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Testimony of
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U.S. House of Representatives
Committee on Transportation and Infrastructure
Subcommittee on Highways and Transit
"The Road Ahead for Automated Vehicles"

Chair DeFazio, Chair Norton, Ranking Member Graves, Ranking Member Davis, and Members of the Subcommittee on Highways and Transit. Thank you for the invitation to provide testimony for the hearing "The Road Ahead for Automated Vehicles."

My name is Nat Beuse and I am the Vice President of Safety at Aurora. Aurora's mission is to deliver the benefits of self-driving technology safely, quickly, and broadly. We are building the Aurora Driver: a platform that brings together software, hardware, and data services, to autonomously operate any vehicle without the need for a human operator in the vehicle. Aurora has offices across 8 cities in 7 states, including our headquarters in Pittsburgh, Pennsylvania, and employs 1,600 employees ranging from hardware and software engineers to commercial drivers and operations specialists.

At Aurora, I lead the team developing and implementing Aurora's rigorous and comprehensive approach to safety. We oversee operational, organizational, and product engineering safety, and work with industry standards groups and regulatory bodies to offer guidance and to define and support the development of best practices and safety standards. Prior to Aurora, I led the safety team at Uber Advanced Technologies Group (ATG) where I further developed their approach to safety. Before working in the private sector, I spent nearly twenty years serving the American public in several capacities including leading the New Car Assessment Program, serving as Director for the Office of Crash Avoidance Standards, and finally as Associate Administrator for the Office of Vehicle Safety Research at the National Highway Traffic Safety Administration (NHTSA). In that last role, I oversaw the nation's motor vehicle safety research program, including automated vehicles and cybersecurity. Today, I also serve on the board of two roadway safety advocacy non-profit organizations, Mothers Against Drunk Driving and Lifesavers, and live in Pittsburgh with my family.

About Aurora

Aurora is delivering the benefits of self-driving technology safely, quickly, and broadly. Founded in 2017 by experts in the autonomous vehicle (AV) industry, Chris Urmson, Sterling Anderson, and Drew Bagnell, Aurora is revolutionizing transportation – making it safer, increasingly accessible, and more reliable and efficient than ever before. Our flagship product, the Aurora Driver, is a platform that brings together software, hardware, and data services, to autonomously operate passenger vehicles, light

commercial vehicles, and heavy-duty trucks. Aurora is partnered with industry leaders across the transportation ecosystem including Toyota, Uber, Volvo Trucks, FedEx, and PACCAR. Aurora tests its vehicles in the Bay Area, Pittsburgh, and Texas, and has offices in those areas as well as in Bozeman, Montana; Seattle, Washington; Louisville, Colorado; and Wixom, Michigan.

We have a diverse and talented team with a multitude of backgrounds and perspectives, focused on creating a transformative business for the long-term and realizing our mission. We also leverage expertise from external groups including our Industry Advisory Council[1] and Safety Advisory Board[2].

Our goal at Aurora is to transform transportation — to make it more democratic, more productive, more dependable, and — crucially — much safer than it is today. The teams we create, the work that we do, and the partnerships we build all serve this mission: To deliver the benefits of self-driving technology safely, quickly, and broadly.

We see incredible opportunities for the Aurora Driver to positively impact transportation. We can save lives while also increasing safety and efficiency on our roads. We can make the movement of people and goods both less expensive and more accessible. We can serve communities and industries in mutually beneficial and transformative ways.

[1] Aurora, "Introducing the Aurora Industry Advisory Council," https://aurora.tech/blog/introducing-the-aurora-industry-advisory-council.
[2] Aurora, "Our Updated Safety Report and First-Ever Safety Advisory Board," https://aurora.tech/blog/aurora-shares-safety-report.

However, unlike other types of vehicle technologies, delivering the full potential of all these opportunities depends on one concept: trust. Our technology needs to be trustworthy. Our company and our engineering work need to be trustworthy. And so our task is to build trust, one step at a time, by making safety the foundation of everything we do from the beginning.

Building Safety for Scale

Safety is at the core of everything we do at Aurora. It shapes who we hire, how we work, and how we develop our products. Everyone at Aurora is empowered to speak up and say something when they see something. We've also built layers of redundancies into every part of the Aurora Driver. We collaborate regularly with the industry to develop industry best practices and voluntary standards, and we openly share our progress in the communities where we are operating. We hold ourselves to rigorous internal safety standards that cover our engineering, operations, and organization.

