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Toward a National Regulatory Framework for Automated Vehicles

Challenges and Opportunities

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Toward a National Regulatory Framework for Automated Vehicles

Challenges and Opportunities

A Summary of a Series of Panels on AV Regulation

June 15, 2022, in Anaheim, CA
September 21, 2022, in Los Angeles, CA
December 9, 2022, in Washington, DC

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Preface

The deployment of automated vehicles (AVs), shared mobility services, and other transformational transportation technologies has the potential to dramatically increase safety, reduce congestion, improve access, enhance sustainability, and spur economic development. However, success in meeting these goals is not assured and there are significant risks that these deployments could cause unintended consequences.

The National Academies-TRB Forum on Preparing for Automated Vehicles and Shared Mobility Services was officially launched in early 2018 to facilitate evidence-based research needed to deploy these technologies in a manner and a timeframe that informs policy to meet these long-term goals. Since then, the Forum has promoted discussion among its members and the public, created white papers, developed research priority lists, and engaged in panels and workshops dedicated to specific questions around automated vehicles and shared mobility.

This circular was developed as a summary of a series of such panels held by this Forum. Mark Norman and Katherine Kortum of TRB served as rapporteurs and authored the circular. Matt Leasure and Kristin White of ITS America reviewed the circular.

The information in this E-Circular represents the collective work of the individual Forum members and not necessarily the organizations, agencies, or companies where they work. The views expressed in this publication are those of the committee and do not necessarily reflect the views of TRB or the National Academies of Sciences, Engineering, and Medicine. This publication has not been subjected to the formal TRB peer-review process.

Introduction

The National Academies-TRB Forum on Preparing for Automated Vehicles and Shared Mobility Services and the ITS America Automated Vehicles Standing Committee hosted a series of panels during 2022. These panels discussed the challenges and opportunities for a national AV regulatory framework. Panelists included representatives from federal agencies, state agencies, localities, industry, and consumer safety groups. The panel discussions were conducted under the Chatham House Rule.

During these meetings, participants discussed challenges and opportunities for advancing a national regulatory framework for AVs, summarized below.

AT THE FEDERAL LEVEL

Challenges	Opportunities
• Many challenges remain to be overcome, and the AV technology needs to be deployed to reduce crashes caused by human factors. • The existing regulatory structure is rooted in the traditional vehicle industry and is not geared to the vehicles of today and tomorrow. • Consistent safety metrics other than crashes are rare across developers and government agencies. • It is insufficient to pursue a regulatory framework focused on safety without including other national priorities such as relieving congestion, promoting sustainability and economic development, and enhancing equity. • We need to try many things to achieve big policy goals. Not all will be successful. • Rulemaking in new industries is challenging because we do not know what we do not know, and the data is always developing. • These technologies are still relatively immature. • It is unclear how over-the-air updates fit into the current vehicle recall construct. • The issue today is how to open the roads to safe and responsible commercialization and deployment of	• There has been extensive coordination within the U.S. Department of Transportation (DOT) in the overall rulemaking process on this issue. • Government can use "soft power" to help achieve policy outcomes—regulations need not be a "technology forcer." • The U.S. DOT will leverage many new grant programs included in the 2022 Infrastructure Investment and Jobs Act (IIJA), along with a key tool—the Highly Automated Systems Safety Center of Excellence. • The U.S. DOT hopes for funding to further expand staff expertise in these new technologies and artificial intelligence (AI). • AV 4.0 is a good blueprint which will become increasingly important going forward. The U.S. DOT is allowing the industry to grow and mature in its own way. • While regulations are being developed, the U.S. DOT can deploy its defect authority when appropriate and legal. • The National Highway Traffic Safety Administration (NHTSA) has recently taken many important initiatives regarding the regulation of AVs, including using its defect authority and issuing recalls.

Challenges	Opportunities
this technology at scale while addressing the existing regulatory framework that does not always accommodate AVs. • Requirements for enacting federal regulations—including those for gathering, analyzing, and responding to public input—result in long timeframes. • The relative roles of on-road testing, testing tracks, and simulation testing of AVs need to be determined and harmonized. • International collaboration should take precedence over competition. The industry is global, and the more we segment it, the more we stifle U.S. innovation. • For trucking, issues besides technology come into play—labor, infrastructure, regulation in terms of the movement of the vehicle itself with waystations. More needs to be done to overcome these hurdles.	• A national regulatory framework has a place for a standardized and detailed explanation of pilot and demonstration projects that is understandable and usable nationwide. • Collaboration among all stakeholders will continue to be a key to success. • Collaborating with and learning from international partners can be done before finalizing rulemaking and can help the U.S. DOT in developing these rules. • From a testing and commercial operations standpoint, significant opportunity exists within the commercial motor vehicles space. • The Federal Motor Carrier Safety Administration (FMCSA) is partnering with industry and states to develop a new system for automated trucks that can also provide a model of how to operate for the full AV industry.

AT THE STATE AND LOCAL LEVELS

Challenges	Opportunities
• The deployment of AVs could be greatly enhanced if individual states did not feel they were "going it alone." • The slow rollout of any regulatory framework at the federal level has resulted in states, and now cities, stepping in and creating their own laws and frameworks. • Most states do not have the capability to develop testing regulations on their own, as state DOT staff have limited expertise and availability to address this issue. They need the assistance of a national framework. • States currently have a patchwork of philosophies, laws, regulations, permitting, testing, deployments, data sharing, and insurance requirements.	• The states are generally taking the lead on regulations. • Engagement with a coalition of the American Association of Motor Vehicle Administrators (AAMVA), the American Association of State Highway and Transportation Officials (AASHTO), regional consortia, and other similar organizations to develop a multi-state or national AV regulatory framework might be feasible now. • Two areas of consistency among states that would be particularly helpful now for industry are permitting mechanisms and traffic laws. • Infrastructure enhancements that will help AVs at all levels will also help the human driver.

Challenges	Opportunities
Stakeholders need more consistency across state lines. • State law enforcement agencies and state DOTs need to collaborate more actively. • Police reports on crashes in most states do not include any fields for advanced driver assistance systems (ADAS) or AVs. • For the thousands of local agencies and metropolitan planning organizations (MPOs), staff and resource limitations make it difficult to participate in these forums. • Vulnerable road users are more concentrated in local communities, including pedestrians, bicyclists, blind and low vision individuals, wheelchair users, and more. • When proposing testing at the local level, companies sometimes overpromise to obtain competitive advantage. • In places where companies are testing and deploying AVs, often only the "bad stuff" is reported on the news. • City staffs need some assurance that the reports on automated and shared vehicles submitted by providers have been reviewed and can be vouched for.	• Pilots testing different use cases can help local agencies create permitting processes that are more effective in addressing real world practices and problems. • Testing that uses the contracting process can give cities more say over where to test, who is engaged, and how to frame questions for evaluation. • Engaging the public in conversations is a critical element for AV testing, especially at the local level.

