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December 10, 2018

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

Docket Number NHTSA-2018-0092

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

Dear Deputy Administrator King:

Nuro, Inc. (hereafter, "Nuro") is pleased to have the opportunity to comment on the National Highway Traffic Safety Administration's ("NHTSA" or "the Agency") advanced notice of proposed rulemaking on a potential Pilot Program for Collaborative Research on Motor Vehicles With High or Full Driving Automation (Docket Number NHTSA-2018-0092). Nuro shares the Agency's perspective that automated driving system (ADS) technology, properly harnessed, has the potential to provide tremendous benefit to road safety, the economy, and the public at large. We strongly support the Agency's efforts to facilitate the research necessary to allow for the rapid development of these technologies and to inform appropriate safety standards for ADS vehicles through a pilot program.

Nuro was founded with the mission to "accelerate the benefits of robotics for everyday life." We are the first company in the nation providing open-to-the-public, on-road goods delivery with unmanned autonomous vehicles. Central to that vision is "R1," a custom robot manufactured in the United States by Nuro exclusively for the purpose of delivery, and engineered from the ground-up with safety in mind. Unlike traditional passenger vehicles, these light-duty robotic delivery vehicles lack driver or passenger compartments; instead, they feature cargo and service compartments.

We believe that ADS vehicles like Nuro's have the potential to be the safest vehicles on U.S. roads, both for other drivers and pedestrians. By transporting goods, not people, we have designed our vehicle with safety innovations possible in nothing else on the road. Our neighborhood electric vehicle is lightweight, has a low top speed, is half the width of a typical car, and has a number of physical features designed to protect pedestrians and other road users.[1]

NHTSA's contemplated pilot program could be an important opportunity to support the development of light-duty robotic delivery vehicles by enabling critical research and demonstration projects, improving our understanding of how appropriate safety standards can be applied to this new kind of

[1] Our approach to safety and the innovations in vehicle design introduced in Nuro's vehicles are described more fully in our Safety Self-Assessment, *Delivering Safety: Nuro's Approach*, available at nuro.ai/safety.

vehicle design. We encourage the Agency to develop a pilot program that enables vehicles like Nuro's to participate.

Below, we address several of the questions the Agency has raised.

Question 1. What potential factors should be considered in designing the structure of a pilot program that would enable the Agency to facilitate, monitor and learn from on-road research through the safe testing and eventual deployment of vehicles with high and full driving automation and associated equipment? *and* **Question 3. What specific difficulties should be addressed in designing a national vehicle pilot program for vehicles with high and full driving automation either through the exemption process relevant for FMVSS or more broadly related to other areas of NHTSA and/or other authorities?**

As the Agency considers the structure of the potential pilot program and what parts of the FMVSS may require exemptions, we encourage the Agency to consider that vehicles designed for different applications may require different approaches in the pilot program and in future regulation. Research from the US Department of Transportation Volpe Center,[2] for example, explored thirteen different potential applications of ADS and identified the distinct ways that the FMVSS may pose regulatory barriers to their development. These findings are consistent with Nuro's own analysis.

We would encourage the Agency to consider four distinct types of light-duty vehicles in different applications in its pilot program, and how different FMVSS would be implicated for each:

1) Full-speed driverless, passenger vehicles: These vehicles would carry passengers, but are intended to lack controls for a human driver, such as a steering wheel or pedals.
2) Full-speed driverless light-duty delivery vehicles: These vehicles would have no human occupants. Like the driverless passenger vehicles, they lack controls for a human driver, but they also do not have any seating positions or need to protect those inside the vehicle. These light-duty vehicles are subject to NHTSA's principle jurisdiction notwithstanding their delivery purpose, if introduced or delivered into interstate commerce.
3) Low-speed driverless passenger vehicles: These vehicles may be used in a variety of applications, including passenger shuttles, but are limited to speeds of 25 mph or less and subject to the requirements of the low-speed vehicle class, including FMVSS No. 500. Some aspects of this standard may not be necessary for all low-speed driverless vehicle designs, such as mirrors.
4) Low-speed driverless delivery vehicles: These vehicles would require similar exemptions as their low-speed passenger counterparts, but would have some differences. For example, a vehicle without human occupants would not have a need for passengers to be able to see out of the vehicle. Nuro's R1 is a low-speed driverless delivery vehicle.

