of robotics for everyday life." We are the first company in the nation to operate a grocery delivery service using unmanned autonomous vehicles ("AVs") on public roads. We currently operate autonomous vehicles in Houston, Texas; Scottsdale, AZ; and the Bay Area of California. We are expanding our autonomous delivery services, along with our partners, to new products and places. Our latest vehicle, "R2," is a custom-designed robot designed for operation on public roads, with safety as our top priority. Unlike traditional passenger vehicles, these light-duty, autonomous delivery vehicles lack an occupant compartment; instead, they feature cargo compartments.

We believe the tremendous benefits of autonomy will first be widely realized in local goods delivery. Delivery AVs can provide an affordable, safe, and electric alternative to driving to the store — while also reducing transportation barriers to accessing fresh groceries, medicine, and other essentials for those who are unable to afford or drive a car. This technology can also help spur economic growth as retailers expand their delivery operations, including new jobs picking-and-packing goods, as well as creating new roles for Americans developing, maintaining, and overseeing the vehicles.

This proceeding is an important step in developing a safety framework for ADS. Safety must always be the top priority for ADS developers and the Agency, and this advanced notice is an opportunity to begin creating a framework that will support the growth of this life-saving technology. As NHTSA recognizes, ADS differ from the features historically regulated by the FMVSS in important ways, including the use of operational limitations like "geofences" that constrain operation to defined domains, system-specific vehicle and sensor designs, and technology that continues to improve its performance even after a vehicle is first introduced into commerce. We therefore applaud NHTSA's efforts here to begin collecting public input on how to depart from the "traditional approach" the Agency has taken to FMVSS.[1] We support the Agency's efforts to leverage all its tools, including guidance and public education, as well as beginning to explore how to address ADS in "a highly performance-oriented manner."[2]

We appreciate the opportunity to provide comments on this advance notice of proposed rulemaking. Highlights of our comments include:

I. **Principles for developing a framework for ADS safety:** In developing a framework for ADS safety, we encourage NHTSA to seek to accelerate the safe adoption of ADS technology, take a performance-oriented approach to ADS safety that enables diverse technologies and business models, use a phased approach, and expeditiously complete in parallel the ongoing rulemakings on modernizing the FMVSS for novel vehicle designs**.** Specifically, we also recommend that NHTSA consider the "totality of safety" of a system, rather than focusing on sub-systems or "primary functions"; enable ODD variation within any framework; encourage developers to use multiple methods of verification and validation; and preserve the ability for traffic laws or planning-system rules to adapt to real-world circumstances.

II. **Best practice guidance for AV developers**: NHTSA should update its past guidance documents to include additional key best practices, such as safety processes, safety culture, continuous improvement, and redundancy.

III. **Establishing common definitions, resources, and approaches:** NHTSA can help support consistency and safety in the industry by playing a convening role and helping drive consensus on definitions such as a standardized collision scale, ODD, disengagements, and close calls; helping develop a publicly-available library of edge case scenarios and supporting industry efforts to define basic driving competence for various ODDs; and providing information for consumers and stakeholders such as by highlighting industry standards and partnering with developers to highlight the reality of today's technology.

[1] U.S. Dep't of Transp., Nat'l Highway Traffic Safety Admin., Framework for Automated Driving System Safety, Advance Notice of Proposed Rulemaking, Docket No. NHTSA-2020-0106, 85 Fed. Reg. 78058, 78072 (Dec. 3, 2020), https://www.govinfo.gov/content/pkg/FR-2020-12-03/pdf/2020-25930.pdf ("ANPRM").
[2] *Id.*

I. Principles for Developing a Framework for ADS Safety

1. Regulation should seek to accelerate the safe adoption of ADS technology.

Nuro supports NHTSA's efforts to begin developing a safety framework for ADS, and encourages NHTSA to use this framework to accelerate the safe adoption of ADS technology. ADS technology can help advance NHTSA's mission to "save lives, prevent injuries, and reduce economic costs due to road traffic crashes."[3]

By avoiding behaviors like speeding, distracted driving, and driving under the influence, and by enabling innovative vehicle designs with new safety features, vehicles with ADS can improve road safety. If we maintain the United States' leadership in this technology, we also can see significant economic growth and new jobs spurred by the investment and deployment of AVs. One study estimated that "over the 32-year period from 2018 to 2050, the discounted present value of AV benefits [for society] could be from $3.2 to $6.3 trillion."[4]

Therefore, Nuro applauds NHTSA's decision to "plac[e] a priority on the safe development and testing of ADS that factors safety into every step toward eventual deployment."[5] Due to the tremendous potential of AVs for improving safety, studies looking at the impacts of a delayed deployment have forecast a significant cost in human life. Modeling from the Mercatus Center estimated that a 10 percent delay in AV deployment could lead to "34,000 additional deaths during a 30-year diffusion period,"[6] and a study from the RAND Corporation estimated that at worst, delayed deployment could cost in excess of 50,000 lives.[7]

