Research, Development & Technology Transfer Program

Research Report:
State of U.S. Automated Vehicle Policy

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16. Abstract This research report prepared for the District Department of Transportation (DDOT) provides an in-depth examination of the current state of automated vehicle (AV) regulations, to support development of a comprehensive regulatory framework for the District. The report covers the fundamentals of AV technology, reviews existing literature on regulatory models, and analyzes current regulations and legislations across various states. Findings highlight the need for integrated federal and state frameworks, local government preparedness, stringent safety standards, and equitable AV deployment. Interviews with cities, states, and operators emphasize the importance of public engagement, consistent data reporting, and adaptive infrastructure. The final report from this work will conclude with strategic recommendations for the District to ensure safe, efficient, and sustainable AV deployment for the District.			
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Author Acknowledgements

Much of this work was completed between July 2024 and December 2024 with some updates to capture documentation released in 2025, but these updates are not exhaustive, and thus this report primarily reflects published literature through March 2025. There continue to be rapid changes in the technology, the industry, and the deployments; therefore, some information in this report may be dated by the time it is published.

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Abbreviations

AAMVA – American Association of Motor Vehicle Administrators

AASHTO – American Association of State Highway and Transportation Officials

ADA – Americans with Disabilities Act

ADAS – Advanced Driver Assistance Systems

ADS – Automated Driving Systems

ADP – Automated Driving Providers

AI/ML – Artificial Intelligence/Machine Learning

AV – Automated Vehicle

AVIA – Autonomous Vehicle Industry Association

AVSC – Automated Vehicle Safety Consortium

AV STEP – ADS-Equipped Vehicle Safety, Transparency, and Evaluation Program

CBI – Confidential Business Information

CDC – Centers for Disease Control and Prevention

CDS – Curb Data Specification

C.F.R. – Code of Federal Regulations

CPUC – California Public Utilities Commission

CRS – Congressional Research Service

CV – Connected Vehicle

DDOT – District Department of Transportation

DDT – Dynamic Driving Task

DMV – Department of Motor Vehicles

DoD – Department of Defense

DOT – Department of Transportation

FMCSRs – Federal Motor Carrier Safety Regulations

FMVSS – Federal Motor Vehicle Safety Standards

HAV – Highly Automated Vehicle

LiDAR – Light Detection and Ranging

MaaS – Mobility as a Service

MDS – Mobility Data Specification

NCHRP – National Cooperative Highway Research Program

NHTSA – National Highway Traffic Safety Administration

ODD – Operational Design Domain

PUDO – Pick-Up/Drop-Off

SAE – Society of Automotive Engineers

SFCTA – San Francisco County Transportation Authority

SGO – Standing General Order

TNC – Transportation Network Company

TRB – Transportation Research Board

U.S.C. – United States Code

UAOVA – Uniform Automated Operation of Vehicles Act

UNECE – United Nations Economic Commission for Europe

USDOT – United States Department of Transportation

V2X – Vehicle-to-Everything

VMT – Vehicle Miles Traveled

WAV – Wheelchair Accessible Vehicle

ZOV – Zero Occupant Vehicle

1 Introduction

The District Department of Transportation (DDOT) has engaged the Kimley-Horn team (led by Kimley-Horn and Associates, with support from Blue Door Strategy and Research, Cityfi, Symmetra Design, and TB&A) to support the District in developing a forward-looking regulatory and legislative framework for the deployment of automated vehicles (AVs), also referred to as autonomous vehicles. This effort was launched at a pivotal moment: real-world AV deployments are accelerating, but at the same time, the industry remains nascent, with rapidly evolving technology and uneven safety performance across operators.

Robotaxis, automated shuttles, and automated delivery vehicles are now operating in cities such as Phoenix, San Francisco, Austin, Las Vegas, Atlanta, and Los Angeles. Automated freight operations are underway in Texas, Arizona, and Arkansas. In the last year, robotaxi operators have announced the desire to deploy in a number of additional U.S. cities in 2026, including San Diego, Detroit, Miami, Dallas, Nashville, Houston, Orlando, and San Antonio. Multiple operators are actively testing in the District of Columbia with the intent to move to deployment once that is legally permissible.

Meanwhile, state and federal policy is still in development. AVs raise fundamentally different risks than conventional vehicles. They involve software-driven decision-making, remote operations, complex liability structures, and continuous data collection. As a result, protecting public safety and the public interest requires more than simply applying existing traffic laws and managing through traditional enforcement means.

The differences between AVs and conventional vehicles also complicate the regulatory landscape. Traditionally, the federal government has regulated vehicle design and equipment, states have regulated licensing, and states and cities have regulated operations, enforcement, data, and liability. The line between vehicles and operators is less clear in AVs and has created the potential for gaps in oversight as well as the need for new governance frameworks. Educated governance at this stage will allow the District to best control the nature of how this technology arrives on its streets and to ensure the technology offers a safe, reliable, and equitable service from the onset.

1.1 Purpose of this Report

The purpose of this project is to support the District in developing a regulatory and legislative framework for AV deployments that aligns with and supports the District's transportation and planning policy goals. This research report was designed to provide DDOT and the District with the research, policy grounding, and comparative insight needed to make informed decisions about how AV deployments could be legislated and regulated in DC. It serves as the analytical foundation for the development of policy options and legislative recommendations but does not offer recommendations.

Moreover, this research does not attempt to predict which companies will succeed or which technologies will dominate. Instead, it focuses on the governance systems that the District will need regardless of which vendors or business models prevail. Specifically, the work examines:

- How AVs are being regulated, tested, and deployed in leading U.S. states and cities
- What data and safety oversight mechanisms are used to protect public safety and manage risk
- How equity, accessibility, and workforce impacts are being addressed
- How cities are managing curb space, congestion, and public trust

The emphasis is on identifying those policy levers that the District could realistically use to shape how AVs operate in the District in a way that aligns with the District's goals and values and its unique operating environment.

1.2 Structure of this Report

This research and interview-based work was conducted primarily between July 2024 and March 2025, with supplemental updates in late 2025 reflecting some key recent developments in the industry and regulatory environment. The research done in this report is to provide a comprehensive summary and synthesis of the current state of AV regulations, with a focus on deployment. The report brings together four major strands of work, captured in the primary sections of the report:

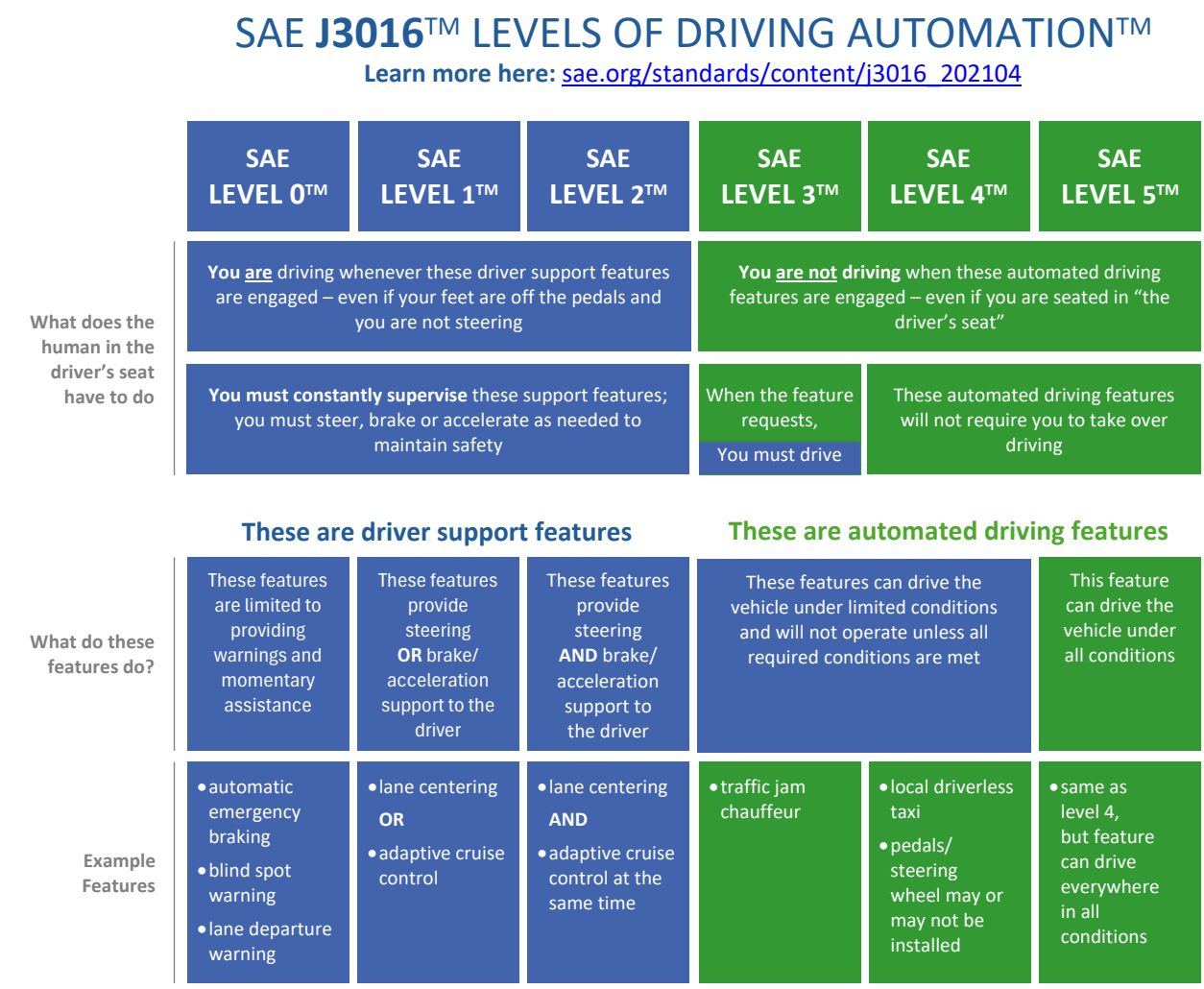
- A national and international literature review;
- A review of current U.S.-based AV regulations (as of late 2024) and interviews with peer cities, states, and AV operators to identify best practices and lessons learned for regulation and oversight of AVs;
- An assessment of current data requirements being used elsewhere; and
- A brief review of potential impacts to and considerations for workforce.

Together, these inputs establish a baseline and identify emerging issues related to AV deployment for DDOT and the District as they consider how to best manage and regulate AVs. The final section highlights where the District is today and outlines the approach for bringing this research into practical application in the District in the future.

1.3 AV Basics

AVs are vehicles equipped with an automated driving system (ADS) capable of performing part or all of the dynamic driving task (DDT)—steering, braking, accelerating, and monitoring the roadway—without human intervention under defined conditions. These systems are commonly classified using the Society of Automotive Engineers (SAE) levels of automation, from Level 0 (no automation) to Level 5 (full automation in all conditions). **Figure 1**, developed by SAE, denotes the roles of the human driver and automated driving features for the various levels of driving automation. While generalized, it provides a reasonable framework for the levels in a way that the general public can easily understand.

Figure 1: SAE International J3016™ Levels of Driving Automation



Most current commercial AV deployments operate at SAE Level 4, meaning the vehicle can drive itself without human input, but only within a defined operational design domain (ODD)—for example, in prescribed geographic areas, certain weather conditions, or on certain roadway types. When operating outside its ODD, the vehicle must execute a fallback strategy that achieves a minimal risk condition or transitions control to a human driver (in-vehicle or remote, if available).

AVs also continuously collect, process, and transmit large volumes of information related to location, speed, trajectory, sensor inputs, internal and external activity, and weather and roadway conditions. To ensure safe operations and public safety and security, there is a role for government to understand when, where, and how these vehicles are operating, and being able to quickly and easily dissect issues when they inevitably do occur. This makes data sharing requirements and reporting, data governance, and cybersecurity central to proper government oversight.

2 Literature Review

The literature review performed for this project was intended to explore sources that deal primarily with the emerging legislative, regulatory, and policy considerations surrounding AVs and ADS. This review *did not* focus on topics such as technology, standards, societal impacts, etc.

Collectively, the documents highlight a rapidly evolving domain where public agencies, industry actors, and research institutions are attempting to keep pace with technological advances while safeguarding public safety, equity, and sustainability. Themes recurring across sources include: the preference for a unified regulatory framework, the importance of public trust and transparency, the growing centrality of data governance, equity considerations in AV deployment, and the role of infrastructure modernization. While some publications focus on high-level national frameworks, others offer granular city-level strategies, technical safety requirements, or insights into public perception and real-world deployments.

Across the literature, there is strong consensus that AV deployment must be managed proactively and adaptively. Regulators are urged to establish clear legal definitions, operational requirements, and safety obligations while allowing the flexibility needed for technological innovation. Cities are advised to use pilots and iterative implementation to understand impacts before scaling. International and federal perspectives emphasize harmonization across jurisdictions to avoid fragmented regulatory environments. Equity-focused research stresses the obligation to ensure benefits accrue broadly, especially for underserved communities and vulnerable road users.

This synthesis integrates findings across the reviewed sources, identifying shared conclusions as well as contrasting viewpoints, and distills implications for policy, governance, public agencies, and urban mobility planning. The documents reviewed are listed in the Bibliography. Summaries of these reviews are provided in **Appendix A.**

2.1 Regulatory Frameworks and Governance Models

National and State-Level Approaches

Several sources—including the American Association of Motor Vehicle Administrators (AAMVA) (2024), Loftus-Otway & Gallun (2024), Norman & Kortum (2023), and Hemphill (2020)—stress that U.S. regulatory progress has been incremental and uneven. A persistent challenge is the patchwork of state-specific rules governing testing, permitting, operator requirements, remote driving, and licensing. AAMVA (2024) advocates for clarified definitions, a state-led agency, formalized committees, and structured permitting processes. Loftus-Otway & Gallun (2024) calls for federal baseline legislation and encourages states to adopt uniform statutes such as the Uniform Automated Operation of Vehicles Act (UAOVA, described further in Section 3). These efforts aim to reduce legal uncertainty, streamline compliance, and ensure consistent safety standards.

Norman & Kortum (2023) emphasizes that the federal regulatory apparatus—particularly the National Highway Traffic Safety Administration (NHTSA)—has not yet articulated comprehensive rules for AV performance or safety. The United States Department of Transportation (USDOT) is described as constrained by long rulemaking timelines and insufficient safety metrics specific to automated functions. The recommended remedy is a national regulatory framework coordinated with states, enabling predictable rules for manufacturers and operators.

Hemphill (2020) adds that while innovation requires regulatory adaptability, the absence of federal leadership risks hindering deployment. He recommends performance-based, non-prescriptive safety rules that balance flexibility and oversight. Industry is encouraged to participate in voluntary safety self-assessments, though the literature notes these are inconsistently adopted and lack audit mechanisms.

International Regulatory Developments

The framework under the United Nations Economic Commission for Europe (UNECE) World Forum for Harmonization of Vehicle Regulations (WP.29) represents the most mature international regulatory model. It outlines safety validation principles, cybersecurity requirements, software update rules, and holistic in-use monitoring for Level 3+ ADS (UNECE, 2025). The European Union, United Kingdom, Japan, China, and other jurisdictions are pursuing consistent validation methodologies, emphasizing safety case approaches and data transparency. Compared to the U.S., international regimes display more uniformity and stronger federal/national guidance, providing an instructive contrast.

2.2 Local Government Preparedness and Urban Policy

City Planning, Ordinances, and Pilot Governance

City-focused sources (Cityfi and Urbanism Next Center, 2023; DC Office of Planning, 2021; DDOT, 2020; D'Agostino, 2024b) suggest cities must prepare for AVs in terms of governance processes, regulatory authority, and public engagement. Unlike national frameworks, local perspectives emphasize operational realities—curb management, traffic congestion, land use, workforce transition, and displacement of other modes such as transit.

Cityfi and the Urbanism Next Center (2023) stress clear local goals, broad community engagement, and transparent pilot design. AV policies should be aligned with citywide safety, equity, and environmental goals—not driven solely by vendor timelines. The authors encourage cities to use iterative, risk-managed pilot projects, beginning with limited ODDs and human safety drivers.

The DC Office of Planning (2021) highlights concerns with increases in vehicle miles traveled (VMT), curbside conflicts, congestion, and potential degradation of transit and active transportation. It calls for equity requirements, data-sharing mandates, and strategies ensuring AVs contribute to Vision Zero.

DDOT (2020) uses scenario planning to show how different AV futures could reshape mobility, land use, and economic patterns. It identifies both benefits (safety, mobility, accessibility) and risks (sprawl,

revenue losses, congestion), underscoring the need for proactive planning, congestion pricing, and zoning reforms.

The Autonomous Vehicle Industry Association (AVIA) (2025b) highlights how companies like Motional, Nuro, and Zoox actively collaborate with local authorities, first responders, and community leaders to increase understanding and safety around AVs. They provide training for emergency responders and engage with the public through events and educational programs. Motional holds community events, Nuro partners with law enforcement to ensure AVs detect and respond to emergency vehicles, and Zoox gathers data on local conditions to improve vehicle operations. Zoox also implemented external speakers on their vehicles to provide essential information to emergency responders.

Infrastructure and Operational Readiness

Multiple sources highlight the infrastructure demands of AV deployment. These include:

- Potentially upgraded traffic signals and communication infrastructure to potentially support operations;
- High-quality digital mapping and standardized data on curb policies;
- Mobility hubs for multimodal integration; and
- Charging infrastructure (with California requiring fleet electrification by 2030).

Shladover (2022) argues that physical and digital infrastructure gaps remain major barriers to safe AV operation in complex urban environments. Additionally, jurisdictions struggle to define what level of pavement markings, signage, mapping, and connected-vehicle infrastructure is needed to reliably support AVs (Olds et al, 2025). There is no shared national readiness framework, though several projects are underway at the time of report preparation to begin to address this gap.

AVIA (2025a) reported that AVs have driven over 145 million miles on U.S. public roads, marking a twofold increase in automated miles driven since last reported in June 2024. Despite substantial increases, the map in the report shows that nearly all testing and deployment activity is concentrated in the southern half of the United States.

2.3 Safety Standards, Verification, and Technology Readiness

Safety Assurance and Testing

Safety assurance is one of the strongest cross-cutting themes that was present in recent literature. The literature consistently states that many AV technologies (many firms are developing “automated” in different ways) are not yet ready for unrestricted widespread deployment, particularly in dense urban settings. Shaldover’s articles (2016, 2021, 2022, 2024) consistently argue that technology remains immature, with persistent concerns about perception failures, unpredictable urban hazards, and insufficient transparency. These pieces press for regular safety audits, mandatory reporting, and heightened cybersecurity protections.

D'Agostino (2024a) advocates for safety case methodologies modeled on nuclear, maritime, and aerospace industries—structured arguments supported by evidence demonstrating that risks are reduced to acceptable levels. This approach is increasingly used internationally and may complement or partially replace traditional Federal Motor Vehicle Safety Standards (FMVSS) structures.

The current foundation of AV safety assurance in the US rests primarily on standards developed by SAE and best practices from its Automated Vehicle Safety Consortium (AVSC). While the SAE J3016 established the six-level taxonomy of driving automation, it is a taxonomy standard, not a safety standard. It defines terms and responsibilities but does not prescribe how a system must be tested or proven safe. Several other standards have been developed for elements of ADS safety and others are under development, but the process takes time and standards from SAE and other standards development organizations do not cover the full range of needs. To address this gap, the AVSC was established to develop safety principles, common terminology, and best practices leading to standards that would improve public confidence in the safe operation of Level 4 and Level 5 vehicles ahead of their widespread deployment. The AVSC has provided guidance on metrics for assessing ADS safety performance, ODD definition, and behavioral competency evaluation, as well as a 2025 best practice covering ADS-dedicated vehicle decision-making and behavior.

Despite the growing body of industry-led standards, the United States still lacks an overarching federal safety framework governing what AV developers must demonstrate before deploying on public roads. NHTSA acknowledged in its December 2024 proposed rulemaking that the data, methods, and metrics to support comprehensive ADS safety standards do not yet exist. Its proposal for the ADS-equipped Vehicle Safety, Transparency, and Evaluation Program (AV STEP) offered a voluntary national framework aimed at improving public transparency while allowing for responsible development of the technology, but it, again, was voluntary and has not advanced since the federal administration changed.

Based on a consumer survey, J.D. Power states that standardized and independently tested safety standards are critical for consumer trust (AVIA, 2025a).

Human Interaction, Fallback, and Remote Operations

D'Agostino et al. (2024a) note that as ADS capabilities increase, there need to be clear policies that distinguish between:

- Safety drivers;
- Remote operators; and
- Automated fallback systems.

D'Agostino et al. (2024a) and Olds et al. (2025) highlight the risk of human-automation misalignment, such as operator complacency and delayed takeover responses. Clear training, fatigue management, and command authority policies are recommended.

2.4 Data Governance, Transparency, and Privacy

Data is a foundational element of AV oversight. AAMVA (2024), Cityfi and Urbanism Next Center (2023), Norman & Kortum (2023), Shladover (2024), D'Agostino et al. (2024a), and AVIA (2025a) all emphasize that reliable safety oversight requires standardized data formats, regular reporting, and shared metrics. Yet AV developers often treat data as proprietary, creating accountability gaps.

The literature calls for:

- Standardized data specifications (e.g., Mobility Data Specification (MDS), Curb Data Specification (CDS));
- National or state-level data repositories;
- Transparent reporting of disengagements, crashes, and safety performance; and
- Explicit privacy protections and cybersecurity requirements.

D'Agostino et al. (2024a) highlights tension between safety and privacy: regulators need certain data to validate safety, but data access must be balanced with individual rights and intellectual property protections.

AVIA (2025a) stresses the importance of cybersecurity and data privacy, recommending robust protocols to protect against cyber threats and ensure public trust in AV systems.

2.5 Equity, Accessibility, and Public Trust

Equity is one of the key themes frequently mentioned in policy literature. However, equity can be defined and approached in several ways. Key questions exist in how AVs, and particularly AV fleets, will be able to equitably serve geographic communities, socioeconomic communities, as well as persons with various disabilities.

For instance, people with visual impairments that limit or preclude them from driving tend to be advocates for AVs, as AVs may provide them with a lower-cost, more responsive option for personalized service and greater independence. Mark Riccobono, President of the National Federation of the Blind**,** underscores AVs' potential to improve independence and mobility for visually impaired individuals in AVIA (2025b). He advocates for policies like the Autonomous Vehicle Accessibility Act, which would grant equal rights for disabled Americans to travel in AVs without a driver's license, supporting more accessible and equitable transportation options.

However, only some of those with mobility limitations can benefit from AVs unless the vehicles are wheelchair accessible vehicles (WAVs) and ensure safe entry and exit (D'Agnostino et al., 2024b; Congressional Research Service (CRS), 2025). How to provide services that equitably serve all communities well continues to be a key topic of discussion. D'Agostino et al. (2024b) highlights concerns from disability advocates around vehicle design, interactions with blind pedestrians, and inadequate

wheelchair-accessible AV options. The literature suggests requiring AV companies to meet accessibility benchmarks as a condition of operation.

Ehsani et al. (2024) demonstrates empirically that public trust in AVs increases when messaging emphasizes benefits for vulnerable populations and underserved communities. Multiple sources call for mandatory equity requirements, including:

- Accessibility standards (wheelchair-accessible AVs);
- Deployment footprints that include underserved areas;
- Pricing transparency and protections against discriminatory practices; and
- Stakeholder engagement with disability and advocacy groups.

Public trust issues are heightened by highly publicized AV failures. Several sources (Cityfi and Urbanism Next Center, 2023; Norman & Kortum, 2023) note that risk communication, transparency (especially through data), and participatory planning are essential to avoid public backlash.

2.6 Transit Integration, Shared Mobility, and Sustainability

Stantec and Applied Research Associates (ARA) (2020) emphasizes the potential for AVs to strengthen public transit through first/last-mile services, mobility hubs, and Mobility as a Service (MaaS) integration. However, the researchers caution that without strong governance, AVs could cannibalize transit ridership, worsen congestion, and contribute to higher emissions.

To mitigate these risks, the literature recommends:

- Partnerships between transit agencies and AV operators;
- Equity-centered MaaS platforms;
- Integrated fare systems;
- Policies discouraging single-occupancy AV trips; and
- Sustainability requirements, including fleet electrification.

The DDOT (2020) scenarios illustrate how AV impacts vary widely depending on pricing and regulatory choices. Congestion pricing, HOV prioritization, and shared fleets consistently perform better on sustainability metrics in that report's modeling.

2.7 Synthesis and Implications

Across the literature, several conclusions emerge:

1) Regulation is lagging technology, with the lack of clear federal guidance remaining a challenge;
2) Safety is not yet assured, and comprehensive, auditable verification frameworks are critical;
3) Cities are on the front lines and must use pilots, iterative governance, and robust community engagement;
4) Equity must be embedded from the outset, not treated as an afterthought;

5) Data is the backbone of accountability, but standards and mandates are inconsistent;
6) Adequate maintenance of current roadway and traffic infrastructure is essential, with additional potential benefits for both operators and government from emerging digital infrastructure upgrades; and
7) Public trust is fragile and requires transparency, outreach, and demonstrated societal value.

While some literature is optimistic about AVs' ability to improve safety and mobility, others caution that unmanaged deployment could worsen congestion, reduce transit use, and exacerbate inequities. The overall consensus is that the public sector must proactively shape the AV future—not react to it.

3 Current State of Legislation and Regulations

The United States lacks a single unified regulatory framework for AVs, reflecting a longstanding division of authority between federal and state governments. While the federal government regulates vehicle design and equipment, states retain authority over licensing, operations, and enforcement, resulting in a range of state and local approaches as AV deployments expand. These differences are not solely a byproduct of regulatory gaps but reflect varying operational contexts and the role of states and local jurisdictions as the primary managers of public roadways. As AV technologies evolve, the absence of a shared understanding of how software-based "drivers" should be overseen in real-world operations has emerged as a key challenge.

Federal involvement could complement state and local authority in areas traditionally led at the national level, such as safety standards, cybersecurity, and product liability, while preserving meaningful local oversight. At the same time, broad federal preemption risks limiting the ability of state and local agencies to address practical operational realities, including the need for ongoing support and management as these systems are introduced onto public streets.

This section summarizes the current federal–state regulatory structure and the key challenges that shape AV governance today.

3.1 Summary of Federal and State Responsibilities

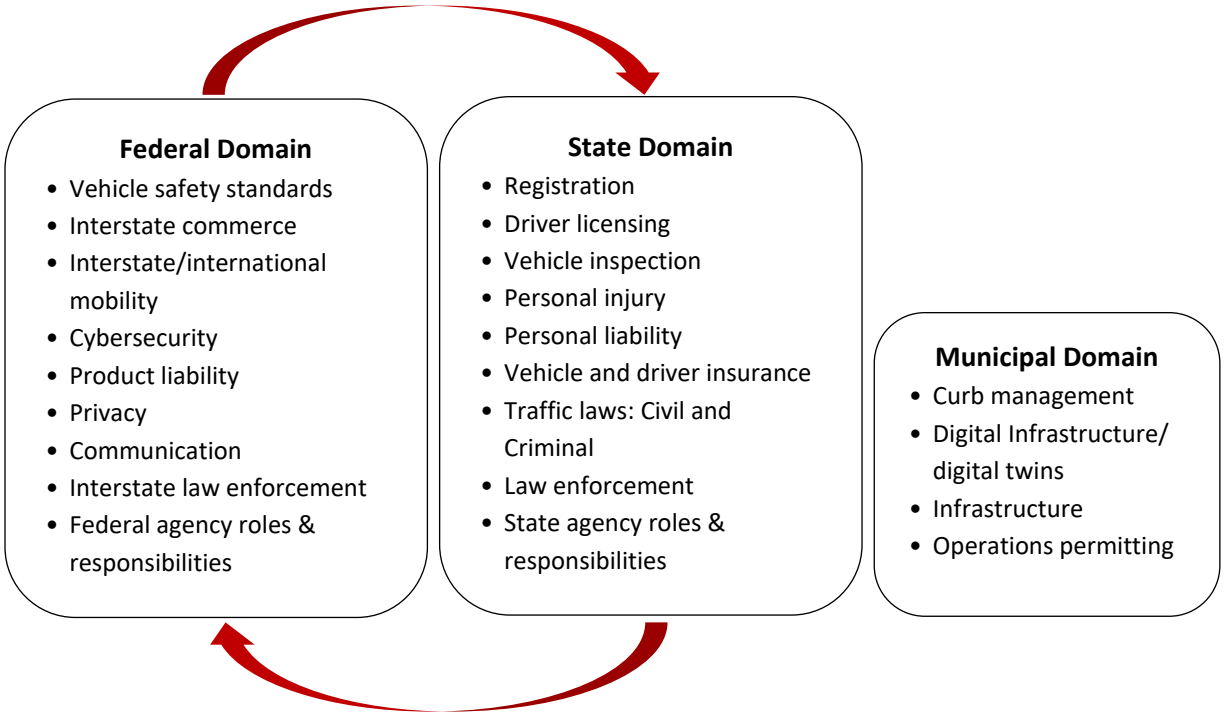
Responsibility Matrix

Researchers developed a framework by categorizing key AV regulation issues according to federal, state, and other domains, identifying where laws such as the United States Code (U.S.C.), Code of Federal Regulations (C.F.R.), and Interstate Compacts intersect with traditional state controls. **Figure 2** illustrates the traditional division of responsibilities, with the federal government regulating vehicles and equipment, and states managing driver and vehicle operations. However, these roles may shift as AV deployment advances. Under the U.S. federalist structure, the federal government plays a collaborative role in regulating driving alongside the states, with federal law taking precedence when conflicts arise.