It is worth noting how far the industry has come in the last decade in the development of standards for AVs. In 2017, USDOT published AV 2.0, which lists exactly 3 standards (SAE J3016, ISO 26262, and MIL-STD-882E) that should be considered by automated driving system (ADS) developers. Fast forward to 2021, and USDOT's comprehensive plan lists 20 different standards that ADS developers should consider. And based on Aurora's involvement in industry standards development, we know there are over a dozen more standards and best practices currently under development across the various standards organizations.

I am pleased to share just a few examples of where we have developed industry leading approaches to safety that have been openly shared with our fellow industry partners, the public, regulators, and other safety stakeholders.

Managing Safety Risks

As we like to say at Aurora, "Safety is a team sport." We take a holistic view of safety, focusing on creating a strong safety culture that permeates every part of our company, including how we do business. A key part of that approach to safety is implementing our own Safety Management System, commonly referred to as SMS. This is an organizational approach — employed by safety-critical industries like aviation, maritime shipping, and rail — that standardizes how safety is managed at a company. SMS is a rigorous, internationally accepted framework that is mandated for other modes of transportation and provides a reproducible and auditable record of safety management within a company. SMS starts at the top, with our CEO being our Accountable Executive for the safety of operations, instilling safety into every aspect of the company.

A SMS ensures that safety information is presented to the right person, at the right time, and that there is accountability and transparency for every safety action taken across the company. This approach ensures that safety is prioritized as we make decisions, with features such as a Safety Review Board for safety risk management decisions and a clear and easy-to-use Safety Concern Reporting process for all employees. It also enables us to measure our safety performance over time to work for constant improvement in our policies, processes, systems, and controls.

At Aurora, we are building our SMS on four key components — a detailed Safety Risk Management structure, a robust Safety Assurance program, disciplined Safety Policy documentation, and an engaging Safety Culture that includes safety education and events. Our SMS helps us proactively identify safety issues, resolve them as early as possible, and institutionalize the learning for future application. It also ensures our entire company values safety, understands our safety procedures, uses a common language to talk about risk, and is appropriately empowered to take action on safety.

Safety Advisory Board

Building a team with depth and breadth of safety expertise is a key part of our safety approach. Inside Aurora, we have multi-disciplinary experts with decades of experience in autonomous and automotive safety. And to ensure we're always testing our assumptions and raising our safety standards, we also leverage the expertise of safety leaders outside of Aurora. We created the Safety Advisory Board to gain hundreds of years' collective experience in safety, offering the company an external perspective on Aurora's overall approach to safety, as well as other broader industry topics, like how we engage with regulators and the public. The Board also offers feedback on systematically managing, controlling, and mitigating safety risks.

This Board is made of experts from fields including aviation safety, insurance, emergency/trauma medicine, automotive safety, and academia:

- Shailen Bhatt, Senior Vice President for Global Transportation Innovation, AECOM
- Dave Carbaugh, Former Chief Pilot Flight Operations, The Boeing Company
- Dr. Adrian Lund, Managing Member of HITCH42, LLC and former President of the Insurance Institute for Highway Safety
- Dr. Victoria Chibuogu Nneji, Lead Engineer & Innovation Strategist at Edge Case Research
- Karen Rasmussen, Executive Director of the Independent Carrier Safety Association (ICSA)[3]
- Dr. Jeff Runge, President of Biologue, Inc. and former Administrator of the National Highway Traffic Safety Administration
- George Snyder, President and CEO of GHS Aviation Group

Safety Case Framework

How do we know if an AV is safe enough to drive on public roads? It's a question that has been asked since society first started talking about the potential for AVs to grace our roads. At Aurora, we are using a safety case-based approach, a defined way to evaluate when our vehicles are acceptably safe to operate on public roads and to assess that they are not creating an unreasonable risk to roadway safety.

In August 2021, we publicly released Aurora's Safety Case Framework — the first AV Safety Case Framework that applies to both autonomous trucks and passenger vehicles. We believe that a Safety Case Framework is the most effective and efficient path to safely removing the vehicle operator and it is an imperative component for any company looking to operate without a vehicle operator and safely

[3] "Aurora Welcomes Trucking and Freight Expert to Company's Safety Advisory Board," Business Wire, https://www.businesswire.com/news/home/20211015005433/en/Aurora-Welcomes-Trucking-and-Freight-Expert-to-Company%E2%80%99s-Safety-Advisory-Board.

deliver commercial-ready AVs at scale. The Aurora Safety Case Framework assesses the entire development lifecycle of our vehicles, allowing us to accelerate our path to deployment and determine when AVs are acceptably safe for public roads. We are the only AV company currently operating in our industry to publicly share its Safety Case Framework.