The approach contemplated by NHTSA in the ANPRM, together with actions by industry, can help ensure those benefits are realized. The ANPRM's emphasis on guidance and consumer information[8] in the near term can contribute to the following of safety best practices by developers, and in the longer term, we agree with NHTSA that "performance-oriented approaches and metrics [. . .] would accommodate the design flexibility needed to ensure that manufacturers can pursue safety innovations and novel designs in these new technologies."[9]

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[3] *Id.* at 78061.
[4] W. David Montgomery, "Public and Private Benefits of Autonomous Vehicles," Securing America's Future Energy (June 2018), 3, https://avworkforce.secureenergy.org/wp-content/uploads/2018/06/W.-David-Montgomery-Report-June-2018.pdf.
[5] ANPRM, 85 Fed. Reg. at 78061.
[6] Brent Skorup and Jennifer Huddleston, "Safety Exemptions and the Regulatory Approach to Autonomous Vehicles," Mercatus Center at George Mason University, 3-4 (2019), *available at* https://www.mercatus.org/system/files/skorup_and_huddleston_-_pic_-_nhtsa_gm_hav_exemptions_-_v1.pdf.
[7] Nidhi Kalra and David G. Groves, "The Enemy of Good: Estimating the Cost of Waiting for Nearly Perfect Automated Vehicles," RAND Corporation (2017), *available at* https://www.rand.org/pubs/research_reports/RR2150.html.
[8] *See* ANPRM, 85 Fed. Reg. at 78060.
[9] *Id.* at 78059.

2. Take a performance-oriented approach to ADS safety that enables diverse technologies and business models

"Technology Neutrality / Performance-Based" was rightly identified by NHTSA as one of the most critical factors to consider in a framework for ADS Safety.[10] We applaud the recognition by NHTSA that any standards for ADS will need to be "drafted in a highly performance-oriented manner."[11] New business models, vehicle types, and ADS applications have been rapidly emerging over the past several years, and standards that foreclose or limit certain applications could reduce the opportunity for safety improvement and economic growth. Therefore, it is critical that an ADS safety approach consider diverse vehicles (e.g., goods-only occupantless vehicles, passenger vehicles, dual-use vehicles); business models (e.g., last-mile goods delivery, robotaxi, long-haul trucking), and ownership models (e.g., owned by manufacturers in a fleet, partnerships between developers and other businesses, sold generally to the public).

Consider the "totality of safety" across a system, rather than focusing on sub-systems or "primary functions"

Nuro recommends that NHTSA consider the safety of ADS and ADS-equipped vehicles from an end-to-end, system-level perspective. NHTSA should consider the capabilities and performance levels that various ADS and ADS-equipped vehicles require to operate in the real world, rather than requirements for its specific components or subsystems (what NHTSA refers to as "primary functions," like sensing or perception, in the ANPRM). Per the Systems Engineering process, sub-system and component level requirements are derived from higher-level performance or functional requirements. Focusing at the system level will allow organizations to decompose the system requirements that are appropriate for their subsystems, and better accommodate innovative applications of ADS technology and diverse Operating Design Domains ("ODD").

To illustrate why setting performance measures at the subsystem or component level is inappropriate for an ADS-equipped vehicle, take the example of a camera. The traditional approach NHTSA has taken with the FMVSS would be to set specific performance requirements for a camera,[12] for example measuring camera resolution. But because an ADS vehicle uses algorithms or machine learning to process the information from a camera, and depending on the sophistication of those techniques (such as joint machine learning models that merge radar, lidar, and camera, which would make it harder to evaluate a single sensor's performance or contribution), the information received by the ADS may be of higher or lower fidelity, regardless of the camera resolution. A company could also choose to rely more on other kinds of sensors, like lidar and radar, and place less reliance on the camera. They may also choose different approaches to fusing information from the different sensors, which could reduce the required resolution. The compute hardware chosen for processing can also affect the ability

[10] *See id.* at 78073.
[11] *Id.* at 78072.
[12] *See, e.g.*, FMVSS No. 111.S14.3.

and time required to get a high quality image. Further, camera resolution is not static — it can be affected by environmental factors, such as weather.

Measuring ADS performance even at the "primary function" level of sensing also presents challenges. Decisions beyond the Perception systems, including Planning system decisions on how to respond to issues like sensor degradation (e.g., detecting and coming to a safe stop, relying on other sensor types), can affect what is required from the sensing function. Therefore, in an ADS-equipped vehicle, setting standards at the component or even sub-system level may not accurately measure safety, and could limit innovative approaches.