As this technology has developed, most states have developed their own legislation, regulations, and policies for AVs. Despite various reports identifying challenges and the need for harmonization of legislation and regulations between jurisdictions to facilitate smooth AV deployment, little work has actually been advanced to date. Approaches to AV oversight are still evolving and the choice of whether to harmonize around the more stringent or less stringent approaches is still undecided, possibly influenced by politician's (and the public's) sense of how likely this technology is to deliver (Loftus-Otway & Gallun, 2024).

At the federal level, NHTSA has emphasized innovation over regulation, but as AV technology continues to evolve and move into deployment, a balance must be struck between fostering innovation and ensuring legal certainty, safety, and consistency across states. Whether full harmonization or reliance on existing agreements will suffice remains a question for future legal and regulatory developments.

Figure 2: Interplay between Federal and State Domains for AVs



Source: adapted from Loftus-Otway & Gallun, 2024

Federal Regulatory Review

Chapter 3 of the National Cooperative Highway Research Program (NCHRP) Legal Research Digest (LRD) 91 (Loftus-Otway & Gallun, 2024) explores the federal government's role in regulating AVs within the U.S. federalist legal structure where both federal and state governments share regulatory responsibilities. The federal government, primarily through NHTSA, traditionally regulates vehicles and equipment. As AV deployment has progressed, NHTSA's policies have shifted from broad guidelines to more specific regulatory focus areas, including cybersecurity, data sharing, and AV equipment standards. This shift reflects NHTSA's understanding of the complex challenges posed by AV technology, including the need to ensure system safety, protect consumer data, and maintain public trust. As the deployment of AVs continues to grow, NHTSA's role is likely to further develop, potentially leading to more formalized regulations and new legislative frameworks to support the safe and consistent implementation of AV technology nationwide.

Despite these developments, the federal regulatory framework for AVs remains incomplete, with several legislative proposals in Congress yet to be enacted. This gap has left significant regulatory responsibilities to the states, resulting in a fragmented approach to AV regulation across the country.

State Regulatory Review

While federal agencies like NHTSA can provide guidelines and oversight, the day-to-day enforcement of safety regulations often falls to state and local authorities. While some states have implemented stringent safety requirements, including regular inspections, specific equipment standards, and enhanced cybersecurity protocols, others have taken a more relaxed approach, either by relying solely on federal guidelines or by giving AV manufacturers more flexibility. This lack of uniformity may create challenges in adhering to legal or regulatory requirements as AVs move between states, complicating efforts to ensure seamless operation across different jurisdictions. Challenges for interstate harmonization at the short-, medium-, and long-term are shown in **Table 1**. **Table 2** compares, at a basic level, the differences in statutory requirements across states.

Initially, state laws regarding AVs primarily focused on testing with a limited number of vehicles on public roads, rather than full fleet deployment. These laws often vary based on the level of automation, determining whether an operator needs to be licensed and whether an operator must be physically present in the vehicle during operation. This variability contributes to national dis-harmonization, as some states classify Level 3–5 vehicles as fully automated for public road use, while others restrict this category to Levels 4 and 5.

As AV technology evolved, various stakeholders—including state governments, industry groups, and organizations—began to craft more standardized legal language to regulate the testing and operation of these vehicles. The UAOVA of 2019 (described in more detail in the next section) and the SAE J3016 Taxonomy (2016-2021) have been particularly influential in shaping state laws. While these documents have provided a foundation for some level of harmonization, the adoption of their provisions has not been uniform across all states. The extent to which these frameworks have been incorporated into state laws often depends on how recently the state's AV statutes were enacted.

Local governments also play a critical role in the regulatory process, especially in urban areas where AV deployment can have significant impacts on traffic management, curbside management, pedestrian safety, other for-hire operations, and public transit. Ongoing collaboration between federal, state, and local governments is essential for successful deployment. State governments have taken varying approaches to local oversight, with a number of states actively preempting the ability of local governments to directly regulate AVs in an effort to provide a more systemic approach to AVs statewide.

Table 1: L3-5 Areas of Challenge for Interstate Harmonization at the Short-, Medium- and Long-Term

Short Term	Medium Term	Long Term
• Lack of standardized definitions and key terms for legal analysis • Vehicle registration and titling that identifies AVs • AV driver licensing and education and training • AV dealer education standards • Vehicle inspection standards • Manufacturing and aftermarket additions standards • Platooning protocols and reciprocity/agreements across state lines • Interaction plans for law enforcement engagement to be developed	• AV product liability tort frameworks • Cybersecurity Laws for data collection data breaches and use of data and data protection for consumers • Vehicle inspection and maintenance harmonization standards to reduce unsafe vehicles crossing jurisdictional lines • Maintenance and aftermarket adaptations including recall process are not set • Crash reporting protocols so technology issues can be reviewed and monitored	• Technical manuals for state DOTs, DMVs, and local jurisdictions need updating/changes • Consumer protection laws for data and vehicle safety/maintenance • Ensuring a system that does not impact civil and disability rights, and does not cause equity issues or disproportionate impacts for Environmental Justice communities • Criminal and civil code adjustment for safe operation and crash reporting requirements

Source: Loftus-Otway & Gallun, 2024

Table 2: US Autonomous Vehicle Laws: Deployment and Testing (circa June 2023)

State	Deployment or Testing	Operator Licensed	Operator in Vehicle	Insurance Coverage $ in millions	Local Authority Preemption	SAE or UAOVA Terms Incorporated	Privacy
AL	D-C	ND	No	Yes $2	✓	✓	
AZ	D	LOA	LOA	Yes			
AK	D-C	Yes	LOA	Yes		✓	
CA	D	DOV	No	Yes $5		✓	✓
CO	D	No	ND	No	✓		✓
CT	T	Yes	Yes	Yes $5		✓	✓
DC	T	Yes	No	Yes $5			
FL	D	LOA	LOA	Yes	✓	✓	
GA	D	LOA	LOA	Yes		✓	
HI	T	ND	Yes	ND			
IL	T	Yes	Yes	Yes	✓		
IA	D	Yes	LOA	Yes	✓		✓
KS	D	LOA	No	Yes	✓		
LA	D-C	DOV	No	Yes $2			
ME		ND	No	Yes $5			
MA	T	Yes	Yes	Yes			
MI	D	Yes	No	Yes	✓		
MS	D	ND	No	Yes	✓		
MT							✓
NE	D	LOA	LOA	Yes	✓		
NV	D	LOA	LOA	Yes		✓	
NH	D	DOV	LOA	Yes	✓	✓	
NM	T	DOV	LOA	Yes $5			
NY	T	Yes	Yes	Yes $5			
NC	D	LOA	No	Yes	✓		
ND	D	LOA	LOA	Yes	✓		
OH	T	Yes	No	Yes			
OK	D	ND	No	Yes $1	✓	✓	
PA	D	Yes	No	Yes $1	✓		
TN	D	No	No	Yes $5	✓	✓	✓
TX	D	No	No	Yes	✓		
UT	D	LOA	No	Yes	✓	✓	✓
VT	T	Yes	Yes	Yes $5			
VA	T	ND	ND	No			✓
WA	T	OPV	No	Yes $5			✓[2]
WV	D	LOA	No	Yes			

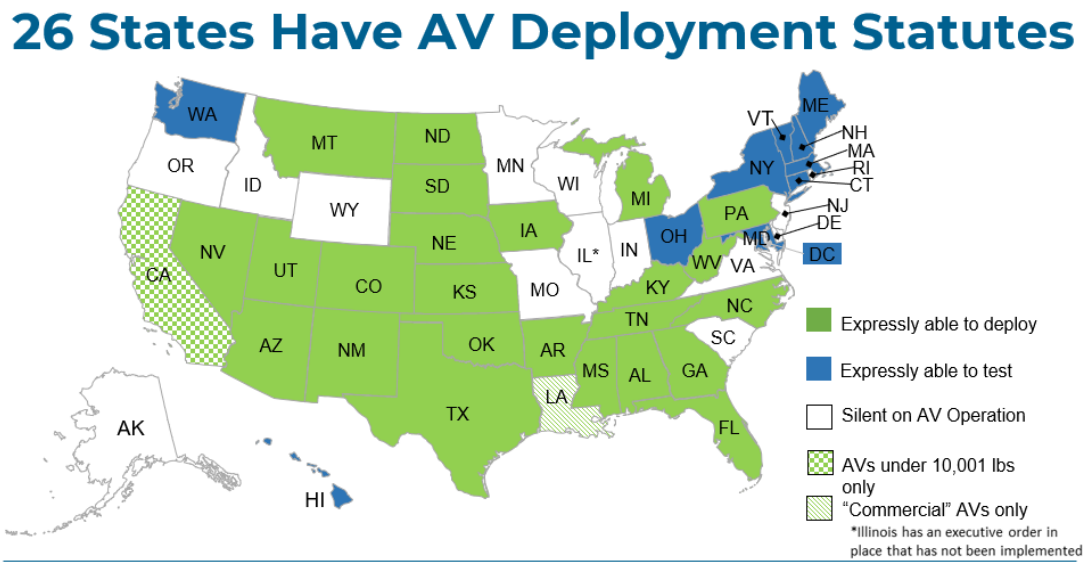
Key: T = Testing, D = Deployment; D-C = Deployment commercial only; LOA = level of automation in vehicle; ND = not addressed/detailed in statute/regulation; OPV = depends if operator present in vehicle; DOV = depends on vehicle.

[1] While Georgia's law uses some SAE terms, it fails to define the SAE levels in its code, despite allowing for the operation of AVs without human operators present in the vehicle.

[2] Washington is for health only.

Source: Loftus-Otway & Gallun, 2024

Figure 3: AV Deployment Statues as of October 2025



Source: AVIA Presentation for Virginia Joint House-Senate Transportation Committee Meeting on October 17, 2025

Uniform Automated Operation of Vehicles Act of 2019

The UAOVA, drafted by the National Conference of Commissioners on Uniform State Laws, provides a legal structure for the ownership, registration, and operation of AVs on public roads. It aims to address the wide-ranging challenges and safety considerations posed by automated driving technology. This act covers the deployment of AVs on roads held open to the public by reconciling automated driving with a typical state motor vehicle code. Many of the act's sections—including definitions, driver licensing, vehicle registration, equipment, and rules of the road—correspond to, refer to, and can be incorporated into existing sections of a typical vehicle code. This act also introduces the concept of automated driving providers (ADPs) as a legal entity that must declare itself to the state and designate the AVs for which it will act as the legal driver when the vehicle is in automated operation. The ADP might be an ADS developer, a vehicle manufacturer, a fleet operator, an insurer, or another kind of market participant that has yet to emerge. Only an AV that is associated with an ADP may be registered. In this way, the UAOVA uses the motor vehicle registration framework that already exists in states—and that applies to both conventional and AVs—to incentivize self-identification by ADPs. By harnessing an existing framework, the act also seeks to respect and empower state motor vehicle agencies.

Questions answered by the UAOVA:

- Who is the driver of an AV?
- Who gets the ticket for a traffic violation?
- How do you register an AV?

- Do you need a driver's license to use an AV?

Detailed breakdown of the act:

1) **Definitions and Scope**: The act defines various terms crucial to AV legislation, such as AV, ADS, DDT, and "automated driving provider" (ADP). An AV is a vehicle equipped with an ADS that can perform the entire dynamic driving task (such as steering and braking) without human intervention under some circumstances. However, the act does not cover vehicles with driver assistance systems that require a human driver to monitor the road. It clarifies that the act is limited to AVs intended for public road use and does not address remote driving or research-focused AV testing.
2) **ADPs**: To operate an AV on public roads, an entity must qualify as an ADP, which effectively serves as the "driver" of the vehicle. ADPs can include manufacturers, system developers, or fleet operators. They are responsible for AV compliance with traffic laws and safe operation. To qualify, an ADP must have actively participated in developing the ADS submitted a safety report to NHTSA or be registered as a vehicle or equipment manufacturer with NHTSA. The ADP must also declare itself to the state, committing to the safe deployment of AVs and assuming accountability for their operation.
3) **Vehicle Registration**: AV registration is conditioned on association with a recognized ADP. A vehicle owner, often different from the ADP, must register the AV with the state, providing notice of its automated capability. If a vehicle becomes automated through modification, the owner must obtain new registration specifically as an AV. The act allows the state to decline, suspend, or revoke registration if the vehicle or ADP fails to comply with safety or legal standards. This ensures that only AVs with credible oversight are legally registered and operated on public roads.
4) **Equipment and Maintenance Requirements**: The UAOVA mandates that AVs meet existing state equipment requirements but adjusts certain provisions that are specific to human-driven vehicles. For instance, dedicated AVs without human driving controls, such as steering wheels or pedals, do not need to comply with these requirements. AVs must be properly maintained and equipped to uphold road safety standards. Additionally, AVs are exempt from certain electronic device restrictions, provided these devices do not interfere with law enforcement or compromise public safety.
5) **Rules of the Road**: ADPs are held responsible for ensuring their AVs comply with traffic laws during automated operation. The act holds the ADP legally accountable for any traffic violations by the AV, effectively making them liable for infractions just as a human driver would be. It also addresses specific rule exemptions, such as allowing AVs to be unattended without being considered abandoned as long as they are lawfully registered and not obstructing traffic or creating hazards. Minimum following distances set for human drivers may also be relaxed for AVs capable of maintaining safe proximity based on advanced response systems.
6) **Enforcement and Uniformity**: The act promotes consistency across state laws to facilitate interstate travel and AV deployment by allowing reciprocal recognition of ADPs and AV registrations between states that have adopted the UAOVA. It empowers state agencies to oversee and enforce the standards set by the act, including the authority to revoke recognition of ADPs or suspend AV registrations if safety standards are not met. The goal is to create a cohesive regulatory environment

that minimizes legal ambiguity and supports the responsible, scalable deployment of AVs nationwide.

7) **Other Provisions**: The UAOVA includes optional sections on severability (to ensure parts of the act remain effective even if others are invalidated) and provides guidelines for states on codifying the act within their existing vehicle codes. Additionally, the act stresses that existing vehicle laws remain applicable to AVs where compatible, ensuring continuity with general vehicle insurance, maintenance, and registration requirements.

AAMVA Recommendations: Guidelines for Regulating Vehicles with Automated Driving Systems, Edition 4 (March 2024)

The *Guidelines for Regulating Vehicles with Automated Driving Systems* provides a robust regulatory framework, developed by AAMVA's Automated Vehicles Subcommittee, for states and provinces to navigate the challenges posed by advanced driving technologies.

1) Guiding Principles and Collaboration
   a) **Guiding Approach**: AAMVA advocates for a balance between safety and innovation, urging a consistent regulatory approach to avoid obstacles for vehicle manufacturers and to foster collaboration between jurisdictions.
   b) **Collaboration**: The guidelines emphasize engaging various stakeholders—federal, state, and local government agencies; industry leaders; law enforcement; and academic researchers—to develop and implement effective regulations. Partnerships with organizations like the Canadian Council of Motor Transport Administrators and the Commercial Vehicle Safety Alliance ensure that guidelines account for diverse regional needs.
2) Vehicle Classification and Terminology
   a) **SAE Levels of Automation**: AAMVA adopts SAE's classification system to help jurisdictions understand automation capabilities:
   b) **Definitions**: The guidelines distinguish between Advanced Driver Assistance Systems (ADAS) (driver-assist features, often Levels 1-2) and ADS (full autonomy potential, Levels 3-5) to clarify oversight and licensing needs.
3) Administrative Considerations
   a) **Lead Agency**: Each jurisdiction is encouraged to designate a lead agency—typically a department of motor vehicles or transportation—to spearhead AV-related programs, coordinate with stakeholders, and oversee testing and deployment.
   b) **Jurisdictional Committees**: Establishing a committee, including representatives from transportation, safety, law enforcement, and public health sectors, ensures comprehensive oversight. This committee is tasked with reviewing testing applications, advising on vehicle safety protocols, and addressing AV technology's social and economic impacts.
   c) **Review of Existing Laws**: Jurisdictions are advised to review current motor vehicle codes to identify and amend laws that may unintentionally hinder AV testing and deployment, focusing on licensing, driver education, and traffic laws.
4) Vehicle Considerations

a) **Permitting for Testing and Deployment**: Jurisdictions should develop permit requirements for manufacturers and operators to test AVs on public roads, ensuring compliance with safety standards.
b) **Vehicle Registration and Titling**: AVs should be identifiable through specific registration and titling, distinguishing them from conventional vehicles. The guidelines recommend designating ADS capability on titles and permit processes.
c) **Compliance with Safety Standards**: AVs must meet federal and state safety standards, including regular inspections to confirm operational readiness.
d) **Insurance Requirements**: AVs must meet financial responsibility requirements, like liability insurance, to cover incidents involving ADS.

5) Driver Licensing Considerations
   a) **Redefining Driver Roles**: The guidelines address the evolving role of "driver" with AVs, distinguishing between in-vehicle drivers, remote operators, and fully autonomous vehicle occupants.
   b) **Remote Driving**: For AVs with remote operation capabilities, jurisdictions should establish licensing requirements and training standards for remote drivers, who may be responsible for certain control actions.
   c) **Skills Testing and Public Education**: Jurisdictions should adapt driver education and testing to include knowledge about AV technologies, such as ADAS features, to enhance public understanding and safety.
6) Law Enforcement and Public Safety
   a) **Vehicle Identification and Incident Reporting**: AVs should be easily identifiable for law enforcement, possibly through specific indicators like ADS marker lamps or visible ADS-equipped labels. Reporting systems must capture details specific to AV-related incidents.
   b) **Crash and Incident Protocols**: Law enforcement should be equipped with protocols for handling incidents involving AVs. The guidelines recommend that ADS functionality cannot override traffic laws and may include emergency stop features for law enforcement use.
   c) **Distracted Driving and Operational Responsibility**: AV users must adhere to existing traffic laws, and law enforcement should be trained on AV-specific challenges, such as monitoring driver engagement in Levels 2-3 and handling fully autonomous vehicles at Levels 4-5.
7) Cybersecurity and Data Management
   a) **Cybersecurity Protocols**: AVs must implement security measures throughout the vehicle's lifecycle to protect against cyber threats. The guidelines highlight the need for ongoing cybersecurity practices, secure data transmission, and mechanisms to address potential hacking attempts.
   b) **Data Privacy and Use**: AVs collect significant data, necessitating policies for data access, storage, and usage that protect user privacy and outline permitted data collection for operational and incident reporting purposes. Jurisdictions are advised to set clear policies on data retention and sharing.
8) Emerging Use Cases and Future Directions

a) **Low-Speed Shuttles and Automated Delivery Vehicles**: The guidelines suggest frameworks for deploying specialized AVs, such as low-speed shuttles for short public transport routes and automated delivery vehicles. These AV types require unique considerations, such as restricted operational areas and specific safety requirements.
b) **Next Steps for Jurisdictions**: AAMVA recommends that jurisdictions continue updating regulations as technology evolves, including staying informed on research, engaging in dialogue with industry partners, and promoting public awareness.

The document also includes appendices with summaries of recommendations for jurisdictions and for manufacturers when regulating AVs.

3.2 Summary of Existing and Proposed Legislations

This section provides a clear, structured overview of the existing AV legislation in Pennsylvania and Ohio as of October 2024 and existing and proposed AV legislation in California as of December 2025. These states were selected as they tended to be the most advanced in implementing deployment regulations and their models seemed to be more relevant to DC than other states. While other states such as Arizona and Texas have deployments, their approach to regulations tends to be fairly hands off. The purpose of this section is to summarize the regulatory requirements, approval pathways, operational constraints, and reporting obligations that shape AV testing and deployment today in states with oversight models relatively comparable to the District's approach, offering a foundation for comparing state approaches and identifying areas where harmonization or policy development may be needed.

California

The following sections summarize draft proposed regulatory language for a potential updating to the rules governing autonomous vehicles in California, released by the California Department of Motor Vehicles in 2025. The public comment period for this draft language closed on December 18, 2025.

Testing (Article 3.7)

Primary Requirements for Manufacturer's Testing Permit:

- Testing must be conducted by the manufacturer or an employee, contractor, or designee authorized by the manufacturer.
- The manufacturer must provide evidence of financial responsibility in the amount of $5,000,000 to respond to judgments for damages.
- A testing permit must be approved and issued prior to commencing testing on public roads. The regulations distinguish between a Manufacturer's Testing Permit and a Manufacturer's Testing Permit – Driverless.
- The Department will notify the applicant within 10 calendar days whether an application is complete or deficient.

- Applicants will be provided with a reasonable opportunity to correct deficiencies. Applications may be denied if deficiencies are not corrected after notice.
- Testing permits are valid for two years and may be renewed upon submission of a renewal application and payment of the $3,600 biennial renewal fee.
- Vehicles may not be tested on public roads unless they have first been tested under controlled conditions that reasonably simulate the intended ODD. Manufacturers must reasonably determine that operation within each ODD is safe.
- Manufacturers are prohibited from testing on public roads if members of the public who are not employees, contractors, or designees are charged a fee or if the manufacturer receives compensation for providing rides.

Requirements and Qualifications for Test Drivers:

- Test drivers must be employees, contractors, or designees of the manufacturer.
- The test driver must be either in immediate physical control of the vehicle or actively monitoring vehicle operations and capable of taking immediate control.
- Test drivers must comply with all applicable traffic laws, except where deviation is necessary to ensure safety.
- Test drivers must understand the limitations of the autonomous technology and be capable of safely operating the vehicle under all testing conditions.
- Manufacturers must identify test drivers to the Department in writing, including full name, driver license number, and issuing jurisdiction.
- Test drivers must have held a valid driver license for at least three consecutive years prior to application.
- Test drivers must have a clean driving record as defined by regulation.
- Test drivers must complete the manufacturer's autonomous vehicle test driver training program.

Driverless Testing Requirements:

- Manufacturers must certify that local authorities have been notified prior to driverless testing and provide copies of the notifications to the Department. Notifications must include:
    - The vehicle's ODD
    - A list of public roads used for testing
    - Testing start date
    - Days and times of operation
    - Number and type of vehicles
    - Manufacturer point-of-contact information
- The manufacturer must certify the following:
    - The existence of a communication link between the vehicle and a remote operator, if applicable
    - Continuous monitoring of vehicle status and the communication link

    - The method used to monitor the communication link
- Vehicles must be capable of displaying or transmitting information to law enforcement following a collision or upon request.
- Manufacturers must self-certify that the vehicle meets the SAE definition of Level 4 or Level 5 automation.
- A Law Enforcement Interaction Plan must be submitted, addressing:
    - Communication with remote operators
    - Access to ownership, registration, and insurance information
    - Safe vehicle removal procedures
    - Identification of autonomous mode and disengagement procedures
    - Guidance for electric or hybrid vehicles, if applicable
    - Description of the ODD
    - Additional safety-related information as necessary
- The plan must be submitted to the California Highway Patrol by e-mail within 10 days of approval. The plan must be accessible online
- Manufacturers must maintain an autonomous vehicle training program.

Application Requirements:

- Prior to applying for a testing permit, a manufacturer must enroll in the Employer Pull Notice program [1]. Application will be denied if the manufacturer fails to enroll.
- The department will notify the tester within 10 days if their application is complete or deficient.
- Fee of $3,600 for the processing of the application – this will permit the operation of 10 AVs and up to 20 test drivers.
- The manufacturer will need to submit additional pages to add more than 10 vehicles and more than 20 drivers by submitting a $50 fee for each additional set of 1 – 10 vehicles and 1- 20 drivers.
- Any changes or modifications to the testing permit will require a $70 processing fee.

Permit Suspension / Revocation [2]:

- Financial responsibility requirements are not maintained
- Vehicle Code violations occur
- Driverless vehicles operate outside the approved ODD
- Disclosures required by subdivision (i) [3] of are not made
- The Department determines that an act or omission presents an unreasonable public safety risk

[1] This program enables commercial and government organizations to monitor the driving records of employees who drive for them and should assure more responsible driving.

[2] Covers driver and driverless testing.

[3] Subdivision (i) relates to their additional fees and application material for testing more than 10 vehicles.

In the event of a suspension or revocation:

- The Department will provide 15 days' written notice prior to suspension or revocation, except where public safety requires immediate action.
- Permit holders may submit a Demand for Hearing within 60 days.
- Permits may be reinstated upon verification that deficiencies have been corrected.

Reporting Requirements:

- Any collisions must be reported within 10 days. All persons involved must be identified.
- Any disengagements to autonomous mode must be reported.
- An annual report must be submitted by January 1st of each year they are testing. This report will include:
    - Test driver and driverless testing can be submitted in a single report.
    - The report will include specific data about disengagements (location, driver or driverless, description of cause).
    - Total vehicle miles driven for each month.

Deployment (Article 3.8)

Financial requirements:

- Manufacturers must demonstrate the ability to respond to judgments for injury, death, or property damage through insurance or surety instruments, as specified in regulation.

Application for a Permit for Post-Testing Deployment:

- Deployment applications must be approved prior to operation and must identify the vehicle's ODD.
- Manufacturers must certify that vehicles are incapable of operating in autonomous mode outside the approved ODD.
- Applications must identify restricted or commonly occurring conditions (e.g., weather, construction zones, geofencing).
- Manufacturers must describe vehicle behavior when outside the ODD or when encountering restricted conditions.
- A $3,275 processing fee is required.
- Vehicles must include a data recorder capable of storing at least 30 seconds of pre-collision data retrievable by commercially available tools.
- Manufacturers must certify:
    - Compliance with applicable vehicle codes and local regulations
    - Availability of technology updates at least annually
    - Continuous updating of mapping and localization data
    - Compliance with applicable cybersecurity standards

    - Completion of testing and validation demonstrating public-road safety

Additional Driverless Deployment Requirements:

- A communication link with a remote operator, if applicable
- Ability to display or transmit ownership/operator information to law enforcement
- NHTSA exemption documentation if operating without manual controls

Required Supporting Submittals:

- Identification of system limitations and user education materials
- Owner's manual or equivalent, including:
    - Engagement/disengagement procedures
    - Visual indicators of autonomous operation
    - Manufacturer and operator responsibilities
- Description of education provided to subsequent owners
- Educational materials must be available online and at no cost to law enforcement
- Certification of SAE Level 3, 4, or 5 automation and description of minimal-risk condition behavior

Application Review:

- Applicants will be notified within 30 business days if an application is incomplete.
- Manufacturers have up to one year to cure deficiencies.
- Applications not approved within one year will expire.
- Amendments may be submitted as necessary.

Safety Defect Reporting:

- Manufacturers identifying safety-related defects posing unreasonable risk must submit reports consistent with 49 C.F.R. Part 573.

Deployment Permit Suspension or Revocation:

- Deployment permits remain valid unless suspended, revoked, or surrendered.
- Additional grounds for suspension or revocation include:
    - Undisclosed or misrepresented safety-related functions
    - NHTSA determinations of federal safety system interference
    - Open NHTSA recalls
    - Department of Motor Vehicles (DMV) determinations of unsafe vehicle performance

Pennsylvania

Pennsylvania's framework focuses on structured oversight of Highly Automated Vehicle (HAV) testing, requiring operators to obtain authorization through the Pennsylvania Department of Transportation (PennDOT) and adhere to detailed safety, training, and reporting obligations. The state emphasizes risk mitigation, transparent communication with local jurisdictions, and robust operational controls, particularly when testing involves public passengers or single-operator configurations.

Notice of testing application and authorization process:

- Tester shall submit their Notice of Testing application through PennDOT's website.
- The application does include a section for vehicle accessibility for wheelchair users (accessibility and accommodations such as a ramp, lift, securing restraints, etc.) and any other amenities for drivers or passengers with disabilities.
- Information for all safety drivers, contractors, employees, and designees must be included.
- The tester will identify if the HAV provides rides to the public. If the tester provides rides to the public, they need to provide the following:
    - A copy of any Terms and Conditions that a passenger agrees to when riding in the HAV, if applicable.
    - Information on training and/or guidance related to passenger safety, if applicable.
    - Information on how the Tester ensures the safety driver and secondary safety associate stay focused on driving tasks and not become distracted due to passengers in the vehicle.
    - State whether the services are free to passengers or if a fare is charged.
    - Identify zip code(s) where services are provided.
    - Describe how the HAV provides feedback to passengers during the trip (e.g., mobile app or auditory alerts), if applicable.
- Tester must acknowledge that a secondary safety associate is present in the vehicle (in the forward passenger seat if installed in the vehicle) unless the Tester complies with Section 8 of their guidance – Testing with a Single Safety Driver. Both must have completed their safety driver training program.
- Tester must acknowledge that the HAV has an audio signal or visual display inside the vehicle to indicate when the ADS is engaged.
- The HAV is equipped with a means to store operational data before a collision occurs. The data shall be made available to PennDOT and applicable law enforcement agencies upon request in the event of a reportable crash.
- PennDOT will share the Notice of Testing and the Semi-Annual Data Collection Form upon request of any municipality where testing will be occurring [4].