In each of these applications, different FMVSS are implicated, and different exemption approaches will be required — a program that provides exemptions only for driver controls would enable full-speed driverless passenger vehicles, but would be insufficient for vehicles without human occupants. For

[2] Anita Kim, David Perlman, Dan Bogard and Ryan Harrington, John A. Volpe National Transportation Systems Research Center, *Review of Federal Motor Vehicle Safety Standards(FMVSS) for Automated Vehicles: Identifying potential barriers and challenges for the certification of automated vehicles using existing FMVSS*, Preliminary Report – March 2016.

example, crashworthiness standards assume the presence of a human occupant, and therefore require vehicles, among other things, to use energy absorbing materials to protect the occupants and a certain amount of structure to manage the crash forces. While this is important in passenger vehicles, there are no human occupants to protect in light-duty delivery vehicles, and the structural materials could potentially increase the severity of injuries to pedestrians and other road users in the event of a collision. Nuro has developed a vehicle that uses softer, deformable materials designed to protect pedestrians; Nuro is able to apply this innovation, made possible by our application of goods delivery, on its low-speed vehicle design, but it might not be permitted for light-duty delivery vehicles capable of higher speeds without exemption under the current FMVSS (and possibly the bumper standard).

In this pilot program, we encourage NHTSA to consider how innovations can be enabled through a program design that recognizes the distinct opportunities and safety impacts of each different vehicle type and application. At a minimum, this would include providing exemptions to a different set of safety standards for each vehicle type, but we also encourage NHTSA to consider implementing faster pilot program approval timelines for vehicles with safety innovations or reduced crashworthiness risk due to their lack of human occupants, and designing the program application to require information only on topics relevant to that vehicle design.

Establishing a pilot program that enables all four vehicle types would be consistent with the Agency's goal of maintaining technology neutrality, allow development of new business models that benefit consumers, and enable the enhanced safety benefits of designs that lack human occupants or operate at low speeds.

Question 2. If NHTSA were to create a pilot program, how long would there be a need for such a program? What number of vehicles should be involved? Should NHTSA encourage the conducting of research projects in multiple locations with different weather conditions, topographical features, traffic densities, etc.?

A longer-term pilot program with flexibility on geography and number of vehicles would best serve NHTSA's objective of providing manufacturers "broad opportunities to gain practical, real world experience, in locations of their choosing, with different approaches to, and combinations of, hardware and software in order to learn which approaches and combinations offer the greatest levels of safety and reliability."

A long-term pilot, lasting 5 or more years, would best fit the nature of ADS vehicle manufacturing. The regulatory relief granted through the pilot program would apply to durable vehicles manufactured with the intent of lasting for several years; a long-term pilot would enable research over the life of participating vehicles. Accordingly, exemptions should be available for the life of the vehicle, just as they now are for exemptions granted pursuant to Section 30113 of the Safety Act. In addition, because the planning and manufacturing cycle is typically a multi-year process, a longer-term pilot would offer the ability to introduce new generations of vehicles that incorporate the safety learnings from initial tests, providing additional insights to manufacturers and NHTSA.

In addition, Nuro supports a flexible pilot program that allows for operation in multiple geographies. The ability to operate in diverse weather conditions, road types, and traffic cultures is a critical aspect

of ADS development, and the gradual expansion of the Operational Design Domain ("ODD"). The pilot program would enable the greatest development in technology and provide the most information to NHTSA if participants are able to operate in multiple locations and add additional geographies over time.

Similarly, it would be inconsistent with the pilot program's objective to impose a strict, upfront limit on the number of vehicles or number of vehicle types involved in a pilot because it would limit the diversity of geographies, environments, and applications that a manufacturer would be able to test in during the program. Instead, the number of vehicles per manufacturer should be based on the objectives and scope of the specific pilot application. This would allow NHTSA to determine if the scope of each proposed pilot is appropriate, rather than setting a limit in the abstract. Limiting the permissible number of vehicles within the pilot to a small number would also reduce the potential for learning in each pilot, reducing both the program's efficacy and efficiency, as each pilot program applicant will still need to bear the costs of applying and the Agency will need to bear the cost of administration.