AT THE INDUSTRY LEVEL

Challenges	Opportunities
• The issues of scaling the technology and deployment have at least as much to do with regulatory impediments as with technology. • The patchwork of laws and regulations across the states inhibits the testing and deployment of AVs. • There is disagreement on the effectiveness of voluntary standards and voluntary safety self-assessments.	• Companies' level of adherence to existing voluntary guidelines will inform future decision-making. • To date, the industry has a strong safety record. Industry can establish a definition of safe performance and AV technology can be designed to fit that definition. • Several industry members have developed safety case frameworks and guidelines, which can be shared and built upon.

Challenges	Opportunities
• While many companies have a strong safety culture, some do not and are trying to do unsafe things.	• Many in industry want a set of best practices from U.S. DOT addressing how to test, and a set of scenarios the industry could use to test against specific government regulations. • Public/private sector coalitions have opportunities to collaborate on and to build upon existing sets of AV policy principles.

AT THE CONSUMER LEVEL

Challenges	Opportunities
• There is no consistency across developers and governments establishing how to create an operational design domain (ODD) and meaningfully explain it to the public. • Questions remain about the potential impact of AVs on the private ownership of vehicles. • The broad range of the end users of these technologies is important to consider. The same playbook will not work for all. • As we have seen with ADAS, overreliance on these systems by users has created some unsafe situations that continue to unfold on the roads. • We need to better education users on what technology can and cannot do to counter misconceptions generated from advertising and other sources. • Providing national standards is as important for today's ADAS as it is for future more advanced AVs. • A major challenge will be the human factors of integrating these highly automated vehicles into the existing fleet.	• Consumer education needs to be top of mind at the federal, state, local, and industry levels. • Honesty about the capabilities and limitations of these technologies is key to credibility and success. Honest conversations should take precedence over salesmanship. • Innovation in public engagement is needed, including taking advantage of newer communications channels.

The Current AV Regulatory Landscape

In "Preparing for the Future of Transportation—Automated Vehicles 3.0"[1] the U.S. DOT describes the roles in automation:

> *The traditional roles of the Federal Government, State and local governments, and private industry are well suited for addressing automation. The Federal Government is responsible for regulating the safety performance of vehicles and vehicle equipment, as well as their commercial operation in interstate commerce, while States and local governments play the lead role in licensing drivers, establishing rules of the road, and formulating policy in tort liability and insurance. Private industry remains a primary source of transportation research investment and commercial technology development. Governments at all levels should not unnecessarily impede such innovation. The Department relies on partners to play their respective roles, while continuing to encourage open dialogue and frequent engagement.*

The report then summarizes the roles of the public and private sectors in vehicle automation.

Despite these reassurances, considerable debate continues about the need and timing for a national regulatory framework for automated vehicles (AVs). AV legislation in Congress has not moved forward for several years. At the state level, philosophies and approaches vary. As of 2020, 29 states had enacted AV-related legislation and governors in 11 states had issued executive orders. At least 10 states had done neither.[2] Even among those states taking legislative or executive action, considerable differences exist.

The resulting variations are challenging both the public and private sectors. Questions include:

- Should there be a national regulatory framework?
- Is the technology currently mature enough to issue such a framework?
- What level of specificity would allow useful consistency without inhibiting innovation?
- What national goals and priorities, if any, should a framework address besides safety?
- Without a national regulatory framework, how can states, local agencies, and the private sector address these issues?
- What kind of public education can avoid overreliance or under reliance on these technologies?

[1] Preparing for the Future of Transportation – Automated Vehicles 3.0
[2] Autonomous Vehicles | Self-Driving Vehicles Enacted Legislation - NCSL

The TRB/ITS America Panels

These questions and others were the focus of a series of three panels during 2022 hosted by the National Academies-TRB Forum on Preparing for Automated Vehicles and Shared Mobility Services (TRB AV/SM Forum) and the ITS America Automated Vehicles Standing Committee. The panel discussions, conducted under the Chatham House Rule, included the following:

Regulatory Issues for AVs
June 15, 2022, Washington, DC

> Hosted by the TRB Executive Committee and organized by the TRB AV/SM Forum. Panelists included officials from ITS America, Alliance for Automotive Innovation, and the American Association of Motor Vehicle Administrators

National Regulatory Framework for AVs: Industry, Community, and State Regulatory Perspectives
September 21, 2022, Los Angeles, CA

> This meeting included two panel discussions. The first involved industry and community representatives (the Autonomous Vehicle Industry Association, Uber, Applied Intuition, and the Knight Foundation). The second included state government regulatory representatives (California, Connecticut, California, and Washington).

National Regulatory Framework for AVs: U.S. DOT, ADS Developers, and Safety
December 9, 2022, Washington, DC

> The U.S. DOT panel included representatives from the Secretary's office, NHTSA, and FMCSA. The automated driving systems (ADS) developers panel included representatives from the Alliance for Automotive Innovation, Aurora, and Embark. A representative from the American Automobile Association (AAA) led the safety discussion.

Names and affiliations of all panelists are in the appendix.

Panelists and meeting participants discussed the challenges and opportunities of a national AV regulatory framework. Organizers asked the following questions of panel members as a starting point:

1. What are appropriate regulatory roles for the federal, state, and local levels of government, considering that automated driving systems incorporate both in-vehicle devices and driving behaviors?
2. How much needs to be defined consistently at the national level versus state and local levels, considering the diversity of automated driving services likely to be developed and deployed to meet a variety of transportation needs?

3. What should be included, and what should not be included, in a national regulatory framework?

As expected, participants had both areas of agreement and differences of opinion. In accordance with National Academies' procedures, this document does not attempt to provide consensus. Rather, the following is a summary of points made during these discussions. As per the Chatham House Rule, neither the identity nor the affiliation of the panelist(s) or any other participant are attributed.

Federal Perspectives

THE FEDERAL RULEMAKING PROCESSES—CHALLENGES AND OPPORTUNITIES

The U.S. DOT uses rulemaking to advance policy priorities, such as addressing climate change, creating high quality jobs, increasing safety, and increasing equity. Achieving big policy goals requires a great deal of effort. Not every effort will be successful or effective.

The federal government also helps create guiderails, using its "soft power" to address policy outcomes. Rulemaking must not be a "technology forcer."

Rulemaking is an iterative process that is challenging in any new industry. You do not know what you do not know, and the data are always evolving. The Secretary of Transportation has directed the Department to follow the science and the data. U.S. DOT relies on continuing research for good data and on industry testing, input, and information. That back-and-forth makes this process complicated but important.

The level of excitement about this technology makes it easy to forget how immature it is. NHTSA is currently developing performance standards for ADAS and automatic emergency braking (AEB). These are not mature technologies but are simple compared to level 3, 4, and 5 AVs.

Federal requirements to gather, analyze, and respond to public input also add to the timeline for federal regulations.

Many AV-related issues result from long-standing rules. As written, some U.S. DOT regulations require a human driver. Until these regulations change, users will have a limited ability to operate at AV level 4 or 5. Industry will advance the technology, and as companies apply for exemptions, U.S. DOT will evaluate their data to ensure each exemption provides equal safety.