[4] Testers can provide a redacted notice. Only information they deem confidential or trade secret should be redacted.

- PennDOT will share crash reporting with any applicable municipality.
- PennDOT will share the contents of the Emergency Responder Plan with any applicable emergency service responder.
- The Safety and Risk Mitigation Plan is operator focused and aims to ensure that the Tester has a program to ensure driver training that encompasses both traditional driver performance expectations and proper driver to HAV test vehicle interaction. The Testers Safety and Risk Mitigation Plan will need to include:
    - A general overview of the intended ODD for testing.
    - A description of how the ADS is disengaged.
    - A description of the methods to ensure continued functionality of the software and hardware systems.
    - A description of the criminal background and driver record checks required by the Tester for safety drivers.
    - A description of safety driver training program.

PennDOT has allowed themselves 10 business days to approve, decline, or request clarification on an application. If approved, PennDOT will provide the Tester with an "Authorization Letter" which is valid for a year, with annual renewals. The tester will have 30 days to respond to PennDOT if clarification is needed.

If declined, PennDOT will provide a written explanation to the Tester providing the reasons why the application was declined and provide an opportunity to meet with PennDOT. The Tester may resubmit until authorization is granted.

After receiving an Authorization Letter, testers will need to notify PennDOT of any material changes to their testing program or ODD.

Requirements for a Single Safety Driver: Testers are allowed to test using a single safety driver. If they request the use of a single safety driver, they must submit a Single Safety Driver Testing Plan for the PennDOT's review.

This plan must demonstrate that the skills, knowledge, and abilities gained by the safety driver through the training and operating procedures address any safety risks associated with removing the secondary safety associate. Details of this plan are found in section 8 of PennDOT's guidance. Below is a summary of several of the more interesting points of the plan and driver requirements:

- Safety Case(s) for specific situations within the ODD.
- A description of any enhanced driver training beyond what is outlined in the previous sections of their guidance.
- A description of auditing procedures implemented by the Tester.
- A description of applicable performance and conformance monitoring metrics
- Test driver's driving record. The driver must meet the following:

    - No convictions for driving a vehicle under the influence of alcohol within the last 3 years.
    - No convictions for refusing to submit to chemical testing of blood or breath within the last 3 years.
    - No convictions for driving a vehicle while under the influence of a controlled substance within the last 3 years.
    - No convictions for leaving the scene of an accident within the last 3 years.
    - No convictions for committing a felony involving the use of a vehicle within the last 3 years.
    - No convictions for causing a crash involving death or personal injury while driving a vehicle within the last 3 years.
    - No conviction for causing a crash involving damage to unattended vehicle or property while driving a vehicle within the last 3 years.
    - No convictions for driving a vehicle while their driving privilege was suspended, revoked, cancelled or recalled or while subject to disqualification of an out-of-state service order within the last 3 years.
    - No convictions for using a vehicle to commit a felony within the last 3 years.
    - No convictions of a serious traffic violations within the last 3 years.
- The test driver must have HAV operating experience [5], including:
    - 200 hours of total HAV operating experience in the vehicle(s) or class of vehicle(s) for which the safety driver is licensed and will be operating for testing purposes
        - A minimum of 100 hours of operating experience must have occurred on public roads.
        - If an operator is transitioning from a personal HAV vehicle to a HAV commercial motor vehicle, an additional 40 hours of operating experience is needed in the new vehicle.
    - 30 hours of nighttime HAV operating experience, if operations will be performed during nighttime conditions.
    - 30 hours of inclement weather HAV operating experience, if operations will be performed during inclement weather conditions

If certain situations fall within the Tester's ODD, the Tester will need to provide PennDOT with a safety case for review. Situations such as:

- Testing within an Active Work Zone;
- Testing within an Active School Zone;
- Testing within an Emergency Response Area;
- Testing on Snow-Covered trafficways;
- Testing around Vulnerable Highway Users; and

[5] PennDOT defines experience as occurring when the ADS is engaged and a secondary safety associate is present

- Testing within Tunnels.

Emergency Service Responder Plan

The Emergency Service Responder Plan should provide the necessary information for emergency service responders to safely address an incident involving the HAV. The Emergency Service Responder Plan will need to include:

- How to identify the vehicle (e.g., branding);
- How to secure the vehicle (e.g., disengaging the ADS);
- Location of vehicle registration and proof of insurance;
- Extrication considerations (extrication meaning to rescuing people trapped inside a vehicle.);
- Towing considerations;
- Firefighting considerations;
- Post-crash considerations; and
- Any other applicable considerations.

Suspending, Revoking and Temporarily Restricting Authorization

PennDOT may suspend or revoke testing authorization where any act makes the conduct of HAV testing on trafficways by the Tester an unreasonable risk to the public based on PennDOT's reasonable determination. Reasons for temporary suspension or revocation include:

- A determination that the Tester falsified any responses in the "Notice of Testing" application.
- A Tester's HAV is involved in a crash that results in serious bodily injury or death.
- The Tester's HAV shares proprietary ADS software with any HAV that is involved in a crash that results in serious bodily injury or death.
- The Tester fails to disclose any known violations of reasons 2 or 3.

The tester can request reinstatement and PennDOT will consider any action the Tester took to correct deficiencies.

PennDOT and the Pennsylvania Turnpike Commission reserve the right to request Testers temporarily prohibit or restrict testing on select trafficways or statewide during certain circumstances.

- During emergencies, HAVs will only be prohibited if there are active restrictions for other classes of vehicles. To ensure safety, all ongoing testing should be concluded before the date and time specified in the notice.
- Special Events – Includes, but not limited to, dignitary visits, major conventions/summits, and superload movements. Only special events with potential dynamic closures and/or safety/security concerns will be considered for temporary prohibition or restricted testing. PennDOT or PTC shall provide at least one days' notice to the HAV Tester. To the extent

possible, PennDOT and the Pennsylvania Turnpike Commission shall attempt to provide three to five days' notice.

- Safety Concerns – Includes, but not limited to, complex and/or irregular work zone patterns. PennDOT shall maintain a list of trafficways where testing is prohibited and notify HAV Testers three business days in advance of the list changing.

Semi-Annual Reporting

On a semi-annual basis, the HAV Tester will provide the following information to PennDOT through the "Semi-Annual Collection Form" found in Appendix A and on the PennDOT website. Data will include:

- Approximate miles traveled by ADS-engaged HAVs in Pennsylvania.
- Type of roadway where the majority of testing occurred:
    - Interstate Highways and Other Freeways and Expressways
    - Arterial, Collector, and Local roadways within an Urban Boundary, including both small and large boundaries.
    - Arterial, Collector, and Local roadways outside of an Urban Boundary, including both small and large boundaries.
- Zip code(s) where HAVs were tested on public trafficways.
- Approximate number of employees in Pennsylvania involved with HAV testing.
- If applicable, the approximate number of new jobs created in Pennsylvania because of HAV testing.
- If applicable, the approximate number of new facilities constructed, purchased, or rented in Pennsylvania because of testing.
- Information regarding the number of times the following elements were encountered within the ODD:
    - Active Work Zones
    - Active School Zones
    - Active Emergency Response Vehicles
    - Snow-Covered Trafficways
    - Tunnels

The initial "Semi-Annual Collection Form" should be submitted to PennDOT on either June 1st or December 1st, ensuring less than six months of testing has occurred before submission.

Ohio

Ohio adopts a permissive but accountable approach to AV testing, allowing operations on all public roads while requiring companies to register with DriveOhio and demonstrate safe system behavior. The state's model centers on operator responsibility, municipal notification, and cooperation with law enforcement, supported by a streamlined reporting and oversight structure.

Testing on all public roads in Ohio is permitted, regardless of participation in DriveOhio's AV pilot program.

How to test or operate AVs in Ohio:

- Registering with DriveOhio:
  - Business name and address.
  - Vehicle make, model, and license plate number.
  - Contact information for the driver/designated operator.
  - Proof of insurance.
  - The municipalities where they plan to test.
  - Information on the conditions under which the vehicle can operate in fully autonomous mode.
  - Safety certifications.
- Assurance that the vehicle can operate safely:
  - Proof that the vehicle can comply with all traffic laws and safely shutdown if it begins malfunctioning.
  - The company must provide DriveOhio with a safety plan.
- Designation of an operator:
  - Identify who will be responsible for driving the vehicle and ensure it follows all traffic regulations.
  - The designated operator must actively monitor the vehicle at all times and have the ability to safely shut it down in the event of a malfunction.
  - Designated operators must have a valid driver's license and are not required to be inside the vehicle when testing.
  - The company must inform DriveOhio and the municipality where they plan to test prior to driving when there is no operator inside the vehicle.
- Cooperating fully with law enforcement:
  - The vehicle must be cooperative in the event the vehicle violates any laws or is involved in any collision.
  - The vehicle's operator must also report any collisions to DriveOhio.

The Governor reserves the right to pause the testing of any vehicle if there is evidence that the vehicle or technology is not working properly.

3.3 Interview Summaries: Cities, States & Operators

The research team conducted interviews with four peer cities, seven state agencies, and five operators to identify best practices, lessons learned, and recommendations for DDOT as they set out to develop regulations governing the deployment of autonomous vehicles.

The research team developed an interview guide to organize and facilitate each peer city, state, and operator interview. Not every question was covered in every interview, and some unanticipated but informative topics arose as well, but the questions contained in the guide helped to anchor each interview.

Cities

Peer cities were selected based on the following criteria:

- Active autonomous vehicle testing or commercial deployments;
- Seasoned staff who dedicate all or a portion of their position to autonomous vehicle policy; and
- Alignment with DDOT and the District's overall transportation goals (e.g., safety, efficiency, equity, and sustainability).

Cityfi identified the following cities and key staff and conducted interviews on the dates listed below.

Table 3: Interviewed Cities

City	Agency	Date
Austin, TX	Department of Transportation and Public Works	09/12/24
Seattle, WA	Department of Transportation	09/20/24
San Francisco, CA	Municipal Transportation Agency (SFMTA)	09/20/24
Phoenix, AZ	Street Transportation Department	09/18/24

Key Learnings

1) **Lack of clear best practices for cities regulating AVs**: Currently, there is no established "best practice" for cities to follow when regulating autonomous vehicles. Most cities lack the authority to oversee or regulate AVs because state laws often preempt local regulations. In interviews, city representatives expressed a desire for states to create a collaborative framework for AV regulation that prioritizes urban concerns and goals, serving as a model for others.
2) **Significant land requirements for AV fleet depots**: Autonomous vehicle fleet providers will need substantial land for their depots. Given that many cities are land-constrained, there is a considerable risk that these depots could be located in low-income neighborhoods or outside the city, potentially leading to inequitable impacts. These areas may experience increased vehicle traffic without receiving the benefits of AV services.
3) **High power demands for AV depot infrastructure**: AV fleet depots will require significant power capacity, not only for charging electric vehicles but also to support the data processing needs of AVs. Unlike human-operated electric vehicles, AVs function as computers on wheels, collecting, storing, and transmitting vast amounts of data, which requires additional energy beyond what is needed for propulsion.
4) **Critical importance of data requirements and validation**: Ensuring that data requirements and validation processes are robust is crucial for the safe and effective operation of AVs. This includes

accurate data collection, transmission, and analysis, which are vital for maintaining the reliability and safety of AV systems.

5) **Challenges with ticketing and citations for AVs**: The issue of how to manage tickets and citations for AVs remains unresolved in many cities. A practical system for issuing and processing fines or citations for traffic violations involving AVs needs to be developed, as current methods for human drivers do not easily translate to autonomous systems.
6) **Need for consumer protection policies in AV operations**: The District should consider implementing consumer protection policies for AV-related incidents. For example, if an AV is involved in a minor collision, such as a rear-end crash, there must be a clear process for the human driver to receive insurance information and resolve the situation, even though no human is driving the AV.
7) **Training AV software for all streets and emergency scenarios**: AV software should be capable of navigating every street within a city, even those where the vehicles do not regularly operate. This is important in emergencies, where AVs may need to quickly exit an area. Additionally, by expanding AV capabilities to cover all streets, providers can avoid using incomplete mapping as an excuse to delay service expansion to underserved or less profitable areas.

States

The following states were identified and interviewed on the dates listed below.

Table 4: Interviewed States

State	Agency	Date
Arizona	Arizona Commerce Authority	10/2/2024
California	California Department of Motor Vehicles	10/22/2024
Maryland	Maryland Department of Transportation Connected and Automated Vehicle Working Group Motor Vehicle Administration Maryland Transit Administration	10/11/2024
Michigan	Michigan Department of Transportation	10/15/2024
Ohio	DriveOhio	10/21/2024
Pennsylvania	Pennsylvania Department of Transportation	9/30/2024
Virginia	Richmond Metropolitan Transportation Authority	10/11/2024

Key Learnings

1) State-Specific AV Strategies
   a) **Arizona** focuses on AV deployment with federal alignment and robust public sector training.
   b) **California** requires manufacturers to self-certify and have strong stakeholder involvement for drafting new regulations.
   c) **Maryland** adopts federal guidance for its AV permit process, focusing on emergency response and collaborative crash reporting.

d) **Michigan** emphasizes economic growth, with preemption laws to standardize statewide AV guidelines.
e) **Ohio** promotes pilot programs for Level 4 and 5 automation, with an emphasis on local collaboration.
f) **Pennsylvania** invests in accessibility and integration with public transit.
g) **Virginia** is in early stages, focusing on ride-hailing and smart road testing.

2) **Regulatory Variability:** States are at different stages in AV regulation.
   a) Some, like California, have established detailed frameworks, including reporting and compliance requirements.
   b) Others, like Virginia, lack formal regulations but aim to align future rules with neighboring jurisdictions, such as DC.

3) **Public and Stakeholder Engagement:** Most states are requiring some level of consultation and/or information sharing
   a) Open forums in Arizona and Maryland ensure transparency.
   b) States like Pennsylvania involve committees to explore AV benefits and challenges, focusing on mobility and accessibility improvements.

4) **Infrastructure Readiness:** States agree that future investments in physical and digital infrastructure are critical for future AV development.
   a) Smart corridors in Virginia and connected vehicle testing hubs in Michigan prepare for AV scalability.
   b) Ohio explores infrastructure compatibility with AVs, including striping, ADA access, and curbside management.

5) **Equity and Accessibility:** States agree that priority should be given to underserved communities as requirement for AV companies.
   a) Maryland integrates microtransit services for first-mile/last-mile solutions.
   b) Pennsylvania emphasizes accessibility for disabled riders and enhanced Americans with Disabilities Act (ADA) compliance.

6) **Workforce Development:** Automation's impact on jobs is acknowledged
   a) Arizona partners with local institutions for AV-specific workforce training (e.g., Drive-48 program).
   b) Virginia is developing workforce strategies to manage the employment shifts caused by AV technologies.

7) **Data Collection and Metrics:** States demand detailed operational data and have expressed difficulty in extracting useful information.
   a) California focuses on disengagement reasons and crash reporting.
   b) Pennsylvania collects data on miles driven, vehicle traffic conditions, and operator violations.
   c) States like Virginia seek metrics like frequency of use, passenger numbers, and disengagement events.

8) **Safety and Cybersecurity:** All states agree that ensuring AV safety is a top priority.
   a) Safety metrics like crash rate reduction and emergency disengagement protocols are mandatory in many states.

b) Cybersecurity measures protect AV systems from hacking, with Maryland and Virginia actively developing such protocols.

9) **Public Transit Integration:** AVs are being linked with public transit.
   a) Automated shuttles in Ohio connect underserved areas to community centers and transit hubs.
   b) Ride-hailing is framed as a complement to public transit in Virginia, with mandatory links to bus stops and transit options.
10) **Economic Development:** States view AVs as economic drivers.
   a) Ohio positions itself as a key testing hub to attract AV companies.
   b) Michigan focuses on creating new companies and growth opportunities through AV advancements.
11) **Preemption Laws and Local Autonomy:** Preemption laws create statewide consistency, but some believe localities have more flexibility in creating regulations and are less restricted in pushing guidelines forward.
   a) Michigan mandates uniform rules for AV operations, preventing city-level variations.
   b) Maryland does not preempt municipalities, allowing localized AV policies.
12) **Pilot Programs and Testing:** Pilot programs allow controlled AV experimentation.
   a) Ohio's Autonomous Vehicle pilot program focuses on Level 4 and 5 testing.
   b) Virginia's Smart Roads Test Bed and truck platooning trials explore AV readiness for complex traffic conditions.
13) **Zero-Occupant Vehicle (ZOV) Management:** Managing "zombie vehicles" is a growing concern.
   a) Virginia considers fees per mile to disincentivize empty AV operations and mitigate congestion.
14) **Emergency Response and Training:** States develop AV-specific response protocols.
   a) Maryland integrates AV emergency plans into testing permits.
   b) Pennsylvania provides mobile apps to help emergency personnel access vehicle information and respond effectively.
15) **Collaboration Needs:** States emphasize partnerships.
   a) Public-private collaborations in Arizona and Ohio support AV testing.
   b) States participate in multi-state dialogues to harmonize regulations and share best practices.

Operators

In addition to interviews with state and local agencies, the consulting team also interviewed representatives of several AV companies that have expressed potential interest in operating within the District. These interviews took place via video conference and telephone in August–October 2024. The summary below reflects information gathered through these interviews, as well as additional publicly available information that the companies identified as relevant. The comments presented in this section do not reflect the opinions of the research team; rather, they reflect the perspectives of AV operators and industry representatives.

The following operators were interviewed:

Table 5: Interviewed Operators

Operator	Date
Volkswagen	08/29/24
Uber	09/06/24
Nuro	09/12/24
Anonymous Shared/Shuttle	09/13/24
Anonymous Robotaxi Company	10/08/24

Summary of Feedback from Operators

All AV companies reported operating under significant financial constraints. Revenue-generating operations are crucial to company viability. As a result, companies prioritize markets that demonstrate strong consumer demand, high-quality infrastructure, opportunities for service expansion, and predictable, well-established regulatory frameworks.

All AV companies—including robotaxi, delivery, and shared transit providers—are working to demonstrate the soundness of their business models and technologies for investors. The AV industry is relatively new. Its technology, hardware, partnerships, business models, and operational capabilities are still evolving. For example, robotaxi companies that currently use traditional four-door passenger vehicles anticipate a future transition to purpose-built AVs to serve a range of purposes and differently abled customers. They expect to provide accessible mobility in the future, but there is currently limited capacity to address diverse human mobility needs.

This is also true for robotaxi companies' selection of ODDs and neighborhoods for service. Today, they must select their initial ODDs to maximize revenue. Once they have achieved financial milestones, they may be more likely to provide service to underserved communities.

If a region adopts regulations that a company considers too expensive or challenging to revenue, they will not prioritize that market for operations.

It was suggested that the District establish a special zone or zones within the District to permit AV companies to demonstrate their capabilities for Congress.

Pressures for Financial Viability

AV companies must scale revenue operations to demonstrate their market viability for current and future investors. The ongoing costs of innovation and market development are huge; maintaining cash flow is critical; investors require a promising ROI, which means a clear path to revenue operations and scale. This is the "bottom-line" for all companies when they assess the opportunities and costs associated with a new market.

Business "Models"

There are differences among the AV developers in terms of their locus of operations, target customers, and sources of revenues. These interviews focused on companies that intend to operate within cities, which excludes long-haul freight, and – for now – warehouse to retail delivery operations. Most of the companies interviewed intend to provide personal transportation and goods delivery services, where the consumer pays for the service.

A different business model is also common among several AV companies that focus on shared mobility, as with shuttle vehicles. Theirs is a wholesale model, where a third party pays for the transport service, usually a public transit authority, sometimes the owner of a campus or geographically based facility like a university, residential or large health facility.

All business models predict future profitability, but for now the companies depend upon a steady stream of investment funding from investors who, in turn, anticipate a significant return on investment. To maintain investor interest, the companies need to demonstrate the quality of their service and technology and market/public acceptance.

Revenue and Costs

Revenue is a primary consideration for all companies. Without a clear, timely, and sustainable path to revenue, there are no investors. Without investors, there is no cash flow, no further innovation, and no market viability.

The costs of entering a new region are high and include the following:

- Setting up local operations (maintenance facility, electric power, staffing, etc.);
- Teaching the ADS to operate in the new environment;
- Identifying and addressing infrastructure idiosyncrasies within ODDs;
- Meeting applicable regulatory requirements;
- Engaging with elected and appointed officials and the general public;
- Training with public safety officers and first responders; and
- Conducting public communications.

Factors in Considering New Markets

AV companies look at several factors when considering new markets. The existing demand for ride-hailing and delivery services predicts a strong market for robotaxis. Companies also consider the quality of built infrastructure and signal systems, weather conditions, local driving customs, and—of crucial importance—regulatory stability.

Companies seek a predictable, stable regulatory environment. This holds true whether the region is or is not regulated, as with the contrasting regulatory climates of California and Texas. Because the cost of developing a new market is so high, companies cannot afford the risk of future regulations that may undermine the value of their investment.

Expectation of public acceptance is also influential. Companies prefer communities that are willing to work with new technologies and willing to accept some level of risk in exchange for innovation.

Safe Operations

There are many well-publicized examples of highly automated vehicles in cities performing unexpected, illegal, and dangerous operations. Companies often defend their ADS with reference to human drivers, whose dangerous driving maneuvers are rarely publicized. Each company interviewed expressed full company commitment to a safe systems approach and continual safety improvement. Each company provides reference information on their website and in blogs about their safe systems approach. With that said, no company has been entirely transparent when explaining the ADS errors that have led to publicly reported dangerous or disruptive driving performance.

Traffic Congestion and Tailpipe Emissions

All robotaxis and small automated delivery vehicles' operating algorithms are designed to minimize non-revenue miles to preserve energy. They are likely to run empty when enroute to a pickup. Companies endeavor to keep these trips to a minimum and as short as possible. When not on call or in service, the vehicles are programmed to find a legal curb space or parking lot.

There are public examples of AVs disrupting traffic in cities, which can contribute to greater air pollution. Companies assert that these AV incidents may be fewer in number than similar but unpublicized incidents with human drivers, and they expect that with continued AV fleet operations, there will be fewer and fewer incidents over time.

Equitable Service and Access

Company representatives agree that their operations should not exacerbate existing societal inequities. They also assert that automated mobility should not be held accountable for addressing deeper, pre-existing societal inequities.

All companies anticipate future vehicle and cabin designs, and human interfaces, that will capably serve people with a range of physical and cognitive disabilities. A few companies have prioritized an all-new vehicle design for this purpose. Others expect that the new designs will be introduced in the future, following further investment and/or partnerships for this purpose.

Delivery services assert that they can help to address the inequity of food deserts and access with batched deliveries to manage costs.

There is some openness to working with local authorities on equity issues. For example, service response times are often a function of proximity to the operations depot, thus, the authority might help to locate or prepare a space for the operations depot in proximity to a low-income or low transit-service neighborhood. A multimodal mobility program like MaaS might support an AV shuttle or robotaxi link from underserved communities to the established Metro system.

Shared Mobility

Shared mobility AV companies work with public sector agencies and the community to develop a route(s) and service levels. These services are sponsored by a local authority and funded by that authority or by a third party. They seek to demonstrate the technical capability, financial feasibility, and public acceptance of shared AV transit as an adjunct or complement to existing transit services for improved mobility and access. Shared mobility AV companies do not set up routes and services independently of local authorities and the local community.

Public Acceptance

All companies are concerned with public acceptance. Most consider first responders and public safety officials as one of the most critical groups with which to establish strong community working relationships. Each company has its own approach with the first responders that includes “how to” training with the vehicle systems. There is some movement among the AV companies towards a more standardized training and interface for the first responders for better efficiency and safety.

Company advocates and lobbyists frequently meet with regionally elected and appointed officials to educate them about ADS and to promote public acceptance of the AV services.

Show-and-tell is a popular approach towards public acceptance. For example, it is common to see an AV vehicle and company staff at farmers markets in San Francisco. A few companies invest in more structured exploration of public attitudes and values, such as through focus groups.

The AVs themselves are often the most visible ambassadors on behalf of the companies. The more people who have good experiences in a robotaxi or with an AV delivery or shuttle service, the higher the level of community acceptance. Companies are very alert to the periodic problems with vehicle operations and work to minimize the negative impact of those incidents on public opinion.

The District is an attractive destination for all AV companies to demonstrate their vehicles for Congress. Members of Congress represent the general public, and gaining a higher level of acceptance among Members may help to lead towards favorable AV national legislation.

Reporting Requirements and Regulations

All companies comply with NHTSA Standing General Order (SGO) reporting requirements and with state AV regulations. None of the companies are willing to commit to more complete reporting transparency. All companies expect NHTSA to write the national safety regulations for AV operations. They see this as consistent with established NHTSA authority for vehicle safety.

Where a region wants to attract AV operations, fewer regulatory and reporting requirements, coupled with a strong consumer market, make the region much more attractive to operators. Regions with more elaborate operating and reporting requirements are less attractive candidates for AV company operations.

Operating in DC

The District is an attractive destination for demonstrating ADS capabilities but challenging as a destination for operations. Companies identified the lack of a good base of operations locations within the District; they would likely set up maintenance and refueling outside of the District, and thus license their vehicles in Maryland, Virginia, or—if legal—in another state where they have existing operations.

Most companies expressed little concern when asked about operating among the many different law enforcement authorities in DC. Similarly, they felt that the ADS would be capable of responding appropriately to motorcades, security details, police, and emergency responders. No one said that DC would be less attractive as a destination because of these unique local driving characteristics.

Additional Industry Perspectives

Additional Industry Perspectives have also been captured at the end of the literature summary for *Autonomous Vehicle Industry Association State of AV 2025*, in **Appendix A**. AV Regulatory Literature Review Summaries.

4 Data Collection and Reporting

This section outlines the main sources of publicly available data on ADS, focusing on federal crash reporting under NHTSA's SGO and state-level programs such as California's AV testing reports. These datasets offer important but incomplete visibility into ADS performance, reflecting the fragmented and limited nature of current reporting frameworks.

4.1 NHTSA SGO on Crash Reporting

Crash Data Reporting

The data reporting criteria outlined in the NHTSA document *Second Amended Standing General Order 2021-01* focus on incidents involving vehicles equipped with ADS or Level 2 ADAS. Key criteria for reporting are:

1) Incident Reporting: Manufacturers and operators must report specific crashes involving vehicles equipped with ADS or Level 2 ADAS. The incidents must be reported if:
   a) A crash occurs while the ADS or Level 2 ADAS is engaged, or immediately after it is in use.
   b) The crash results in a fatality, hospital-treated injury, vehicle tow-away, airbag deployment, or involves a vulnerable road user.
2) Reporting Timelines:
   a) Within 1 Day: If the crash results in a fatality or a hospital-treated injury.
   b) Within 5 Days: For crashes resulting in a vehicle tow-away or airbag deployment.
   c) Monthly Reports: All other incidents that are not required to be reported within 1 or 5 days must be reported on a monthly basis.
3) Information Required:
   a) Detailed information about the incident, including the ADS or ADAS version, whether the vehicle was within its ODD, and a narrative description of the incident.
   b) Updated reports if any new or materially different information becomes available after the initial report.
4) Submission Format:
   a) Reports must be submitted electronically via the NHTSA Incident Report Portal.
5) Confidential Business Information (CBI):
   a) Certain details in the reports can be claimed as CBI, such as the ADS/ADAS hardware and software versions, whether the vehicle was within its ODD, and specific narrative details.

From July 2021 through December 2025, nearly 2,000 ADS crashes have been reported (after removing most duplicate responses), with the bulk of the reports coming from Waymo, followed by Cruise (no longer in business) and Zoox. Crash reporting locations match with where most testing and deployment activity has occurred: California, Arizona, and Texas. Most of the reported crashes involved no injuries

and were property damage only. There have been more than 150 injury crashes, however, and AVs have been involved in two crashes where there were fatalities (though the AVs have not been at fault according to news reports). There have been 6 total incidents reported to the SGO in the District as of December 15, 2025: three involving Waymo and three involving Argo AI, all of which were property damage only except one minor injury crash reported by Argo AI in July 2021.

Advantages and Limitations of the NHTSA SGO

While the SGO data collection framework provides significant advantages in enhancing safety oversight and ensuring timely, standardized reporting of ADS and ADAS incidents, it also has notable limitations, including potential data gaps, reliance on self-reporting, and constraints on the scope and detail of the data collected.

Advantages

One of the primary advantages of the SGO is its focus on enhancing safety oversight. By mandating comprehensive incident reporting for crashes involving ADS and Level 2 ADAS, NHTSA can closely monitor the performance of these systems and identify potential safety issues or defects early. The requirement for timely reporting—within 1 day, 5 days, or on a monthly basis—ensures that data is collected promptly, allowing NHTSA to respond quickly to emerging safety concerns and take appropriate regulatory actions.