Finally, it will be important to introduce flexibility into the program. Over time, manufacturers and NHTSA will develop even more confidence in how to to make these vehicles as safe as possible; new geographies or capabilities will be introduced; partner and user needs will shift; and individual vehicles may be decommissioned. Freezing the technology and scope at the time of application would prevent improvements in safety or utility, and reduce the ability to learn. The pilot should include a system for adding geographies, vehicle types, and additional vehicles after application approval, designed to minimize burden for both program participants and the Agency.

Question 7. What types of performance measures should be considered to ensure safety while allowing for innovation of emerging technology in vehicles with high and full driving automation participating in a pilot program?

Nuro supports NHTSA's contemplated approach of using performance measures instead of prescriptive regulation. A performance measure approach would ensure safe operation and allow for innovation in system software and vehicle design. This approach could play an important role in the industry by setting a minimum level of performance that all manufacturers must meet, contributing to public trust, while also allowing companies to innovate in ways that exceed the prescribed safety performance, as Nuro has done with its front-end design described above, or take new approaches to meeting the standard.

As NHTSA considers what performance measures should apply, we encourage the Agency to create measures that are appropriate to the vehicle's ODD. The challenges of metrics that do not consider vehicles' specific ODD can be seen in the use of disengagement rates (i.e., the miles traveled autonomously between instances of a vehicle operator disengaging the autonomy system), which some have suggested as a metric for evaluating vehicle safety:

- Disengagement rates include both desirable and undesirable cases: some system designs might be performing as intended when disengaging and turning control over to a human operator, such as in a SAE Level 3 Autonomy system or a Level 4 system designed to use remote operation in complex cases outside its ODD.

- Varying operating environments: The significance of the disengagement rate is highly dependent on the environment within a vehicle's ODD (e.g., road type, weather conditions, traffic congestion) — operating in a city is very different from a highway. Further, an ADS designed for highway use will drive more miles, yet is not necessarily safer or more capable than a city vehicle with a lower rate of miles per disengagement.
- Different definitions: There is not yet an agreed taxonomy of what counts as a disengagement; by way of example, in one state requiring disengagement reporting, some manufacturers have reported disengagements when turning off the vehicle at the end of the day, while others have excluded that case.

Beyond the deficiencies of disengagements as a metric, this example illustrates the importance of designing performance measures that take into account the specific ODD of a vehicle.

Question 8. How should the Operational Design Domains of individual vehicle models be defined and reinforced and how should Federal, State and local authorities work together to ensure that they are observed?

Nuro agrees with the Agency that "any pilot program for the testing of vehicles with high and full driving automation should include defined Operational Design Domains as a component of safe automated vehicle operation." As described in our Safety Self-Assessment, Nuro's vehicles are designed to operate autonomously only within their ODD; at other times, they are remotely operated by humans. The ODD is defined by factors such as road speed and type, weather conditions, and whether we have mapped the area. Before operating an ADS on public roads, we clearly specify its ODD, and include in our operational procedures methods for ensuring our vehicles do not operate outside those parameters, such as a pre-drive checklist that includes examining weather conditions.

Nuro's ODD will evolve over time. As our technology develops and we meet research milestones, we will progressively expand the ODD in various ways. For example, while our initial testing began in limited California geographies, we have expanded to additional areas and other weather conditions, including to Scottsdale, Arizona. In addition, in our pilot program in Scottsdale, we began by delivering groceries with modified Toyota Prius vehicles with safety drivers present in the vehicles, and intend to proceed to using our R1 custom vehicle once we have completed sufficient testing with the Prius vehicles. In these and other ways, we intend to continually evolve our ODD (including the ODD of vehicles in a potential pilot program) as we learn to better navigate new conditions, and to update the software on new and existing vehicles to provide them improved capabilities, engaging community stakeholders as appropriate.

