American Center for Mobility
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U.S. Senate Committee on Commerce, Science, and Transportation
Driving Innovation: The Future of Automotive Mobility, Safety, and Technology

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Introduction

Subcommittee Chair Senator Peters and Ranking Member Senator Fischer, Full Committee Chair Senator Cantwell and Ranking Member Senator Wicker, and other members of the Commerce Committee, I thank you for the invitation to speak regarding the future of vehicle safety, mobility, and technology and the ways in which Congress and stakeholders can help the automotive industry, which merges now with the mobility industry, to provide equitable access, create job growth, and position America at the forefront of global innovation.

My name is Reuben Sarkar, and I am the President & CEO of the American Center for Mobility (ACM), a non-profit, public private partnership comprised of government, industry, and academic organizations. ACM is uniquely positioned for accelerating the mobility industry through research, testing, standards development, and educational workforce programming. Located in Southeast Michigan on over 500-acres at the historic Willow Run site, where 80 years ago Henry Ford led America in the Arsenal of Democracy by creating a new workforce and using innovative technologies to build one bomber an hour, an effort that helped win WWII. Today, the Willow Run site has over $200M invested into new mobility innovations including infrastructure, facilities, technologies, and equipment that make up the ACM's premiere global smart mobility test center. This test center provides a safe platform for the research, testing and validation of emerging vehicle and mobility technologies, environments for showcasing vehicle technologies and convening industry, government, and academic activities, and an innovation technology campus for the co-location of mobility companies. ACM is a neutral convener of mobility topics, led by an Industry Advisory Board comprised of automotive, communications, and technology companies that inform ACM on facility development, and form dedicated committees that focus and inform on a variety of mobility topics.

My remarks today will focus primarily on ACM's core competencies in research, testing, standards development, and educational workforce development. Further, I will comment on the importance of the differentiation between closed track and open road testing, and the continued need for smart mobility test centers as leading-edge, controlled, and safe places to research, test and validate new mobility technologies.

Relevant Statistics

According to NHTSA, there were 36,096 fatalities in motor vehicle traffic crashes in 2019, a slight decrease over 2018, the vast majority resulting from human error.[1] Based on preliminary projections, GHSA estimates that the nationwide number of pedestrians killed in motor vehicle crashes in 2019 was 6,590, an increase of 5% from 2018, which in turn was up 3.4% from 2017.[2] The average U.S. household spends over 15% of its total family expenditures on transportation, making it the most expensive spending category after housing.[3] This can be up to 30% for lower income households. From an energy and environment perspective, the transportation sector accounts for approximately 30% of total U.S. energy needs and is the largest source of

[1] https://www.nhtsa.gov/press-releases/roadway-fatalities-2019-fars
[2] Pedestrian Traffic Fatalities by State: 2019 Preliminary Data | GHSA
[3] Transportation Energy Data Book Edition 37, ORNL, Table 10.1.

greenhouse gas (GHG) emissions in the energy sector.[4] However, advances in mobility technologies ranging from automation, telecommunications, data and compute have the U.S. at the beginning of a transformation of the way that people and goods are moved through an emerging mobility ecosystem – one that offers the promise to make transportation safer, more affordable, accessible, and cleaner. Transportation is also critical to the overall economy, from the movement of goods and people, to accessing food, jobs, education, and healthcare.

State of Mobility Innovation

The state of mobility innovation, as it pertains to ACM's areas of expertise, is dependent on the validation and readiness of vehicle technologies (e.g., automation), communications (e.g., cellular C-V2X, 5G), data & computational infrastructure, cybersecurity, standards and regulations, and educational workforce development.

Smart Mobility Test Centers

Smart Mobility Test Centers, such as ACM's, have been established on the principle of leveraging a three-tiered approach to AV technology development and validation. The use of virtual simulation followed by testing in a controlled environment and then carefully managed on-road testing is proven to be an effective comprehensive testing and development approach. It is acknowledged that autonomous vehicle (AV) technology companies cannot move directly to wide-scale on-road deployments by testing solely on public roads without incurring some level of risk and incurring prohibitive development costs and timelines. Also acknowledged is that it could take hundreds of millions, if not billions, of public road miles to encounter adequate scenarios and edge cases necessary to validate these advanced technologies. The ability to efficiently utilize the three-tiered methodology for testing has proven to be a more effective approach to advancing the technology and progress toward validation.