The use of a standardized reporting format through the NHTSA Incident Report Portal also ensures consistency in data collection across different manufacturers and operators, facilitating easier comparison and analysis. Additionally, the SGO prioritizes data collection on more severe and high-risk incidents, such as those resulting in fatalities, hospital-treated injuries, vehicle tow-aways, or involving vulnerable road users. This focus on high-risk scenarios likely provides the most valuable safety insights. Moreover, the flexibility to update previously submitted reports when new or materially different information becomes available ensures that NHTSA has the most accurate and up-to-date information. The SGO also promotes public accountability by making certain information publicly available, enhancing public trust and enabling independent verification of safety data by researchers and other stakeholders.

Limitations

The SGO focuses primarily on crashes involving ADS and Level 2 ADAS while these systems are engaged or shortly after disengagement, potentially missing incidents where these features played an indirect role or where there are non-crash-related safety concerns, such as system malfunctions or software errors. The SGO relies heavily on manufacturer self-reporting, which means the accuracy and completeness of the data depend on manufacturers and operators to report incidents truthfully and fully. There is a risk of underreporting or selective reporting, especially if incidents could negatively impact a company's reputation or legal standing. Additionally, the SGO does not require reporting for all types of incidents; minor incidents not meeting the defined criteria may not be reported, potentially missing data that could provide insights into near-misses or less severe safety risks.

The variability in the depth and quality of narrative descriptions in the reports can also limit the understanding of the full context or contributing factors of each incident. Furthermore, the SGO allows manufacturers to claim certain parts of the report as CBI to protect proprietary technology details, which can limit transparency and the availability of data for independent analysis and public scrutiny. Reporting requirements may impose a significant administrative burden on manufacturers and operators, especially smaller companies or those testing in limited markets, which could potentially discourage innovation or lead to non-compliance. The SGO's primary focus on collecting post-incident data does not emphasize proactive data collection, such as system performance metrics during normal operation, which could help identify potential safety issues before an incident occurs. Finally, the effectiveness of data collection can be limited by the technological capabilities of the manufacturers' data collection and reporting systems, leading to inconsistencies or gaps in the data provided.

The SGO data is not normalized for factors such as the number of vehicles in operation, the distances traveled, or the operational driving domain. As a result, comparisons between manufacturers or operators may be misleading. A company reporting more crashes may simply have more vehicles in operation or more advanced data collection capabilities, rather than a higher incidence of crashes relative to the total number of vehicles.

4.2 California DMV Autonomous Vehicle Crash and Disengagement Reporting

Crash and Disengagement Data Reporting

California DMV regulations, specifically Title 13, § 227.48, mandate that AV manufacturers report collisions to the DMV within 10 days using form OL 316 (included in **Appendix B**), detailing involved parties and the incident, while § 227.50 covers annual disengagement reporting (when autonomous mode is disengaged) and mileage data, all contributing to transparency and public safety, with summaries available on the CA DMV's AV page and research dashboards. Key reporting requirements include:

1) Collision Reporting
    a) Manufacturers must report any collision involving an autonomous vehicle operating on a public road that results in property damage, bodily injury, or death.
    b) Reports must be submitted to the DMV within 10 days of the collision using a standardized reporting form.
    c) Required information includes identification of involved parties and a narrative description of the incident.
    d) These requirements apply in addition to any other applicable state or local crash reporting obligations.
2) Disengagement and Mileage Reporting
    a) Manufacturers must retain data related to disengagements from autonomous mode, defined as events where the autonomous system is deactivated due to system failure, safety concerns, or intervention by a test driver or remote operator.

b) Manufacturers are required to submit annual disengagement reports summarizing:
    i) The number and circumstances of disengagements
    ii) Whether the vehicle was operating with or without a driver
    iii) Environmental and roadway conditions at the time of disengagement
    iv) The total miles driven in autonomous mode by month
c) Annual reports are due by January 1 and cover a standardized reporting period defined by regulation.

3) Data Availability and Transparency
a) California publishes annual disengagement summaries and individual collision reports on the DMV website.
b) Collision data are made available on a per-manufacturer basis rather than through a single consolidated database.

Advantages and Limitations of the California Reporting Framework

Advantages

California's AV reporting framework provides a longstanding and transparent mechanism for tracking autonomous vehicle performance during public-road testing. Mandatory collision and disengagement reporting enables longitudinal analysis of AV technology development, particularly for higher-level ADS. Annual disengagement reports, which include contextual information such as roadway and environmental conditions, offer insight into system limitations, operational challenges, and technology maturity.

The framework also captures exposure data (VMT in autonomous mode), supporting normalized performance metrics and trend analysis over time. California's reporting regime has been instrumental in identifying industry-wide challenges related to perception, planning, localization, and ODD limitations, especially in complex urban environments.

Limitations

Despite its strengths, the California reporting framework has notable limitations. Disengagement reporting applies primarily to vehicles operating under testing permits and does not consistently capture driverless operations, where disengagements may not be required under certain regulatory interpretations. In addition, there is a lack of standardized taxonomy for disengagement causes across manufacturers, making cross-company comparisons difficult.

Collision data are not aggregated into a single statewide dataset, requiring manual review of manufacturer-specific reports to assess overall trends. As with the federal SGO, California's framework relies on manufacturer self-reporting, introducing potential variability in reporting completeness, timeliness, and narrative detail.

Finally, reporting requirements focus largely on post-incident outcomes and do not systematically capture near-misses, routine system performance metrics, or proactive safety indicators. Differences in testing environments, operational scope, and VMT further limit direct comparison of disengagement rates or collision frequencies without additional normalization or contextual analysis.

4.3 California Public Utilities Commission (CPUC) AV Program Quarterly Reporting

This section describes the quarterly reporting requirements for all entities participating in California's AV Passenger Service pilot and deployment programs. Under the relevant CPUC decisions, companies operating AV fleets must submit verified, aggregated, and anonymized data each quarter—including VMT, electric vs. non-electric usage, idle time, trip occupancy, wheelchair-accessible rides, and service-level metrics (full list of fields in **Appendix C**). These reports help regulators and the public track AV performance, usage trends, accessibility, and safety across California.

Pilot Program Reporting

Pursuant to Decisions 18-05-043 and 20-11-046 (as modified by Decision 21-05-017), on a quarterly basis, each entity participating in the AV Passenger Service pilot programs must submit a verified report containing the following data, disaggregated and anonymized, to provide information regarding each AV operating in the pilot programs:

- Total quarterly VMT during passenger service by all vehicles in the entity's list of AV equipment, provided per-vehicle
- Total quarterly VMT during passenger service that are served by electric vehicles or other vehicles not using an internal combustion engine, provided per-vehicle
- Total quarterly VMT during passenger service, from the vehicle's starting location when it first accepted a trip request to the pickup point for each requested trip, expressed in miles and provided per-vehicle
- Amount of time each vehicle waits between ending one passenger trip and initiating the next passenger trip, expressed as both a daily average and a monthly total in hours or fraction of hours for each vehicle (idling or dwell time)
- Vehicle occupancy (total number of passengers) in each vehicle for each trip
- Total number of WAV rides requested
- Total number of WAV rides requested but unfulfilled because no WAV was available
- Total number of WAV rides requested but unfulfilled because the vehicle operator denied the request
- Total number of WAV rides accepted and fulfilled

Pursuant to Decision 24-11-002, the following has been added to the AV Pilot Program reporting requirement:

- Participants in the Commission's AV Passenger Service Pilot (AV Pilot) programs reporting over 300 passenger service trips in a quarter shall submit the expanded data reports currently required of participants in the Phase I AV Passenger Service Deployment (AV Deployment) programs;
- AV Pilot participants reporting less than 300 passenger service trips in a quarter shall continue to submit the AV Pilot data reports described in the Pilot and Deployment Decisions;
- AV Pilot participants reporting no trips in a quarter shall submit an attestation to that effect, rather than a full set of reports;
- AV Deployment and AV Pilot participants exceeding 300 quarterly passenger service trips shall report incident-level and fleet-level data on stoppage events (i.e., situations where AVs have stopped and are not moving when they should be).

Quarterly reports from December 2018 to May 2024:

- Companies include: Argo AI (last report Q3 2022), Aurora, AutoX, Cruise (last report Q3 2024), Deeproute (last report Q3 2023), Ghost (last report Q1 2024), Motional (last report Q1 2024), Tensor, Waymo, WeRide Corp, Zoox

Deployment Program Reporting

Pursuant to Decision 20-11-046, as modified by Decision 21-05-017, carriers participating in CPUC's AV Passenger Service Deployment programs are required to submit quarterly operational data reports to the Commission.

- Scope of Data: Required data elements are specified in Ordering Paragraphs 5(k) and 7(m) and detailed in Appendix A of the decisions, which together define the full set of reporting requirements.
- Deployment Timeline: The first AV Passenger Service Deployment permits were issued in February 2022.
- Reporting Participation: To date, only Waymo and Cruise have submitted quarterly deployment reports under this program.
- Current Status: Waymo continues to submit quarterly reports, while Cruise ceased reporting after August 2024.

4.4 Autonomous Vehicles Testing and Operating in the State of Arizona

Arizona does not have any statutory requirements for data reporting, but they have developed an informal system for reporting AV crashes to their Department of Public Safety and have convened their emergency responders to consider how to develop a reporting scheme for learning about their AV interaction challenges ("informal incidents"). Arizona DOT maintains an incident log for AV events.

They ask companies to report crashes that are reportable under the NHTSA SGO and any related events that are likely to draw public attention or concern, and ADOT uses their judgment about the description

of each crash to estimate whether the AV was “at fault,” In addition to the information shown online, they have another database that includes event location and they cross-check their data with the NHTSA SGO data every month. They do not have any record of AV mileage driven and have not requested time of day for reportable incidents.

4.5 San Francisco Fire Department Reports on AV-related Incidents

The San Francisco Fire Department has generated some 55 “Unusual Occurrence” reports documenting times when AVs meandered into fire and emergency scenes between April 2022 and August 2023. The primary causes of incidents described in the report mostly revolve around interactions with AVs from companies like Cruise and Waymo. Common issues include:

- **Blocking Emergency Response Paths**: AVs frequently stop in front of fire engines or other emergency vehicles, delaying their response times during critical situations.
- **Failure to Recognize Emergency Situations**: AVs often continue through intersections, sometimes stopping abruptly or failing to yield to emergency lights and sirens, potentially causing unsafe conditions.
- **Inadequate Recognition of Scene Hazards**: AVs have, on several occasions, driven over hoses or ignored caution tape, creating additional risks at emergency scenes.
- **Limited Remote Control Capabilities**: When AVs are contacted through remote support, response times are slow, and the vehicles sometimes fail to move promptly, further delaying emergency services.

These incidents highlight a recurring lack of AV responsiveness to emergency scenarios, creating potential risks for first responders and the public.

5 Potential Workforce Impacts from Automated Vehicles in Cities

The transition to AVs represents a profound shift in the global workforce, extending far beyond the displacement of drivers. Recent literature from the Organisation for Economic Co-operation and Development (OECD), Urban Institute, and academic journals highlight a complex duality: while automation threatens traditional transportation roles, it simultaneously should create demand for high-tech skills in vehicle operations and maintenance, cybersecurity, remote management, and urban and regional planning and redesign.

Key themes across key sources include:

- **Displacement vs. Transition:** The narrative is shifting from "mass unemployment" to "workforce transition," where the quality of new jobs and the equity of the transition are in the forefront of conversations.
- **Equity and Access:** There are significant concerns that the benefits of AVs (efficiency, safety) may bypass low-income populations and the existing workforce unless specific policy interventions—such as those addressing algorithmic bias and public transport integration—are implemented.
- **New "Hidden" Labor:** Automated mobility will rely heavily on less visible forms of labor, including remote monitoring, vehicle operations and maintenance, and the maintenance and management of digital infrastructure.

This summary synthesizes findings from a number of key sources published between 2023 and 2025 regarding the workforce impacts of AVs.

5.1 Key Workforce Impact Issues

Job Displacement in Traditional Sectors: The most immediate concern identified is the displacement of human drivers. Mouratidis and Peters (2025) explicitly highlight the risk of unemployment for bus drivers as public agencies and transit authorities explore driverless shuttles to reduce operating costs. Similarly, Chamber Of Commerce (2023) provides a broader context, identifying that automation risks are anticipated to be geographically concentrated; metropolitan regions and cities with high densities of routine manual and administrative jobs face higher displacement risks. The displacement is not just about driving; it includes administrative and logistical support roles that automation can impact.

The "Skills Gap" and Educational Lag: International Transport Forum (ITF) (2023) by the OECD emphasizes that the transport workforce is in a critical transition period. The issue is not just a lack of jobs, but a mismatch between the existing workforce's skills and the new requirements of an automated fleet. Drivers cannot simply "become" cybersecurity analysts without significant retraining. There is a pressing need for "upskilling" initiatives that are currently lagging behind the technology's deployment.

Redefining "Driving" as "Monitoring"

Several sources, including Sadaf et al. (2023), point to a shift in the nature of work. The role of the "driver" is evolving into that of a "systems monitor." This reduces the physical burden of driving but increases the cognitive load related to vigilance and technical troubleshooting. This shift requires a workforce that is tech-literate and capable of managing complex human-machine interfaces.

5.2 Jobs and Sectors that Could Be Significantly Impacted

The widespread adoption of AVs will extend far beyond simply displacing drivers, potentially creating a ripple effect across legal, medical, and service sectors. There has been a host of literature that speculates on the potential impacts of job displacement and creation by automated vehicles.

Below identify some of the jobs that are likely to be negatively impacted, both directly and indirectly, by AVs.

Direct Displacement: The Driving Workforce

Long-Haul Truck Drivers: Trucking is often cited as the first major sector for automation because highway driving is less complex and more predictable than urban driving. Autonomous trucks can operate 24/7 without mandatory rest breaks, drastically increasing efficiency for logistics companies. While "last-mile" delivery (city streets) may still require humans for some time, the bulk of long-distance interstate trucking could become mostly automated.

Rideshare and Taxi Drivers: The business model of companies like Uber and Waymo relies on eventually removing the human driver to lower costs. "Robotaxis" are already operating in multiple cities and metropolitan regions and are projected to expand rapidly. As the cost of autonomous rides drops below the cost of human-driven rides, human drivers will struggle to compete on price and availability.

Bus and Transit Operators: Fixed-route public transit systems are often cited as an ideal use case for automation. Transit agencies and local governments are already piloting autonomous shuttles to reduce operating budgets and address driver shortages. Traditional bus driving roles may disappear, though some may transition into "on-board attendant" roles focused on passenger safety and assistance rather than driving.

Indirect Impact: The Support Economy

Traffic Police and Parking Enforcement: AVs are theoretically programmed to strictly obey traffic laws. They should not speed, run red lights, or park illegally. As fleets convert to automation, revenue from traffic tickets—and the need for officers to issue them—will likely decrease significantly.

Insurance Adjusters: With fewer crashes and a shift toward fleet ownership (where a manufacturer insures its own cars), the traditional consumer auto insurance model may collapse. Determining fault

will become a data-forensic task handled largely by software, reducing the need for human adjusters to inspect damage and interview witnesses.

Auto Body Repair Technicians: The primary promise of AVs is safety. By communicating with each other and reacting faster than humans, AVs are expected to reduce the frequency of collisions. Fewer crashes should also mean less auto repair work. Additionally, the repair work that remains will involve expensive, sensitive sensors that may require specialized manufacturer certification, potentially requiring such work to be completed by the vehicle operators.

Emergency Response and Hospital Staff: The Center for Disease Control and Prevention (CDC) estimates roughly 2.6 million emergency room visits in 2022 due to vehicular crashes (CDC, 2024). This represents approximately 2% to 2.5% of all emergency room visits in the United States. When looking strictly at *injury-related* emergency room visits (excluding illness), motor vehicle crashes account for a larger share, typically around 6% to 10%. The potential for reduced collisions, and the reduced severity of collisions, while a positive for society, may reduce the need for trauma staff.

Personal Injury Lawyers: Current auto law relies heavily on "driver negligence" (e.g., drunk, distracted, or aggressive driving). If crashes become rare and are caused by software failures rather than human error, liability shifts from individuals to manufacturers (product liability). This reduces the volume of small-claims cases that currently sustain a portion of the legal industry.

Opportunities that May Be Created

New Higher-Value Roles: The deployment of AVs should create a number of new employment opportunities. Sadaf et al. (2023) underscores the demand for cybersecurity professionals to protect automated vehicles and connected infrastructure. Additionally, the maintenance of AVs requires a new breed of technician capable of servicing Light Detection and Ranging (LiDAR), radar, and advanced onboard computers, offering a pathway for technical vocational careers that may be a more high-tech version of today's automobile mechanic.

Enhanced Public Transport Services: Mouratidis and Peters (2025) suggest that while driving jobs may decrease, the lower operating costs of AVs could allow transit agencies to run *more* service and routes. This expansion could may migrate to newer customer-facing roles, such as on-board passenger assistants for the elderly or disabled—roles that focus more on customer service and safety than the mechanics of driving.

Improved Job Access for Non-Drivers: Urban Institute (2023) highlights a critical opportunity for the broader workforce: AVs can bridge the "last mile" gap for low-income workers who currently struggle to access jobs due to unreliable public transit. By providing affordable, on-demand mobility, AVs could better connect underserved communities to employment centers, potentially improving job access and raising overall workforce participation.

5.3 Additional Concerns and Challenges

Algorithmic Bias and Inequity: A major concern raised by Urban Institute (2023) is the potential for algorithmic bias in how AV fleets are deployed. If route-optimizing algorithms prioritize wealthy neighborhoods or profitable routes, they may systematically exclude low-income and minority workers from the benefits of the technology. There is a fear that the "efficiency" driven by computer vision and AI will come at the cost of social equity.

The "Hidden" Human Costs of Computer Vision: Iapaolo (2023) introduces a more philosophical but critical workforce concern: the reliance on "computer vision" reshapes the urban form to suit machines rather than people. This "machine-readable" city requires a vast, often invisible workforce of data labelers and annotators (often low-paid) to train the AI. Furthermore, the push to make cities "readable" for AVs may lead to urban planning decisions that prioritize vehicle flow over pedestrian spaces, impacting people who rely on active transportation.

Cybersecurity and Safety Risks: Gherardini and Cabri (2024) highlights the reliance on interconnected systems introduces profound safety risks. A workforce ill-equipped to handle cybersecurity threats could lead to catastrophic system failures. The economic pressure to cut costs may also lead to insufficient human oversight, increasing the risk of accidents during the "mixed traffic" transition phase where AVs and human drivers share the road.

Rebound Effects on Travel Demand: Dai, Li, and Liu (2024) warn of a "rebound effect" where the ease of automated travel leads to increased VMT and congestion. This could negatively impact the logistics workforce by creating gridlock, despite the theoretical efficiency of the vehicles themselves. It implies that without demand management, the "work" of transporting goods and people could become less efficient due to sheer volume.

6 Where the District Stands Today and Next Steps

The District is neither an early laissez-faire adopter, nor has it signaled it is closed to AV deployments. It is in a unique situation and at a strategic point, as it is able to learn from the successes and failures of other jurisdictions while still having the ability to shape how AV deployments will integrate into its transportation system, communities, and economy.

This research report provides the foundation for that next step: moving from testing-focused AV experimentation to a durable, principle-driven regulatory deployment framework that embraces this innovation to continue to support a vibrant economy and vibrant communities, while protecting the District's values and the public interest.

Integrating AVs into urban environments such as the District poses a number of regulatory and operational challenges. However, DC's unique governance in this space also creates policy opportunities, with the purview of a state government but the perspective of a city.

6.1 AV Work in the District to Date

Legislation and Governance

The District has already taken several important steps toward AV readiness:

- **District of Columbia Autonomous Vehicle Act of 2012**: authorized operation of AVs on District roadways. [6]
- **2018 AV Principles Statement and Establishment of the AV Working Group**: District Government adopted a formal set of principles centered on safety, equity, efficiency, and sustainability. The Mayor established the AV Working Group to proactively prepare the District for the likely transformative effects of AVs and to ensure that AV deployment benefits the District, its environment, and all its residents and visitors in alignment with District policies and priorities.
- **Autonomous Vehicles Testing Program Amendment Act of 2020:** updated the 2012 legislation to expand and better define the framework for AV testing, including moving responsibility from the Department of Motor Vehicles to DDOT and opening the possibility of driverless testing.
- **2021 Comprehensive Plan**: the Transportation Element lists a number of Policies and Actions to ensure that AVs align with the Comprehensive Plan's stated goals.

[6] The current AV Testing law can be found at D.C. Code § 50-2351 et seq.: https://code.dccouncil.gov/us/dc/council/code/titles/50/chapters/23A. The Code provides links to the prior legislation that created and amended this section (items from 2012, 2020, and 2024 are noted in this list).

- **2024 – AV Testing Regulations (2nd Proposed)**: DDOT proposed rules for a testing permit program, aligning with emerging national practices and enabling controlled AV trials in the District. Once the rules are finalized, DDOT would open an application for testing permits. [7]
- **Public Life and Activity Zones Amendment ("PLAZA") Act of 2024:** amended the Autonomous Vehicle Act (of 2012, updated in 2020) to establish interim testing requirements until DDOT has the permit application available. This law requires notification of testing, that a safety operator be in the vehicle at all times, and mandates crash reporting.s

These actions place the District in a transitional position: still open to and flexible to permit innovation, but without a regulatory framework.

Testing Activity

AV testing activity through early 2026 has included both short- and long-term testing operations:

- 2018-2022: Argo AI and Ford conduct sustained testing citywide
- 2020-2021: Optimus Ride tests in the Navy Yard area, providing food delivery and then some passenger service
- 2023: Cruise conducts short-term data collection
- 2024, 2025: Nuro conducts short-term data collections
- 2024, 2025-present: Waymo visits on a “road trip” then returns in 2025 for sustained testing citywide with stated intention to move to commercial deployment when possible
- 2025-present: Zoox conducts sustained testing citywide
- 2025-2026: Beep and Adastec conduct a short-term test of an AV bus in partnership with USDOT

6.2 District Goals and Priorities for AVs

The Government of the District of Columbia has taken significant steps toward preparing the District to integrate AVs safely. This includes the development of an AV Principles Statement, creating an AV Agency Impact Matrix, and conducting a study on AVs' potential impacts.

District Principles for AV Deployment

In 2018, the District’s Interagency Working Group on Automated Vehicles released the “Autonomous Vehicles Principles Statement” establishing four guiding principles for AV deployment:

- **Safety** – Reduce driver, passenger, and pedestrian injuries and fatalities, and protect consumer data.

[7] *District of Columbia Register* vol. 71, no. 47, Nov 22, 2024, and directly available at https://dcregs.dc.gov/Common/NoticeDetail.aspx?NoticeId=N138524

- **Equity** – Improve access across geographies and populations, expand accessibility for people with disabilities, and mitigate potential negative impacts such as job displacement or built-environment inequities.
- **Efficiency** – Reduce congestion, lower system costs, cut pollution, and improve the movement of people and goods.
- **Sustainability** – Improve environmental outcomes, ensure financial viability, and maintain adaptability as technologies and infrastructure evolve.

To ensure these principles are translated into enforceable policy, the District also seeks to embody four cross-cutting attributes in its AV framework:

- **Adaptability** – Regulations must be flexible enough to evolve as technology and business models change.
- **Transparency and Privacy** – Public agencies must have access to the data needed for safety and oversight while protecting individual privacy and proprietary information.
- **Comprehensiveness** – Policies must address safety, operations, infrastructure, data, workforce, equity, and enforcement in an integrated way.
- **Alignment** – AV policy must reinforce, not undermine, the District's existing transportation, land use, climate, and equity goals.

These principles and attributes provide the foundation for this research and for the recommendations that will follow.

Other Guiding Documents

The District's Comprehensive Plan further identifies policies and actions for how AVs should be integrated into the District's transportation system. Section T-5.1 Autonomous Vehicles within the Transportation Element call out safety, shared use, reduced congestion and VMT, equitable access, and person throughput as goals, as well as the need to monitor the effects of AVs on mobility, infrastructure, economic development, and the built environment.

DDOT's vision is to "continue to be a national leader in creating safety and mobility solutions for the existing and emerging transportation challenges within our community. We will prioritize building safer infrastructure across all 8 wards, utilize innovative technologies and strategies to reduce congestion and greenhouse gas emissions and expand our transit systems to connect residents to economic opportunities" (District Department of Transportation, *Vision*, n.d.). Autonomous vehicles have the potential to support this vision – providing a safe mobility option that reduces congestion and emissions while supporting and expanding our transit system – but only if appropriately deployed.

DDOT (2021) defined 7 overall transportation goals in the moveDC plan—safety, equity, mobility, project delivery, management and operations, sustainability, and enjoyable spaces—and a series of supporting policies, strategies, and metrics to achieve those goals. AVs come through in policy R, "adapt policies to ensure equitable service, privacy protections, and data driven decision making as technology and new

transportation services arise" and supporting strategies 38 and 29—to study how new vehicle technologies affect the transportation system and to ensure equitable adoption of mobility. This project directly advances that policy and strategies.

6.3 Policy Levers Identification Methodology

Based on this work, the District will develop a list of available policy levers that might address many of the considerations identified in the previous sections–with the goal of influencing the nature of AV deployments within the District. *Policy levers* refer to the potential authorities and tools at the District's disposal to influence AV deployments. *Policies* refer to the specific incentives, disincentives, requirements, and parameters that could be built into legislation or regulations to push deployments toward delivering the outcomes the District wants for its transportation system.

The consultant team has developed the following approach to help develop, analyze, and prioritize policy levers available to the District:

1) Review existing policies, regulations, and case studies from other jurisdictions that have started to regulate AVs.
2) Develop a list of the policy levers available to the District to influence the nature of AV deployments.
3) Develop a long list of potential policies (within each lever) that the District might consider in order to influence the nature of AV deployments.
4) Identify the District transportation and for-hire mobility goal(s) that each policy would support.
5) Evaluate each policy using the following criteria:
    a) Will the policy lever encourage progress toward District-stated goals?
    b) Does the District have the ability to oversee and enforce the policy?
    c) Does District government have the capability and capacity (internally or through external support) to collect, maintain, and analyze data that will be able to measure changes from the policy?
    d) Is the policy strong enough to ensure compliance?
    e) Will there be enough political support for the policy to be supported and enforced?
    f) Will there be public impact considerations to the policy?
    g) Develop a "short list" of policies with the greatest potential for achieving the District's goals and objectives.
    h) For each "short list" policy, develop and refine more detailed policy language, including how the policy would be funded and enforced, and how it will be measured or monitored. These policies will be incorporated into the deployment recommendations.

For the next steps of this work, the Team will work with internal District partners and stakeholders to identify and prioritize proposed policy levers and additional actions to support the successful deployment of AVs in the District.

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8 Appendices

Appendix A. AV Regulatory Literature Review Summaries

This appendix compiles extensive research, guidelines, and policy recommendations on the regulation, deployment, and impact of AVs and ADS. It emphasizes the need for consistent legal frameworks across jurisdictions to ensure safe and equitable integration of AV technologies. Organizations like the AAMVA recommend establishing lead agencies and committees to oversee AV deployment, updating driver licensing systems to include ADS technologies, and implementing robust permit processes for testing. Public education campaigns and law enforcement protocols are critical to fostering trust and ensuring smooth interactions with AVs. Other reports stress the importance of addressing equity and accessibility challenges by prioritizing underserved communities and ensuring AVs benefit vulnerable populations, such as those with disabilities or low incomes. Infrastructure improvements, including mobility hubs and smart traffic systems, are vital for supporting AV operations.

Key technological and regulatory challenges include harmonizing state and federal regulations, ensuring robust data privacy and cybersecurity measures, and addressing public concerns over safety and liability. Reports also highlight the importance of ongoing collaboration among stakeholders, including government, industry, and academia, to create adaptable regulatory frameworks. Pilot programs and incremental AV deployment are advocated to gather real-world insights and build public trust. Moreover, international cooperation is seen as essential for creating global standards that facilitate cross-border AV operations. Collectively, these findings underscore the transformative potential of AVs to improve mobility, safety, and sustainability, provided that their deployment is guided by thoughtful, equitable, and data-driven policies.

Note: Part of the summaries in this document were compiled by ChatGPT and reviewed by the Project Team.

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(Title are hyperlinked to their summary)

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Key Recommendations

- Establish a Lead Agency and Committee: Each jurisdiction should designate a lead agency and form an ADS-equipped vehicle committee to oversee the testing and deployment of AVs.
- Implement a Permit Process: Develop a comprehensive permit process for manufacturers and entities testing ADS-equipped vehicles on public roadways.
- Driver Licensing and Training: Update driver licensing requirements and training programs to include the operation of ADS and ADAS technologies.
- Public Education: Enhance public education and awareness regarding the safe use of automated driving technologies.
- Data Management: Establish clear policies for data collection, access, and usage, ensuring privacy and cybersecurity.
- Law Enforcement Protocols: Develop specific protocols for law enforcement interaction with ADS-equipped vehicles, including crash and incident reporting.
- Vehicle Inspection and Safety Standards: Ensure ADS-equipped vehicles meet federal and national safety standards and undergo periodic inspections.