We believe the only viable way to validate that an AV is safe enough to drive on the road is to develop a structured argument, using a framework of claims and the evidence to support those claims. Building a Safety Case Framework allows us to demonstrate exactly how we are approaching safety and the many factors we are taking into consideration — a stark contrast to simply reporting on miles driven or disengagements, which do not necessarily provide support for the fact that a vehicle is safe for any specific context or environment. This structured approach is the only way Aurora believes we can safely commercialize our AVs.

No single piece of evidence captures the totality of safety. There are complex interactions and relationships between the many elements that go into an AV. Ultimately, evidence without a claim is simply trivia and, conversely, a claim without evidence is baseless. A safety case-based approach brings these two essential concepts together in a logical manner to effectively show the work that we are doing to determine our vehicles are safe to operate on public roads. Along with delivering a safe product, being transparent with our approach is an important part of developing autonomous technology.

Our top-level claim, that the Aurora Driver is acceptably safe to operate on public roads, is broken down into the following five safety principles:

- Proficient
- Fail-safe
- Continuously improving
- Resilient
- Trustworthy

1. Proficient - An AV cannot be considered safe to operate on public roads unless it is suitably proficient. Proficiency includes the design, engineering, and testing necessary to develop a product. This safety principle contains the engineering requirements for nominal operations and performance.

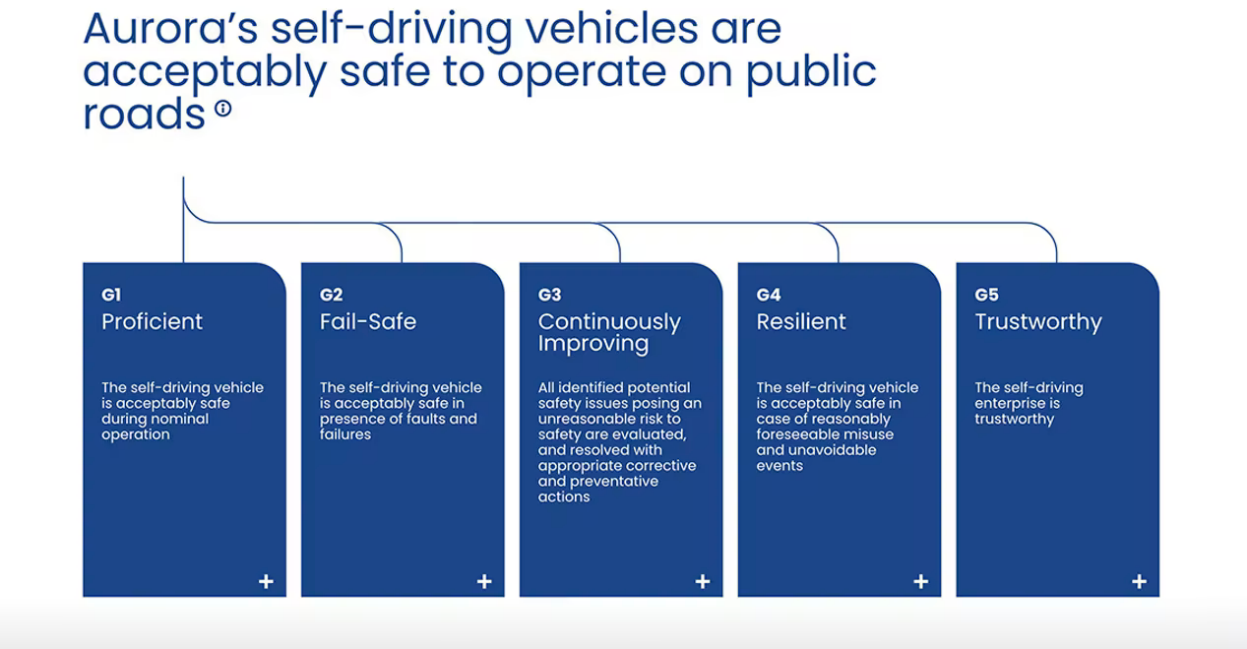
2. Fail-Safe - The fail-safe principle addresses how the AV behaves in the presence of faults and failures. No system is ever 100% perfect; components will wear out or have premature failures from time to time. The Aurora Driver is designed to detect and safely mitigate these failures. This safety principle contains the fault detection, mitigation, and notifications built into the vehicle to ensure that in the event of a fault or failure, the Aurora Driver will behave in an acceptably safe manner.