It is a common theme in the AV industry that more advanced tools for modeling and simulation, coupled with better access to data management and analytics is needed to effectively support virtual testing activities. Leveraging virtual testing as a key component within the development cycle is one way to compress the overall development cycle. The ability to run millions of miles *virtually* in simulation to identify the limits of operating systems can save months or even years of development and data gathering time within the validation cycle. Modeling and simulation also allow for the integration of advanced features such as Augmented Reality and Machine Learning into the process, adding to the acceleration and rigor of the overall development cycle timeline. The more advanced the tools are, the more effective the virtual simulation is, resulting in less overall development cycle time and cost efficiencies. In many cases these advanced modeling and simulation tools are developed and enhanced through targeted research including federally funded research in partnership with U.S National Laboratories and AV test beds that is leading to development of more of these advanced tools.

Analysis of large public driving data sets is a necessary approach to identifying a more expansive library of edge cases that need to be run in simulation and validated in a closed track

[4] Transportation Energy Data Book Edition 37, ORNL, Table 2.1 U.S. Consumption of Total Energy by End-Use Sector

environment, prior to considering public road deployment. This supports the continued need for the availability of smart mobility test centers as leading-edge, controlled, and safe places to research, test and validate new mobility technologies. These controlled test beds require continued investment to provide state of the art capabilities and upgrades with evolving technologies necessary to enable the industry in the acceleration of advanced mobility solutions. Test activities and system validation accomplished in these controlled test beds are a necessary precursor to eventual testing and validation on public roads and to maintaining global leadership in new deployments.

Controlled track testing is essential to the development and validation cycle as it allows for critical activities that are difficult to accomplish in a public road environment such as the following:

- Testing against true edge case with unsafe maneuvers, erratic movements, incorporating multiple controlled vehicles.
- Validating interoperability between two or more manufacturers, which would be time consuming and difficult on public roads.
- Achieving reliability & repeatability for testing, necessary to achieve validation.
- Accelerating the development cycle. By managing scenarios and experiences in a controlled environment and leveraging advanced tools it is possible to achieve an equivalent of track-to-road mileage as high as 1-to-5000 miles. Public road driving does not expose vehicles to challenging circumstances often enough through normal driving.
- Scheduling controlled weather testing. Public road testing would require you to wait for specific weather situations that may need to be tested against. Certain weather conditions can be created in controlled environment test beds.
- Offering unlimited configurations and technology integrations. Testing new and variable infrastructure technologies with vehicle technologies could be costly in a public road environment due to bureaucracy and timing to install and switch them in and out.
- Testing against variable communications and connectivity levels. Controlled environments allow for the ability to establish variability in connectivity and latency.
- Testing at night that is necessary to validate sensor detection and classification.
- Engaging vulnerable road users, such as pedestrians, bicyclists, motorcyclists, and scooters into real world edge case testing which is not advisable or in many cases allowed in public road environments.

Having national recognition and a level of Federal support for these AV test beds has taken a step back. In January 2017, the USDOT designated several facilities as national AV Proving Grounds (AVPG). This designation allowed for the facilities to coordinate, share best practices, and support the collective enhancement of these necessary resources. Following the designation of the AVPGs, Congress approved funding for which AVPG's could be eligible. The designations were rescinded in the fall of 2018 and the coordination and collaboration of these facilities has reduced significantly. There would be relevant value and national benefit for re-establishing those designations and establishing programs that support their growth and function.

