April 1, 2021

Steven Cliff
Acting Administrator
National Highway Traffic Safety Administration
1200 New Jersey Avenue, SE
Washington, DC 20590

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Docket No. NHTSA-2020-0106

Rivian Automotive, LLC Response to Advanced Notice of Proposed Rulemaking: Framework for Automated Driving System Safety

Dear Acting Administrator Cliff:

Rivian Automotive, LLC, ("Rivian") appreciates the opportunity to respond to the U.S. Department of Transportation's (USDOT) National Highway Traffic Safety Administration (NHTSA) Advanced Notice of Proposed Rulemaking (ANPRM) on a *Framework for Automated Driving System Safety.*

We applaud USDOT and NHTSA's continued leadership in advancing the safe testing and deployment of automated driving systems (ADS) in motor vehicles. As NHTSA has estimated, traffic crashes in the U.S. claimed 36,096 lives in 2019,[1] and the U.S. social harm (economic and societal impact) of motor vehicle crashes according to the U.S. Department of Transportation's most recent estimate is $242 billion annually.[2] With 94 percent of serious crashes caused by human error – and the potential for automated driving technologies to mitigate human error in the driving equation – the fundamental goal of automated vehicles (AV) is the reduction of injury and fatalities relative to current technologies. As previously noted by NHTSA leadership[3] and RAND researchers,[4] requiring the elimination of all crashes under automated vehicle control will delay or prevent the deployment of ADS that will improve overall motor vehicle safety.

Rivian

Founded in 2009, Rivian is an independent U.S. based California company dedicated to the production and distribution of Electric Adventure Vehicles™ – namely trucks and SUVs. These zero emission vehicles encourage consumers to enjoy the outdoors and seek adventure in

[1] https://www.nhtsa.gov/press-releases/2019-fatality-data-traffic-deaths-2020-q2-projections#:~:text=The%20FARS%20data%20indicate%20that,the%20same%20period%20in%202019.
[2] https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812013
[3] https://www.automotiveworld.com/articles/dont-want-perfect-get-way-good-says-rosekind/
[4] https://www.rand.org/blog/articles/2017/11/why-waiting-for-perfect-autonomous-vehicles-may-cost-lives.html

environmentally friendly ways. In addition, we have a commitment with our investment partner, Amazon, to develop and produce 100,000 all-electric heavy-duty class 2b and 3 trucks by 2030 for last-mile delivery. With a substantial presence in California and Michigan, and a manufacturing facility in Normal, IL, the R1T truck, R1S SUV, and delivery van will go into production in calendar year 2021.

Rivian's line of vehicles supports our mission to Keep The World Adventurous Forever™, by offering compelling and clean all-electric alternatives to internal combustion engine technology. Rivian believes that environmental sustainability can only be reached with the electrification and automation of all motor vehicle transportation sectors – including heavy-duty trucks. As a heavy-duty truck, our last-mile delivery van will displace stop-and-go operation of high emission diesel and gasoline powered vehicles typically operated in higher density population areas that disproportionately affect at-risk communities. In addition to criteria pollution reduction benefits, the delivery van order will displace over 5 million tons of carbon emissions.

In addition to being an electric vehicle manufacturer, we are also an AV manufacturer. Rivian Driver+, a SAE Level 2 technology, is standard on every vehicle we build. The system delivers true hands-free driving assistance, along with our full set of safety features, and it continually adds functionality through over-the-air updates. By making Driver+ standard, our goal is to make driving safer for everyone.

Our electric delivery vans for Amazon are more sophisticated and equipped with more innovative safety features than commercial vehicles before it. A suite of highway and traffic assist technologies to help protect drivers and the community, including state-of-the-art sensor detection, a 360-degree surround view camera and Alexa integration for hands-free access to route information and the latest weather updates. These advanced safety features will lessen the cognitive load on drivers and help improve safety for all road-users.

Below we provide a response to the questions posed throughout the ANPRM focusing on Safety Framework and Research.

Safety Framework

General/Conceptual

Rivian's conception of a Federal safety framework for ADS is one that will provide guidelines on a process through which companies would choose to submit a voluntary self-assessment report during multiple phases of development of their hardware and software for deployment on public roads. NHTSA would provide feedback to the ADS manufacturer on its self-assessment and perceived safety issues. We recommend that NHTSA provide guidance on this process through recommended engineering processes, verification and validation methodologies, and testing.

A manufacturer's demonstration of the safety of its ADS to the agency should be an open, transparent, and collaborative process. NHTSA should make clear the development documentation, tests, and other items that will be requested from the manufacturer to demonstrate the safety of its systems. This collaborative process should begin with submission of

a manufacturer's first voluntary self-assessment, so that the manufacturer can address these topics early in the development process.