In terms of the timelines for connected and automated applications (CAV), dedicated short-range communications (DSRC) technology and policy issues have taken significant time and effort to study. It is difficult to measure the impact this experience has had on deployment timelines.

The U.S. DOT has and can take steps to help safe deployment of AVs, including through its research programs. The U.S. DOT will leverage many new grant programs included in the IIJA. For example, in November 2022, it closed applications for the Strengthening Mobility and Revolutionizing Transportation (SMART) grant program in which AVs were eligible for projects. Another tool is the Highly Automated Systems Safety Center of Excellence. Even though U.S. DOT is not authorized to commercialize or deploy fleets of vehicles, it can help shape operations and testing.

The U.S. DOT has also coordinated internally in this overall rulemaking process more than ever before. Clear direction from the Secretary, holding agencies to timelines, creating forums to share and collaborate, and working in parallel instead of sequentially all help speed the processes.

The U.S. DOT also hopes for funding to hire experts in new technologies and artificial intelligence to better decide when and how to regulate the industry.

HOW EFFECTIVE ARE VOLUNTARY GUIDELINES?

The industry is testing new products and trying to improve them. The U.S. DOT does not want to interfere with this process, allowing the industry to grow and develop in its own way.

NHTSA has undertaken many important AV initiatives, even though some may discount them because the initiatives are voluntary. However, AV 4.0[3] is a good blueprint that will become increasingly important. NHTSA initiated the Standing General Order,[4] mandating certain ADAS and AV reporting so the administration can monitor and analyze current operations. In a significant development, NHTSA compelled its first recall of an AV vehicle in 2022.

In the future, NHTSA will scrutinize operations based on data generated from the Standing General Order and from the voluntary safety plans filed under AV 4.0. Companies' adherence to those voluntary guidelines will inform further decision-making.

COLLABORATION IS ESSENTIAL

Collaboration with industry, coalitions, advocates, research programs and university transportation centers (UTCs), and many others is a principle of federal rulemaking. The U.S. DOT uses its resources to convene and engage with groups, to visit testing sites and industry partners, and to conduct outreach to its many stakeholders.

Becoming more flexible and integrated is important. Solutions can come from parts of U.S. DOT that seem unrelated or are unexpected. In addition, U.S. DOT is collaborating with other federal departments and with the White House Office of Technology Policy.

In external coordination, the Department is trying to avoid silos that would hamper deployment of innovation. The Department must consider whether any of its decisions preclude growth, development, and innovation in any domain.

THE ROLE OF THE FMCSA

Since 2021, FMCSA has been helping create a safe framework for deploying AVs and commercial motor vehicles (CMVs). FMCSA has focused on the guiding innovation principles set out by the Secretary of Transportation. FMCSA's responsibility is around the safe operations of CMVs, beginning where NHTSA's authority ends.

> *[Rapporteur's Note: In a February 1, 2023, Federal Register notice[5], the FMCSA requested public comment about factors the Administration should consider in amending the Federal Motor Carrier Safety Regulations (FMCSRs) to establish a regulatory framework for ADS-equipped CMV operations. The FMCSA previously published an advance notice of proposed rulemaking (ANPRM) on May 28, 2019, seeking comments on FMCSRs that may need to be amended, revised, or eliminated to facilitate the safe introduction of ADS-equipped CMVs onto the nation's roadways. FMCSA continues to consider amendments to the FMCSRs to ensure the safe integration of ADS-equipped CMVs into interstate motor carriers' operations and issued this 2023 ANPRM to request additional information. Comments were due by March 20, 2023.]*

[3] Ensuring American Leadership in Automated Vehicle Technologies - AV 4.0
[4] NHTSA Standing General Order – ADS and ADAS Crash Reporting
[5] FMCSA February 1, 2023, Federal Register Notice

Significant opportunity for testing and commercial operations exists within the CMV space. FMCSA tries to stay out of the way of testing and innovation, but safety always comes first for them.

When an 80,000-pound vehicle travels at highway speeds, the owner, driver, and all involved must take serious care. As the vehicle leaves its point of origin and travels along public roads, all parties must coordinate to ensure it is in good working condition. Since 2021, FMCSA has worked intentionally and deliberately to ensure this holds for AVs and ADAS-equipped trucks. Although some want FMCSA to move faster, the overall process has provided the framework within which the administration can operate.

INTERNATIONAL COLLABORATION AND COMPETITION

International collaboration should take precedence over competition. This is a global industry. The more we segment it, the more we will stifle U.S. innovation. Collaborating with international partners can occur prior to finalizing rulemaking and can help the Department in developing these rules.

The Department is coordinating with its counterparts in the European Commission. The Commission adopted a Vehicle General Safety Regulation[6] requiring certain safety features in new vehicles to assist the driver. It has also adopted technical rules for AVs. According to the Commission,

> *the technical rules set out via a delegated and implementing act will establish a comprehensive assessment of safety and maturity of the fully automated vehicles before they are placed on the EU market. They will cover testing procedures, cybersecurity requirements, data recording rules as well as monitoring of safety performance and incident reporting requirements by manufacturers of fully driverless vehicles.*[7]

The Department is talking to European regulators about their experiences with developing rules for ADAS and AEB. NHTSA is learning from the United Nations Economic Commission for Europe's World Forum for Harmonization of Vehicle Regulations (WP.29).[8]

FMCSA has met with international counterparts, including Japan, Germany, the UK, and Italy. These governments are testing AVs and collecting significant amounts of data. The United States can benefit from what they have learned.

WORKING WITH THE STATES

States are generally doing good work on AVs right now. However, they vary in their level of testing and ability to share data. The U.S. DOT can help balance out differences in the always-concerning patchwork of state regulations.

It may be possible to develop a coalition of AAMVA, AASHTO, and other similar organizations to plan for a national or multi-state AV regulatory framework.

States' opinions vary on the degree of cooperation and communication between the U.S. DOT and the states on these issues.

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[6] EU Vehicle General Safety Regulation
[7] https://ec.europa.eu/commission/presscorner/detail/en/ip_22_4312
[8] UNECE World Forum for Harmonization of Vehicle Regulations (WP.29)

GUARDING AGAINST BAD ACTORS

These technologies have amazing promise, but irresponsible actors developing, implementing, or deploying them can damage the whole industry.

While U.S. DOT and others are developing regulations, U.S. DOT can deploy its defect authority when appropriate and legal. U.S. DOT is hiring additional staff to improve its abilities to detect and respond to defects in advanced technologies and AI.

U.S. DOT can also help teach users about the technology's capabilities and limitations. This would help counter misconceptions created from advertising and other sources.

State Perspectives

THE NEED FOR NEW APPROACHES

Today's regulatory structure is rooted in the traditional automotive industry. But vehicles have changed, and that traditional approach may no longer make sense. Current issues include over-the-air updates, a Silicon Valley technology industry, and teleoperations, none of which existed when the regulatory structure began. It is important to step back, consider how jurisdictions should regulate, and only then address specifics. Some believe regulations should be strict about what vehicles can and cannot do; others think they should be less prescriptive.