Automated Vehicles

Automated vehicles (AV's) or self-driving cars have demonstrated millions of miles of operation on public roads. In 2020, California Department of Motor Vehicles reported 1,955,201 of self-driving miles recorded in the state, down from 2,855,739 miles driven in 2019 due in part to COVID. Since 2017, California has demonstrated a 4-8-fold increase in the number of self-driven miles achieved without human intervention ranging between ~28,000 – 30,000 miles driven between AV disengagements. This represents substantial improvements in self-driving without human intervention from just a few years earlier. [5] Industry leaders have demonstrated more than 20,000,000 AV miles including 74,000 miles without any safety-drivers.[6]

However, according to NHTSA in 2019 on average there were 1.1 traffic fatalities per 100 million vehicle miles traveled,[7] meaning that the market leaders have only driven roughly 20% of the of the miles typically associated with a single traffic fatality. Studies have shown that to prove that an AV is 20% better than a human driver with respect to fatalities you would have to drive 5 billion miles. To demonstrate the same 20% improvement with regards to avoiding crashes or avoiding injuries it would take 28 million and 170 million miles, respectively, which can take decades or more to accumulate through driving on public roads.[8] While driving on public roadways demonstrates the real-world potential of these technologies and provides the most naturalistic driving data, it is prohibitive from a time, cost, and risk perspective to test AV's for commercial deployment solely on public roads.

Advanced Driver Assistance Systems (ADAS)

Advanced Driver Assistance Systems (ADAS) with lower levels of automation have been demonstrated to prevent or lessen the severity of crashes and are being commercially deployed with continued product development to enhance Level 2 automated performance. In 2019, research performed by the Insurance Institute for Highway Safety (IIHS) found that these systems can help to prevent and lessen the severity of crashes, with autobraking reducing front-to-rear crashes with injuries by 56%, forward collision warning systems reducing front-to-rear crashes with injuries by 20%, and blind spot detection reduced lane-change crashes with injuries by 23%.[9]

Communications and Connectivity

Communications technologies that enable vehicle to everything connectivity (V2X) are still at the nascent phase of deployment. Recent FCC rulemakings on the 5.9 GHz spectrum have made dedicated short-range communications (DSRC) obsolete and require new upgrades to cellular C-V2X technologies that are only now starting to be deployed for purposes of testing. 5G (or the

[5] https://www.dmv.ca.gov/portal/vehicle-industry-services/autonomous-vehicles/disengagement-reports/
[6] https://storage.googleapis.com/sdc-prod/v1/safety-report/2020-09-waymo-safety-report.pdf
[7] https://www.nhtsa.gov/press-releases/roadway-fatalities-2019-fars
[8] Kalra, Nidhi and Susan M. Paddock, Next Stop, Neptune? Why We Can't Rely on Test-Driving Alone to Assess the Safety of Autonomous Vehicles, Santa Monica, Calif.: RAND Corporation, IG-128, 2017. As of April 08, 2021: https://www.rand.org/pubs/infographics/IG128.html
[9] https://www.iihs.org/media/259e5bbd-f859-42a7-bd54-3888f7a2d3ef/e9boUQ/Topics/ADVANCED%20DRIVER%20ASSISTANCE/IIHS-real-world-CA-benefits.pdf

fifth-generation technology standard of broadband cellular networks) has the potential to bring order of magnitude faster speeds (>10X), lower latencies and the bandwidth needed to connect many more devices than today's 4G technologies. We are seeing the roll out of 5G for personal devices such as cell phones today, but the full capabilities and infrastructure required to enhance vehicle control and operation through 5G connectivity are still years away.

Connected vehicles and automated vehicles can be considered mutually exclusive technologies. AV's can be self-driven without being connected, reacting to what they can sense. However, to get the full benefits from cooperative driving, connected *and* automated vehicles (CAVs) require vehicle to vehicle and infrastructure (V2V and V2I) communication. There is still an open debate as to the degree to which connectivity is required for wide-scale deployment of level 4-5 AVs beyond specific operating design domains (ODDs) such as geofenced or low speed vehicle applications. If deployed properly, CAVs can greatly improve the safety, congestion, operational efficiency, and throughput of our transportation system, and further new streams of commerce and consumer experiences. CAV technologies require wide-spread, reliable, interoperable infrastructure networks, the timeline for deployment of which is still unknown. As such, AV developers are pursuing to deploy AVs in parallel with connectivity that will evolve over time.