To ensure that manufacturers assess each core element of safety effectively, NHTSA should establish a phased approach towards the submissions of the voluntary self-assessments. The development of ADS at increasing levels of autonomy is an iterative process, not a "one and done" proposition. NHTSA should provide early feedback on the manufacturer's core elements of safety. By providing this early feedback, NHTSA would create clear expectations for the manufacturer's next phase of submission and ensure that key performance indicators, such as on-road and simulations tests, are mutually agreed upon.

Assessment

To best assess whether each manufacturer has adequately demonstrated the extent of its ADS' ability to meet each prioritized element of safety, NHTSA should adopt system level guidance.

For this system level guidance, we agree with the core elements of "sensing," "perception," "planning," and "control" as described in this notice. "Sense, Plan, Act" is an established paradigm in robotics and most modern architectures act as a variant of this paradigm.[5] [6] Automated driving tasks rely heavily on perception, so it is reasonable for NHTSA to put special emphasis on the perception modalities of sensing. Further, key automotive companies are already adopting this approach.[7] [8]

Following the Sense, Plan, Act paradigm, Rivian would also recommend that the agency add the high-level objectives of each executor to its core elements.

For "perception" and "sensing", object detection and object tracking are key results and their quantitative metrics (accuracy, precision, recall, etc.) are technology agnostic. We believe a standard which defines reasonable assumptions and results of tracking and detection would be most useful. Furthermore, without accurate environment information from tracking and detection, prediction and planning are limited to general conservative approximations of the surrounding environment.

"Planning" and "control" require a fully dynamic environment for their assessment. An optimal means for NHTSA to acquire sufficient data to provide meaningful feedback to ADS manufacturers on the real world performance of their ADS relative to these elements would include a combination of scenario tests in a simulated environment where sensor and perception feeds are assumed to be absolutely accurate.

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[5] Motion Planning: Wild Frontiers; Steven M. Lavalle; http://lavalle.pl/papers/Lav11c.pdf

[6] Springer Handbook of Robotics; Siciliano, Khatib; 2008

[7] Continental; https://www.continental-automotive.com/en-gl/Passenger-Cars/Company/Chassis-Safety-Division/SensePlanAct

[8] Bosch; https://www.bosch-mobility-solutions.com/en/highlights/automated-mobility/sense-think-act/

For “prediction” and “planning”, Rivian recommends building from work conducted in the ADS research community, including that which is currently in progress. Propositions of the IEEE working group P2846 highlight the need for a technology agnostic, risk-minimized planning framework. This framework also focuses on fundamental principles and assumptions that should be satisfied by any planner.

For “control”, Rivian would recommend that NHTSA leverage current community work establishing verified control of the given system. For example, ISO 26262 provides guidelines for the safety critical systems at the controller level.

Finally, and at this point in the industry’s development of ADS, Rivian recommends that NHTSA should start by defining broad guidelines (as opposed to regulations), thereby creating a general framework for manufacturers to follow while allowing room to develop and innovate technologies in order to achieve deployment of ADS. NHTSA should continuously review developments by manufacturers – looking at maturity in their ADS capabilities and determining which of these guidelines could transition toward regulations for ADS.

Standards/Methodologies

At this juncture, it is premature for NHTSA to adopt Federal motor vehicle safety standards (FMVSS) or to consider validating the appropriateness of FMVSS, particularly via vehicle/ADS system simulation or modified vehicles on closed roads. The subjective nature and nascent state of current validation measures present the potential of adversely impacting the innovation and creative development of safe ADS systems should these measures be adopted as regulatory requirements.

While Rivian cautions against the premature adoption of FMVSS, Rivian does recommend that the following voluntary standards should, at present, be considered as useful in the development and evaluation of ADS systems:

- ISO 26262:2018 (Functional Safety)
- PAS 21448 (Safety of the Intended Function)
- ISO/SAE 21434 (Cybersecurity)
- IEEE WG P2846 (Autonomous Vehicle Decision Making)
- UNECE 79 (Uniform provisions concerning the approval of vehicles with regard to steering equipment)
- UNECE WP on Automated/Autonomous and Connected Vehicles
- EU Directive 2010/40/EU

Assessment

For rule-based and statistical methodologies best suited for assessing the extent to which an ADS meets the core functions of ADS safety performance, Rivian recommends continually measuring specific perception, planning and controls Key Performance Indicators (KPI) collected over miles driven in autonomous mode. This methodology will provide a statistic profile to understand the

"margin to safety" (setting a minimum threshold for identified critical ADS KPIs and then measuring a level of margin from the minimal thresholds). In addition, Rivian recommends measuring the same perception, planning and KPIs on vehicles driving by a human driver to use as a comparison data to vehicles in autonomy mode to further demonstrate better margin to safety for autonomy algorithms versus human driving.