Safety management system standards and safety cultures are as important in state agencies as in the private sector. States need to oversee testing within and across states, perhaps embedding that oversight in policy and legislation.

Any infrastructure improvements helpful for AVs and ADAS will also be helpful for human drivers. Better visibility of lane markings, including width, reflectivity, and maintenance standards, is one example.

RECOGNIZING AND ADDRESSING THE DIFFERENCES AMONG THE STATES

Some states have sought to regulate submission of data about crashes occurring and miles driven. Others believe state governments should stay out of the way. Any federal framework or regulation needs to recognize and account for states' philosophical differences.

Some states are better equipped for testing and deploying AVs, regardless of the status of legislation. Activity is clustered in states with centers of industry and technology or in states that are sunny, dry, and warm. These conditions obviously do not apply everywhere.

States also vary in the roles the state DOT and department of motor vehicles (DMV) play. Any national framework needs to recognize the critical role played by the state DMVs.

A definition of a driver including "non-human" drivers needs to be consistent across state lines.

Police crash reports in most states do not include any information about ADAS or AVs. Most states do not know whether a vehicle has ADAS, and this information needs to be in the vehicle registration processes. This information affects how law enforcement officials are trained on crash investigations and how they interact with the vehicles. It can also help determine whether the technology played any role in the crash.

State requirements for AV operators' insurance also vary significantly. However, having insurance is not the same as operating safely.

LACK OF GUIDANCE LIMITS DEPLOYMENT OF AVS BY THE STATES

States are doing a lot of work on AV regulations, but largely doing so blind. AV deployment would be enhanced if individual states did not feel they were "going it alone."

Consider two actual seemingly "simple" use cases. The first is deployment of an autonomous truck mounted attenuator (ATMA). The second is an autonomous shuttle moving goods between staging locations and a food bank.

The first enhances safety by removing a worker from an ATMA, a vehicle specifically designed to be struck. However, no recommended practices exist for the state's response when an ATMA is hit. While five or six states have at least one ATMA, lack of guidance has limited their actual deployment.

In the second case, an autonomous shuttle was moving goods between a food bank and staging locations. A human driver cut the shuttle off, resulting in the AV coming to an emergency stop. A second driver had been following too closely and hit the AV. The state had to discontinue the autonomous shuttle operation as it reassessed the overall safety and any potentially overlooked contributing factors. Again, the state had no federal guidance.

These are two examples, but states will continue to face others. States and other jurisdictions need to document and discuss these events so no state will have to face them alone as these technologies are deployed at scale.

COLLABORATION AMONG THE STATES

States need to continue coordinating though associations like AASHTO, AAMVA, and regional consortia to develop common approaches to sharing information and data and to develop consistent guidelines and regulations.

The Ohio DOT leads a pooled fund study[9] with the Federal Highway Administration (FHWA), Colorado, Connecticut, Maryland, Michigan, Minnesota, Ohio, Pennsylvania, Texas, and Virginia. This study is establishing projects to research vehicle-roadway interaction, including studying data failures and how to mitigate them, identifying and defining standards, and encouraging interoperability across state borders. The group engaged Partners for Automated Vehicle Education (PAVE) to help include industry perspectives in the discussions. The group has also produced an Infrastructure Owner Operator (IOO) Strategic Roadmap for Accelerated Adoption of Automated Vehicles.[10]

The New England Transportation Consortium authored a report entitled "Coordinating State Policies, Laws, and Regulations for Automated Driving Systems across New England."[11] The report provides a coordinated multi-state approach to policies, laws, and regulations that would allow ADS-equipped vehicles to operate efficiently and consistently across the New England states.

[9] Automated Vehicle Pooled Fund Study TPF-5(453)
[10] Infrastructure Owner Operator (IOO) Strategic Roadmap for Accelerated Adoption of Automated Vehicles (AVs)
[11] Coordinating State Policies, Laws, and Regulations for Automated Driving Systems across New England

REGULATING HEAVY-DUTY AUTOMATED TRUCKS

Trucking is a near-term AV deployment possibility. The public may be wary of an 80,000-pound vehicle traveling at 80 mph without a driver, but autonomous technology can help goods movement.

However, regulating heavy-duty automated trucks involves many issues for the states. The many players involved include the FMCSA, the Commercial Vehicle Safety Alliance (CVSA), law enforcement, and more. Trucks carry a variety of load types, which can be political. Many factors besides technology come into play, such as the labor force, infrastructure needs, and regulating the vehicle in and out of waystations. The industry, including research organizations, needs to do more to overcome these hurdles.

EDUCATING THE PUBLIC ON LEVELS OF VEHICLE AUTOMATION

Vehicle manufacturers are introducing level 3 AVs, where the human driver plays less of a role in certain conditions. States may have a role in educating the public on levels of automation so people can take advantage of the safety benefits without over-relying on the technology. Information in the owner's manual is not enough. As public agencies, states are responsible for the transportation system. They therefore have a strong interest in increasing the public's understanding and avoiding overhyping the technology.

Practitioners understand the SAE language for levels of automation[12], but the public does not. Manufacturers are defining their vehicles' automation level through marketing. Some believe an independent body may be better suited to determine what vehicles are at which automation level. Consumer Reports[13] and other organizations are trying to simplify what ADAS terms mean. States need to get ahead and stay ahead of that. From a regulatory perspective, nobody has yet addressed the vocabulary.

Immense opportunities exist for research on these and other public education questions.

PRINCIPLES FOR A NATIONAL AV REGULATORY FRAMEWORK

AASHTO's CAV Policy Principles[14] prioritize the need for a national framework. When AASHTO asked state DOTs about their priorities, states answered (1) a national framework, (2) national consistency, (3) national standards, and (4) guidance. However, not all states agreed on what those terms mean.

The ten principles included in the AASHTO CAV policy are as follows:

1. A national strategy and vision are needed.
2. Safety is paramount.
3. Support sustainability.
4. The future is connected and automated.
5. Promote innovative Federal infrastructure investment.
6. Advance equity, access, and quality of life.

[12] The automated vehicle industry generally uses SAE J3016 Recommended Practice: Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles as a reference for defining increasing levels of automation in vehicles.
[13] Clearing the Confusion About Advanced Car-Safety Feature Names – Consumer Reports
[14] AASHTO Connected and Automated Vehicle Policy Principles

7. Preserve traditional state and Federal roles.
8. Uniform national policy is essential to avoid a patchwork approach.
9. Strong Federal leadership is crucial to foster industry collaboration and community engagement.
10. Promote data sharing that preserves data privacy and security.

The full document provides more details on each of these points. AASHTO presented this policy as one of multiple reauthorization policies.

On the DMV side, an AAMVA AV subcommittee has developed best practices for testing and deployment of AVs for all jurisdictions in the United States and Canada. Jurisdictions can use these practices if they decide to administer AVs.[15] These practices account for a variety of state philosophies, given that some states are more regulation-oriented than others. AAMVA continues to publish documents about items to consider, whether around vehicles, law enforcement, or the driver. AAMVA also addresses differences between federal and state responsibilities. Throughout that process, NHTSA is a key partner.