Even beyond the ADS itself, redundant systems (such as an independent and complementary ADAS-type system like Automatic Emergency Braking) and the choice of base vehicle can affect overall safety, further illustrating why NHTSA should not set standards for subsystems or components. For example, a base vehicle choice of an occupantless vehicle like Nuro's can be much safer than the average vehicle on the road today, because they do not carry passengers who could be injured in a crash, their narrow width reduces the probability of a crash, and their lower mass and pedestrian-protecting designs can decrease crash severity. A recent study by the Virginia Tech Transportation Institute found that within their specific ODD, occupantless vehicles reduce the risk of fatality by 58% and injury by 62% for every mile of driving they replace.[13] This means that an occupantless vehicle could be more than twice as safe as a passenger vehicle with an identical ADS. Of note, this not only affects the probability of a crash, but also its potential severity. Failing to consider the vehicle that is associated with an ADS when developing a framework for ADS safety would leave out a critically important aspect of safety performance. Setting standards at the component, sub-system, or "primary function" level, rather than the system level, would not accurately measure safety.

Of course, manufacturers must evaluate and set performance targets for their own subsystems and components as part of their development and safety assurance process. However, we believe that because these internal targets are specific to each vehicle, system, and ODD; can regularly evolve; and must also consider business considerations like reliability in addition to safety, sub-system level performance standards are not the optimal method for NHTSA to consider ADS safety.

The totality of safety approach also fits well with the concept of a safety case. As NHTSA notes, a safety case is tailored to the application and ODD of a particular ADS, and makes an argument as to why, all things considered, the vehicle is safe. Therefore, Nuro supports NHTSA's contemplated development of guidance on the development of safety cases for ADS and ADS-equipped vehicles.[14]

Enable ODD variation

[13] *See* Witcher et al., "Estimating Crash Consequences for Occupantless Automated Vehicles," Virginia Tech Transportation Institute (2021), *available at* https://vtechworks.lib.vt.edu/handle/10919/102365.
[14] *See* ANPRM, 85 Fed. Reg. at 78067.

Even while considering performance at the system level, it is critical that NHTSA's safety framework is adaptable to diverse ODDs.[15] Some developers of ADS are designing systems for use in local environments. For example, Nuro's R2 is designed for last-mile delivery of goods, operating at a maximum speed of 25 miles per hour, and restricted to local roads. Other developers may envision a system that is exclusively used on highways, traveling from interstate exit to interstate exit.[16] Finally, some developers imagine a generally applicable system that will be used across multiple road types, vehicle types, cargo types, and environmental conditions.

The requirements of these different potential applications for ADS are very different. For example, the sensor requirements for a highway vehicle are optimized for longer distances due to higher-speeds, while the R2's sensor stack is optimized for the lower speeds but greater diversity of road users in neighborhoods. In addition to the problems described above with sub-system level metrics, a one-size-fits-all "vision test" that is not customized to the specific ODD of each system would not accurately measure the perception capabilities of that system (and as discussed above, is inconsistent with a totality of safety approach). Each operator's specific choices of deployment area, driving time of day, weather, and routing rules will drastically alter the exposure to different hazards even within the scope of a single town, city, or state; for this reason, a driving or vision test would have to closely match the risks expected to be encountered in an ODD, in proportion to how often they are actually encountered in that ODD, to accurately assess safety. This may be difficult to do as test assumptions can often differ from real world risks.

ODD likewise matters for issues like controls and latency; the requirements are different depending on speed, environmental conditions, and base vehicle capabilities (e.g. stopping distance).

Performance measures must therefore be developed in a way that can be tailored to a particular ODD. The aspects of each "primary function" (in NHTSA's taxonomy: sensing, perception, planning, control) that matter, and the specific performance thresholds on each primary function, will vary significantly with the ODD. Taking a "totality of safety" approach, as discussed above, can help ensure that regulatory approaches work across ODDs.

Within the current FMVSS, one example of a performance-oriented standard that accommodates diverse ODDs is FMVSS No. 135, Light vehicle brake systems. Rather than prescribe a specific braking system, FMVSS No. 135 focuses on stopping distance (performance standard), and includes a formula for adapting the performance requirement of stopping

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[15] There are many factors that go into the definition of an ODD, including vehicle speed, road types, environmental conditions, and even whether certain kinds of turns are in-scope. *See* Eric Thorn, Shawn Kimmel, and Michelle Chaka, Nat'l Highway Traffic Safety Admin., "A Framework for Automated Driving System Testable Cases and Scenarios" (2018), *available at* https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13882-automateddrivingsystems_092618_v1a_tag.pdf.

[16] *See* Ike, "Powered by Ike: How We're Working with the Trucking Industry," Medium (Sept. 1, 2020) https://medium.com/ike-blog/powered-by-ike-e0722bfc5dd2.

distance to vehicles with a top speed of less than 100 km/hr (accommodates ODD variation).[17] While this example is simpler than the challenge of ODD variation with an ADS, as top speed is only one aspect of an ODD, it illustrates how standards can be developed that are performance-oriented and accommodate ODD variation.

NHTSA should also seek regulatory approaches that support developers who build systems with a very restricted ODD. A restricted ODD can enhance road safety by allowing system designs that are optimized for the situations most likely to occur in that environment, reduce the frequency of cases that are challenging for all ADS, and reduce both the frequency and severity of crashes.