Report Summary

AAMVA provides a comprehensive framework for the regulation of vehicles with ADS. The guidelines, updated in this fourth edition, aim to promote consistency and safety across jurisdictions. The report covers various aspects of vehicle automation, including ADAS and full ADS, providing recommendations for testing, deployment, administration, driver licensing, law enforcement, and cybersecurity.

Chapter 1: Introduction

- Overview: The introduction highlights the rapid advancement in vehicle automation and the need for jurisdictions to adapt to these changes. The AAMVA's guidelines aim to assist in creating a standardized regulatory framework.
- Guiding Principles: Emphasizes consistency, support for technology development, and public safety.
- Collaboration: Encourages collaboration among stakeholders, including government agencies, manufacturers, and research institutions.

Chapter 2: Automated Vehicle Classification, Terms, Acronyms, and Technologies

- Vehicle Classification: Details the SAE International's six-tier classification system for driving automation from Level 0 (No Automation) to Level 5 (Full Automation).
- Key Terms and Definitions: Provides definitions for critical terms such as ADS, ADAS, remote driver, and DDT.

Chapter 3: Administrative Considerations

- Lead Agency: Recommends establishing a lead agency within each jurisdiction to oversee ADS testing and deployment.
- Committee Formation: Suggests forming a committee with representatives from various sectors to guide ADS policies.
- Legal Review: Jurisdictions should review and update laws to remove barriers to ADS deployment and ensure safety.

Chapter 4: Vehicle Considerations

- Permit Process: Outlines the need for a robust permit process for ADS testing.
- Registration and Titling: Provides guidelines for the registration and titling of ADS-equipped vehicles.
- Safety Standards: Emphasizes compliance with federal and national safety standards.

Chapter 5: Driver Licensing Considerations

- Role Definitions: Clarifies the roles of drivers and passengers in ADS-equipped vehicles.
- Licensing Requirements: Updates driver licensing requirements to include ADS operation.
- Training Programs: Recommends training programs for drivers, educators, and examiners on ADS technologies.

Chapter 6: Law Enforcement Considerations

- Vehicle Identification: Advises on protocols for identifying ADS-equipped vehicles.
- Crash Reporting: Details procedures for reporting crashes and incidents involving ADS vehicles.
- Operational Responsibility: Defines the responsibilities of law enforcement in managing ADS operations and incidents.

Chapter 7: Other Considerations

- Cybersecurity: Highlights the importance of cybersecurity measures throughout the vehicle's lifecycle.
- Data Collection: Establishes guidelines for data management, including privacy policies.
- Low-Speed Automated Shuttles: Provides insights into the regulation of low-speed automated shuttles for specific community needs.

Appendix A: Summary of Recommended Jurisdictional Guidelines for Regulating Vehicles with Driving Automation Systems

Appendix B: Summary of Recommendations for Manufacturers and Other Entities for Regulating Vehicles with Driving Automation Systems

Conclusion

The safe and effective integration of ADS-equipped vehicles requires a coordinated effort among various stakeholders. By adopting the AAMVA's guidelines, jurisdictions can ensure consistent regulatory practices, enhance public safety, and support technological advancements in vehicle automation. Collaboration, continuous learning, and adaptability are key to navigating the evolving landscape of ADS.

Automated Vehicles Act 2024 (UK)

Purpose & Scope

- The Act establishes a framework regulating the use of vehicles that can travel autonomously (i.e., without continuous human supervision) on public roads in Great Britain.
- It does not cover mere testing only; the focus is on vehicles authorized for use in automated mode.
- It introduces a broad definition of "self-driving" vehicles (rather than strictly referencing SAE levels) acknowledging features that allow the vehicle to travel autonomously without human input for part or all of a journey.

Key Legal Elements

- Authorization Regime: Before a vehicle can be used autonomously on roads, it must be authorized by regulatory authorities. The vehicle must pass a "self-driving test" (designed or adapted to drive itself, safely and legally).
- Operating Modes: The Act distinguishes between (a) a mode where a human user is in-charge and ready to intervene ("user-in-charge" mode) and (b) a mode with no human driver in the vehicle ("no-user-in-charge" mode).
- New Legal Actors:
    - The "Authorised Self-Driving Entity" (ASDE), which is responsible for ensuring the vehicle continues to meet requirements.
    - The "user-in-charge" (UiC) when a human is present and ready to take over.
    - The "no-user-in-charge operator" (NUiC) for services where there are no human driver (e.g., robo-taxis) and oversight is provided remotely or otherwise.
- Safety Standards & Principles: The Act mandates that authorized vehicles must meet safety standards (to be developed via secondary legislation) and includes government power to publish "Statement of Safety Principles" which set the expectation that AVs must be at least as safe as a careful competent human driver and ideally improve overall road safety.
- Marketing and Consumer Protection: The Act introduces offences for misleading marketing of automated capabilities (so that only authorized AVs may advertise as "self-driving/driverless/autonomous") and aims to protect consumers from confusion about what a vehicle is legally authorized to do.
- Regulatory and Enforcement Powers:
    - Powers to adapt existing vehicle-type approval and road traffic legislation to accommodate AVs.
    - Powers for the Secretary of State to enforce compliance: authorization can be varied, suspended or withdrawn; monetary penalties may apply.

Implementation & Timeline

- The Act received Royal Assent in May 2024.
- Full implementation depends on secondary regulations (detailed rules) being developed: e.g., safety principles, authorization processes, licensing of passenger services, data-sharing regimes.
- The UK government has launched an "Implementation Programme" (Feb 2025) to bring the regulatory regime into operation, with deployment targeted for 2027 and some services (automated passenger services) potentially earlier.

Implications / Relevance for a State-DOT / Operations Perspective

- For a state-type agency or transportation safety/operations engineer, the Act is important because it:
    - Clarifies **liability and responsibility** when vehicles operate without a human driver (the ASDE/NUiC model) — meaning infrastructure owners/planners must be aware of interface/regulatory changes.
    - Sets the precedent for **authorization and oversight** of AVs, which may align with or inform U.S. state DOT or other jurisdiction frameworks.
    - Implies a need for **data-sharing, incident-investigation, performance monitoring** for AVs in operational use — important for network operations, routing, and safety management.
    - Signals the UK's move toward full deployment of driverless (no-user-in-charge) services—state agencies should consider how infrastructure, network operations, flood closure protocols, signal control and routing systems may need to adapt to vehicles operating under these conditions.

Autonomous Vehicle Industry Association (AVIA). (2025a). Securing American Leadership in Autonomous Vehicles: *Advancing the Framework for Automated Driving System Safety*

Key Issues

- Federal inaction creating uncertainty: Slow federal progress leads to state patchwork and market fragmentation.
- FMVSS outdated for automation: Rules mandating steering wheels, pedals, and driver-focused controls obstruct driverless designs.
- Lack of national data infrastructure: No unified system for reporting and analyzing AV incidents.
- Barriers to testing and deployment: Existing legal restrictions (e.g., "make inoperative") impede safe technical advances.
- Inequitable regulatory environment: Original equipment manufacturers (OEMs) have broader testing authority than independent AV developers.
- Insufficient regulator resources: NHTSA and FMCSA are underfunded relative to oversight needs.
- Cybersecurity and privacy are underregulated: No mandated plans or standards for AV cybersecurity or data handling.
- Supply-chain vulnerabilities: Heavy reliance on foreign sensor manufacturers; limited domestic production.
- Lack of clarity for autonomous trucking: Federal Motor Carrier Safety Regulations (FMCSRs) still assume a human driver, creating operational ambiguity.
- Accessibility barriers**:** People with disabilities face inconsistent state rules restricting AV ridership.

Key Recommendations

(All recommendations drawn directly from AVIA's policy proposals.)

- AV Safety, Transparency, and Accountability
    - Require ADS behavioral competency tests through a new FMVSS, including detection/response to vulnerable road users, ODD-limit detection, and minimum risk condition requirements.
    - Mandate an ADS Safety Case, requiring manufacturers to document hardware/software architecture, hazard analyses, validation evidence, and crash-detection/response logic.
    - Establish a National AV Safety Data Repository with standardized incident reporting, improved data quality, aligned thresholds for crash reporting, and clear confidentiality protections.
- Advancing American Leadership on AVs
    - Modernize FMVSS to clarify that manual controls, telltales, and indicators are not required for Level 4–5 ADS-dedicated vehicles if equivalent safety is met.

    - Launch a USDOT Autonomous Vehicle Demonstration Program as an enhanced, voluntary pathway for non-traditional vehicle designs requiring FMVSS exemptions.
    - Update federal law to allow safe disabling or repurposing of manual controls during autonomous operation without violating "make inoperative" provisions.
    - Expand FAST Act testing and evaluation eligibility so AV developers—not just OEMs—can test nonconforming vehicles needed for AV commercialization.
    - Pass the AV Accessibility Act to ensure individuals with disabilities can ride in ADS vehicles and to study accessible infrastructure for AV pickup/drop-off.
    - Require cybersecurity and privacy plans from AV manufacturers, including intrusion detection and data-use policies.
- Supporting Supply Chain Resiliency Through Autonomous Trucking
    - FMCSA should codify that no human driver is required in Level 4–5 ADS commercial motor vehicles (CMVs).
    - Update inspection, hours-of-service, and related rules to reflect driverless CMVs and support the Enhanced CMV Inspection Program.
    - Approve cab-mounted warning beacons for stopped autonomous trucks to replace traditional warning triangles.
- Supporting Safety Regulators with Enhanced Resources
    - Congress should increase federal funding for USDOT, NHTSA, and FMCSA to ensure regulators can oversee AV deployment and safety effectively.
- Protecting National Security While Promoting AV Leadership
    - Ensure supply-chain security for connected vehicles while avoiding unnecessary burdens on U.S. AV companies.
    - Fund domestic manufacturing of AV sensors, including pilot programs to expand U.S. production capacity and strengthen national competitiveness.

Report Summary

Securing American Leadership in Autonomous Vehicles outlines the Autonomous Vehicle Industry Association's blueprint for a comprehensive federal framework to accelerate safe AV deployment while maintaining U.S. global leadership. AVIA argues that although AV technology is already operating in multiple U.S. states, federal inaction has resulted in regulatory fragmentation and uncertainty, prompting states to fill the void and allowing competitor nations, especially China, to advance aggressively. The white paper calls for a reinvigorated federal approach through targeted legislation and USDOT rulemaking to establish national standards that ensure safety, promote innovation, and create consistent expectations for manufacturers and regulators alike.

AVIA's recommendations span five domains: AV safety and transparency, leadership in regulatory modernization, supply-chain resilience through autonomous trucking, increased regulatory resources, and national-security-aligned industrial policy. Key proposals include creating FMVSS-based ADS competency tests, requiring safety cases, building a national AV safety repository, modernizing FMVSS to accommodate ADS-dedicated vehicles, and supporting domestic manufacturing of critical sensors.

Collectively, these actions aim to deliver safer roads, stronger economic competitiveness, improved accessibility for people with disabilities, and a robust nationwide ecosystem that enables AV deployment at scale.

1) Context and Motivation
    a) AVs already deploy nationwide in passenger, delivery, shuttle, and freight applications.
    b) Federal inaction has led to state-by-state patchwork regulation, complicating national deployment.
    c) Strategic competitors—particularly China—are rapidly advancing AV deployment with strong government support.
    d) AVIA argues that only a coherent federal framework can preserve U.S. leadership.
2) AV Safety, Transparency, and Accountability
    a) ADS Driving Competency Standard: NHTSA should create FMVSS requirements for core ADS behaviors such as vulnerable road user detection, ODD-limit handling, minimum risk condition, emergency-vehicle response, and driver-handover for Level 3.
    b) ADS Safety Case Requirement: Manufacturers must document hazard analyses, engineering methodologies, validation testing, dynamic-driving-task performance, and crash-response capabilities.
    c) National AV Safety Data Repository: Requires standardized, non-duplicative, confidential reporting, expanded data categories, and more realistic deadlines (120 hours instead of 24).
3) Advancing American Leadership on AVs
    a) FMVSS Modernization: Clarify that Level 4–5 ADS-dedicated vehicles do not require manual controls or driver-oriented telltales/indicators if performance standards are met.
    b) USDOT Demonstration Program: Provide a voluntary pathway for AV designs needing exemptions, without compromising existing self-certification or rulemaking processes.
    c) Testing and Evaluation Reforms: Update laws so disabling or altering manual controls during ADS operation is legal; expand FAST Act authority so all AV developers can test nonconforming vehicles.
    d) Cybersecurity and Privacy Plans: Legislation should mandate detailed policies for intrusion detection, false command detection, data handling, and user privacy.
    e) AV Accessibility Act: Ensure individuals with disabilities can ride in AVs and require an accessible-infrastructure study to strengthen AV pickup/drop-off usability.
4) Supply Chain Resiliency Through Autonomous Trucking
    a) Codify that no human driver is required in Level 4–5 ADS commercial vehicles under FMCSRs.
    b) Support consensus inspection protocols through programs like the Commercial Vehicle Safety Alliance's Enhanced CMV Inspection.
    c) Authorize cab-mounted warning beacons in place of traditional emergency triangles for driverless CMVs.
5) Supporting Safety Regulators with Enhanced Resources
    a) Increase appropriations for USDOT, NHTSA, and FMCSA so regulators can handle AV oversight, build new programs, and manage workforce needs.

6) Protecting National Security While Promoting AV Leadership
   a) Support federal efforts to review security risks from connected vehicles but avoid harming U.S. companies.
   b) Develop domestic manufacturing capacity for sensors and other critical AV hardware through grants and pilot programs (e.g., based on lessons from Montana's Headwaters Tech Hub).

Autonomous Vehicle Industry Association (AVIA). (2025b). State of AV 2025.

The Autonomous Vehicle Industry Association (AVIA) showcases the innovative industry through interviews with industry leaders, geographic spotlights, and demonstrating AV use cases—whether by the private sector, federal government, or Americans in need of new transportation opportunities.

1) Industry Growth and Deployment:
    a) AVs have driven nearly 70 million miles on U.S. roads, marking a 59% increase in automated miles driven since last reported in July 2023. Major states leading AV deployment include Texas, California, Arizona, and Florida, each with favorable regulatory environments.
    b) The report highlights expansion efforts by AV companies, such as Motional, Waymo, Nuro, Zoox, and others, each advancing autonomous vehicle services in areas like public transportation, delivery services, and emergency support.
        i) AV companies like Motional, Nuro, and Zoox actively collaborate with local authorities, first responders, and community leaders to increase understanding and safety around autonomous vehicles. They provide training for emergency responders and engage with the public through events and educational programs. Motional holds community events, Nuro partners with law enforcement to ensure AVs detect and respond to emergency vehicles, and Zoox gathers data on local conditions to improve vehicle operations. Zoox also implemented external speakers on their vehicles to provide essential information to emergency responders.
2) Safety and Accessibility:
    a) AVIA emphasizes the role of AVs in reducing accidents attributed to human error, with a potential to save lives and improve mobility for vulnerable populations, including the elderly and individuals with disabilities.
    b) The report includes insights from organizations like the National Federation of the Blind, which advocates for AV accessibility, citing AV technology as transformative for providing equal transportation access to the visually impaired.
3) Regulatory Challenges and Policy Needs:
    a) The report identifies a need for a unified federal policy to support AV deployment and innovation, citing feedback from industry CEOs who face public policy and regulatory uncertainty as primary barriers.
    b) AVIA has been active in legislative advocacy, conducting workshops and meetings with the U.S. Department of Transportation, Congress, and state governments to push for regulatory frameworks that support AV testing, deployment, and safety measures.
4) Industry Use Cases and Partnerships:
    a) The report showcases various AV applications in urban and rural settings. Notable use cases include autonomous trucking by companies like Aurora and Kodiak, which enhance supply chain resilience, and autonomous ride-hailing services by Waymo in Phoenix, enhancing urban mobility.

b) Partnerships between AV companies and commercial entities, such as FedEx, Kroger, and Walmart, highlight the growing interest in autonomous delivery solutions, especially for "middle-mile" logistics—transporting goods between distribution points to streamline supply chains.

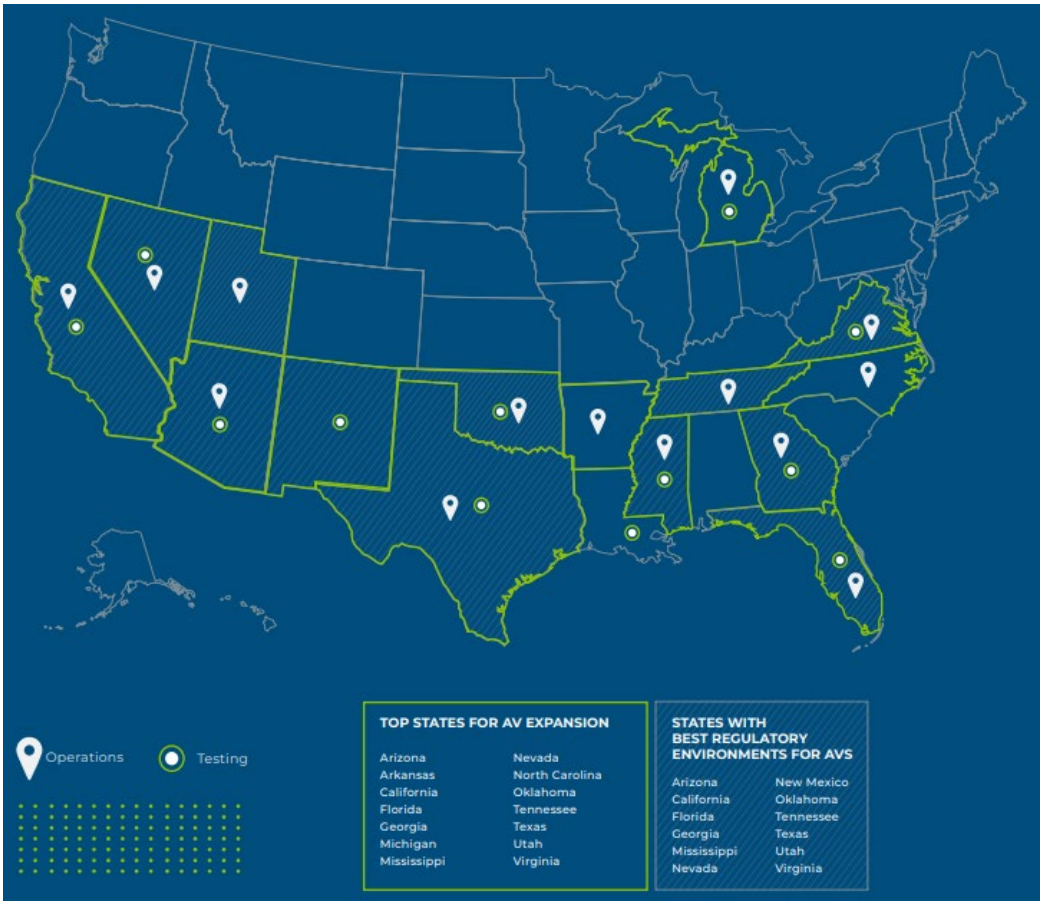
5) Technology and Cybersecurity:
   a) AVIA stresses the importance of cybersecurity and data privacy, recommending robust protocols to protect against cyber threats and ensure public trust in AV systems.
   b) The report discusses innovations in AV technology, such as advanced sensor fusion, machine learning (ML) for better decision-making, and dedicated infrastructure like the Las Vegas Motor Speedway for AV testing.
6) Future Goals and Outlook:
   a) The report anticipates continued growth in the AV sector, with more AV-specific infrastructure and regulatory alignment at the state and federal levels.
   b) AVIA advocates for policies that enable AV technology to meet public safety needs, enhance economic growth, and offer new employment and transportation opportunities across diverse communities.

The following industry perspectives highlight how leading AV developers and advocacy organizations are shaping the future of autonomous mobility. Each interview provides insight into the sector's priorities—from safety frameworks and regulatory needs to accessibility, defense applications, and the use of advanced simulation. Together, these voices illustrate how the AV industry is progressing toward large-scale, policy-aligned deployment across freight, passenger mobility, and public-interest use cases.

1) **Chris Urmson, CEO of Aurora**: Urmson discusses Aurora's focus on autonomous trucking, partnerships with logistics companies, and their "Safety Case Framework," which rigorously tests AV technology to ensure safe deployment. He emphasizes the need for a unified federal regulatory framework to facilitate AV adoption, aiming for driverless trucking by year-end 2024.
2) **Mark Riccobono, President of the National Federation of the Blind**: Riccobono underscores AVs' potential to improve independence and mobility for visually impaired individuals. He advocates for policies like the Autonomous Vehicle Accessibility Act, which would grant equal rights for disabled Americans to travel in AVs without a driver's license, supporting more accessible and equitable transportation options.
3) **Raquel Urtasun, Founder & CEO of Waabi**: Urtasun details Waabi's unique approach to AV development using generative AI and its closed-loop simulator, Waabi World, which allows extensive training and testing in digital environments. She calls for flexible yet safety-focused regulatory frameworks to support autonomous trucking innovation and highlights the importance of transparent, long-term policy engagement with regulators.
4) **Kodiak Robotics**: Represented by their partnerships with the Department of Defense (DoD), Kodiak emphasizes the dual-use potential of AVs for civilian and military applications. Their work includes adapting long-haul trucking technology for off-road military applications, enhancing national security while advancing autonomous logistics for complex terrain.

These interviews collectively illustrate the AV industry's push for safer, inclusive, and policy-aligned growth, focusing on technological advancements and public-private partnerships to achieve broad deployment of AV solutions.

Figure 4: Top States for AV Expansion



Source: AVIA Second Annual State of AV Report (May 2025) –

Cityfi and Urbanism Next Center. (2023). Autonomous Vehicles: A Guide for Cities.

Key Recommendations

- Establish local goals, objectives, and metrics for AV outcomes through community engagement and align AV initiatives with broader city goals related to safety, equity, and environmental sustainability.
- Conduct sustained community engagement throughout all stages of AV deployment using multiple outreach methods, and maintain transparency about risks, expectations, and potential changes during pilot phases.
- Adopt a minimally viable product approach with limited initial scope, develop and communicate risk mitigation strategies, and ensure that safety protocols are implemented and continuously monitored.
- Begin with small-scale pilots and demonstrations, scale deployments based on performance metrics and lessons learned, and retain flexibility to adjust policies, rules, and operational approaches as technology matures.
- Update local ordinances to address AV-specific issues and establish clear agreements with AV operators that define objectives, scope, performance measures, and termination conditions.
- Foster strong partnerships with AV developers, operators, and stakeholders, leverage third-party facilitators when appropriate, and engage regional and national peers to support shared learning and policy alignment.
- Implement a comprehensive data collection and evaluation framework, require or encourage data sharing by AV operators, and utilize established data standards such as MDS and CDS.
- Regularly evaluate AV performance and public impacts, adjust deployment strategies as needed, share lessons learned with peer jurisdictions, and partner with academic institutions or consultants to build long-term capacity.

Report Summary

The "Autonomous Vehicles: A Guide for Cities" provides comprehensive guidance for urban leaders to navigate the complex landscape of AV deployment. The guide emphasizes the importance of setting clear goals aligned with broader city objectives, engaging communities at every step, and managing risks through transparent, incremental approaches. It advocates for robust data collection and sharing, flexible policymaking, and fostering collaborative partnerships with AV developers and stakeholders. By proactively preparing and continuously evaluating AV initiatives, cities can leverage this transformative technology to enhance urban mobility, safety, and equity.

1) Introduction
    a) Purpose: The guidebook aims to assist city staff and leadership in preparing for and managing AV testing, pilots, and deployments. It also serves public stakeholders, non-profits, academic institutions, AV developers, and state and federal governments by providing insights on effective collaboration with cities.

b) Background: The introduction of AVs could significantly impact urban mobility, much like the advent of automobiles did in the early 20th century. The guide emphasizes the need for proactive policy, planning, and community engagement to manage this potential shift.
c) Goals: The guide outlines goals such as defining local objectives, engaging the community, sharing knowledge between cities, ensuring consistent policies, understanding partnership opportunities, and facilitating nimble government responses.

2) Getting Ready
a) Preparation: Cities should not introduce AV technologies in isolation. It's crucial to consult with stakeholders, manage expectations, and share feedback. This involves extensive planning and resource allocation.
b) Community Engagement: Engaging a diverse range of community representatives can improve the value of demonstrations, shape future deployments, and evaluate technology across various perspectives and needs.
c) Regulations: Cities need to revisit local ordinances and regulations to address any "gray areas" related to AV technology. This includes clarifying definitions, reporting requirements, operational limits, and liability issues.
d) Collaboration: Effective collaboration across jurisdictions and sectors is essential. Cities can learn from each other through structured collaboration based on the level of risk each entity can manage.

3) Demonstrations and Pilots
a) Purpose and Benefits: Pilots and demonstrations are critical for testing, observing, and learning about AV technology. They help in crafting policy frameworks, managing risks, and engaging the public.
b) Design and Evaluation: Successful pilots should have a clear scope, limited duration, defined success metrics, and a decision-making process for scaling or ending the pilot. Public participation and transparent evaluation are key to gaining trust.
c) Flexibility: Policies and rules may need adjustments during demonstrations. It's important to maintain flexibility and agility to make in-flight changes as more is learned.
d) Risk Management: Both public agencies and AV developers should assess and manage risks by limiting the scope and complexity of pilots initially. Transparent risk mitigation plans should be shared with the public to build trust.

4) Deployment
a) Pre-Launch Preparation: Before launching new AV services, cities and AV companies should work together to educate the public and relevant city departments, especially public safety officers.
b) Incremental Approach: Deployments should start small and scale up based on defined criteria and successful operation. This might include using human safety drivers initially until safety thresholds are met.
c) Public Relations: Transparency with the public about issues and changes is vital. Continuous engagement with the community and stakeholders should be maintained throughout the deployment.

d) Data Sharing: AV operators should be encouraged or required to share data with the city to evaluate performance and manage the system effectively. Public agencies can use proxy or observational data when direct data sharing is not possible.

5) Evaluating, Iterating, and Sharing
   a) Continuous Learning: Both public and private sectors are continuously learning about AV deployments. Policies should be flexible and evolve based on evaluations of demonstrations and deployments.
   b) Collaboration and Information Sharing: Building a community of counterparts across cities and agencies can help public officials stay current with changes in AV technology and collaborate more effectively.
   c) Capacity Building: Cities often lack the capacity to manage and evaluate emerging technologies. Partnering with universities, consultants, and community partners can help augment staff capacity and strategic planning.

Conclusion

As cities face the imminent integration of autonomous vehicles, proactive and informed management is essential to harness their potential benefits while mitigating risks. The guide underscores the necessity of clear objectives, community engagement, and collaborative partnerships to ensure AV deployments align with public goals. Through flexible, data-driven policies and continuous learning, cities can create a sustainable and equitable urban mobility future. Embracing these practices will enable cities to not only adapt to but also shape the future of autonomous transportation, ensuring it serves the broader public interest.

Congressional Research Service (CRS). (Updated July 22, 2025). Safety Considerations for Automated Passenger Vehicles

Key Issues

- Regulatory fragmentation: Significant divergence across states; absence of unified federal framework.
- No ADS-specific FMVSS or performance standards: Current federal standards assume manual control.
- SGO is temporary: Lack of permanent national crash-reporting requirements.
- Data-access and transparency challenges: Proprietary systems hinder investigations and oversight.
- Cybersecurity vulnerabilities: No mandated minimum cybersecurity requirements for ADS.
- Liability ambiguity: Unclear allocation of fault between manufacturers, operators, occupants, and remote supporters.
- Federal-state friction: Tension between state licensing/traffic law and federal vehicle-safety authority.
- Human-factors and accessibility gaps: Uncertainty about safe human-machine interface design, passenger behavior, and equitable access.

Key Recommendations

- Strengthen the Federal Regulatory Framework
    - Clarify NHTSA's statutory authority to regulate ADS-equipped vehicles, including performance standards for ADS and cybersecurity requirements.
    - Modernize FMVSS to better align with vehicles that lack traditional controls, have non-traditional interiors, or rely entirely on ADS for the dynamic driving task.
    - Provide Congress with updated legislative tools to enable NHTSA to establish ADS-specific safety standards and mandate safety assessments.
- Improve Data Collection and Transparency
    - Establish permanent AV crash and incident reporting requirements to replace or supplement existing Standing General Orders.
    - Require standardized safety assessments (such as safety cases, ADS descriptions, ODD definitions, and failure mitigation strategies) for developers seeking deployment at scale.
    - Increase public availability of safety performance data to enhance consumer trust and enable independent safety analysis.
- Enhance Federal–State Coordination
    - Develop federal guidance that harmonizes state approaches to AV testing, licensing, and operations to avoid a patchwork of inconsistent rules.

    - Establish clearer boundaries between state jurisdiction over driver licensing/operations and federal authority over vehicle safety.
- Address Cybersecurity and Software Integrity
    - Mandate minimum cybersecurity performance requirements for ADS, including secure software updates and protection against remote intrusions.
    - Require AV developers to incorporate software monitoring and anomaly detection systems to mitigate safety-critical failures.
- Clarify Liability and Insurance Frameworks
    - Support development of liability structures that reflect ADS operation, including circumstances where no human driver is in control.
    - Encourage insurers and regulators to adapt underwriting models based on AV operational data and risk profiles.
- Support Research, Pilots, and Deployment Pathways
    - Continue federal investment in ADS safety research, including human factors, sensor failure, artificial intelligence/machine learning (AI/ML) robustness, and accessibility.
    - Support structured pilot programs like AV STEP to generate real-world evidence for future FMVSS and ADS performance standards.