WORKING WITH LOCAL AGENCIES

With so many local agencies of various sizes and capabilities, AV regulations often need to be at the state level to avoid an unmanageable patchwork. Local jurisdictions—even those most interested in developing these technologies—come to the states for guidance. States need to have model policies, regulations, and best practices in place.

[15] AAVMA Safe Testing and Deployment of Vehicles Equipped with Automated Driving Systems Guidelines

Local Perspectives

LOCAL RESOURCES ARE LIMITED

Thousands of cities, MPOs, and transit agencies are examining these discussions, though they often have trouble participating in paid forums. All players need to cooperate to make it easier for local agencies to participate.

One approach to maximize limited resources is to partner with communities to deploy smaller tests in shorter time periods. The rapid technology development and the jurisdictions' limited resources require that agility.

Testing is critical, but evaluation is just as important. Many cities' staff capacity is limited for evaluations. Many staff are not familiar with the technology and unable to fully evaluate it. How will we assess if it works or not? Evaluation helps develop the right questions to learn and embed those lessons in the next round.

Widespread digital literacy is a key to scalability. If this technology is for a broad audience, those localities, audiences, and businesses need to be both digitally literate and ready to interact digitally—such as with digital payments. In the United States, practitioners often assume more digital literacy than exists. It is not a regulatory need but still needs to be addressed.

LOCAL COMMUNITIES PROVIDE TESTBEDS FOR BROADER RANGE OF IMPACTS

In the push for "smart cities," transportation has had more influence than other aspects of urban design. Technology may not be in place for a broad range of locally important use cases and impacts. These include not only transportation impacts such as safety and congestion, but also social, economic, environmental, and equity impacts. Vulnerable road users, including pedestrians, bicyclists, those who are blind or have low vision, and those who use wheelchairs, are more concentrated in local communities. Safety needs to be a priority for those outside the vehicles, not just those inside.

Pilot tests can help cities create permitting processes to better address real world practices and problems. Without testing and partnerships, cities' decisions may be more difficult to make, and the decisions' impacts on broader issues will be more problematic.

A USE CASE—DELIVERY ROBOTS

In 2021, cities partnered with The Knight Foundation and a robot delivery service to deploy delivery devices in non-traditional areas. These deployments centered on equity and inclusion use cases, addressing mobility needs in the community. The contract gave the city control over testing locations, which were not limited to high-end neighborhoods. In Miami, the Foundation operated in Little Havana, a Spanish-speaking community, and is studying how the devices help small businesses. Detroit focused on the Corktown district. San Jose centered on a food co-op delivering meals and library books to families with basic needs. In each case, the Foundation focused on populations not usually engaged in these pilots.

Cities did not know much about the technology in these robot delivery services. For example, the robot's speed meant it could not fully cross the street during the pedestrian phase.

People on the ground who interact with the technology know little about it. Testing helps them understand it and make needed changes in their infrastructure.

The robot delivery technology needs smooth infrastructure, predictable weather, and simple infrastructure at intersections. ADA-compliant and pedestrian-friendly accessible streets are not just for people anymore; for example, robots were stuck on sidewalks without a ramp. There were fewer concerns, especially from disability rights communities, about human-computer interaction on sidewalks than expected.

The pilots also studied how residents reacted to the technology. At first people were excited and curious about the devices. They soon began to ask questions about why delivery was from a device instead of a person, how these devices would impact jobs, and what the privacy implications would be.

People loved taking pictures of the bots and posting them on social media. The robot provider used public engagement to refine their privacy policies, which benefited everyone.

The Knight Foundation attempted to work with multiple partners, but some did not want to be subjected to public evaluation and reporting. More companies need to be willing to join partnerships to test these services.

EXPERIENCES WITH LOCAL/PRIVATE SECTOR PARTNERSHIPS

The nature of these partnerships depends on whether or not it is a contract between the city and the research organization. If so, the contracting process gives cities more control over where the testing occurs, who is involved, and how to frame the evaluation.

Contracting with cities is difficult but possible. Cities struggle with expectations for what technology will do. Sometimes cities' expectations are more ambitious than what the technology can do, which leads to eroding confidence. Companies often overpromise, hoping to gain competitive advantage. Nonetheless, cities need to know what they will receive. Cities are directly beholden to the public and cannot just rely on what the vendor tells them.

There is a need for more convening of cities to share knowledge. This is especially important for smaller jurisdictions. For example, alternative structures can allow funding to go through community foundations or other central repositories. Contracting through the foundation can be much faster than through a city. Different structures can leverage nonprofits or community foundations as the front end of a contract for one or more localities, allowing faster contracting.

Cities large and small struggle with contracting and try to innovate. The federal government needs to be as flexible as possible in its partnerships. U.S. DOT's SMART grants, allowing cohorts to share their capacity and infrastructure, were helpful.

PUBLIC ENGAGEMENT IS KEY AT THE LOCAL LEVEL

At the local level, public engagement is critical for AV testing. These public conversations can validate and shape the testing and will then help inform policies and a regulatory structure.

The public is quick to think about the implications of AVs. We cannot shy away from conversations about, for example, what effects autonomy will have on jobs. The more we delay that conversation, the more knee-jerk the reaction will be.

Public engagement can help identify clear beneficial use cases. These might include reducing the time people spend traveling during lunch breaks or providing delivery to homebound residents.

In places testing and deploying AVs, often only the “bad stuff” is reported on the news. This creates public pressure to slow or stop testing and deploying AVs.

Public engagement cannot be performative. Social media can help and can be as valuable as focus groups or town halls. We need innovation in public engagement, including using newer communications channels. People embedded in communities can also collect quantitative and qualitative feedback.

Money is needed for public engagement efforts. This project had a million dollars for public engagement, more than most cities can afford. Cities and industry both need to find ways to do this engagement without philanthropic support.

Industry Perspectives

REGULATORY ISSUES ARE IMPEDING INDUSTRY'S AV DEPLOYMENT TO IMPROVE SAFETY

We have talked about these issues for several years now. Industry has a sense of urgency to deploy this technology for many reasons, as discussed previously.

There may be a need for some regulatory humility. It is not clear that either this community or the federal government has decided what is worth regulating.

Not all technology is ready. However, the issues of scaling the technology and deployment have at least as much to do with regulatory impediments as technology. The differences between federal and state roles are well known: the federal government regulates vehicle safety while states and locals address drivers and operations safety.

However, the slow rollout of any federal regulatory framework has muddied that clear division. States, and now cities, have created their own laws and frameworks. Much of the technology is ready and it is rolling out in some places.

For the last several years, safety has taken precedence over other issues such as mobility, economic benefits, and sustainability. The prominence of the safety and supply chain crises led to less discussion about mobility. It almost seems quaint to talk about mobility issues.

To date, the industry has a strong safety record. Industry can establish a definition of safe performance and AV technology can be designed to fit that definition.