While we support a phased approach to the ADS safety framework, we would not advise NHTSA to create separate ADS standards based on particular vehicle types or business models. Some developers are building ADS designed to work across multiple vehicle platforms and use cases. In addition, this approach could inadvertently delay certain applications that may have significant social benefits. Instead, NHTSA should seek to assess the performance of the overall system as it performs in its particular ODD, compared to expected performance by a safe system in that ODD.

Encourage multiple methods of verification and validation

Developers do and should use a combination of methods to verify and validate the safety of an ADS. These methods include simulation, closed-course testing including accelerated testing, and on-road testing. Each method of validation has its benefits and drawbacks, and relying on any single method could lead to gaps or excessive risk to the public.

- **Simulation**: Enables developers to validate performance at scale, without exposing the public or employees to risk.
- **Closed-course testing**: Validates new software releases without risk to the public, and enables accelerated testing (i.e., exposing the system to multiple variations of rare but challenging situations).
- **Public-road testing**: Validates the accuracy of the simulation, collects data on how the entire vehicle performs under the conditions it will eventually need to handle on its own, and finds additional complex cases to challenge and improve software.

Of particular concern would be a regulatory requirement for a threshold number of miles, either for public road testing of software, miles driven manually to collect more data for simulations, or on closed courses. This requirement would be arbitrary and not reflective of legitimate variations in development approach and ODD scale. Such a requirement could also encourage driving that is not necessary to advance the software, creating incremental risk. Applying a mileage threshold to a specific vehicle platform would be particularly inappropriate because it would encourage the driving of unnecessary miles with a production, fully driverless system with no safety driver present for any ADS-Dedicated Vehicle ("ADS-DV"). In addition, a

[17] *See* FMVSS No. 135.S6.5.2, S7.5.3(b).

minimum mileage requirement could prevent new entrants and reduce competition. Finally, such a measure risks providing a misleading indicator of performance, because not all miles have equal value for informing or evaluating software; for example, highway miles may be collected more rapidly (due to higher average speeds), but typically would involve fewer interesting events per mile, like pedestrian interactions. Therefore, we were pleased to see that the ANPRM did not propose such an arbitrary requirement.

We encourage NHTSA to create a flexible framework that adapts to the ODD of each ADS, and allows for multiple data sources (including simulation, closed-course testing, public road testing, documentation, and other options) in any demonstration of safety.

Preserve the ability for traffic laws or planning-system rules to adapt to real-world circumstances

In the ANPRM, NHTSA summarizes several rules-based standards that are being developed for one aspect of the ADS, the Planning system, and gives them as an example of a potential FMVSS.[18] In addition, NHTSA states it "could require that ADS be designed such that they must follow all applicable traffic laws in the areas of operation."[19]

One of the significant advantages of an ADS is that it can be programmed to follow state and local traffic laws, avoiding major drivers of traffic crashes like speeding. However, in considering the possibility of including in the framework standards or requirements that ADS adhere to specific rules, we encourage NHTSA to recognize that traffic laws are designed to adapt to the circumstances, and so a blanket federal requirement to follow all applicable traffic laws could inadvertently prohibit some desirable conduct.

As NHTSA acknowledged in the ANPRM, state and local officials have traditionally had the responsibility for designing and enforcing these laws, and that role should be preserved. The discretion of state and local law enforcement to apply the rules as makes sense under the circumstances, including for unusual situations and local customization, is critical to ensuring they maximize safety as applied. That individual discretion, however, also means that "follow all applicable traffic laws" may be challenging to apply as a FMVSS, which must be "objective."[20] It also is unnecessary for the federal government to require this, because all states have established penalties for traffic violations, which are calibrated to the level of risk shown by a specific driving behavior (whereas a deviation from the FMVSS could require a recall).

While following traffic laws will be the rule for ADS-equipped vehicles, there may be times when exceptions are necessary. State and local traffic laws sometimes explicitly contemplate deviation from the "rules," when reasonable to do so in the interest of safety. For example, Washington State statutes state, "[n]otwithstanding the [other provisions of the rules of the road chapter] every driver of a vehicle shall exercise due care to avoid colliding with any pedestrian

[18] *See* ANPRM, 85 Fed. Reg. at 78072.
[19] *Id.* at 78071.
[20] The National Traffic and Motor Vehicle Safety Act, 49 U.S.C. 30111(a) (1966, as amended).

upon any roadway....”[21] Many traffic laws, including overtaking and passing another vehicle,[22] operating at a minimum speed,[23] or following another vehicle,[24] also explicitly contemplate context-specific judgment. Therefore, a requirement to simply follow all state and local traffic laws may not be sufficiently specified.

Likewise, rules-based standards for the Planning system that promote defensive driving can make an important contribution to ensuring the safe operation of ADS-equipped vehicles. Nuro is a member of the IEEE P2846 Working Group that is developing a common set of assumptions along these lines. However, Nuro's experience in developing our ADS and that of most of our industry peers has shown that defensive driving has the potential to be too defensive: it can become unsafe if it becomes unpredictable for other road users, for example by not seizing the right of way when appropriate. As other road users' expectations of AVs evolve over time, ADS developers need flexibility to adapt.