In terms of quanta of evidence necessary for reliable demonstrations of the performance levels achieved for the core elements noted by NHTSA, Rivian recommends that both vehicle miles driven and simulated data are key data types required to prove the level of performance for an ADS system. In addition, structured "testing to fail" (e.g., testing in a controlled environment and by controlling parameters of the test to purposely reduce the margin of safety to determine the response of the ADS system) better quantifies the margin of safety and controllability of the vehicle during corner case scenarios.

Rivian suggests three areas for ADS system argumentation that would reliably and persuasively demonstrate levels of performance achieved for the core functions of ADS safety –

1) core ADS functionality demonstrating the fundamentals of ADS technology;
2) operational predictable degraded core ADS functionality in the presence of an external limitation to prove the capability of adjusting performance but maintaining safe functionality; and,
3) achieving vehicle safe state of the ADS system in the presence of an external limitation to prove the system can achieve a suitable safe state for the vehicle, its occupant(s) and surrounding actors.

Rivian suggests the following types of data to demonstrate ADS safety performance –

- KPI information and supporting data over time to show core functionality build out and functionality improvement in ADS algorithms;
- close track test scenerios demonstrating how ADS systems react to safety critical events (e.g., reaction to a person unexpectantly walking in front of a vehicle, reaction to a cyclist weaving on the road, etc.);
- close track scenerios demonstrating how ADS systems respond to environmental factors (e.g., heavy rain, wet road conditions, bright sun, fog, etc.);
- simulation data modeling high milage showing high volume scenarios with ADS metric analysis; and,
- real world continuous data collection from an AV fleet demonstrating diverse scenarios with ADS metrics.

NHTSA Research

Global Survey

In terms of additional research that would support a creation of a safety framework, NHTSA should, as an immediate action, survey the state of autonomous driving regulatory developments related to a safety framework in other countries and regions such as Germany, UK, the EU, Japan, Korea, and China. Germany and China, for instance, have each coordinated national government-industry efforts in this area for the past three years and it would be instructive for NHTSA to understand the directions in which they are heading with their ADS research. Further, this survey could help identify bodies of work and research which could be leveraged by NHTSA to expedite its own advancement in this area. Once a full survey of global efforts is completed, NHTSA would be better positioned address open issues and also to build its research plan on the foundation of research and data that has been gathered and published by trusted entities such as university labs and standards organizations.

Simulation as a Verification and Validation Tool

One tool that would be highly useful as an aspect of NHTSA research is an open source simulator where a "virtual test drive" can be performed on a platform whose code is fully transparent and open. Research on the verification and validation of perception and control algorithms in the simulator could help evaluate the tool as a test for the efficacy of safety frameworks. Other support tools such as sensor modeling for the simulator would also accelerate the virtual portion of the test and verification process.

Scenario Testing

Aligning with our recommendation for system level testing, NHTSA should research scenarios that the agency could use for a baseline for vehicle testing. Without a specified set of scenarios, miles driven per intervention and qualifying tests do not guarantee a minimum level of performance across ADS. For example, an ADS tested in a dense urban setting will exhibit a different disengagement frequency than an ADS tested on rural highways. Without consistency among assumptions and variables, it is impossible to gauge relative performance.

For researching the scenarios, or the operating domains referenced above, the agency should begin by devising simple operating domains that can then be compounded to create increasingly complex scenarios to test against without having to create additional new scenarios from the beginning. Rivian also recommends interjecting an expectation of stochasticity per scenario to test ADS robustness. Further, expectations for object tracking and object detection performance in the scenarios described above would add a layer of assurance to the ADS system. And, minimum requirements for "planning" could be developed with the minimum object tracking requirements in mind.

Infrastructure Enhancements

As an extension to NHTSA research, Rivian recommends that the agency, in conjunction with the Federal Highway Administration, examine road infrastructure and the extent to which certain roadway enhancements or improvements could assist ADS manufacturers in expanding the ODD for their systems. An examination of certain infrastructure elements (such as road markings or localized traffic signal beacons (or, transponders)) would benefit both human operators and ADS through eventual improvements that could support navigation, particularly in adverse weather conditions such as fog, snow, or other precipitation.

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Rivian appreciates the opportunity to engage with USDOT and NHTSA through this comment process and as we work with other stakeholders throughout the ecosystem to enable and deploy ADS. Thank you for your consideration of our feedback and ongoing efforts to ensure American leadership in the safe testing and deployment of this life-saving technology. If you have any questions or require follow-up information, please contact me at nbell@rivian.com.

Sincerely,

Nancy Bell

Nancy Bell
Director, Regulatory Affairs & Associate General Counsel