Addressing the safety crisis requires us to scale up AV technology and deploy it. Hurdles and obstacles exist now; these result from consumer acceptance issues, regulatory hurdles, and more. We need to overcome these hurdles and deploy the technology to start reducing the many crashes resulting from human factors.

CHALLENGES AND OPPORTUNITIES FOR U.S. DOT AND NHTSA

NHTSA will likely have a hard time issuing federal motor vehicle safety standards (FMVSS) or analogous constructs. It takes a long time to enact standards, a problem the states understand.

NHTSA is trying to create a single performance-based FMVSS. This is a challenging goal, and measuring performance is not easy. Those measurements might be a driving test with a limited number of scenarios. There are many types of operational design domains (ODDs) and no easy answer about which is "the one." However, NHTSA can continue to address this issue while others are safely deploying and operating the technology.

Federal regulations are designed to identify a specific safety problem and apply a solution to fix that problem. AV technology operates differently. It is designed to automatically manage the dynamic driving task, not address a particular safety problem.

In the absence of FMVSS, what safety and regulatory vacuums exist and how should they be addressed?

At the federal level, development of a regulatory framework has three phases. The final phase 3, future regulations for ADS and AVs, is the "holy grail." That is far in the future, as the data are not available yet to solve that. Phase 2 addresses the existing regulatory framework that does not always accommodate AVs, especially non-conventionally designed vehicles. To solve phase 2, we will need to fix current regulations to accommodate AVs now. But first we need to focus on phase 1. Phase 1 will describe how to open the roads now to safe and widespread

commercialization and deployment. In the meantime, we will try to make progress on phase 2 and will think about phase 3.

NHTSA has the authority to issue recalls for safety concerns and has done so twice for ADS. This is not a gray zone or vacuum of authority. If NHTSA considers an issue to be design or performance-based, the authority exists. NHTSA crash data are available to the public. This data set is imperfect but still useful.

NHTSA is directing a lot of resources to these issues. They have looked at other technologies that actuate part of the driving task and have established performance tests to analyze their safety. Eventually, we can move these tests forward at a system level.

Many in industry want U.S. DOT to create best practices about how to test technologies. They want a set of test scenarios the industry could use for specific government regulations.

Some in the industry are sometimes unsure of the roles and activities of agencies within the U.S. DOT. NHTSA, FMCSA, and FHWA have roles that can seem to overlap. FHWA has a long history of collaborating with industry to introduce new products.

It is not clear whether over-the-air updates are a settled issue. These do not fit well into the current recall process, which the federal government may want to consider. The recall process is designed to help people who bought a vehicle from a dealership. It is not clear if that authority can be exercised for manufacturer or developer technology. These are open questions.

INDUSTRY HAS DEVELOPED SAFETY ASSESSMENTS, METRICS, AND GUIDELINES

Industry members have developed multiple safety case frameworks and guidelines.[16] [17] [18] [19] [20] Six years ago, only one or two industry standards applied to self-driving, but now 20 or more exist. In general, there is a high level of minimum safety assurance and transparency to build consumer trust. The industry can do more and is doing so every day.

A research idea is analysis of NHTSA guidance in the context of industry and European actions over the last 6-7 years. What holes have been plugged and what was not in the framework? Industry members have made commitments on safety self-assessments and transparency.

One way to help technology acceptance is to develop consistent safety metrics. Other than crashes, these vary across developers and state or local agencies. That leads to questions about consistency in safety approaches. Developers approach safety in many ways, resulting in a lot of innovation. But the lack of consistency in safety messaging makes it difficult for people to understand the safety risks associated with a particular technology.

A challenge is determining a leading safety indicator. One such indicator could be spatial separation from other road users. A second is how well users obey traffic laws. A third is a traditional insurance metric for hard braking events. It would be helpful to see and publicly share how AVs perform against traditional insurance metrics. FMCSA has studied metrics such as truck lane weaving and stability within lanes. Parallel comparisons on passenger vehicles would be helpful.

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[16] Safety Guidelines for Autonomous Mobility and Delivery Providers on the Uber Platform
[17] Policy Roadmap to Advance Automated Vehicle Innovation – Alliance for Automotive Innovation
[18] Safety Case Framework - Aurora
[19] Automated Vehicle Safety Consortium – Overview and Best Practice Documents
[20] Guidelines for Safe On-Road Testing of SAE Level 3, 4, and 5 Prototype Automated Driving Systems (ADS) J3018_201503

To bring AVs to ridesharing and other platforms, companies must trust the vehicles' safety features. They believe current federal and state roles are adequate to allow for technology deployment. The federal government and states can continue focusing on their respective areas of expertise.

These steps can help industry. They may also be valuable for others struggling with the same challenges without federal clarity. The safety case frameworks provide many approaches, including voluntary safety self-assessments and other types of proofs of safety. All approaches are helpful, but all are different. Some have arisen through the Institute of Electrical and Electronics Engineers, SAE International, the Automated Vehicle Safety Consortium (AVSC), and other entities addressing key parts of the safety problem. Industry members need to consider all safety approaches for current and prospective partners. Companies must be comfortable with a partner on their platform and in customer facing operations, not just behind the scenes in research and development.

The AVSC is an industry program of SAE Industry Technologies Consortia. The AVSC quickly publishes best practices to inform industry-wide standards for the safe deployment of ADS. Every member in the group commits to meeting the standards once published. These standards could be incorporated into a national regulatory framework.

THE IMPORTANCE OF COMPANY SAFETY CULTURES

Many assume, sometimes implicitly, that the industry is homogeneous and working diligently to improve safety. Over 50 companies are testing on public roads in California alone. Some companies do not have a safety culture and take actions that are unsafe. Guardrails will prevent these companies from causing public incidents that will damage the public perception of automation. We need to cooperate to create those guardrails protecting the industry from bad actions of irresponsible companies.

The industry needs to focus more on organizational safety. To date, safety has mostly been directed at engineering and operations. There is less focus on the culture of safety within organizations. A brief document could describe a company's safety management system (SMS). If a company has a robust SMS and safety culture, employees can find and address potential risks before they become a problem on the road.

Understanding the elements of a good company SMS would be a good research project.

REGULATORY ISSUES AFFECTING AV TESTING

AV testing companies are seeking ways to build a safety assurance case strong enough for the government. They want to know how impact standards are evolving, how FMVSS will look for AVs, and how to build scenarios that meet regulatory requirements.

Before publishing a request for proposals, every Department of Defense (DOD) program defines specific testing requirements. This is how DOD evaluates all of its autonomy programs. This approach may not be perfectly transferable to the commercial sector.

On-road testing, testing tracks, and simulation testing of AVs all help to ensure AV safety, though it is not yet clear how to harmonize these efforts. How can simulation tools support on-road testing? What is the right mix of test track versus on-road versus virtual testing? What is the right testing cadence? When should OEMs (original equipment manufacturers) approach regulators? How should OEMs share data, and what data is helpful?

The government can also use modeling simulation tools, though policy makers, regulators, and lawmakers have not understood simulation well. Europeans have published

modeling simulation papers in peer-reviewed journals. This information is important, because a deeper understanding of the value of simulation will help reassure policy makers and encourage deployment.