In developing the framework, we encourage NHTSA to consider what the traffic rule or defensive driving principle intends to achieve, rather than mandating strict adherence to every rule, and to prioritize those rules that are most critical to protecting public safety, as measured by the number and severity of real world crashes that are attributable to deviation from that rule. Standards should focus on achieving clearly defined safety objectives.

3. Nuro supports NHTSA's proposal to use a phased approach in its ADS safety framework.

We support NHTSA's plan to use a phased approach for regulations. In the near term, guidance is most useful while manufacturers are in a phase of testing and limited pilots and deployments, and limited data are yet available to NHTSA. A new safety case guidance, as well as updates to the guidance in *Federal Automated Vehicles Policy* in 2016 (“FAVP”) and *Automated Driving Systems: A Vision for Safety 2.0* in 2017 (“AV 2.0”) as described below, can help encourage new entrants and all existing developers to follow best practices in developing their systems. If NHTSA observes a pattern of deviation from these best practices that endangers public safety, it may be necessary to mandate some of them, such as the requirements mentioned in NHTSA's advance proposal that vehicles be able to come to a safe stop and that vehicles are constrained to operating autonomously to their ODD.

As NHTSA has repeatedly recognized, the Safety Act already includes a performance-oriented standard that can protect public safety and in fact accounts for the “vast majority of recalls,”

[21] Rev. Code Wash. 46.6.145.
[22] *See, e.g.,* Cal. Veh. Code 21751 (“On a two-lane highway, no vehicle shall be driven to the left side of the center of the roadway in overtaking and passing another vehicle proceeding in the same direction unless the left side is clearly visible and free of oncoming traffic for a sufficient distance ahead to permit such overtaking and passing to be completely made without interfering with the safe operation of any vehicle approaching from the opposite direction.”).
[23] *See, e.g.,* Cal. Veh. Code 22400 (“No person shall drive upon a highway at such a slow speed as to impede or block the normal and reasonable movement of traffic unless the reduced speed is necessary for safe operation...”).
[24] *See, e.g.,* Ariz. Rev. Stat. 28-730 (“The driver of a motor vehicle shall not follow another vehicle more closely than is reasonable and prudent....”).

which is the defect authority.[25] This authority is highly performance-oriented because it focuses broadly on the key goal of NHTSA's oversight, as demonstrated by real-world performance data — does a technology pose an unreasonable risk to safety?

Nonetheless, Nuro believes that highly-performance oriented standards beyond the defect authority, established within the self-certification structure, may ultimately be needed in the future, but it is too early for NHTSA to define and implement such standards. We agree with NHTSA that "issuing performance standards for ADS competency has been and remains premature…."[26] ADS technology continues to evolve rapidly, and testing and development is ongoing. While the number of AVs on public roads remains a small fraction of the overall US vehicle fleet,[27] there are modest benefits to creating restrictive regulations on their performance, but premature regulation could present a significant risk. It is possible that performance standards issued today could prevent novel designs or new approaches to ADS that are safer or more effective, but that NHTSA is not yet familiar with or that have not yet been developed.

Nuro also agrees with NHTSA's interpretation of the Safety Act as outlined in the ANPRM, that sufficient data are required in support of a particular FMVSS to show that it "meet[s] the need for motor vehicle safety."[28] As more ADS-equipped vehicles are deployed, NHTSA will be able to gather additional data to shape and support FMVSS. Therefore, we also encourage NHTSA to complete its planned rulemaking on improving the process for considering Part 555 exemptions,[29] and provide prompt consideration to future exemption petitions, to ensure manufacturers are able to deploy vehicles and provide data on their performance to NHTSA.

As NHTSA considers its safety framework, Nuro strongly supports maintaining the self-certification approach created by the Safety Act. Nuro agrees with NHTSA's recent position in its AV Guidance: "[NHTSA] [r]eaffirms U.S. DOT's reliance on a self-certification approach, rather than type approval, as the way to balance and promote safety and innovation. . . ."[30] Self-certification has worked well in the U.S. since the formation of the Agency, and is particularly well suited to a rapidly evolving technology like ADS, where software can be

[25] ANPRM, 85 Fed. Reg. at 78068, fn. 63.
[26] ANPRM, 85 Fed. Reg. at 78072.
[27] USDOT estimated that there are approximately 1,400 self-driving vehicles on the road, as of 2019. *See* Darrell Etherington, "Over 1,400 self-driving vehicles are now in testing by 80+ companies across the US," *TechCrunch*, June 11, 2019, https://techcrunch.com/2019/06/11/over-1400-self-driving-vehicles-are-now-in-testing-by-80-companies-across-the-u-s/. There were 297 million registered vehicles as of 2018, the most recent year available. Nat'l Highway Traffic Safety Admin., "Traffic Safety Facts: A Compilation of Motor Vehicle Crash Data" (2020), https://cdan.nhtsa.gov/tsftables/National%20Statistics.pdf.
[28] 49 U.S.C. 30111(a).
[29] *See* RIN 2127-AM11.
[30] U.S. Dep't of Transp., "Automated Vehicles 3.0: Preparing for the Future of Transportation," 6 (2019) https://www.transportation.gov/sites/dot.gov/files/docs/policy-initiatives/automated-vehicles/320711/preparing-future-transportation-automated-vehicle-30.pdf.

continually upgraded with new improvements that increase safety and expand the ODD during a particular vehicle's life.