Report Summary

The July 2025 Congressional Research Service (CRS) update on Safety Considerations for Automated Passenger Vehicles provides Congress with a comprehensive overview of the federal regulatory environment for AVs, with particular emphasis on NHTSA's evolving role. The report highlights the gap between existing FMVSS—written for human-driven vehicles—and the emerging generation of ADS-equipped vehicles that may lack steering wheels, pedals, or human drivers altogether. CRS outlines how NHTSA currently relies on indirect oversight tools—such as defect authority, Standing General Orders for crash reporting, exemptions, and voluntary guidance—while major rulemakings and congressional action will ultimately be necessary to establish a durable regulatory framework.

CRS concludes that although AV technology continues to advance, the absence of ADS-specific performance standards, cybersecurity requirements, and transparent safety metrics remain significant policy challenges. The report emphasizes that federal–state coordination, improved data transparency, cybersecurity protections, and modernization of FMVSS are critical steps for enabling safe deployment. Policymakers and analysts rely on this report because it distills technical and regulatory complexities into an accessible framework that outlines where federal authority is clear, where it is limited, and where congressional action may be required to ensure safe national deployment of automated passenger vehicles.

1) Overview of Automated Vehicle Technology
    a) Defines SAE Levels 0–5, focusing on Levels 3–5 that perform the full dynamic driving task under some or all conditions.
    b) Explains distinctions between driver assistance (ADAS) and true ADS.

c) Discusses operational design domain (ODD), fallback strategies, and minimum risk conditions.

2) Federal Regulatory Authority (NHTSA)
   a) NHTSA is responsible for vehicle safety standards (FMVSS) and recalls but currently has no ADS-specific performance standards.
   b) Oversight relies on:
      i) Defect investigation and recall authority.
      ii) Standing General Orders requiring crash and incident reporting.
      iii) 49 U.S.C. § 30112 exemptions for vehicles that do not meet FMVSS.
      iv) Voluntary guidance (AV Policy documents, ADS safety self-assessments).
   c) CRS highlights debate about whether NHTSA's authority adequately covers software-driven vehicles and artificial intelligence decision-making.
3) FMVSS Modernization Challenges
   a) Current FMVSS assumes human drivers and traditional controls.
   b) AVs with non-traditional interiors (e.g., no steering wheel) may conflict with specific FMVSS requirements.
   c) NHTSA has begun reviewing FMVSS applicability and exploring rulemakings on:
      i) Crashworthiness for new seating configurations.
      ii) Telltales/controls (FMVSS 101).
      iii) ADS-specific crash avoidance testing.
   d) CRS notes potential congressional action to accelerate or mandate updates.
4) Crash Reporting and Data Needs
   a) NHTSA's Standing General Orders require reporting of ADS and Level 2 ADAS crashes; however, they are temporary and investigatory tools.
   b) CRS notes widespread agreement that permanent AV incident reporting standards are needed.
   c) Insufficient transparency limits independent safety analysis and consumer trust.
   d) Stakeholders have called for standardized safety metrics and public-facing dashboards.
5) ADS Safety Assessments and Safety Cases
   a) Voluntary ADS Safety Self-Assessments lack enforceability.
   b) CRS identifies strong interest in:
      i) Mandatory safety cases similar to aviation or rail,
      ii) Required disclosure of system capabilities, limitations, and safety mitigations,
      iii) Pre-deployment test evidence (simulation, track, and on-road results).
   c) The AV STEP represents movement toward structured assessments but remains voluntary.
6) Cybersecurity and Software Safety
   a) ADS vehicles rely heavily on networked software, making cybersecurity integral to safety.
   b) Key concerns include:
      i) Remote hacking, spoofing, and unauthorized control,
      ii) Integrity of over-the-air updates, and
      iii) Vulnerabilities in perception sensors and ML pipelines.
   c) CRS suggests Congress may need to require minimum cybersecurity performance standards.
7) Federal-State Relationship

a) States regulate licensing, insurance, and traffic laws; the federal government regulates vehicle design and safety.
b) Lack of clear federal AV standards results in states setting differing AV testing and deployment requirements.
c) CRS warns of fragmentation complicating multi-state commercial ADS operations.
d) Calls for federal guidelines or model policies to harmonize state approaches.

8) Liability and Insurance Considerations
   a) ADS raises questions about:
      i) Who is the "driver" in Level 4–5 vehicles,
      ii) How liability shifts between human occupants, manufacturers, and operators,
      iii) How insurers should evaluate AV risk without standardized safety data.
   b) CRS notes emerging interest in federal guidance but traditionally states govern liability.
9) Human Factors and Accessibility
   a) AVs may improve mobility for older adults, people with disabilities, and underserved communities.
   b) Safety concerns include:
      i) Human–machine interface clarity,
      ii) Passenger restraint in non-traditional seating,
      iii) Communication with pedestrians and cyclists,
      iv) Safe entry/exit for wheelchair users.
   c) CRS highlights need for standards supporting inclusive design.
10) Current and Pending Rulemakings
   a) CRS summarizes multiple active NHTSA regulatory initiatives, including:
      i) Incident Reporting (to replace SGO reporting).
      ii) AV STEP (voluntary national safety evaluation program).
      iii) Telltales and controls rulemaking (FMVSS 101 update).
      iv) FMVSS updates for crashworthiness in ADS vehicles.
      v) Expanded exemption programs for domestic manufacturers.
      vi) Safety framework inquiries for ADS performance standards.
11) Congressional Options Identified in the Report
   a) Direct NHTSA to issue ADS-specific safety performance standards.
   b) Mandate cybersecurity requirements for ADS.
   c) Require standardized safety assessments or certification processes.
   d) Clarify liability frameworks at the federal level.
   e) Provide funding for ADS testing, research, and pilot deployments.
   f) Create federal preemption provisions to harmonize state regulation.
12) Overall Conclusions from CRS
   a) The U.S. is at a regulatory inflection point: deployment is increasing, but regulatory structure remains incomplete.
   b) Without clear federal performance standards, safety oversight relies on piecemeal tools.

c) Policymakers should consider actions that modernize FMVSS, improve data transparency, strengthen cybersecurity protections, and provide structured deployment pathways.
d) The report emphasizes that congressional direction will likely determine the pace and structure of ADS regulation over the coming decade.

D'Agostino, M. C., et al. (July 2024). A Blueprint for Improving Automated Driving System Safety.

Key Recommendations

- Reform FMVSS: Update the FMVSS to include specific requirements for ADS vehicles. This could involve creating new FMVSSs for ADS, reforming exemption processes, and investing in simulation platforms.
- Adopt a Safety Case Approach: Implement a structured argument supported by evidence to justify that an ADS is acceptably safe for a specific application in a specific operating environment.
- Standardize Data Collection: Develop a centralized data collection system with standardized formats to streamline data collection across regulatory bodies while ensuring privacy and proprietary interests are protected.
- Enhance ADS Privacy Policies: Implement privacy risk assessments and independent tests for data security to ensure consumer data is held securely and separate from personal demographic information.
- Regulate Human Alternatives and Fallbacks: Establish guidelines for safety drivers and remote operators, including training requirements, fatigue management policies, and authority levels.
- Encourage Collaboration: Foster collaboration among engineers, policy experts, and legal scholars to develop comprehensive safety standards and protocols.

Report Summary

Vehicle automation represents a new safety frontier, necessitating updates to safety oversight systems. This white paper explores the technical and legal landscape of ADS safety, focusing on AI/ML techniques, safety definitions across disciplines, and key policy considerations. The analysis highlights potential reforms to FMVSS and a holistic risk analysis "safety case" approach. It also addresses liability issues in robotics and the importance of human-machine interaction policies. The paper concludes that collaboration among engineers, policy experts, and legal scholars is essential for developing a comprehensive blueprint for ADS safety.

1) Introduction
    a) Technological Foundations: ADS relies on sensors like cameras, radar, lidar, and GPS to perform real-time environmental perception, prediction, and planning tasks. Advances in artificial intelligence, including reinforcement learning and neural networks, enhance ADS accuracy.
2) Defining Safety
    a) Multidisciplinary Definitions: Safety is defined differently across engineering, regulatory, and legal sectors. It includes concepts like roadsmanship and cultural norms.
    b) Risk Analysis: Standards organizations like the International Organization for Standardization and SAE define safety as the "absence of unreasonable risk," focusing on consensus-based standards and risk management protocols.

3) ADS Policy Considerations
    a) General Safety Policy: Two main approaches are identified:
        i) FMVSS Reform: Federal regulatory actions to update safety standards and processes.
        ii) Safety Case Approach: A structured argument demonstrating safety through detailed evidence, used in other high-risk industries like nuclear and maritime.
    b) Data Collection and Privacy:
        i) Data Collection: Develop centralized data systems, aligning formats across regulatory bodies. Examples include USDOT Data Exchange and FAA's ASIAS program.
        ii) Privacy Considerations: Implement privacy risk assessments and define criteria for trade secrets to protect consumer and proprietary data.
    c) Human Alternatives and Fallback:
        i) Safety Drivers: Establish training and legal liability awareness guidelines, including fatigue management and automation complacency alerts.
        ii) Remote Operators: Define classifications, control levels, and operational restrictions for remote operators, ensuring safety during fleet scaling.
4) Conclusion
    a) Collaboration: Emphasize the need for interdisciplinary collaboration to advance ADS safety standards.
    b) Strategic Approaches: Highlight the potential of FMVSS reforms and the safety case approach as strategic pathways for ensuring ADS safety.
    c) Data and Privacy: Stress the importance of standardized data collection and robust privacy policies.
    d) Human Factors: Address the significance of human reliability in ADS safety, particularly for safety drivers and remote operators.
5) Additional Key Points
    a) International Examples: Regulatory approaches from the European Union and the UK are highlighted, emphasizing multi-pillar validation methodologies and in-use regulation.
    b) Regulatory Investigations: Case studies of regulatory responses to ADS incidents, such as those involving Pony.ai and Cruise Automation, illustrate the complexities of ensuring ADS safety.

Conclusion

The rapid advancement of ADS technologies necessitates a comprehensive approach to safety, integrating technical, regulatory, and legal perspectives. By reforming existing safety standards, adopting innovative safety case approaches, and addressing data privacy and human factors, stakeholders can create a robust framework for ADS safety. Collaboration across disciplines will be crucial in developing effective policies and ensuring the safe integration of ADS into the transportation system.

D'Agostino, M. C., et al. (May 2024). Experiences with Autonomous Vehicles in U.S. Cities.

Key Recommendations

- Enhance Multi-Stakeholder Communication
    - Establish Open Channels: Create regular forums and communication channels for local governments, AV companies, and community-based organizations (CBOs) to share updates, address concerns, and collaborate on solutions.
    - Develop Playbooks: Formulate standardized protocols for day-to-day operations and interactions with AVs, especially for first responders.
- Prioritize Equity and Accessibility
    - Set Concrete Timelines and Requirements: Federal, state, and local governments should establish clear timelines and regulatory requirements for AV companies to ensure accessibility for people with disabilities.
    - Provide Subsidies and Incentives: Offer financial incentives or subsidies to encourage AV deployment in underserved and rural areas, ensuring equitable access.
- Strengthen Safety Standards and Data Collection
    - Update Federal Safety Standards: FMVSS needs to be revised to accommodate AV technologies and ensure comprehensive safety testing, including pedestrian crashworthiness.
    - Standardize Data Collection: Implement standardized data collection and sharing protocols, such as MDS, to ensure transparency and enable cities to make data-driven decisions.
- Foster Accountability and Transparency
    - Ensure Accountability Mechanisms: Governments should enforce accountability through mechanisms such as permit revocation for non-compliance and mandatory arbitration clauses that allow for legal recourse in case of accidents.
    - Mandate Pricing Transparency: Require AV companies to provide clear and transparent pricing, including surge pricing details, to prevent inequities.
- Encourage Sustainable Practices
    - Promote Electrification: Enforce existing legislation and create new incentives to ensure that AV fleets are electrified by 2030, reducing greenhouse gas emissions.
    - Support Shared Mobility: Encourage AV companies to develop shared mobility options that complement public transit and active transportation modes, fostering a car-light lifestyle.
- Invest in Community Engagement
    - Include Diverse Voices: Engage a broad spectrum of community representatives, including disability advocates, bicyclist groups, and rural community organizations, in the planning and deployment of AV services.

- Educational Campaigns: Launch public awareness campaigns to educate communities about AV technologies, their benefits, and how to interact safely with AVs.

Report Summary

The "Experiences with Autonomous Vehicles in U.S. Cities" report, authored by UC Davis researchers, investigates the deployment and impact of AVs across various U.S. cities. The study synthesizes insights from multiple stakeholders, including city officials, AV industry representatives, and community-based organizations. It emphasizes the importance of multi-stakeholder communication, equitable access, and robust data collection to ensure the safe and effective integration of AVs into urban environments. Key findings highlight the mixed optimism about AV benefits, the need for updated safety standards, and the importance of ensuring accessibility for people with disabilities. The report underscores the necessity for collaborative efforts between industry, government, and community organizations to navigate the complex challenges posed by AV technologies.

1) Executive Summary
   a) Definition and Scope: HAVs can perform driving tasks without human intervention, posing unique challenges for regulators and city planners.
   b) Project Goals: The study aimed to:
      i) Gather experiences from local partners, AV companies, and research partners.
      ii) Identify stakeholder priorities and gaps that University of California Institute of Transportation Studies research might fill.
      iii) Focus on equitable access for disabled, bicyclists, and vulnerable road users.
      iv) Inform AV policymaking by reviewing early experiences.
   c) Workshops and Findings:
      i) City Workshop: Included public sector employees from various cities. Highlights include:
         (1) Mixed optimism about AV benefits.
         (2) Concerns over incidents like stalled vehicles and collisions.
         (3) Importance of data collection for infrastructure planning and transparency.
      ii) Community-Based Organizations Workshop: Included disability advocates. Highlights include:
         (1) Varied stances on AV priority.
         (2) Emphasis on accountability for AV companies.
         (3) Concerns over pricing transparency and equitable access.
      iii) AV Industry Representatives: Discussed community outreach, regulatory challenges, and disability access.
2) Background
   a) Safety: Safety in AVs is defined as protection against unreasonable risk of accidents. Federal and state regulators are working to establish comprehensive safety frameworks and standards.
   b) Equity and Disability Access: AVs have the potential to improve mobility for people with disabilities and low-income communities. However, there are challenges in providing wheelchair-accessible AV services.

c) Sustainability: AVs, particularly electric and shared ones, could lead to better environmental outcomes. California has legislated that AV fleets must be electrified by 2030.

3) Study Methodology
   a) Workshops and Interviews: Conducted with city and state-level stakeholders, community-based organizations, and AV industry representatives between June and December 2023.
   b) Participants: Included city representatives from Los Angeles, San Francisco, Washington DC, Seattle, Grand Rapids, Boston, Pittsburgh, Arizona, and Massachusetts, as well as representatives from CBOs like Disability Rights Education and Defense Fund and the League of American Bicyclists.
4) Results and Takeaways
   a) From AV Industry Leaders:
      i) Community Outreach: AV companies prioritize community engagement before launching services.
      ii) Success Metrics: Include miles driven, safe operation in urban environments, and interactions with vulnerable road users.
      iii) Governance: Need for updated federal vehicle safety standards and clearer data sharing protocols.
      iv) Disability Access: AV companies are making strides in accommodating riders with vision and hearing disabilities but face challenges in providing wheelchair-accessible services.
   b) From City and State Representatives:
      i) Preemption and Local Control: Diverse views on state versus local control of AV regulations.
      ii) Data Collection: Importance of data for infrastructure planning and transparency.
      iii) Day-to-Day Issue Resolution: Need for standardized protocols for AV interactions with emergency responders.
   c) From Community-Based Organizations:
      i) Accountability: Ensuring AV companies fulfill their promises to communities.
      ii) Safety and Accessibility: Addressing safety concerns for people with disabilities and ensuring equitable access to AV services.
      iii) Policy Goals: Advocating for concrete timelines, requirements, and the ability to hold AV companies accountable.
5) Conclusion
   a) Optimism and Challenges: While there is optimism about the potential benefits of AVs, there are significant challenges to address in terms of safety, equity, and accountability.
   b) Collaboration Needed: It will require collaboration between industry, government, and community organizations to forge a safe, sustainable, and equitable path for AVs. More research and policy development are necessary to establish best practices and ensure open communication among stakeholders.

Conclusion

The integration of autonomous vehicles into U.S. cities presents a nuanced reality, with both significant opportunities and challenges. While there is widespread optimism about the potential benefits of AVs,

including improved safety, accessibility, and sustainability, there are legitimate concerns that need to be addressed. Effective collaboration between industry, government, and community-based organizations is essential to forge a path toward a safe, equitable, and sustainable AV future. This report calls for comprehensive policy frameworks, enhanced communication channels, and rigorous accountability measures to ensure that AV deployment aligns with the broader goals of urban development and community well-being. Continued research and dialogue are crucial to establishing best practices and fostering an environment where AV technologies can thrive responsibly.

District of Columbia Office of Planning. (2021). Transportation Element: 2021 Comprehensive Plan.

Key Recommendations

- Enhance Safety with AVs:
    - Ensure AVs account for human error to support the Vision Zero goal of eliminating serious injuries and fatalities.
    - Use street design principles and speed limitations to protect vulnerable users.
- Promote Shared Use of AVs:
    - Incentivize the use of shared AVs to complement existing shared-use services like public transit, carsharing, and bike sharing.
- Minimize Traffic Congestion and VMT:
- Implement strategies to prevent increases in VMT and congestion due to AVs.
- Ensure Equitable Access:
    - Guarantee that AV fleet services are accessible to all users throughout the District.
- Monitor Person Throughput:
    - Prioritize modes that carry the most people per lane-mile and ensure AVs do not displace sustainable transportation options like walking and cycling.
- Evaluate AV Impacts:
    - Continuously monitor and address the effects of AVs on mobility, infrastructure, economic development, and land use.
- Support Research and Data Sharing:
    - Conduct ongoing research on AV impacts and encourage data sharing from AV manufacturers and operators to inform policy development.

Report Summary

The 2021 Comprehensive Plan for Washington, DC, outlines significant measures to integrate AVs into the city's transportation system. The plan emphasizes safety, efficiency, and equitable access while addressing the potential impacts of AVs on traffic congestion, curbside management, and overall transportation patterns. The policies and actions recommended aim to harness the benefits of AV technology while mitigating potential negative consequences.

1) Overview and Goals
    a) Integration of AVs into the Transportation System:
        i) The District of Columbia Autonomous Vehicle Act of 2012 authorized AV operations on District roadways, aiming to integrate AVs while maintaining equitable access to transportation.
        ii) The moveDC plan recommends the District serve as a test bed for AVs, supporting policy and legal frameworks.
2) Safety and Mobility Enhancements
    a) Vision Zero and AVs:

    i) AVs should be designed to support Vision Zero goals, reducing traffic-related injuries and fatalities through better integration with traffic signals and infrastructure.
  b) Shared AV Services:
    i) Promoting shared AV services to reduce the number of single-occupancy trips and integrate with existing shared transportation services.
  c) Traffic Congestion and VMT:
    i) Strategies are needed to prevent AVs from increasing VMT and traffic congestion, particularly in areas already facing high traffic volumes.
3) Equitable Access and Environmental Sustainability
  a) Equitable AV Adoption:
    i) Ensuring AVs are available to all users, particularly underserved communities, to promote equity in transportation access.
  b) Environmental Considerations:
    i) AVs have the potential to reduce the need for parking and curbside access, contributing to a more efficient use of urban space and reducing environmental impacts.
4) Infrastructure and Technological Integration
  a) Smart City Technologies:
    i) Utilizing smart technologies to enhance the efficiency and safety of AV operations, including dynamic parking meters and connected signals.
  b) Data Sharing and Research:
    i) Encouraging AV operators to share data to support research and policymaking, focusing on impacts on land use, transportation patterns, and racial equity.
  c) Interagency Coordination:
    i) The AV Working Group, consisting of various agencies, should continue to develop policies ensuring AVs enhance safety, efficiency, equity, and sustainability while minimizing negative impacts.
5) Policy and Regulatory Framework
  a) Ongoing Evaluation and Adaptation:
    i) Regularly evaluate the impact of AVs and adapt policies to address emerging challenges and opportunities.
    ii) Encourage public participation in the planning and implementation of AV-related policies.
6) Parking and Curbside Management:
  a) Monitor and adapt to changes in parking and curbside usage due to AVs, using regulatory and technological tools to optimize urban space.

Conclusion

The integration of autonomous vehicles into Washington, DC's transportation system presents both opportunities and challenges. By focusing on safety, efficiency, equitable access, and environmental sustainability, the city can harness the benefits of AV technology while mitigating potential negative impacts. Continuous monitoring, research, and adaptive policies will be essential to ensure that AVs contribute positively to the District's transportation goals and overall quality of life.

District Department of Transportation. (2020). *DC AV Study Final Report.*

Key Recommendations

Policy Recommendations

- Alternative Transportation Pricing Strategies
  - Conduct a detailed analysis of different pricing strategies to manage automobile travel demand effectively, including roadway pricing and congestion fees.
- Vehicle Electrification Incentives
  - Develop and implement policies and programs to incentivize the electrification of the vehicle fleet to reduce greenhouse gas emissions.
- Workforce Retraining Programs
  - Establish programs to retrain workers in industries likely to be impacted by AV technology, focusing on creating new job opportunities.
- Planning and Zoning Adjustments
  - Re-evaluate parking requirements and zoning regulations to accommodate additional residents and adapt to changes brought by AV adoption.

Research Recommendations

- Economic Impact Analysis
  - Conduct a broad economic analysis to understand the effects of automation and emerging technologies on the District's economy.
- Infrastructure Needs Assessment
  - Identify specific infrastructure investments required to support AV deployment and adapt to new transportation technologies.
- Policy and Regulation Review
  - Analyze existing policies and regulations to ensure they can accommodate AV and other emerging transportation technologies.
- Development of Planning Tools
  - Support the creation and updating of tools and processes that incorporate emerging mobility trends for informed local and regional investment decisions.

Operational and Organizational Recommendations

- Increase DDOT Capacity
  - Enhance the capacity of DDOT with dedicated staff positions focusing on emerging technologies.
- Support Pilot Projects
  - Collaborate with other organizations and private entities to support pilot projects involving AV and connected vehicle (CV) technologies.
- Regional Coordination
  - Actively participate in coordinating regional plans and policies for AVs and other emerging transportation technologies.
- Safety-Focused CV Technologies

- Investigate and implement connected vehicle technologies that improve safety in urban environments.

Data Recommendations

- Data Sharing Requirements
  - Develop clear requirements for data sharing by all AV and transportation technology operators in the District, including operational and safety data.
- Regional Data Agreements
  - Establish data sharing agreements between DC agencies and regional entities to ensure effective use of data for planning and operations.
- Legal and Legislative Support
  - Pursue any necessary legal and legislative measures to facilitate data sharing and ensure comprehensive data collection.

These recommendations aim to guide the implementation and integration of autonomous vehicles in a way that maximizes benefits and mitigates potential negative impacts on the District.

Report Summary

1.0 Executive Summary

1. Introduction of Automated Vehicle Technology
   a. AV technologies will revolutionize transportation by changing daily travel choices and urban structures.
   b. The exact timeline for the arrival and adoption of AVs is uncertain, but major investments indicate it will happen.
2. Need for Proactive Planning
   a. Cities must plan proactively for AV technology to maximize benefits and mitigate risks.
   b. Potential impacts include changes in mobility, safety, traffic flow, economic growth, and urban development.
3. Potential Benefits and Challenges
   a. **Benefits:** Increased mobility for vulnerable populations, safety improvements, better traffic flow, economic growth, reduced parking needs, and improved accessibility.
   b. **Challenges:** Increased congestion, pollution, suburban sprawl, reduced revenue from non-AV sources, and job losses in driving-related industries.
4. Four Future Scenarios
   a. Scenario A: Households own Freeway Automated Vehicles
      i. Early availability of freeway automated vehicles, continued car ownership, growth relocation towards suburbs, dedicated AV lanes on freeways.
   b. Scenario B: Shared AV Fleets Expand Quickly
      i. Urban automation in shared fleets, replacement of traditional bus service and off-peak Metrorail, increased households, decreased car ownership.
   c. Scenario C: Strong High-Occupancy Prioritization
      i. Mix of shared and household-owned vehicles, dedicated high-occupany vehicle lanes, development of public and private mobility options to use high-occupancy lanes, increased households.
   d. Scenario D: Regional Congestion Fee

i. Mix of shared and household-owned vehicles, congestion fees on major roads to reduce congestion, AV shuttles for neighborhood circulation.

2.0 Introduction

1. Emerging Transportation Trends
    a. Advances in connectivity and automation are leading to significant changes in transportation.
    b. Other related trends include connected vehicles, shared economy, vehicle electrification, telework, e-commerce, gig economy, changing demographics, and urbanization.
2. Impact on Cities
    a. AVs will transform transportation systems, city structures, residential preferences, and space usage.
    b. Planning must consider multiple possible futures due to uncertainties in technology development and adoption.
3. Scenario Planning Approach
    a. The study used scenario planning to explore potential impacts of AVs.
    b. Scenarios consider varying levels of government intervention and different adoption patterns of AV technologies.

3.0 Scenarios and Assumptions

1. Scenario Descriptions
    a. Scenario A: Freeway Automated Vehicles
        i. Focus on household ownership of AVs with automated freeway travel.
    b. Scenario B: Shared AV Fleets
        i. Expansion of shared AV fleets and microtransit, reducing personal car ownership.
    c. Scenario C: High-Occupancy Prioritization
        i. Emphasis on high-occupancy vehicles and dedicated lanes to improve traffic flow.
    d. Scenario D: Regional Congestion Fee
        i. Implementation of congestion fees to manage road usage and reduce congestion.
2. Impact Analysis
    a. Each scenario analyzed for its potential effects on congestion, job growth, municipal revenues, transit ridership, and other transportation metrics.
    b. Comparisons made with standard forecasts to highlight differences and guide policy decisions.

4.0 Scenario Results

1. Transportation Performance Metrics
    a. Metrics include VMT, congestion levels, transit ridership, emissions, and economic impacts.
    b. Analysis highlights the potential range of outcomes and the need for continuous monitoring and adaptation.
2. Environmental and Safety Impacts

    a. Scenarios evaluated for their effects on greenhouse gas emissions, air quality, and public safety.
    b. AV technology expected to reduce crashes and improve overall safety.
3. Economic and Financial Impacts
    a. Potential changes in job markets, municipal revenues, and economic development due to AV adoption.
    b. Consideration of impacts on various sectors, including transportation, retail, and real estate.

5.0 Recommendations and Next Steps

1. Policy Recommendations
    a. Develop policies to support shared rides and alternative modes of transportation.
    b. Address the economic, social, and environmental impacts of AV technology.
2. Research Recommendations
    a. Further study is needed to understand long-term effects of AVs and refine policies accordingly.
    b. Emphasis on data collection and sharing to support informed decision-making.
3. Operational and Organizational Recommendations
    a. Increase organizational capacity to manage emerging technologies.
    b. Support pilot projects and regional coordination to implement AV solutions effectively.

Appendices

1. Detailed Results by Planning Area
    a. Specific impacts and metrics for different areas within the District and the region.
    b. Comparative analysis of VMT, congestion, transit usage, and emissions across planning areas.
2. Methodology and Assumptions
    a. Explanation of the modeling tools and assumptions used in the scenario analysis.
    b. Description of the process for developing and evaluating the four future scenarios.

Conclusion

The study concludes that AV technology, while promising, requires strong public policy guidance to maximize its benefits and minimize potential drawbacks. All scenarios indicate a likely increase in VMT, which could exacerbate congestion, emissions, and crashes if not properly managed. Key strategies to mitigate these issues include implementing congestion pricing, promoting shared rides, and incentivizing the use of electric vehicles. The study underscores the importance of early and coordinated policy actions to shape the future transportation landscape in a way that supports the District's economic, social, and environmental goals. By focusing on reducing the negative externalities associated with increased vehicle traffic, such as congestion and emissions, the District can sustain high levels of mobility and economic activity while limiting adverse impacts. The findings and recommendations from this study provide a roadmap for policymakers to prepare for and guide the integration of AV technology in the District's transportation system.

Ehsani, J., et al. (March 2024). *Advancing Transportation Equity and Safety Through Autonomous Vehicles*. School of Engineering, Johns Hopkins University.

Key Recommendations

- Prioritize deployment of AVs in communities and populations with the greatest mobility needs — e.g., older adults, low-income households, individuals with disabilities or visual impairment.
- Frame and communicate AV deployment not only as a matter of technology or safety, but as a social benefit and equity-enhancing intervention — to build broader public support.
- Incorporate equity-oriented policy and planning in AV adoption, ensuring that infrastructure, regulations, insurance, and deployment strategies consider historically underserved or high-risk communities.
- Use AV deployment as an opportunity to address broader systemic issues — for example, disparities in crash rates, exposures to traffic hazards, and lack of mobility access — as part of public health and equity strategies.
- Engage stakeholders (policymakers, planners, public health professionals, communities) in decisions about where and how AVs are deployed, to maximize social benefit and avoid reinforcing existing inequities.