In NHTSA's potential pilot program, we encourage the Agency to develop a process for expanding and updating the ODD applicable to a given exemption over time. In particular, we encourage the Agency to enable updates to the exemption's ODD to allow participants to expand to new geographic areas or new traffic environments, apply different vehicle platforms or perception hardware, and operate in additional weather conditions. This process should be designed to minimize the burden on the Agency and pilot program participants, including by, for example, requiring notice rather than approval for some changes, or not requiring notification unless changes to the ODD raise significant new safety issues. It is important to design a process with minimal burden to enable the rapid pace of innovation (requests could potentially come in every few weeks, as software is regularly improved, depending on

how ODD changes are defined), avoid a significant backlog or workload at the Agency, and minimize barriers to implementing safety improvements.

Question 9. What type and amount of data should participants be expected to share with NHTSA and/or with the public for the safe testing of vehicles with high and full driving automation and how frequently should the sharing occur?

Collecting data to aid in the development of future standards is an important objective of the pilot program. To aid in this objective, we believe that understanding manufacturers' validation approach and the safety results of that approach will be most helpful to the Agency. For example, NHTSA might consider using the information learned during the pilot program to provide guidance on the most important testing scenarios that are either difficult or have high exposure. These could include staged scenarios that are challenging for ADS but not encountered frequently, such as debris in the road, or targeted testing of scenes that the vehicle would encounter with a high frequency, such as interaction with pedestrians. This could supplement existing sources such as NHTSA's pre-crash scenarios, which are now based on crash data for human drivers.

As the Agency considers other data requirements, it should consider the readability of the data it collects. NHTSA has already recognized that ADS sensors generate terabytes of data daily, and that it would be impractical to provide all of this information. In addition, the Agency should also consider that some manufacturers have developed custom, proprietary software for interpreting the sensor data, and that some of this sensor data will not be readable by the Agency. To accommodate the issues of volume and readability in the event of a collision, NHTSA could consider requiring a summary of the incident on a prescribed form (as California's DMV regulations require) or a video rendering of the autonomy's perception and planning output, rather than raw sensor data. NHTSA should also consider restricting these data requirements to relevant crashes, excluding, for instance, crashes where the vehicle was not operating autonomously or was in park. Note that the majority of crashes involving ADS vehicles to date have occurred when the vehicle was stopped or not operating autonomously, and in almost all cases the autonomous vehicle was considered to not be at fault.[3] Data requirements might also be tailored to the specific ODD of a pilot program vehicle; for example, statistics on disengagement rates and transition to fallback mechanism are likely not helpful in cases where this is an intended aspect of the ADS.

Nuro also encourages the Agency to limit the collection of information that is sensitive, including commercial or financial information that could cause significant competitive harm, trade secrets, or private customer information. In addition, we encourage NHTSA to provide the same protection to confidential business information collected through the pilot program as it does to CBI collected today through other programs.

[3] Kia Kokalitcheva, "People cause most California autonomous vehicle accidents," *Axios*, Aug. 29, 2018, https://www.axios.com/california-people-cause-most-autonomous-vehicle-accidents-dc962265-c9bb-4b00-ae97-50427f6bc936.html.

Question 13. Which of the following matters should NHTSA consider requiring parties that wish to participate in the pilot program to address in their applications?

c. Test design (e.g., route complexity, weather and related road surface conditions, illumination and institutional review board assessment).

As described above in response to question 8, Nuro would encourage the Agency to develop a flexible program with capacity to evolve the test design over time in response to learnings and the evolution of the ADS technology, subject to notifying the Agency where appropriate.

j. Occupant/non-occupant protection from injury in the event of a crash (crashworthiness) and *l. Consumer education.*

As described above in response to question 3, Nuro encourages the Agency to consider, in its design of the pilot program application, that different vehicle types may require distinct approaches to certain topics. For example, because some light-duty delivery vehicles do not have human occupants, their crashworthiness approach as detailed in a potential application may focus predominantly on protecting other road users. In addition, consumer education approaches will differ between dedicated delivery and passenger vehicles, because consumers will not be able or permitted to enter light-duty delivery vehicles.

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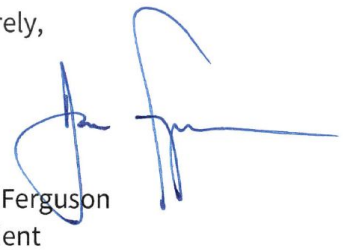
Thank you for the opportunity to comment on this advanced notice of proposed rulemaking. If you have any questions, please do not hesitate to reach out to us.

Sincerely,



David Ferguson
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