CONSISTENCY NEEDED AMONG STATES

In the absence of national AV legislation and regulations, the industry appreciates states' efforts. States can also leverage all the industry's work in establishing safety standards and guides.

However, politics play a key role. Some states will advance state level AV policy. Due to politics, many others must still rely on safety drivers because they cannot engage in these discussions in their state. As a result, significant inconsistencies exist in AV legislation and regulations among states, creating a challenging environment for developers to navigate.

State DOTs have opportunities to cooperate, whether regionally or nationally, to find harmonized approaches. Harmonization would help on at least two fronts. The first is the state level regulatory framework itself. When designing permitting mechanisms, how can they be similar to other states and what possibility exists for reciprocity? For example, if a company is approved in California, is it automatically approved in Washington? The second is the big issue of traffic laws. Consistency among state traffic laws would help both ADS and human drivers.

The question of federal versus state regulation remains significant. What is the actual concern about and the risk of regulatory bifurcation? Bifurcation has occurred with technology for a long time in different ways. We need to be specific about the most concerning issues.

NHTSA has issued guidelines with a long list of issues for states to address. However, states address these issues in very different ways. Even within a state, changes in policy over time create more uncertainty. A constantly updated national clearinghouse would help the industry.

States can focus on fleet management and elements specific to operations and rules of the road. Humans and AVs respond to traffic laws differently. How does this difference impact traffic flow and system performance at scale? That question is valuable from a state perspective.

The intellectual capabilities needed to address AV deployment is much more difficult for states to achieve than it is for the federal government to achieve. States need the federal government to bring stakeholders together to establish a national AV regulatory framework within which states can operate.

State law enforcement agencies and state DOTs need to collaborate more actively. This means exchanging information and cooperating so appropriate permits and laws are in place for AVs to operate. It would be helpful to include multiple entities within state governments to ensure information is shared with IOOs and policy makers as well.

OPERATIONAL DESIGN DOMAINS AND OTHER OPERATIONAL ISSUES

There are several reasons AVs are not widely deployed, at least in certain ODDs. The first is regulatory, then consumer acceptance, then technological. Some ODD standards do exist. However, there is no consistency across developers and governments establishing how to create an ODD and meaningfully explain it to the public. Can we combine a map with environmental considerations in a standardized way?

Safe vehicles and safe driving are not the same. Safe driving integrates seamlessly into the stream of human-driven vehicles, not faster or slower, without any distinctive driving characteristics. If AVs carefully obey the highway speed limit, they will create unsafe conditions,

decrease fuel efficiency, and reduce throughput. It is a challenge to develop driving profiles that are safe and law-abiding while improving fuel efficiency and throughput.

REGULATORY ISSUES AND TRUCKING

State law enforcement does not have the time or resources to inspect every truck on the road. Instead, states rely on a mechanism or algorithm requiring trucks to pull into inspection stations. This is not a perfect system, and many trucks on the roads have violations. Safety blitzes find huge numbers of trucks with brake safety problems, driver violations, and other issues.

The industry is working with federal and state partners to develop a new system for automated trucks that can be an operating model for the full AV industry. This model would enable a trained inspector to inspect every truck before every run every 24 hours. That information would then be provided to law enforcement. Then, when a vehicle passes, enforcement agencies will digitally see the vehicle's pre-inspected status and have complete information about it. That is an example of a federal regulatory framework around safety. State law enforcement agencies that need to implement those rules are collaborating on tactics to let industry operate while satisfying the objectives of federal policy makers.

These principles can help solve other problems, such as the warning triangle issue. These conversations are occurring, and the industry is collaborating with FMCSA. Ultimately it will be important to address those issues through rule making. FMCSA has been addressing this problem, but we do not yet have results. In the meantime, the exemption process can inform good rule making addressing these tactical issues. That will provide clear guidance to states, law enforcement, and administrations within the U.S. DOT about the framework in which AVs will be operating.

REGULATORY ISSUES AT THE LOCAL LEVEL

The coordination between industry and cities is important. Cities manage much of the street system, including curbside access and how people arrive at and handle commerce at the curb. Cities also manage street operations.

Thousands of cities have engaged separately with the technology and industry. A few leaders are creating a city playbook so others can understand how to engage with industry most effectively. This TRB/ITS America group can help cities learn from each other.

Municipalities can use levers such as work zone permits, zoning, and curbside access. Ideally, the experience across cities would be more streamlined than it is now. Many cities have not seen the technology arrive yet and have no experience managing it.

Companies entering cities need to collaborate with the city and public safety officials so that the city residents understand the process. This is critical to gaining long-term public acceptance.

City staff need assurance that someone is reviewing and approving provider-submitted reports on automated and shared vehicles.

In terms of enforcement, cities can issue traffic tickets, but these are not penal offenses and have no jail time. Tickets are meant to address human behavior, not vehicle defects. What is the best way for local agencies to work with a provider whose vehicle has an issue complying with traffic rules?

THE PRIVATE OWNERSHIP ISSUE

Many people are hesitant or ambivalent about AV technology. This is partly because we talk about AVs as a way to reduce private car ownership. The desire to move away from private vehicle ownership needs to be in other forums, not dragging down the conversation on AV deployment. We need to focus on technology safety concerns and how to deploy the technology in the immediate future.

Human Factors Safety Issues

ACCOMMODATING THE BROAD DIVERSITY OF USERS

The broad range of end users of these technologies is important. Younger and older drivers have different needs, and the country is full of people with different abilities, body shapes, languages, and more. The same playbook will not always work. The federal government needs to ensure the technology works for a broad range of users.

AVOIDING OVERRELIANCE ON THE TECHNOLOGY

As with ADAS, overreliance on these systems has created some unsafe driving situations. Many people believe self-driving vehicles are available to buy today. Too many also seem to believe that "hands-off" or "feet-off" features also mean "brain off."

We need to be honest about the limitations of ADAS features as well as their benefits. If we are not, we will lose users' trust, and it will be almost impossible to regain it.

Many estimates of potential crash reductions with ADAS technologies are based on testing within limited speeds and circumstances. We need more robust data from actual on-the-road experience.

Drivers who do not trust the technology could take actions just as dangerous as drivers who trust it too much. Many who drive unsafely, such as not signaling lane changes, will disengage safety technologies to avoid repeated visual, audio, and tactile warnings. And older drivers, whose flexibility and reaction times may have diminished, often hesitate to rely on these unfamiliar technologies.

STANDARDIZING TERMINOLOGIES AND INTERFACES

Providing national standards is as important for today's ADAS as for more advanced AVs in the future. Currently, users face dozens of different names for the same features in different brands—features as common as automatic emergency braking or adaptive cruise control. User interfaces also differ by vehicle make and model. This becomes especially confusing when users operate different vehicles or rent them.