Report Summary

The article argues that AVs—beyond their technical promise for safety—have the potential to advance health equity by improving transportation access, reducing crash-related mortality (which disproportionately affects marginalized communities), and alleviating structural inequities in mobility. In a nationally representative survey of U.S. adults, the authors show that public support for AVs increases substantially once respondents are informed about AVs' potential to serve vulnerable populations (e.g., older adults, low-income individuals, persons with visual impairments). The authors conclude that by intentionally prioritizing AV deployment to meet the needs of those with limited access to safe, reliable mobility, policymakers and planners can harness AVs not just for general technological progress—but as tools for social benefit, equity, and safety.

1) Disproportionate Burden of Traffic-related Harm on Vulnerable Communities
    a) The authors foreground that motor vehicle crashes remain a leading cause of death in the U.S., with minorities and disadvantaged groups bearing a disproportionate share of harms.
    b) Recognizing transportation as a social determinant of health—limited mobility often constrains access to jobs, care, and essential services.
2) Potential of AVs to Advance Safety and Equity
    a) AVs offer not just safety improvements, but also reductions in congestion, emissions, and mobility barriers.
    b) AVs could expand access to transportation for groups currently underserved by traditional transit (e.g., people with disabilities, older adults, low-income individuals).
3) Public Opinion and Framing Matter

a) The study's experiment demonstrated that public support for AVs increases dramatically when their deployment is framed in terms of social benefit and equity—rising from ~26.4% to a majority.
b) This suggests that public resistance to AVs may be—at least in part—a matter of perception, which can be shifted by highlighting equitable outcomes and social value.

4) Policy & Planning as Levers for Equity-Oriented Deployment
   a) The authors call for intentional policy design to ensure AV deployment benefits underserved communities rather than exacerbating inequities.
   b) They note implications for practitioners, insurers, regulators, and urban planners: deployment strategy must align with safety, access, and fairness.
5) Broader Structural & Systemic Context—Equity + Mobility as Public Good
   a) The paper situates AV deployment not just as a technological change, but as part of structural efforts to address systemic inequities: racial/ethnic disparities in crash mortality, inequitable access to transit, environmental burdens, and social isolation.
   b) AVs are presented as a potential tool in a broader societal push to address social determinants of health—not a silver bullet, but a promising component.

Conclusion

The authors of "Advancing Transportation Equity and Safety Through Autonomous Vehicles" make a compelling case that AVs hold more than just technological promise—they represent an opportunity to advance social justice, public health, and equity. Their survey-based evidence suggests that public acceptance of AVs increases substantially when their social utility is emphasized, especially for underserved populations. But realizing that potential depends heavily on intentional, equity-centered planning and policy: deploying AVs where mobility needs are greatest, engaging communities and stakeholders, and integrating AV deployment into broader efforts to reduce structural inequities in transportation and health. In doing so, AVs could become not just a feature of future mobility, but a lever for greater transportation justice and health equity.

Eliot, Lance and Mark Fagan. (2021). Developing Urban Mobility Policy in Response to Autonomous Vehicles: A Multi-Party Policy Development Simulation.

Key Recommendations

- Foster MaaS: Establish a comprehensive trip-planning, booking, and payment platform for multi-modal transport journeys.
- Rethink Curb Design and Street Space Allocation: Reevaluate the role of the curb to balance the needs of various users including AVs, pedestrians, and cyclists.
- Manage and Reduce Congestion: Develop strategies to control traffic congestion, including incentives for multi-rider AV trips and penalties for illegal drop-offs.
- Establish Data-Sharing Guidelines and Agreements: Create clear guidelines on data sharing between AV operators and city authorities, ensuring privacy and utility.
- Reposition Revenues: Plan for alternative revenue mechanisms to offset expected losses from traditional sources like parking fees and traffic fines due to AVs.

Report Summary

The document provides a comprehensive framework for developing urban mobility policies in response to the arrival of AVs. It outlines a multi-party simulation designed to help cities anticipate and manage the challenges associated with AV deployment, such as congestion, privacy concerns, and equitable access. The simulation encourages stakeholders to consider a range of policy actions, including fostering MaaS, rethinking curb usage, managing congestion, establishing data-sharing agreements, and repositioning revenue streams. By proactively addressing these issues, cities can better prepare for the transformative impact of AVs on urban mobility.

1) Simulation Overview:
   a) Purpose: Develop a consensus on urban mobility policy for AVs.
   b) Structure: Three sessions including roundtables and one-on-one meetings.
   c) Participants: AV providers, advocacy groups, and city officials.
2) Simulation Scenario:
   a) City Characteristics: Population of 900,000; growing density; significant reliance on personal vehicles.
   b) AV Operations: Several AV companies operate within the city, focusing on different transportation needs (ride-hailing, shuttles, delivery).
   c) Challenges: Concerns about congestion, privacy, equitable access, and the impact on traditional public transit.
3) Five Potential Policy Actions:
   a) **MaaS:** Integrate various transportation modes into a seamless service.
   b) **Curb Management:** Prioritize the use of curb space for different purposes throughout the day.
   c) **Congestion Control:** Use policies to manage AV impact on traffic, especially regarding potential "zombie cars."
   d) **Data Governance:** Define how AV-related data should be shared, used, and protected.
   e) **Revenue Planning:** Anticipate and mitigate the financial impact of reduced revenue from parking and traffic violations.

4) Post-Simulation Mapping:
    a) **Propensity Matrix:** Evaluate the pervasiveness of AVs and the maturity of urban mobility policies to guide future planning.
    b) **Balanced Progression:** Cities should aim to develop policies that align with the increasing use of AVs, avoiding instability.

Conclusion

The advent of AVs presents both opportunities and challenges for urban mobility. Cities must be proactive in developing policies that balance the benefits of AVs with potential downsides, such as increased congestion and privacy concerns. The simulation detailed in this document provides a valuable tool for policymakers to engage with stakeholders, explore potential scenarios, and build consensus on the best path forward. By implementing the recommended policy actions, cities can position themselves to harness the advantages of AV technology while mitigating adverse effects, ensuring a more livable and equitable urban environment.

Hemphill, T. A. (2020). *Autonomous vehicles: U.S. regulatory policy challenges*. Technology in Society, 61, 101232.

Key Recommendations

- Establish Federal and State Cooperation Infrastructure
  - Form a national AV advisory council within the federal executive branch.
  - Include relevant agencies, legislative staff, local government representatives, and non-governmental stakeholders.
  - Expand the dialogue to address issues beyond safety, such as cybersecurity and infrastructure development.
- Promote Research Transparency and Data Sharing
  - Develop voluntary guidelines for the release of AV testing and development data by automotive companies.
  - Create data-sharing agreements that ensure the safe storage and transfer of confidential information.
  - Encourage the DOT to lead in establishing best practices for data confidentiality and sharing.
- Balance Innovation and Regulatory Policies
  - Adopt non-prescriptive, performance-based regulatory approaches to encourage innovation.
  - Provide design flexibility and limited exemptions for testing non-traditional vehicle designs (SAE Levels 4 and 5).
  - Introduce new regulatory tools and statutory authorities to support the deployment of advanced AV technologies.
- Implement Base-Line Federal Legislation
  - Pass federal legislation to establish clear and consistent regulatory standards across states.
  - Address unresolved issues such as safety, data privacy, cybersecurity, and liability.
  - Engage automotive industry stakeholders in educating and collaborating with Congress and regulators.
- Enhance Federal Guidance and State Roles
  - Maintain NHTSA's role in regulating safety design and performance aspects of AV technology.
  - Avoid conflicting federal and state regulations that could impede AV deployment.
  - Provide guidance to state agencies on training and licensing test drivers and encourage local governments to facilitate AV testing on local roadways.
- Encourage Voluntary Safety Self-Assessments
  - Request AV developers to publish safety self-assessments to demonstrate risk mitigation during testing.
  - Strongly discourage state or local ordinances that hinder AV testing and deployment.

Report Summary

The paper "Autonomous Vehicles: U.S. Regulatory Policy Challenges" by Thomas A. Hemphill discusses the regulatory landscape for AVs in the United States. It emphasizes the potential safety benefits of AVs, which could significantly reduce traffic fatalities. Despite technological advancements, consumer

skepticism and regulatory challenges persist. The paper reviews state and federal regulatory efforts, noting the diverse approaches among states and the evolving federal guidelines. It proposes a national regulatory framework to harmonize state and federal efforts, promote data sharing, balance innovation with safety, and establish baseline federal legislation to ensure consistent standards across the country.

1) Introduction
    a) USDOT predicts fully automated cars and trucks will eventually become a reality.
    b) Safety is a key motivation, with potential reductions in traffic fatalities by 27% or around 10,000 lives annually.
    c) Despite industry confidence, consumer skepticism remains high, with only 14% willing to use self-driving services like Uber or Lyft.
    d) Media reports on crashes involving AVs contribute to this skepticism.
    e) This paper examines the regulatory environment for AVs in the U.S. and proposes a national regulatory policy framework.
2) Self-Driving Autonomy Levels
    a) The SAE defines six levels of autonomy from "No Autonomy" (Level 0) to "Full Autonomy" (Level 5).
    b) Current technology is at Level 2 (Partial Automation), where vehicles can control certain functions but require driver oversight.
    c) Examples of Level 2 technology include Tesla Autopilot and General Motors Super Cruise.
    d) Level 3 (Conditional Autonomy) and Level 4 (High Automation) technologies will require significant regulatory and stakeholder efforts before commercial deployment.
3) State AV Legislation
    a) Since 2012, 41 states and D.C. have introduced AV-related legislation, with an increasing trend in states considering such legislation annually.
    b) Nevada was the first state to enact AV legislation in 2011, followed by 29 states and Washington D.C. with enacted legislation and 11 states with executive orders.
    c) Regulatory approaches vary widely; for example, Arizona imposes no restrictions, while New York requires direct supervision by state police for AV testing.
4) Federal AV Public Policy Initiatives
    a) The NHTSA released the first AV voluntary guidance in 2016, focusing on a 15-point safety assessment.
    b) The Trump administration's 2017 guidance document, "A Vision for Safety 2.0," revised the safety self-assessment and reduced the guidelines from 15 to 12 points.
    c) In 2018, USDOT published "Preparing for the Future of Transportation: Autonomous Vehicles 3.0," which emphasized stakeholder collaboration and discouraged state or local ordinances hindering AV testing.
5) Proposed National AV Regulatory Policy Framework
    a) Federal and State Cooperation: Establish an AV advisory council for efficient interaction between federal and state governments.
    b) Research Transparency and Data Sharing: Encourage voluntary release of AV testing data, balanced with protecting competitive trade secrets.
    c) Balancing Innovation and Regulation: Develop flexible regulatory tools that promote innovation while ensuring consumer safety.
    d) Base-Line Federal Legislation: Advocate for baseline federal legislation to provide clarity and consistency across states, addressing safety, data privacy, and cybersecurity.
6) Challenges and Future Directions

a) Lack of federal regulatory direction has impeded AV technology commercialization.
b) Regulatory gaps between state and federal levels remain a challenge.
c) Moving forward, comprehensive federal legislation is needed to support the safe and innovative deployment of AV technology, with collaboration among stakeholders to address evolving policy questions.

Conclusion

To realize the potential of AV technology, a collaborative regulatory environment is essential. Federal and state governments must work together, supported by a national AV advisory council. Voluntary data sharing and performance-based regulations will foster innovation while ensuring safety. Passing federal legislation to provide clear, consistent standards is crucial. By addressing these challenges, the U.S. can lead in the safe and efficient deployment of autonomous vehicles, benefiting public safety and technological progress.

Loftus-Otway, Lisa, and Susanna Gallun. (June 2024). *Multistate Coordination and Harmonization for AV Legislation* (NCHRP LRD 91).

Key Recommendations

- Establish a Consistent Legal Framework
  - Federal Legislation: Enact comprehensive federal legislation to create a uniform legal framework for AV deployment across all states.
  - State Coordination: Encourage states to adopt the UAOVA to standardize regulations.
- Clarify Liability and Safety Standards
  - Liability Definitions: Define clear liability standards for AV manufacturers, operators, and users to address legal responsibilities in case of accidents.
  - Safety Protocols: Develop stringent safety standards and protocols for AV operation, including regular inspections and maintenance requirements.
- Improve Enforcement Mechanisms
  - Compliance Monitoring: Implement robust systems for monitoring compliance with AV regulations, including real-time data collection and reporting.
  - Penalties and Sanctions: Establish clear penalties and sanctions for non-compliance to ensure adherence to safety and operational standards.
- Enhance Operator Requirements and Training
  - Licensing and Certification: Create standardized licensing and certification requirements for AV operators, including training programs for remote driving.
  - Continuous Education: Require continuous education and re-certification for AV operators to keep up with technological advancements and regulatory changes.
- Address Technological Barriers
  - Cybersecurity Measures: Implement comprehensive cybersecurity measures to protect AV systems from hacking and data breaches.
  - Data Privacy: Establish strict data privacy standards to safeguard personal information collected by AV systems.
- Promote International Harmonization
  - Global Standards: Align U.S. AV regulations with international standards to facilitate global interoperability and market access.
  - International Collaboration: Foster collaboration with international regulatory bodies to share best practices and harmonize AV legislation globally.
- Foster Industry Collaboration
  - Public-Private Partnerships: Encourage public-private partnerships to leverage industry expertise in developing practical and effective AV regulations.
  - Stakeholder Engagement: Engage industry stakeholders in the regulatory process to ensure that regulations are feasible and support technological innovation.
- Public Awareness and Education
  - Public Campaigns: Launch public awareness campaigns to educate consumers about AV technology, safety features, and legal responsibilities.
  - Stakeholder Training: Provide training for law enforcement, first responders, and other stakeholders on interacting with AVs and managing AV-related incidents.
- Long-Term Research and Development
  - R&D Investments: Invest in research and development to advance AV technology and address emerging challenges in AV deployment.

    - Pilot Programs: Support pilot programs and real-world testing of AVs to gather data and refine regulations based on practical experiences.
- Continuous Review and Adaptation
    - Regulatory Flexibility: Ensure that AV regulations are flexible and adaptable to keep pace with rapid technological advancements.
    - Periodic Reviews: Conduct periodic reviews of AV legislation to identify gaps, assess effectiveness, and make necessary adjustments.

Report Summary

The report "Multistate Coordination and Harmonization for AV Legislation" provides comprehensive guidance on harmonizing AV legislation across states for Levels 3 through 5 vehicles. It addresses the current landscape of federal and state regulations, highlighting the variability and conflicts that arise from differing state laws. The report emphasizes the importance of a consistent regulatory framework to facilitate seamless AV deployment, enhance safety, and promote innovation. Key areas of focus include licensing, registration, operator requirements, equipment standards, and insurance. The report also explores international regulatory approaches and identifies opportunities for harmonization at both national and international levels. Stakeholder collaboration among federal, state, and local governments, industry, and international partners is crucial to achieving a cohesive regulatory environment for AVs.

1) Introduction
    a) Project Purpose: This project aims to provide guidance for multistate coordination and harmonization of AV legislation for Level 3 through 5 vehicles.
    b) Methodology: Researchers reviewed federal and state statutes, regulations, executive orders, policy documents, literature within law journals, and case law. They also analyzed existing compacts and the UAOVA.
2) Technology Characteristics of AVs
    a) NHTSA Standards: The NHTSA has developed policies and guidelines since 2013 to support the deployment of AVs.
    b) Levels of Automation:
        i) Level 3 (L3): Conditional driving automation where the vehicle can perform all driving tasks under certain conditions but requires the human driver to take over when necessary.
        ii) Level 4 (L4): High automation where the vehicle can handle all driving tasks in specific scenarios without human intervention.
        iii) Level 5 (L5): Full automation where the vehicle can perform all driving tasks under all conditions without any human intervention.
    c) Challenges at L3: Determining the handoff between the human driver and the AV system, legal definitions of driver responsibilities, and ensuring safety and liability measures.
3) Federal Regulatory Review
    a) Federalist Structure: The U.S. Constitution’s Supremacy Clause establishes federal preemption over conflicting state laws. However, states have traditional police powers over public safety, including traffic laws.

b) NHTSA's Role: NHTSA regulates AVs using existing tools like interpretations, exemptions, rulemaking, and enforcement. It does not pre-approve new technologies but ensures compliance with FMVSS.
c) Congressional Activity: Various bills have been proposed but not yet enacted, focusing on AV deployment and safety standards.

4) State Regulatory Overview
   a) State Laws Variability: States have differing laws on AV registration, licensing, insurance, and safety. Some states have adopted the UAOVA to standardize regulations.
   b) Remote Driving: Regulations differ on remote driving capabilities and the requirements for remote drivers. Some states have implemented specific training and licensing for remote operation.
   c) Local Government Preemption: States have the authority to preempt local regulations, ensuring uniformity within their jurisdiction.
5) International Activity Overview
   a) Canada: Focuses on harmonizing AV regulations with the U.S. and developing safety standards.
   b) Japan: Emphasizes the development of AV technology and regulatory frameworks to support deployment.
   c) China: Pursues aggressive AV technology development and regulatory implementation.
   d) Australia: Works on establishing a legal framework for AVs, focusing on safety and deployment.
   e) European Union: Harmonizes AV regulations across member states to facilitate cross-border AV operations.
   f) United Kingdom: Develops specific regulations to support AV testing and deployment.
6) Barriers and Conflicts
   a) Legal Barriers: Conflicts between federal and state laws, issues with preemption, and inconsistent definitions and standards.
   b) Technological Barriers: Challenges related to cybersecurity, data privacy, and the interoperability of AV systems.
   c) Regulatory Gaps: Lack of comprehensive federal legislation leads to a patchwork of state-specific regulations, causing uncertainty for AV developers and operators.
7) Opportunities for Harmonization
   a) Existing Processes: Utilization of current frameworks and efforts to harmonize AV regulations across states.
   b) Short-Term Opportunities: Immediate steps include creating a consistent legal framework, clarifying liability and safety standards, and improving enforcement mechanisms.
   c) Medium-Term Opportunities: Focus on developing national guidelines and standards, enhancing interstate collaboration, and addressing technological challenges.
   d) Long-Term Opportunities: Establish comprehensive federal legislation, integrate international standards, and ensure the seamless operation of AVs across state and national borders.

Conclusion

The deployment and regulation of AVs in the United States present both significant challenges and opportunities. Immediate priorities include establishing a consistent legal framework, clarifying liability and safety standards, and improving enforcement mechanisms. In the medium to long term, comprehensive harmonization efforts are necessary, including enacting federal legislation and integrating international standards to ensure the seamless operation of AVs across state and national

borders. Stakeholder collaboration is essential, involving federal, state, and local governments, industry stakeholders, and international partners. By working together, a cohesive regulatory environment can be achieved, promoting the safe and efficient deployment of AVs and fostering technological innovation.

National Highway Traffic Safety Administration (NHTSA). (January 2025). ADS-Equipped Vehicle Safety, Transparency, and Evaluation Program (AV STEP)

Key Issues

- Lack of standardized safety assurance: Current AV deployments rely on inconsistent, voluntary safety cases.
- Transparency gaps: Public lacks comparable safety information across ADS developers.
- Patchwork state reporting systems: No national, harmonized incident-reporting requirement.
- Regulatory uncertainty for deployment: Developers lack a structured federal pathway for commercial operations requiring exemptions.
- Insufficient operational data: NHTSA lacks consistent information needed for future ADS performance standards.
- Limited clarity for enforcement: Need clearer mechanisms to suspend or remove unsafe participants.
- Voluntary nature may limit reach: Program relies on industry participation and does not replace broader regulation.

Key Recommendations

- Establishing a National ADS Oversight Framework
    - Create a unified, voluntary federal program that provides structured oversight of ADS-equipped vehicle deployments while supporting innovation and commercial scaling.
    - Standardize safety evaluations through required ADS Safety Assurances, Operational Safety Monitoring, and post-incident reporting for participants.
- Improving Transparency and Public Trust
    - Require participating developers to submit publicly available summaries of safety cases, system capabilities, ODD descriptions, limitations, and testing methodologies.
    - Mandate regular safety performance updates, including system failures, operational exceedances of ODD, and crash events.
- Strengthening Data Collection for Federal Safety Analysis
    - Require standardized safety performance data, including minimal risk condition activations, ADS disengagements, crash details, and safety-related software updates.
    - Use reporting to build a national dataset that informs future rulemaking and FMVSS modernization for ADS-equipped vehicles.
- Ensuring Safety in Deployment and Operations
    - Allow only ADS platforms that meet minimum eligibility criteria (e.g., documented safety processes, responsible operator, cybersecurity protections, remote operations protocols).
    - Require participants to maintain risk mitigation strategies, including real-time monitoring, geofenced ODD enforcement, fallback systems, and safe stopping protocols.

- Integrating AV STEP With Existing NHTSA Authorities
    - Align AV STEP with NHTSA's defect investigation and enforcement authority so participation does not limit NHTSA's ability to order recalls or initiate investigations.
    - Establish procedures for suspension or removal from AV STEP when safety deficiencies or non-compliance arise.
- Supporting Scalable Commercial Deployment
    - Provide a predictable federal structure that minimizes the current patchwork of state oversight, reducing friction for multi-state ADS operations.
    - Use lessons learned from AV STEP deployments to guide future ADS performance standards and permanent regulatory frameworks.

Report Summary

The AV STEP Proposed Rule (January 2025) establishes NHTSA's first formal, voluntary national framework for evaluating, monitoring, and publicly reporting on the safety performance of ADS-equipped vehicles operating on U.S. roads. The program is designed to bridge the gap between ongoing ADS deployments and the future creation of performance-based federal standards. Under AV STEP, participating developers and operators must meet eligibility requirements, submit an ADS Safety Assurance, define their ODD, and commit to structured monitoring and reporting obligations. NHTSA emphasizes that participation does not exempt manufacturers from defect reporting, recall obligations, or other statutory requirements; instead, it creates a collaborative framework to generate high-quality data, enhance public transparency, and support safe innovation.

Central to AV STEP is a system of safety transparency, where participants publish non-confidential safety summaries describing system capabilities, limitations, safety mitigations, cybersecurity practices, and safety management governance. Participants also undergo ongoing operational safety monitoring, including reporting of crashes, ADS disengagements, minimal risk condition activations, safety-relevant updates, and boundary exceedances. The intent is to produce a national evidence base to inform future FMVSS modernization, ADS performance standards, and regulatory reforms. The proposal has generated broad public and industry response because it represents a major shift toward structured federal AV oversight without imposing a mandatory regulatory regime.

1) Purpose and Scope of AV STEP
    a) Establishes a voluntary national program for developers and operators of SAE Level 3–5 ADS-equipped vehicles.
    b) Designed to support safe deployment, evaluate real-world performance, and generate reliable safety datasets.
    c) Intended as an interim framework pending future ADS-specific safety standards.
2) Eligibility Requirements
    a) Participants must:
        i) Operate ADS-equipped vehicles that already have significant safety engineering and testing.

ii) Demonstrate safety governance structures, including internal safety review and responsible officers.
iii) Provide cybersecurity and software management plans.
iv) Document teleoperation or remote-assistance processes, when applicable.
v) Define ODDs and safety mitigations for ODD boundary exceedance.
vi) Show sufficient maturity for on-road operation, with NHTSA retaining discretion to reject applicants.

3) ADS Safety Assurance (Application Component)
   a) Participants must submit:
      i) A safety case summarizing system architecture, perception and planning capabilities, fallback strategies, and minimal risk condition logic.
      ii) Risk analysis and mitigation documentation.
      iii) Testing validation evidence, including simulation, closed-course, and on-road trials.
      iv) Safety management and organizational processes for continuous safety improvement.
      v) Certification that the ADS is designed to comply with applicable FMVSS unless an exemption is in place.
4) Transparency Requirements
   a) Public disclosures include:
      i) A high-level safety summary describing ADS capabilities, limitations, and safety strategies.
      ii) ODD description (geography, speeds, weather, road types, traffic conditions).
      iii) Known system limitations and mitigation strategies.
      iv) Summary of testing activities and operational experience.
      v) Non-confidential portions posted on NHTSA's public website.
5) Operational Safety Monitoring
   a) Participants must implement:
      i) Real-time ADS monitoring processes and logging.
      ii) Continuous oversight of human remote operators, if used.
      iii) Safety-critical data retention for incident reconstruction.
      iv) Reporting of ODD boundary exceedances, unusual ADS behavior, or system degradations.
6) Reporting Requirements
   a) Mandatory reporting includes:
      i) Crashes, with details similar to (but distinct from) the SGO reporting.
      ii) ADS disengagements or transitions to minimal risk condition initiated by system failure or environmental limits.
      iii) Minimal risk condition activations (safe stop events).
      iv) Safety-relevant software updates.
      v) Annual summaries of operational data.
      vi) Periodic renewal of participation status.
7) NHTSA Oversight and Enforcement
   a) Participation does not limit NHTSA's ability to open investigations, order recalls, or compel information.

b) NHTSA may suspend or revoke participation for significant safety concerns or non-compliance.
c) Participants must comply with defect reporting and other statutory obligations throughout.

8) State and Local Coordination
   a) AV STEP aims to reduce fragmentation by offering a federal layer of oversight.
   b) States may rely on AV STEP documentation for permitting, though state authority remains intact.
   c) NHTSA encourages multijurisdictional operations to generate diverse data.
9) Relationship to FMVSS and Future Rulemaking
   a) AV STEP provides real-world evidence to support modernization of FMVSS for ADS-equipped vehicles.
   b) Data from AV STEP will inform potential future performance-based ADS standards or new safety regulations.
   c) Serves as a precursor to a full federal ADS framework under NHTSA and USDOT's AV principles.
10) Expected Benefits
   a) Improves transparency for the public and safety regulators.
   b) Enhances NHTSA's understanding of ADS safety performance and failure modes.
   c) Enables more consistent and safe deployments across states.
   d) Supports innovation by clarifying expectations for responsible deployment.
   e) Provides a pathway for commercial entities to introduce ADS services while maintaining safety oversight.

National Highway Traffic Safety Administration (NHTSA). (July 2025). Research and Rulemaking Activities on Vehicles Equipped with Automated Driving Systems Report

Key Issues

- FMVSS misalignment with ADS designs: Current safety standards assume human drivers and cannot fully accommodate driverless, unconventional cabin layouts.
- Fragmented and incomplete rulemaking: Multiple ADS-related rulemakings (e.g., telltales, crash reporting, exemption frameworks) remain in early stages.
- Dependence on temporary tools (e.g., SGO): Oversight relies on investigatory orders rather than permanent regulations.
- Insufficient performance-based standards: No unified safety performance criteria for ADS driving behavior.
- Gaps in human-factors understanding: Unknowns around handoff behaviors, accessibility needs, remote operations, and public comprehension.
- Crashworthiness uncertainties: Reclined and novel seating configurations introduce new biomechanical risks not yet regulated.
- Limited data for policymaking: Research programs still building methodologies for objective, standardized ADS evaluation.

Key Recommendations

- Regulatory Framework & Standards
    - Accelerate development of a unified federal regulatory framework for ADS, aligning research, rulemaking, and enforcement activities under DOT's three AV principles: *prioritize safety*, *enable innovation*, *support commercial deployment*.
    - Modernize FMVSS to address ADS-equipped vehicles with unconventional seating, controls, and cabin layouts, informed by NHTSA's multi-volume FMVSS applicability research.
    - Finalize rulemakings on telltales, indicators, and warnings to reflect vehicles without traditional driver controls or displays.
- Data Collection & Safety Oversight
    - Transition the SGO crash reporting requirements into a permanent regulation to ensure continuous, streamlined data reporting for ADS and Level 2 ADAS.
    - Strengthen data-driven safety evaluation tools—simulation, scenario-based testing, and augmented-reality test methods—to improve assessment of ADS performance and system reliability.
    - Expand the AV STEP demonstration program to ensure structured, transparent monitoring of ADS deployments on public roads.
- Testing, Evaluation, and Human Factors
    - Advance research on subsystem performance (perception, planning, control) and AI/ML reliability to identify failure modes and improve industry safety practices.
    - Develop robust performance-based assessment methods applicable across diverse ADS designs and operating environments.
    - Incorporate accessibility, inclusive design, and teleoperation considerations into ADS human-factors rulemaking and research efforts.
- Exemptions, Deployment Pathways, and Industry Support

- Expand the Temporary Exemption Program to domestic manufacturers to support safe deployment and testing of novel ADS designs at scale.
- Use AV STEP as a controlled path for commercial ADS deployments while generating safety and operational data to inform future standards.

Report Summary

The July 2025 NHTSA report to Congress outlines the agency's comprehensive progress toward establishing a modernized regulatory framework for ADS and supporting technologies. Guided by USDOT's AV Framework principles—prioritizing safety, unleashing innovation, and enabling commercial deployment—NHTSA is transitioning from guidance-based oversight to a codified, data-driven regulatory system. Key actions include the Third Amended SGO on crash reporting, which refines requirements for ADS and Level 2 ADAS incident data collection, and forthcoming rulemakings to transform this order into a permanent regulation. These measures aim to sustain near-real-time visibility into ADS performance while reducing reporting burdens and improving clarity for manufacturers and operators.