Data Management and Analytics

CAV technologies can generate terabytes of data per day per vehicle and petabytes even with very small fleets. The challenges to transfer, ingest, store, analyze, manage, and compute with such high volumes of data is one of the largest challenges related to AV's and CAV's, namely what to do with all of this data and how to pay for it. The data however, particularly from driving on public roads is extraordinarily valuable in its use for training artificial intelligence in self-driving vehicles. Those who have access to "naturalistic data" from public self-driving are highly protective of the data as a major competitive advantage. It is very costly to develop and manage public road driving data that provides access to edge case scenarios that are currently not widely available. The infrastructure required to manage and to use this data both from AV development purposes and for AV operational purposes requires substantial investment. Optimizing data along with onboard, edge, and cloud compute is an open area for research and development.

Industry Standards

Standards and Regulations serve as the measuring stick for determining the readiness of vehicle technologies for safe deployment. Industry standards are often used as inputs or referenced in Federal Standards and are actively being developed. However, in the case of the rapidly evolving mobility space they are being developed concurrently with Federal Standards and in some cases may be reactive to Federal Standards once they are released. Federal Test Procedures used in standards are often not tested by industry before they get written into Federal law or standards for U.S. DOT. The ability for industry to test to prospective Federal Standards and to provide objective input before they are written into law would help to ensure the laws are informed, feasible and further streamline both the process of enacting new regulations and the ability to test, validate and deploy new technologies, avoiding a lengthier and more reactive process.

Providing equitable access to world class safety and mobility solutions will likely require creative fleet-operated/managed SAE Level 4 and 5 ADS-dedicated vehicles (ride-hailing or product delivery). This is due to the high cost of these advanced systems, which make it unrealistic for them to be offered on entry level vehicle models and not able to offer equal access. The Industry is recognizing this challenge and has started defining best practices through organizations like the AVSC (Automated Vehicle Safety Consortium). AVSC issued a best practice on passenger-initiated trip interrupt systems, and most recently on safety metrics for fleet operated / managed vehicles. These types of best practice efforts regarding new mobility technologies will help provide a neutral platform to share information, lower costs of technologies and ultimately benefit consumers more equitably. Evolving the best practice guidance into testable standard requirements through work at sites like ACM will ensure adequate standardization of technologies and infrastructure.

Standardization helps to ensure consistent design features for vehicles and infrastructure. This can streamline the testing process by limiting variability and improving interoperability. Testing currently being performed at AV test beds such as ACM require modifications to infrastructure at the test site to account for infrastructure variability. Currently, vehicles must be driven through multiple states to seek out unique infrastructure characteristics to ensure the vehicle is equipped to perform as intended. There is an opportunity to reduce this variability going forward through consistent industry standards and test requirements for new mobility technologies both within the infrastructure and vehicles.

Education and Workforce Development

When the Willow Run WWII bomber factory was built in 1941, it included a workforce training and education center, because Henry Ford knew that an educated workforce is the only real differentiator. Just as it was then, a new era of automotive and mobility technologies brings to the surface the importance of building an inclusive and adaptive educational system, provides equity and opportunity. Long term global competitiveness of the US automotive and mobility sectors is tied directly to the talent pipeline that feeds the American workforce. With any new wave of innovation, there is a spike in demand for the most highly qualified people followed by a gap in supply. On a global scale the ongoing growth in the technology industry has created a critical shortage of talent throughout all major business sectors. This coupled with the recent COVID crisis has intensified the already stressed talent and skills pipeline the automotive and mobility industries have.

In 2019, ACM commissioned the University of Michigan Economic Growth Institute (UofM EGI) to research the skills demands related to the CAV middle skills sector.[10] In many cases with the right training these middle skills jobs could fulfill several current in-demand positions in the automotive sector, while helping create good paying, high quality jobs that keep a large part of our workforce relevant in highly dynamic industries. As more CAV-related products move from

[10] https://www.govrel.umich.edu/index.php/understanding-the-middle-skill-workforce-in-the-connected-automated-vehicle-sector/

the R&D space into production, the demand for middle-skills jobs in the CAV sector have correspondingly grown.