A passenger may perceive an emergency when the ADS is operating as intended. According to a report by the AVSC, "no standards or industry guidance currently address passenger control (agency) for emergency reasons completely unrelated to the ADS's ability to perform the Dynamic Driving Task (DDT)."[21]

[21] Passenger Initiated Emergency Trip Interruption, AVSC

MOVING FROM ADAS TO LEVEL 4/5 AVS

The industry is learning a lot about designing safe and user-friendly ADAS features. We all need to consider these lessons as more highly automated vehicles become available.

At the same time, ADAS is a driver system, and the human driver needs to be in the loop. For level 4, the driver does not need to be involved. Key differences exist in how people interact with a level 4 system and a level 3 system.

A major challenge is the human factor of integrating these highly automated vehicles into the existing fleet. When discussing anticipated benefits, we often assume widespread adoption of these vehicles. But this is far from certain, and older technology will remain on our roads for a long time. There will be major challenges in managing a mixed fleet of different drivers, different technologies, and different levels of impairment. There will also be new risks we cannot envision today. This could be combustible if we are not honest with the public.

Driving simulators can test features of highly automated vehicles and mixed vehicle fleets, including how vehicles and human occupants respond to different conditions and circumstances. Simulators can raise issues and help us to determine what should and should not be allowed.

EDUCATING USERS

Honesty about the capabilities and limitations of these technologies is the key to credibility and success. Honest conversations are more important than salesmanship.

These technologies are changing the way humans experience in-car travel. Some of them can create problems we have not anticipated and do not fully understand. If we do not carefully consider the human role, the safety and benefits of the technologies might lessen. We therefore need to keep consumer education as a priority.

As research into human-machine interfaces expands, it is important to understand technology limitations so consumers can be educated about them. This is especially important for vehicle technologies.

Driver education needs to be more holistic. Today's drivers, especially younger drivers, learn a lot from social media. This adds a new element to the education process, as there is plenty of misinformation on social media. We are not reaching Generation Z drivers with impactful education to make sure they are safe drivers.

Written driver's tests contain many questions not relevant to safe driving. There may be a case for incorporating driving simulators into the driver testing process.

Drivers rarely use their vehicle user manuals, and the manuals are rarely written for a specific vehicle. Salespeople at dealerships might not be familiar with the vehicle's technology or do not take the time to fully educate the buyer. Buyers do not usually want to take the time to learn about a vehicle's technology features after they have already spent hours in the dealership. Over-the-air software updates leave it up to the consumer to understand any changes or new capabilities.

Consumer groups can help distinguish safety-specific features, like driver alerts and reminders, from features that are infotainment or consumer technology. A common consumer complaint is uncertainty as to whether the technology is in place and working. Consumer groups can help explain these issues to people.

Consumer education is important but is not a panacea. The public and the media do not always understand the SAE levels of automation, and we need to do more to educate them.

[Rapporteur's Note: After these panel discussions in 2022, TRB's Behavioral Traffic Safety Cooperative Research Program initiated project BTS-26, "Advanced Driver Assistance Systems (ADAS) Education and Outreach[22]." The project's objectives are to: (1) characterize the current state of ADAS education, training materials, and methods of delivery; (2) identify populations in need of ADAS education and training; (3) identify gaps in existing educational materials and methods of delivery; and (4) identify effective methods of delivering ADAS information and educational materials to target populations.]

[22] BTSCRP Project BTS-26, "Advanced Driver Assistance Systems (ADAS) Education and Outreach"

Research Questions

Questions raised as candidates for future research include the following:

- What are the elements of the regulatory frameworks and safety principles that the public and private sectors have developed to date, and how can they be used to develop a national regulatory framework for AVs?
- How do regulatory frameworks for AVs compare among different countries?
- What safety metrics, in addition to crashes, might help gauge the safety of AVs and advanced driver assist systems?
- What are the relative roles of on-road testing, testing tracks, and simulation testing for AVs?
- How can we develop and maintain a national database tracking the experiences of AV pilots and tests?
- What standards or guidelines should be employed for establishing operational design domains?
- What are the best practices and contract or permitting provisions for government agencies to follow when testing AVs?
- How can vehicle registration requirements, crash reporting standards, and law enforcement forms be revised to identify AVs and ADAS features of vehicles involved in a crash and to determine whether those features played a role in the crash?
- What mechanisms are available to increase consistency among states regarding traffic laws to accommodate AVs and mixed vehicle fleets?
- What are the potential societal benefits and costs of AVs under different scenarios, including levels of private ownership, ridesharing, and electrification? How would these impact a national regulatory framework?
- What kinds of expertise do staff at government agencies need to be able to address issues generated by these advanced technologies?
- What provisions comprise an effective safety management system for AV companies?
- How can the public be better educated on what these vehicle technologies can and cannot do?

APPENDIX

The Panels

Regulatory Issues for AVs

June 15, 2022, Washington, DC

Hosted by the TRB Executive Committee, organized by the TRB AV/SM Forum

Moderator

- Nat Ford, Chair of the TRB Executive Committee, and CEO, Jacksonville Transportation Authority

Panelists

- Kristin White, Chief Operating Officer, ITS America
- Scott Schmidt, Vice President for Safety Policy, Alliance for Automotive Innovation
- Anne Ferro, President and CEO, American Association of Motor Vehicle Administrators

National Regulatory Framework for AVs: Industry, Community, and State Regulatory Perspectives

September 21, 2022, Los Angeles, CA

Industry Panelists

- Ariel Wolf, General Counsel, Autonomous Vehicle Industry Association
- Kevin Gay, Director, Head of Safety - Autonomous Mobility and Delivery, Uber
- Sunmin Kim, Public Policy Director, Applied Intuition

State Government Panelists

- Bernard Soriano, Deputy Director, California DMV
- Daniela Bremmer, Cooperative Automated Transportation Development Manager, Washington DOT
- Ashley Nylen, Assistant Director for Mobility Technology, Colorado DOT
- Peter Calcaterra, Transportation Supervising Planner, Connecticut DOT

Community Panelist

- Lilian Coral, Director of National Strategy, Knight Foundation

National Regulatory Framework for AVs: U.S. DOT, ADS Developers, and Safety

December 9, 2022, Washington, DC

U.S. DOT Panelists

- Vincent White, Senior Advisor for Innovation, U.S. DOT
- Otto Matheke, Director, Office of Vehicle Safety Compliance, NHTSA
- Earl Adams, Chief Counsel, FMCSA

ADS Developers Panelists

- Hilary Cain, Vice President, Technology, Innovation, and Mobility Policy, Alliance for Automotive Innovation
- Nathan Beuse, Vice President of Safety, Aurora
- Emily Warren, Head of Public Policy, Embark Trucks

Safety Panelist

- Devin Gladden, Manager of Federal Affairs, AAA

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The **National Academy of Engineering** was established in 1964 under the charter of the National Academy of Sciences to bring the practices of engineering to advising the nation. Members are elected by their peers for extraordinary contributions to engineering. Dr. John L. Anderson is president.

The **National Academy of Medicine** (formerly the Institute of Medicine) was established in 1970 under the charter of the National Academy of Sciences to advise the nation on medical and health issues. Members are elected by their peers for distinguished contributions to medicine and health. Dr. Victor J. Dzau is president.

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