4. We encourage NHTSA to complete its rulemakings on ADS-Dedicated Vehicles ("ADS-DVs") expeditiously to safeguard American leadership in the safe deployment of ADS technology.

In parallel with further work on an ADS safety framework, we encourage NHTSA to complete its ongoing work to modernize the FMVSS for vehicles without manual controls. We commend NHTSA for its work over the past several years on a rulemaking to update occupant protection standards for ADS-DVs,[31] which — together with contemplated rules on manual controls,[32] telltales,[33] and occupantless delivery vehicles[34] — could facilitate the deployment of occupantless vehicles and other innovative designs that will substantially improve public safety, health, mobility, and the economy.

Occupantless ADS-DVs like Nuro's are one especially promising example of a new vehicle type enabled by ADS technology, with substantial potential benefits for the public.

- **Improve road safety**: Occupantless vehicles decrease the number of vehicle occupants at risk of injury on our roadways, mitigate crash severity due to lower mass (without offsetting risk in occupant protection) and improved pedestrian protection, and reduce the probability of crashes due to a narrow design. A recent study from the Virginia Tech Transportation Institute showed that occupantless vehicles could reduce fatalities by 58% and injuries by 62% for every mile of driving in traditional vehicles that they replace.[35] This is just from the base vehicle design itself, and is in addition to the safety benefits of an ADS that avoids human errors, and a business model that enables more conservative driving and routing because there is no one in the vehicle who could become impatient.

- **Create new jobs**: A 2020 study from Steer estimated that delivery AVs could create and sustain 3.4 million jobs from 2025-35 — from fleet operators and pick-pack workers in retail, to more technical software and hardware engineers.[36] For comparison, there are currently 2.8 million federal government workers in the U.S.

- **Stimulate local economies**: Delivery AVs could generate $1.1 trillion in investment from AV delivery companies, suppliers, and retail partners over the 10 year period, which will generate an estimated $4.1 trillion in total value to the U.S. economy.[37] That is more than

[31] *See* RIN 2127-AM06.
[32] *See* RIN 2127-AM00.
[33] *See* RIN 2127-AM07.
[34] *See* RIN 2127-AM18.
[35] *See* Witcher et al., *supra* note 13.
[36] *See* Steer, "Economic Impacts of Autonomous Delivery Services in the US," 20 (Sept. 2020), *available at* https://us.steergroup.com/en-us/projects/economic-impacts-autonomous-delivery-services-us ("gradual shift" scenario (base case)).
[37] *Id.* at xvi.

the total $3.5 trillion in economic activity from oil and gas extraction over the last decade.

- **Decrease emissions**: Because AVs are more likely to be electric vehicles, like Nuro's 100% battery electric R2, delivery AVs can help reduce CO2 emissions by 407 million tons.[38] That would offset the emissions from powering every household in NYC, LA, Chicago, and Houston combined, for ten years.

- **Give people time**: By replacing trips to the store, delivery AVs could save Americans 21 billion hours of driving to and from the store.[39] That is the equivalent of every user recouping 1.5 hours every week.

- **Provide contactless deliveries**: AVs, and especially occupantless AVs, can enable contactless delivery of medicine, food, and other necessities. Over the past year, Nuro has used our autonomous vehicles to complete contactless grocery deliveries with Kroger and pharmacy deliveries with CVS, deliver food to the needy from food banks in three states, and transport medical supplies and meals at two temporary COVID hospitals in California.

- **Enhance access in food deserts**: 20 million low-income Americans live in areas classified by USDA as food deserts — communities without ready access to the fresh produce or lower prices found in supermarkets — that could benefit from AV delivery, enabling affordable access to fresh food. A Nuro analysis found that 70% could be reached within 30 minutes by delivery AVs traveling on roadways with speed limits of up to 45mph.[40]

We encourage NHTSA to move quickly to finalize the occupant protection rule, and to issue proposed rules modernizing other standards such as manual control references in the crash avoidance standard and telltales and indicators. Only once all FMVSS are modernized will manufacturers have the regulatory certainty needed for design and production investments, and will society receive the full benefits of this new technology.