The Middle Skills report highlighted the forecasted needs for specific jobs, including CAV technicians, safety drivers, CAV maintenance technicians, and cybersecurity technicians through 2022. In addition to the base mechanical, electrical and electronic foundational skills required for these jobs, there is a projected increase after 2022 for enhanced skills in software, data-related systems, systems thinking, and cyber-related work. Because this is a complex set of skills to obtain in a 2-year timeline, the report recommends that through strategic partnerships with OEMs and key industry organizations the "development of experiential education programing could best supplement the institutional programing already developed." Course offerings that upskill and/or re-skill with hands-on, real-world experiences will play a critical role the success of the mobility workforce.

The implications from this middle skills report require immediate and actionable attention towards curriculum development and technology integrations starting with K12 preparation, feasible high school certifications, hands-on high-tech universities, and lifelong professional development. The digital skills needed for the technology era are not just applicable to automotive and mobility-related jobs, but they mirror the overall growing skills needs in manufacturing, smart cities, smart technologies, electrification, infrastructure, healthcare, and general jobs of the future. The investments into curriculum to develop technology related skill sets will strengthen the American workforce and keep the nation competitive globally.

Ensuring America Leads the Global Automotive & Mobility Industry

The safe, timely, and successful deployment of will new mobility solutions such as connected and autonomous vehicles face ongoing challenges in the areas of research to develop new tools, testing to validate technologies, industry standards to support regulations, and education & workforce development to maintain a rigorous and globally competitive workforce. To move the current state of innovation forward, ACM recommends federal policymakers to take action to address the following challenges:

Research & Testing

Develop capability that lower the cost and lead time to validate AV's and CAV's.

- Invest through directed Federal Research and grants into advanced methods and tools to help lower the mileage and cost hurdle for validation AV technologies. This includes development of more capable AV tool chains including modeling and simulation tools that are validated against real-world conditions, data management and analytic (DMAP) platforms, edge case scenarios based on naturalistic data, and augmented reality simulation tools which can compress lead-time, cost, and lessen risk for public road validation.
- Invest into shared use smart mobility test centers and closed tracks as test beds for safe, controlled, repeatable testing and validation and interoperability testing of connected and automated vehicle technologies.

- Provide more funding opportunities for directed Federal Research through NHTSA Indefinite Duration Indefinite Quantity (IDIQ) programs that leverage the capabilities of existing test beds.
- Invest in R&D and demonstration for optimization of communication and on-board vehicle, edge, and cloud compute.
- Establish a National Pilot Program through DOT for AV testing and deployment that incorporates use of AV tool chain and closed track testing ahead of public road demonstrations as part of a simulation to track to road approach to ensure safe deployment of AV pilots.

Industry Standards

Accelerate the development of industry standards as inputs into Federal Standards.

- Provide funding to accelerate the evolution of best practices and guidance documents into consistent repeatable standards and test requirements will provide valuable information that can be referenced by NHTSA in FMVSS rules. Federal Rules that are based on standards help to ensure harmonized system performance from the beginning, and limit costly re-work or re-design. By accelerating and referencing industry developed standards, alignment with industry can be assured.
- Provide funding for testing to evaluate Federal Test Procedures used in standards *before* they get written into Federal law and standards for U.S. DOT. Industry to lead with public standards available through standards (SAE Jdocs, UL, AVSC) for Federal government to reference.
- Establish funding at the federal level for efforts to evolve the best practices being published by industry into standards and test methods to ensure consistent, reliable, fleet managed systems across state lines. This would ensure that OEMs and Fleet Service Providers develop systems that are similar, limiting confusion for the public users.