3. Continuously Improving - The continuously improving principle outlines how we are enshrining the concept of continual improvement into the development of our system. An AV is equipped with sensors, and a fleet of AVs captures significant amounts of data from just a single day's operations. We are able to harness the power of this data to enable continuous improvement. This field data feeds a comprehensive data analysis effort that calculates safety performance indicators and also considers data collected during design and development. This approach to systematically collect and analyze data

allows us to spot trends, regressions from the mean, and emergent behaviors. Aurora also takes a proactive approach to continuous improvement, using risk identification techniques to proactively identify and manage risks.

4. Resilient - AVs are designed to safely operate on public roads, but this does not isolate them from malicious actors or unavoidable events. The resilient principle showcases how the Aurora Driver is capable of withstanding adverse events and intentional misuse and abuse.

5. Trustworthy - Aurora's AV may be Proficient, Fail-Safe, Continuously Improving, and Resilient, but without the trust of the public and governmental regulators, we cannot fully realize our top level claim. The trustworthy safety principle addresses how Aurora plans to gain trust through public, government, and stakeholder engagement, safety transparency, safety culture, as well as external review and advisory activities.



The Aurora Driver & Partnerships

In 2021 alone, we partnered with one of the largest transportation and logistics companies in the world with FedEx, the number one ride hailing platform on the planet with Uber, the number one global vehicle OEM with Toyota, and two of the top three North American OEM's in trucking with Volvo and PACCAR.

We showed how the Aurora Driver can be seamlessly integrated into freight operations via an industry-first collaboration with FedEx and PACCAR. Through this pilot, Aurora-powered PACCAR trucks are regularly and autonomously hauling FedEx loads in Texas between Dallas and Houston – a 500-mile round trip, currently with a trained vehicle operator and co-pilot in the cab gathering data on the Aurora

Driver's performance.[4] We believe this collaboration demonstrates the value of autonomous technology as the economy faces a supply chain crisis, making the need for dynamic logistics solutions more important than ever.

After partnering with Volvo last March, we developed the trucking leader's first-ever prototype truck for autonomous commercial, hub-to-hub freight operations in North America – the Aurora-powered Volvo VNL. As Volvo's flagship long-haul model, and the first vehicle in Volvo's fleet to be designed from the ground up to operate with the Aurora Driver, this represents a significant step toward building and deploying autonomous commercial Level 4 Class 8 trucks at scale for Volvo Autonomous Solutions customers in North America.

Federal Policies to Support the Development of Safe AVs

Aurora takes safety to heart - it is not just a principle for us. It is how we are building a safety culture and process for a future where our families can travel safer in and around vehicles powered by the Aurora Driver. It is unacceptable that we lose over 40,000 people in the United States each year in vehicle crashes, and yet, we are on track for one of the worst years for roadway safety in decades. We are committed to being part of the solution.

There are tremendous opportunities for the whole federal government to continue supporting the development of AV technology here in the United States to provide certainty that companies, including

[4] See "Aurora Illuminated: Aurora Driver Hyperlapse on Texas Roads," Sept. 2021, https://www.youtube.com/watch?v=ttvEppD3Pjk.

Aurora, need to continue investing and building here.[5] Creating a level playing field where the rules are clear and conducive to realizing the benefits for safety, mobility, and efficiency for AV technology is a necessary role of government.

First, Aurora supports the work of Members of this Committee, Congress, and USDOT to ensure that laws and regulations for AVs are performance-based and technology and business-model neutral.

Second, federal leadership supporting the development of AV technology here in the United States is critical. The work that started many years ago at USDOT under Secretary Foxx, continued under Secretary Chao, and carries through today under Secretary Buttigieg. USDOT's guidance, research and rulemakings that have been initiated specific to AVs, along with the Department's use of its convening authority to bring stakeholders together, has laid the foundation for the future. We would like to thank Secretary Buttigieg for raising important safety issues in his six guiding principles for transportation innovation and in the "Comprehensive National Roadway Strategy." We also believe USDOT should be considering the full suite of potential solutions, including AVs, to address the rise in highway fatalities.

We support NHTSA's efforts to modernize the Federal Motor Vehicle Safety Standards (FMVSS) and the Federal Motor Carrier Safety Administration's (FMCSA) efforts to modernize the Federal Motor Carrier Safety Regulations (FMCSR) to encourage the development of new and innovative AV technologies.