II. Best Practice Guidance for AV Developers

With the FAVP and AV 2.0, USDOT outlined a series of best practices for developers, manufacturers, states, and localities. In the intervening four years, the state of the art has continued to advance and there has been broader recognition of the need to apply safety processes like those identified in the ANPRM. We recommend that NHTSA revisit the best practices outlined in these previous guidance documents to ensure they cover all critical, minimum safety steps.

[38] *Id.*
[39] *Id.*
[40] *See* Sola Lawal, "Serving America's Food Deserts," Medium (July 15, 2020), https://medium.com/nuro/serving-americas-food-deserts-a7442e922053.

Developers, including Nuro, use these practices to inform our safety approaches and structure our Voluntary Safety Self-Assessments. Of particular importance, updated best practice guidance from NHTSA could help ensure companies with less mature safety processes are aware of the key steps they should be taking to build a safe system, and help promote broader public trust in AV technology.

We also agree with NHTSA that "guidance documents, as they simply recommend rather than require actions by regulated entities, are more appropriate at this early stage in the development of ADS and ADS-equipped vehicles, reserving mandatory requirements for when the technology is sufficiently mature and actual safety needs have been more clearly identified." [41] An updated guidance on AV best practices will help maintain a high-standard of industry behavior, have an impact in the near term, and support continued innovation in improving safety.

Specifically, we recommend that NHTSA consider the suitability of best practice guidance on the following areas that were not fully addressed in AV 2.0:

- **Safety processes:** Processes like functional safety, including hazard analysis, and SOTIF were covered in AV 2.0, but without the depth of discussion included in the recent ANPRM, and without discussion of supporting tools like Safety Management Systems. The development of a formal industry standard on SOTIF in particular has advanced since 2017. Updated best practices on how AV companies should adapt these standards, originally developed for other contexts, to the development of ADS would be valuable.
- **Safety culture:** A strong safety culture is critical to identifying risks, incorporating safety into every step of the design, and making decisions that prioritize safety over other business objectives. Safety culture involves several elements: engineering rigor and competence, individual and group values, and patterns of behavior that are consistent with fostering the goal of ensuring safety. Safety culture is not amenable to regulation, but NHTSA could articulate best practices. For example, companies should provide a mechanism for anonymous reporting of autonomy safety issues and a zero-retaliation policy against reports of operator safety concerns.
- **Continuous improvement**: Companies should establish feedback loops that ensure unexpected events are reviewed promptly. Many unexpected events will be edge cases that present opportunities for improving the capabilities of the software, but a prompt review cycle also minimizes the risk to the public from any problematic behaviors or regressions in the ADS. Equally important, continuous improvement processes support a learning process so that the factors (whether technical or institutional) that led to any problematic behaviors become less frequent over time.
- **Redundancy**: AV2.0 briefly mentioned redundancy in the context of the System Safety element, but it is a critical strategy and would benefit from further elaboration. When there is not a human driver in the vehicle that can flexibly adapt to component or system failures, redundancy in safety-critical vehicle hardware, sensor, compute, and

[41] ANPRM, 85 Fed. Reg. at 78068.

software is important to reducing the probability of a failure that cannot be safely managed by the system (such as by assuming a minimal risk condition). For example, having redundancy in sensing — either with different sensing modalities or redundant sensors themselves for each distance range (short/medium/long range) — enables resilience to component failures, environmental conditions, and the inherent weaknesses of a particular sensor modality. ISO 26262 provides some guidance, but best practices on how to apply this in the context of autonomous vehicles would help improve safety throughout the industry.

III. Establishing Common Definitions, Resources, and Approaches

A near-term part of NHTSA's ADS safety framework should be to conduct research and convene the industry to establish common approaches, definitions, and assumptions. There are many issues that all ADS developers face where there are multiple valid answers, and where efficiency and/or safety would be served by having a consistent perspective, potentially accelerating the benefits of ADS. While industry is already coming together to advance agreement on many of these issues, NHTSA can play an important role in building consensus on these items, publishing research on common questions, and educating the public.

Provide common definitions

Communication with NHTSA, state and local governments, and the public would be aided by common definitions. NHTSA can play a role in helping achieve consensus on certain definitions.

- **Standardized collision scale**: NHTSA could support the creation of a standardized scale for assessing the severity of collisions, which would be a useful element for developers in measuring the performance of ADS. While a standardized *injury* scale exists, this does not apply in a straightforward way to evaluating the severity of *collisions,* and there is not a universally agreed methodology for translating a simulated collision into a severity metric. Trying to use an injury metric to assess collision severity is complex, because collisions can involve humans of various sizes and vulnerabilities, humans in cars or other vehicles vs. pedestrians or cyclists, secondary impacts, and other confounding factors. For the first time, collisions with ADS-equipped vehicles for the first time could occur without any human actors present (e.g., a single-car crash by an occupantless vehicle) — it is worth noting this collision and assessing its severity, but on an injury scale it would show as no impact. Finally, two collisions of comparable severity could happen to have very different injury outcomes based on factors that are irrelevant to assessing the performance of an ADS (e.g., whether a passenger is wearing a seatbelt).