Education and Workforce Development

The American education system needs to offer skills development for the fourth industrial revolution from a young age, provide new opportunities, and encourage lifelong learning to help American workers thrive for the next hundred years. From a Federal perspective the challenge of empowering the educational system and bringing new opportunities to the automotive and mobility workforce is complex, and the focus of the administration seems rightly aligned. ACM recommends the following areas of focus:

- Implementation of a National Automotive & Mobility Career Awareness and Recruitment Campaign. Industry organizations focused on talent perception and attraction continue to identify the critical need for a lager talent pipeline. Regional surveys show that students are not aware of new opportunities in the emerging auto-mobility workforce and/or they are not encouraged by peers to seek careers in this sector due to historic market volatility. There is a great opportunity to generate interest for a new American workforce through a coordinated national effort that showcases the

diversity of innovative, meaningful, and good paying jobs available today in the automotive and mobility industry.

- K12 Foundations: The skills required for middle skills jobs are complex and technical, education must start earlier with focus on skills development for a technology focused world. Acknowledge the critical need for and support K12 in providing technology-focused, project-based curriculum for teachers and students.
    - Develop K through 12 curricula focused on evolving key skills areas including mechanical, electrical, electronic, software, data-related systems, systems thinking, design thinking and cyber-related work, in addition to development of critical soft-skills communication, task management, collaboration, problem solving, ethics, and logic.
    - Provide teachers with access to focused curriculum using an agile approach that can evolve with the fast pace of technology and industry needs.
    - High School Certifications in high-demand middle skills jobs such as: CAV technicians, safety drivers, CAV maintenance technicians, software developers, and cybersecurity technicians.
- Middle Skills Jobs: The automotive industry has a high demand for middle-skills jobs including CAV technicians, safety drivers, CAV maintenance technicians, and cybersecurity technicians. The skills required for these jobs are highly transferrable throughout the automotive lifecycle from research, design, development, test, validation and through to manufacturing, infrastructure, and service. With these skills workers will have a foundation to build on, coupled with ongoing training for lifelong employability. The gap will not be filled quickly, easily or in a silo by one organization or one state, but through a large-scale nationally coordinated effort that acknowledges the shift in skills needs throughout the automotive and mobility sectors. Success will be in the long-term commitment from industry organizations to provide internships, apprenticeships, and employment, and from government for both academic and learning organizations, and for the students who need time to build this complex set of skills.
- High-Tech Talent: There is a need for high-tech talent, including a variety of engineers including in software, autonomous vehicles, and data science. Addressing outreach, K12 and Middle Skills topics will take time, but will set a base for long-term growth of a high-tech talent pipeline and ultimately, higher skilled and higher paying jobs. In the current workforce there remains an immediate gap in high-tech talent, where the lack of staff translates into slowed technology development timelines. Continued efforts to facilitate foreign support to fill talent gaps, will help companies remain rooted to their American footprint and keep work packages in an accelerated mode.
- Professional Development & Upskilling: With the fast pace of evolving technologies, skills needed in the automotive and mobility industries are quickly changing, too. To remain employable, workers at all levels must adapt to a new learning paradigm in which ongoing skills development is required to stay relevant and in-demand. It is imperative that people have the means and access to develop new skills as fast and as much as they can. Providing incentives for targeted programs that align with industry needs is a viable way to keep the talent pipeline robust on a long-term basis, and American workers best-in-class.

Conclusion

The American Center for Mobility would like to thank Congress for its focus on and attention to the needs of the automotive industry. The ability to keep pace with technology innovations, facilitate their safe implementation into our society, and build a rigorous talent pipeline and a thriving workforce will succeed as much as they are enabled by a comprehensive and ongoing effort between all levels of government, industry, and academia. The ACM encourages purposeful Congressional and Federal engagement and investment into research, testing, standards, and education and workforce development to safely accelerate these enabling mobility solutions to market.

This concludes the American Center for Mobility's statement. Thank you for the opportunity to share insights from the automotive and mobility industry. ACM looks forward to working with Congress in an ongoing effort to address critical issues that influence the ability to accelerate automotive and mobility technology innovations and implementations, and keep America globally competitive.