As you know, the FMVSS and FMCSR were not created with autonomous technology in mind. As such, neither currently contemplate the integration of autonomous technology, like the Aurora Driver, into vehicles, and should be updated to account for this new technology as appropriate to improve the efficiency of the technology's deployment. There are important open rulemakings at NHTSA and FMCSA that need to continue to expeditiously move forward.[6] In preparation for other future regulatory actions, the agencies should continue providing guidance, conducting research, and fostering collaboration among stakeholders to support AV development. Additionally, the existing exemptions process at NHTSA should be used as a bridge to get real-world data to USDOT about innovative vehicle technologies.

Third, we believe Congress should pass legislation confirming the federal government maintains its regulatory authority over the design, construction, and performance of AVs. Every vehicle that is on public roads, including AVs, is subject to the Motor Vehicle Safety Act, which provides NHTSA with broad authority over the safety of motor vehicles and motor vehicle equipment and to issue and update regulations as necessary for the purpose of reducing traffic crashes. States can, and should, continue to regulate the testing and deployment of AVs on their roads in areas such as on-road operations, titling, licensing, test driver training, and the like. Many states have proactively passed legislation on these issues, which support the development of AVs. Still, there is tremendous value in leadership from the

[5] See "Forefront: Securing Pittsburgh's Break-out Position in Autonomous Mobile Systems," Sept. 2021, https://ridc.org/news/autonomy-study/.

[6] See, e.g., NHTSA, Framework for Automated Driving Systems Safety, RIN 2127-AM15; NHTSA, Occupant Protection for Automated Driving Systems, RIN 2127-AM06; and FMCSA, Safe Integration of Automated Driving Systems-Equipped Motor Vehicles, RIN 2126-AC17.

federal government supporting the AV industry and the safety, economic, and mobility benefits of this technology.

As an example, we believe the federal government has the opportunity to provide leadership encouraging uniformity of existing state rules of the road. For example, in some jurisdictions it is required by law to use a bike lane to make a right-hand turn while in others it is prohibited. We do not have a position on what is the safest option, but we do believe that uniformity across states would be beneficial for all road users, including the Aurora Driver. Similarly, we see vastly different autonomous operational permitting requirements across state jurisdictions, with some states allowing operations with few permitting requirements and others instituting significant testing parameters or even outright prohibiting autonomous testing or operation. Such differences in programs slow down the nationwide rollout of this technology. While autonomous operations permitting and traffic law are clearly within state jurisdiction, Congress could provide valuable guidance to states and NHTSA on tackling this patchwork of laws that affects all drivers, regardless of whether they are human or autonomous.

Fourth, Aurora supports maintaining the self-certification process for vehicles in the United States and believes a Safety Case-based argument supported by evidence is the way for companies to make safety determinations as discussed above.

Fifth, we ask Congress to ensure that commissioned research about the job-related impacts of AVs be driven by actual industry experience, and that job quality should be central to any policy and industry conversation. It is encouraging that a USDOT report from last year indicated that potential reductions in long-haul trucking jobs related to AVs are likely to be offset by natural occupational turnover instead of layoffs.[7] Testing and deploying AV technology is a key component of ensuring there are real world models to ground these important conversations as we continue to learn more about new and transitioning jobs.

Finally, transparency is key to building trust with all stakeholders. I am here before the Subcommittee to introduce Aurora and to explain what we are building and how we have safety integrated into every part of the organization. We would like to thank this Committee, and Chairman DeFazio in particular, for his work with industry and labor on the provisions regarding AV trucks in his infrastructure bill considered earlier this Congress. The process demonstrated how leadership from Congress can drive positive outcomes.

We will continue to encourage NHTSA to reach out to industry as it is developing AV-related policies and guidance. When appropriate, we will take the opportunity to comment on the record and suggest concrete improvements to those policies. For example, the difference between driver assistance systems and the autonomous system we are building is critical for the public to understand. The language and definitions NHTSA uses in regulations, orders, and guidance will drive the public discourse and needs to be clear for all stakeholders. We will continue investing in an elevated public discourse on these topics. For example, Aurora is a founding member of PAVE, the Partnership for Automated Vehicle Education, because of how important we believe engagement and education is for all stakeholders.

[7] "Macroeconomic Impacts of Automated Driving Systems in Long-Haul Trucking," Jan. 28, 2021, FWHA-JPO-21-847, https://rosap.ntl.bts.gov/view/dot/54596.

Conclusion

Transparency and collaboration are key to our progress and future at Aurora. We are committed to continuing to work with the Subcommittee as it addresses these important issues and supports safety, innovation, and jobs across the United States. Thank you for the opportunity to provide this testimony and answer the Subcommittee's questions.