  A standardized collision scale would aid benchmarking and reporting. Any such scale should be objective, based on factors such as approach velocity or delta V, type of crash partner, the location of contact on the crash partner, etc. Following the development of

a scale, research showing real-world frequency distributions in various ODDs would aid risk modeling and promote consistency across the industry.

- **ODD**: Industry standards groups have made some progress in defining ODDs[42] and NHTSA has sponsored some research on the subject,[43] but consensus has not yet been achieved.

- **Disengagements and close calls**: These two metrics, while both imperfect and insufficient for evaluating the performance of an ADS, are nonetheless commonly used. [44] For example, NHTSA requires disengagement reporting as a condition of the Nuro R2 exemption, but uses a different definition than California's DMV, and industry participants interpret California's definition in very different ways. Close-calls are more relevant than disengagements, as they represent potential safety incidents, but as it represents a counterfactual situation, it is difficult to achieve a commonly accepted definition. It is important that these definitions be as objective as possible, to avoid gaming or varying interpretations by different actors. NHTSA could facilitate consensus definitions on both terms.

Develop resources on scenarios

NHTSA could consider developing a publicly available scenario library. NHTSA previously published a typology of pre-crash scenarios, and could build on this by providing a typology of scenarios that define basic driving competence, as well as a library of edge cases tailored to various ODDs. As NHTSA correctly recognizes in the ANPRM, an obstacle course test "is likely not sufficient to meet the need for safety in and of itself,"[45] and we are not endorsing a federal driving test as an FMVSS-type regulation (this would encounter many issues such as diverse ODDs and the need for pre-mapping roadways). However, NHTSA can help accelerate the advancement of the industry by providing a useful resource on scenarios, as well as helping encourage developers to build systems that can handle those scenarios that are relevant to their specific ODD. We recommend that NHTSA (1) launch an effort, in partnership with stakeholders and with public participation, to define the scenarios that qualify as basic driving competence for various ODDs, and (2) develop a library of edge cases that is available to all manufacturers. Both of these tasks are today done independently by manufacturers; if NHTSA were to lead on the creation of these assets for the public benefit, it would be more efficient, improve consistency in safety assessment and performance across manufacturers, and help build public trust.

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[42] *See, e.g.,* Automated Vehicle Safety Consortium, "Best Practice for Describing an Operational Design Domain: Conceptual Framework and Lexicon" (2020), *available at* https://avsc.sae-itc.org/principles-02-5471WV-4508798.html?respondentID=28450326#Started
[43] *See* Thorn, Kimmel, and Chaka, *supra* note 15.
[44] *See* Andrew J. Hawkins, "Everyone hates California's self-driving car reports," *The Verge* (Feb. 26, 2020) https://www.theverge.com/2020/2/26/21142685/california-dmv-self-driving-car-disengagement-report-data.
[45] ANPRM, 85 Fed. Reg. at 78071.

Provide information for consumers and stakeholders

USDOT has already taken several successful steps to create transparency and promote information sharing, and Nuro applauds these efforts. By calling for Safety Assessment Letters / Voluntary Safety Self-Assessments in FAVP and AV 2.0; collecting a broad set of potentially relevant industry standards in AV 2.0's appendix and in the ANPRM; collaborating with groups like the Partnership for Autonomous Vehicles on consumer education sessions; and creating a forum for information sharing with the public and states with AV TEST, USDOT has helped provide more information to consumers on current technology.

A number of industry associations are collaborating to develop consensus standards and best practices. Going forwards, NHTSA can continue to spotlight and encourage the development of industry standards like IEEE P2846, which is developing common "Assumptions for Models in Safety-Related Automated Vehicle Behavior,"[46] or the best practices of the Automated Vehicle Safety Consortium. Spotlighting these standards, and the substantial investments the industry is making in the safe development and deployment of these systems, can help increase adoption and build public trust. In the future, NHTSA can build on these standards.

NHTSA should also continue to partner with industry to educate the public on the realities of today's technology, and the distinctions between the driver assistance systems available in consumer vehicles today and AVs being developed by companies like Nuro.

In addition, NHTSA could hold stakeholder workshops or listening sessions to receive more information from the public, including industry stakeholders, about the current state of the technology and any emerging issues.

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Nuro strongly supports NHTSA's efforts to begin developing a framework for ADS safety, and encourages the Agency to consider the principles recommended above as it develops that framework. In addition, we encourage NHTSA to include in the framework the development of best practice guidance, as well as completing research and convening stakeholders to help advance common definitions, resources, and approaches.

Thank you for the opportunity to comment on this advanced notice of proposed rulemaking. If you have any questions, please do not hesitate to contact us.

Sincerely,

David Estrada
Chief Legal and Policy Officer
Nuro, Inc.

[46] *See* IEEE, Working Group: P2846, "Assumptions for Models in Safety-Related Automated Vehicle Behavior," https://sagroups.ieee.org/2846/.