Complementing its rulemaking activity, NHTSA continues an extensive research portfolio evaluating ADS performance, FMVSS applicability, crashworthiness in novel cabin layouts, subsystem reliability, AI/ML safety challenges, human factors, accessibility, cybersecurity, and remote operation. Ongoing rulemakings—including updates to FMVSS, telltales and warnings, exemptions for domestic ADS manufacturers, and the AV STEP demonstration program—are designed to align regulatory structures with emerging ADS designs that lack traditional driver roles. Together, these efforts signal a deliberate move toward a performance-oriented, flexible oversight system that supports safe innovation and positions the United States to maintain leadership in the global AV ecosystem.

1) Policy Context and Purpose
    a) Congress requires biannual reporting on ADS rulemaking and research activities.
    b) The July 2025 report is the second such update, focusing exclusively on SAE Level 3–5 ADS.
    c) USDOT's AV Framework (April 2025) provides the strategic direction for rulemaking.
2) Third Amended SGO on Crash Reporting
    a) Effective June 2025; supersedes earlier versions while preserving enforceability.
    b) Streamlines crash reporting for ADS and Level 2 ADAS while maintaining safety-critical data flow.
    c) Clarifies definitions (e.g., ADS engagement, crash scope, notice requirements).
    d) Requires three years of ongoing reporting; retains update obligations as more information is learned.
    e) Informs defect investigations and safety trends; supports a forthcoming rulemaking to codify the SGO.
3) ADS Research Portfolio
    a) FMVSS applicability: Multi-volume study reviewing 81 standards for compatibility with ADS designs.
    b) System performance assessment: Scenario-based testing, simulation, augmented-reality evaluations, and objective performance metrics.

c) Subsystem and AI/ML safety: Investigation of perception, planning, control, and ML reliability and failure modes.
d) Crashworthiness: Study of reclined seating, rear-facing occupants, child safety in front-row ADS configurations, and interactions with vulnerable road users.
e) Human factors: Development of new human-machine interface approaches, warnings, remote operations, and accessibility standards for diverse users.
f) Cybersecurity: Ongoing research on firmware update security and cyber risk mitigation.

4) Status of Key Rulemakings
a) Pilot Program for HAVs: Being withdrawn; lessons integrated into AV STEP.
b) Crash Avoidance Testing Updates: Notice of Proposed Rulemaking issued; additional requirements under review.
c) Telltales/Indicators (FMVSS 101 updates): Notice of Proposed Rulemaking planned to reflect ADS vehicles without traditional instrument clusters.
d) Temporary Exemption Program (RIN 2127-AM14): Notice of Proposed Rulemaking to broaden eligibility to domestic ADS manufacturers.
e) ADS Safety Framework (RIN 2127-AM15): Further analysis underway to develop a structured safety assessment regime.
f) AV STEP Demonstration Program: Notice of Proposed Rulemaking issued January 2025; provides controlled deployment pathway with enhanced oversight.
g) Incident Reporting Codification (RIN 2127-AM63): Notice of Proposed Rulemaking in development to replace the SGO with a permanent rule.

5) Overall Direction and Future Outlook
a) NHTSA is shifting from ad hoc oversight tools to permanent regulatory structures.
b) Data-driven safety evaluation (SGO + AV STEP) will shape future FMVSS, performance-based standards, and enforcement.
c) Research, rulemaking, and enforcement activities are increasingly integrated to support a scalable national AV regulatory framework.
d) The agency positions AV regulation as both a public safety mandate and a national competitiveness priority.

Norman, Mark and Kortum, Katherine. (2023). Toward a National Regulatory Framework for Automated Vehicles: Challenges and Opportunities (TRB Circular E-C284).

Key Recommendations

- Federal Leadership and Framework Development
    - USDOT should spearhead the creation of a national regulatory framework that encompasses safety, equity, and sustainability.
    - Implement the Highly Automated Systems Safety Center of Excellence to expand staff expertise and streamline AV regulations.
- State and Local Coordination
    - Encourage states to adopt a uniform approach to AV regulations to avoid a patchwork system.
    - Support state and local agencies with resources and guidance for AV testing and deployment.
- Industry Collaboration
    - Promote the adoption of industry-wide safety standards and voluntary safety self-assessments.
    - Foster public-private partnerships to advance AV technology and deployment.
- Public Engagement and Education
    - Develop comprehensive public education campaigns about the capabilities and limitations of AV technologies.
    - Involve local communities in pilot projects to build trust and gather feedback.
- Research and Data Sharing
    - Establish a national database to track AV pilot projects and share data on performance and safety.
    - Conduct research on safety metrics beyond crashes to better understand AV impacts.

Report Summary

The TRB Circular E-C284, "Toward a National Regulatory Framework for Automated Vehicles: Challenges and Opportunities," summarizes a series of panels held in 2022 by the TRB Forum on Preparing for Automated Vehicles and Shared Mobility Services. The panels discussed the current regulatory landscape for AVs in the United States and examined federal, state, local, and industry perspectives on developing a cohesive national framework. Key points include the need for consistent safety metrics, the importance of federal leadership in creating guidelines, and the necessity of collaboration among all stakeholders to address the evolving AV technology landscape.

Federal Perspectives

Challenges:

- Existing regulations are not designed for AV technology.
- Long timeframes for rulemaking due to requirements for public input and data analysis.
- Immature technology and evolving data complicate regulatory efforts.

Opportunities:

- Leveraging grant programs from the Infrastructure Investment and Jobs Act (IIJA).
- Developing performance standards for ADAS and AVs.
- Enhancing internal coordination within the U.S. DOT and international collaboration.

State Perspectives

Challenges:

- States face a patchwork of regulations, permitting, testing, and insurance requirements.
- Limited resources and expertise at the state level to develop AV regulations.

Opportunities:

- Collaboration through associations like the American Association of State Highway and Transportation Officials (AASHTO) and AAMVA.
- Consistent permitting mechanisms and traffic laws across states.
- Increased federal support and guidance to harmonize state regulations.

Local Perspectives

Challenges:

- Limited resources and staff capacity for testing and evaluating AV technologies.
- Lack of public awareness and understanding of AV capabilities and limitations.

Opportunities:

- Pilot tests to address real-world practices and problems.
- Public engagement to build trust and gather community feedback.
- Partnerships with industry and research organizations to advance local AV initiatives.

Industry Perspectives

Challenges:

- Regulatory impediments to scaling and deploying AV technology.
- Inconsistent safety metrics and voluntary guidelines.

Opportunities:

- Development of safety case frameworks and industry standards.

- Collaboration with federal and state agencies to create best practices for testing and deployment.
- Public-private partnerships to address regulatory and operational challenges.

Human Factors and Safety Issues

Challenges:

- Overreliance on ADAS features leading to unsafe driving situations.
- Lack of standardization in terminologies and user interfaces across different vehicle makes and models.

Opportunities:

- Standardizing safety features and interfaces to improve user understanding and trust.
- Educating the public on the capabilities and limitations of AV technologies.
- Research on human factors to ensure safe integration of AVs into the existing fleet.

Conclusion

A cohesive national regulatory framework for AVs is essential to advance the technology while ensuring safety, equity, and sustainability. Federal leadership is crucial in setting guidelines and standards, while state and local agencies must coordinate their efforts to avoid regulatory fragmentation. Industry collaboration and public engagement are key to building trust and addressing the challenges of AV deployment. Ongoing research and data sharing will support the development of effective policies and regulations, fostering a safe and innovative AV ecosystem.

Olds, T., et al. (April 2025). Recent Experiences in Advancing and Deploying of Automated Vehicle Technologies

Key Issues

- Regulatory fragmentation and uncertainty: States face inconsistent and sometimes ambiguous statutory environments—especially around the definition of "driver," roles of software vs. human operators, and the division of federal vs. state authority. This patchwork complicates planning and does not clearly correlate with more or better deployments.
- No clear link between permissive laws and deployment success: Highly permissive states sometimes see limited AV activity, while more tightly regulated states can see extensive deployments, indicating that policy permissiveness alone does not drive deployment scale or quality.
- State DOT mission misaligned with AV system complexity: Infrastructure Owner-Operators (IOOs) are responsible for roads and facilities, not vehicle design. Yet AV pilots often demand that they engage in vehicle behavior, software performance, and safety-case questions outside their core mission and expertise.
- Unclear definition of "AV-ready" infrastructure: States struggle to define what level of pavement markings, signage, mapping, and connected-vehicle infrastructure is needed to reliably support AVs. There is no shared national readiness framework.
- Resource constraints and limited technical capacity: Most agencies lack dedicated AV staff, long-term funding, and in-house expertise. A few states with strong programs (e.g., Florida, Ohio, Minnesota, Utah, North Carolina) demonstrate the importance of sustained champions and organizational structures.
- AV shuttle pilots often fail to scale: Many shuttle projects encountered reliability problems (Global Navigation Satellite System, Vehicle-to-Everything (V2X), weather, battery range, low speeds) and often provided lower-quality service than conventional transit, leading to poor ridership and limited long-term viability.
- Procurement and project delivery barriers: Traditional procurement processes are slow and inflexible, poorly suited to iterative pilots and rapidly evolving AV technology, delaying deployments and limiting innovation.
- Mixed results from connected-vehicle deployments: While CV/V2X infrastructure is widely seen as beneficial, several states reported technical failures, interoperability challenges, or unclear value in supporting AVs.
- Emergency response conflicts and training gaps: AVs have created new operational challenges for first responders (e.g., unusual stopping behavior, difficulty moving vehicles), and many jurisdictions lack standardized protocols or training for AV incidents.
- Fragmented data governance and limited transparency: Approaches to AV data collection, storage, sharing, and public reporting vary widely; in many deployments, states lack robust access to operational data held by private AV operators.

- No common definition of “pilot” versus “deployment”: States and industry use these terms inconsistently, which complicates expectations, evaluation, and communication with the public and policymakers.

Key Recommendations

- Build dedicated AV organizational capacity: Create or strengthen AV/CAV units within DOTs, secure multi-year funding, and invest in staff training and partnerships (e.g., universities, MPOs, private sector).
- Seek clearer federal guidance and national alignment: Encourage USDOT/NHTSA to clarify definitions (driver, operator, ADS levels), safety expectations, and state–federal roles, and to harmonize state policy where possible.
- Use phased, data-driven deployment strategies: Start with pilots, scale only when data demonstrate safety and public benefit, and embed continuous monitoring and adaptation.
- Focus on meaningful public benefit and equity: Design AV projects to solve real problems (e.g., ADA access, rural connectivity, first/last-mile, aging populations), not just “technology demos.”
- Strengthen public engagement and communication: Use demonstrations, outreach, and transparent reporting to build trust, address skepticism, and incorporate community needs and concerns.
- Integrate emergency responders early: Co-develop training, incident-response protocols, and data-sharing practices with police, fire, emergency medical services, and traffic incident management teams.
- Advance infrastructure readiness in a targeted way: Improve lane markings, signage, mapping, and—where appropriate—CV infrastructure, while recognizing that “perfect infrastructure” is neither realistic nor required for all deployments.
- Develop consistent data governance frameworks: Define what data are collected (safety, operations, equity), how long they are stored, who can access them, and how they are used to support policy and operations.
- Document and share lessons learned: Publish findings from pilots and deployments so that other states can avoid repeating failures and can adapt successful concepts more quickly.

Report Summary

NCHRP Domestic Scan 23-02 provides a national snapshot of how state DOTs and partner agencies are advancing and deploying AV technologies, highlighting both promising practices and systemic barriers. The scan finds that states are highly motivated—citing safety, mobility, and economic development goals—but operate in a fragmented regulatory landscape with limited resources and uneven technical capacity. States have experimented with a wide range of use cases, from AV shuttles and rural ADS pilots to freight automation and connected-vehicle corridors. These efforts have produced valuable lessons on infrastructure readiness, public engagement, organizational structure, emergency response, procurement, and data governance.

However, the scan also underscores persistent challenges: regulatory ambiguity, lack of national alignment, unclear expectations for "AV-ready" infrastructure, unreliable pilot operations (especially for AV shuttles), and fragmented data practices that limit learning and transparency. Successful programs share common traits—strong internal champions, dedicated units, long-term funding, close collaboration with local partners and first responders, and phased, data-driven deployment strategies. The report concludes that states can move AV integration forward by building institutional capacity, emphasizing measurable public benefits, and working toward national alignment, while continuously documenting and sharing lessons learned to accelerate collective progress.

1) Background and Purpose of the Scan
    a) Conducted under the NCHRP Domestic Scan Program to document real-world AV and ADS experiences across the U.S.
    b) Focused on SAE Level 3+ ADS/AV, especially as they intersect with state DOT responsibilities—roadway operations, safety, and infrastructure.
2) Policy and Regulatory Context
    a) States vary widely in their statutory approaches, from highly permissive AV laws to more cautious, regulated frameworks.
    b) Regulatory model (permissive vs. restrictive) does not guarantee higher or lower AV activity; other factors (industry interest, geography, partnerships) matter at least as much.
    c) All participating states express a need for clearer federal direction and more consistent national policy.
3) Organizational Models and Capacity
    a) Some states use centralized programs (e.g., DriveOhio, Minnesota DOT's CAV office, Florida DOT programs) to coordinate AV efforts statewide.
    b) Others rely on grassroots or city-led models (e.g., Seattle's work with Zoox) that emerge from local conditions and concerns.
    c) Staffing and expertise shortages are common; agencies rely heavily on a few committed individuals, consultants, or university partners.
4) Pilot and Deployment Experiences
    a) AV shuttle pilots:
        i) Often limited by low speed, narrow ODD, Global Navigation Satellite System and LiDAR challenges, weather sensitivity, and awkward integration with transit networks.
        ii) Many did not transition from "pilot" to permanent service due to cost, reliability, or low ridership.
    b) Freight and highway-focused AV:
        i) Several states see stronger potential for AV in freight corridors, with efforts emphasizing public-private partnerships and long-haul trucking.
    c) Rural ADS pilots:
        i) Projects like Ohio's rural ADS demonstrations highlight challenges with localization, object detection, and connectivity, but also provide rich data for future refinement.
5) Infrastructure Readiness and CV Integration

a) States debate how much to invest in specialized AV infrastructure (e.g., enhanced markings) versus expecting AVs to handle typical conditions.
b) V2X deployments show promise, but inconsistent performance and lack of shared standards limit their contribution to AV operations.

6) Public Engagement, Equity, and Public Benefit
   a) Hands-on demonstrations (rides in AVs, open houses, "roadshows") significantly improve public understanding and acceptance.
   b) Equity-focused projects (e.g., NJ Transit, mobility for older adults or people with disabilities) illustrate how AVs can support specific populations, though they require thoughtful design and sustained support.
   c) Many pilots struggled when service quality (speed, reliability, routing) was lower than existing alternatives—highlighting the need to deliver tangible benefit, not just novelty.
7) Emergency Response and First-Responder Coordination
   a) States report incidents where AVs blocked emergency vehicles, stopped in unexpected locations, or were difficult to move after crashes.
   b) Successful programs built dedicated training, protocols, and communication channels with first responders, sometimes including joint exercises with AV companies.
8) Lessons Learned, Data Governance, and Knowledge Sharing
   a) Systematic lessons-learned reporting (e.g., Utah shuttle reports, North Carolina's CASSI program, Minnesota and Florida documentation) provides roadmaps others can adapt.
   b) Data governance is emerging as a critical capability: states need policies for what AV data they collect, how it is stored and shared, and how to maintain privacy and proprietary protections while enabling public benefit.
   c) The scan itself is intended as a vehicle for national knowledge transfer, with explicit strategies to disseminate findings via AASHTO, TRB, ITS America, SAE, and others.
9) Overall Conclusions
   a) States are converging on common themes: the need for phased, data-driven approaches; clear federal guidance; institutional capacity; and robust collaboration across agencies and with industry.
1) AV technologies are not yet "plug-and-play" for DOTs; success requires deliberate planning, realistic expectations, and continuous adaptation.
   b) If states address policy gaps, invest in capacity and infrastructure, and commit to transparent learning, AV technologies can ultimately enhance safety, mobility, and equity in the transportation system.

San Francisco County Transportation Authority (SFCTA). (April 2023). TNCs 2020: A Profile of Ride-Hailing in California

The San Francisco County Transportation Authority (SFCTA) 2023 report, "TNCs 2020: A Profile of Ride-Hailing in California," offers the first comprehensive statewide analysis of ride-hailing activity by major providers, based on the 2020 public annual reports filed by Uber and Lyft to the CPUC. The report examines key aspects of the TNC market — including trip volumes, spatial distribution, safety incidents, labor conditions, environmental impacts, and accessibility. Its purpose is to inform policymakers, planners, and the public about how ride-hailing affects congestion, equity, safety, and environmental goals, especially in dense urban regions such as San Francisco.

Figure 5: TNC Activity Across California

Key Findings

- Inconsistent and incomplete data reporting means Annual Reports filed by Uber and Lyft do not provide a clear accounting of ride-hailing activity and impacts. This means it is not possible to determine even basic facts such as the number of trips that occurred.
- Uber and Lyft trips are highly concentrated in the urban areas of San Francisco, Los Angeles and San Diego counties, and San Francisco has 500 times more trips per square mile than the rest of the state.
- Lyft reports three times more total public safety incidents per trip than Uber, and 30 times more assaults and harassments per trip. But the rates suggest the companies may be reporting public safety incidents differently, pointing to the need for increased review by regulators.

- Uber and Lyft drivers may violate legal drive-time limits, with 1.3 million driver-days exceeding California's 10-hour drive time for drivers providing passenger transportation. Due to limitations in the Annual Report data requirements, this report cannot confirm that such drive-time violations have occurred.
- Lyft's incomplete reports prevent environmental oversight. Uber produced an estimated 494,000 metric tons of CO2 in 2020.
- Half of wheelchair-accessible trip requests statewide go unfulfilled, and Uber provides 16 times as many wheelchair-accessible trips as Lyft.

San Francisco County Transportation Authority (SFCTA). (September 2025). Conceptual Safety-Focused AV Permitting Framework

Key Issues

- Lack of transparent, performance-based AV safety standards: Current state and federal permitting processes do not require quantifiable safety benchmarks or operational performance metrics for AV deployment.
- Insufficient operational data and limited public reporting: Critical safety indicators—such as unplanned stops, vehicle retrievals, interference with emergency response, and system fallback events—are not systematically collected or shared.
- Fragmented oversight structure: Federal and state regulators control vehicle design and operational authorization, leaving local jurisdictions with minimal tools to manage AV impacts despite bearing the public-safety consequences.
- Documented safety issues in urban operations: San Francisco has experienced AV-related crashes, traffic disruptions, unauthorized stopping, and emergency-response obstruction, highlighting operational weaknesses not captured by existing regulatory requirements.
- Permitting systems allow scaling without demonstrated safety performance: Operators may expand fleet size, service area, and hours without proving safety under constrained conditions or meeting defined thresholds.
- Reactive rather than proactive risk management: Current oversight mechanisms intervene only after incidents occur, with no structured framework for incremental progress or rollback based on safety performance.
- Limited authority for regulators to impose operational constraints: Jurisdictions lack mechanisms to require reduced fleet sizes, restricted service zones, or mitigations when AV performance is inadequate.
- Rapid growth outpacing regulatory capacity: The rate of AV deployment exceeds the ability of existing institutions to monitor, evaluate, and manage cumulative safety risks.
- No unified method for comparing AV operators: Differences in reporting formats, metrics, and data availability make it difficult to evaluate relative safety performance or identify systemic issues across operators.
- Public trust undermined by data gaps and unclear accountability: Without transparent safety information, communities and policymakers cannot assess whether AV deployment advances or compromises public safety.

Key Recommendations

- Adopt a phased, performance-based permitting system where AV operators progress through defined stages only after meeting safety thresholds.
- Require standardized operational and safety metrics—including collision rates, disengagements, unplanned stops, emergency-response interference events, retrievals, and fallback activations.

- Mandate regular and transparent data reporting to state and local authorities, with public disclosure of appropriate aggregated safety metrics.
- Introduce operational constraints in early phases (fleet size, geography, hours, weather, speed limits) to limit risk exposure until the operator demonstrates safe performance.
- Use clear performance thresholds ("go/no-go" criteria) tied to specific VMT and operational contexts.
- Allow regulators to pause, condition, or roll back deployment when performance declines, incidents accumulate, or system reliability degrades.
- Provide local jurisdictions with a defined role in reviewing safety data, recommending mitigations, and participating in permit progression decisions.
- Ensure the framework is adaptable and scalable, allowing refinement of metrics, thresholds, and procedures as AV technology evolves.
- Promote cross-agency collaboration—state DMV, CPUC, city agencies, emergency services, and transit authorities—to align oversight and share safety-critical information.
- Use the framework as a model for other cities and states, recognizing that high-density urban environments require more robust safety management.

Report Summary

The SFCTA's *Conceptual Safety-Focused AV Permitting Framework* responds to a central challenge in automated-vehicle deployment: rapid expansion of AV operations in urban environments without corresponding performance-based safety oversight. As San Francisco has become a national testbed for autonomous services, real-world incidents—including crashes, stalled vehicles, and interference with emergency responders—have shown that current state and federal permitting regimes lack the safety, transparency, and operational controls necessary to manage risk effectively.

To address this gap, SFCTA proposes an incremental, data-driven permitting model. Operators would begin in a constrained operating phase and advance only after demonstrating quantifiable safety performance across standardized metrics. Regulators would have the authority to impose operational limits, require additional mitigations, or roll back deployment if safety deteriorates. The framework emphasizes transparency, accountability, and local jurisdiction involvement—recognizing that AV deployment must support public safety, mobility, and equity objectives in dense, complex cities. The result is a proactive, scalable governance model that balances innovation with responsibility, offering a template for jurisdictions nationwide.

1) Context and Motivation
   a) San Francisco hosts some of the most extensive AV deployments in the country, including driverless passenger services.
   b) Documented operational incidents have raised public-safety concerns and highlighted gaps in oversight.
   c) Current regulatory authorities (federal FMVSS, state DMV/CPUC, local traffic operations) are misaligned, leaving no single agency responsible for comprehensive risk management.

2) Limitations of Current Permitting Structures
    a) State agencies do not require ongoing performance demonstrations to scale operations.
    b) Reporting requirements vary widely, with many critical data categories omitted.
    c) Public versions of safety submissions are often highly redacted, limiting transparency.
    d) Local governments lack meaningful levers to address real-world impacts on emergency response, congestion, and street operations.
3) Proposed Phased Permitting Framework
    a) Operators proceed through **five deployment phases**, from testing with safety drivers to full driverless commercial operations.
    b) Early stages impose **strict operational constraints**, such as limited service zones, restricted hours, and capped fleet sizes.
    c) Advancement requires achieving **quantitative safety thresholds** measured over a minimum number of vehicle-miles.
    d) Requirements adjust based on the operator's performance, with regulators empowered to grant provisional approvals or require reversion.
4) Safety and Operational Metrics
    a) The framework identifies metrics such as:
        i) Collisions (fatal, injury, and property-damage-only)
        ii) System disengagements and fallback events
        iii) Unplanned stops or immobilizations
        iv) Incidents requiring vehicle retrieval
        v) Interference with police, fire, emergency medical services, transit, or other essential operations
        vi) Traffic-law violations recorded by the operator or public agencies
5) Data Reporting and Transparency
    a) Operators must report granular data to regulators at regular intervals.
    b) Aggregated safety metrics are made available to the public to build trust and accountability.
    c) Standardized definitions ensure consistency across operators and environments.
6) Regulatory Tools and Flexibility
    a) Agencies may:
        i) delay or deny phase progression;
        ii) impose additional mitigations;
        iii) modify operational constraints;
        iv) revert operators to prior phases after safety setbacks.
    b) This flexibility provides proactive, preventative management rather than reactive responses post-incident.
7) Local Government Role
    a) Cities receive access to operational data and influence deployment decisions.
    b) Local authorities can evaluate AV impacts on emergency response, transit operations, pedestrian safety, and neighborhood traffic.
    c) The framework emphasizes interagency coordination for comprehensive oversight.

8) Case Study / Illustrative Application
   a) A synthetic scenario demonstrates how an operator might advance through deployment phases based on safety performance.
   b) Shows how regulators identify failure cases, adjust conditions, and determine whether an operator is ready for broader deployment.
9) Broader Policy Implications
   a) SFCTA views this model as scalable to other jurisdictions.
   b) Demonstrates a method to align innovation with public safety and accountability.
   c) Provides a potential template for integrating local perspectives into a predominantly state- and federal-driven regulatory domain.

Table 1. Operational Parameters (SFCTA 2025)

OPERATING PARAMETER	REASON FOR INCLUSION	SF CONTEXT
Fleet size The number of vehicles an operator is authorized to operate	The more AVs in operation, the higher the likelihood of a road safety incident involving the operator — all other things being equal Promotes safety and transportation system performance by allowing the control of the scale of deployment and any associated impacts	Uber and Lyft combined were estimated to have up to 6,000 vehicles on the road at a time in San Francisco in 2016, with significant impacts[14]
Hours of operation The hours of the day that the operator is authorized to operate	Certain hours of the day bring about more exposure to other road users Promotes safety by restricting AV operations to times of the day when there are fewer road users present and less complex operating conditions	Traffic congestion is heaviest in San Francisco on weekdays from 7 to 9 AM and from 3 to 6 PM
Geography The area where the AVs are authorized to operate	The larger the authorized geography, the higher the likelihood that such geography includes areas where road safety incidents are more prone to happen, where emergency response activities are more intense, or where general traffic is heavier. Limits operations to smaller or less complex areas	Traffic congestion is concentrated in the northeast quadrant of San Francisco, where downtown and other dense neighborhoods are located and the transportation system is most complex.
Maximum speed The maximum speed the AVs are authorized to reach.	The higher the speed of the AV at the moment of impact, the higher the likelihood of serious injuries or other adverse consequences Promotes safety by potentially mitigating the severity of crashes	SF is lowering speeds on over 45 miles of roadways in the city.

Road type The type of road facility — freeways, major arterials, minor arterials, collectors, minor roads — that the operator is authorized to use.	Different road types carry more or less traffic and require different types of planning and maneuvering. Promotes safety by limiting the complexity and variety within the operating environment	-
Weather The weather conditions — rain, snow, ice, fog — that the operator is authorized for under a given phase of the process	Visibility and surface conditions may increase the likelihood of a collision Promotes safety by restricting AV operations with limited visibility or slippery road surfaces, among others, due to weather events	San Francisco can experience heavy fog, rain, and wind which limit visibility

14 TNCs were estimated to have contributed 50% of the growth in congestion in San Francisco from 2010 to 2016. Gregory D. Erhardt et al., Do transportation network companies decrease or increase congestion? Sci. Adv.5, eaau2670(2019). DOI:10.1126/sciadv.aau2670

Table 2. Deployment Stages (SFCTA 2025)

PHASE	TESTING WITH DRIVER	DRIVERLESS PILOT	DRIVERLESS COMMERCIAL		
			1	2	3
Fleet size	100 vehicles per 250 thousand population	50 vehicles per 250 thousand population	100 vehicles per 250 thousand population	500 vehicles per 250 thousand population	1000 vehicles per 250 thousand population
Hours of operation	24/7	Evening hours	Evening hours	Midday & Evening hours	24/7
Geography	Few or no limitations on deployment area	Mainly low density, residential deployment areas	Mainly low density, residential deployment areas	Deployment area excludes the urban core	Few or no limitations on deployment area
Speeds	Up to 65 mph	Up to 25 mph	Up to 25 mph	Up to 35 mph	Up to 65 mph
Road types	Freeways, arterials, locals	Arterials, locals	Arterials, locals	Arterials, locals	Freeways, arterials, locals
Weather	All	Fair, up to minor rain/fog	Fair, up to minor rain/fog	Fair, up to minor rain/fog	All

Table 3. Deployment Stages (SFCTA 2025)

METRIC TYPE	METRIC	NOTES
Safety	Property Damage Only (PDO) collisions / VMT	PDO collisions are an event of physical impact between an AV and another road user or property that only results in any property damage, and does not result in an injury or a fatality

	Injuries / VMT	Rate of injuries resulting from a collision between an AV and another road user or property that results in any injury, and does not result in a fatality
	Fatalities / VMT	Rate of fatalities resulting from a collision between an AV and another road user or property
	1st responder obstructions / VMT	Any incident reported by first responders wherein an AV obstructed the fulfillment of their duties Note: this metric is not currently reported to regulators
	Disengagements / VMT	Disengagements are instances when the ADS is precluded from performing the dynamic driving task (whether because of technology failure or situations requiring the test driver to take manual control)
	Unplanned stops > 2 minutes / VMT	Unplanned stops are instances in which an AV remains stopped on a travel lane for a certain amount of time when the conditions on the road require vehicle flow
	Unplanned stops > 15 minutes / VMT	Unplanned stops meaning instances in which an AV remains stopped on a travel lane for a certain amount of time when the conditions on the road require vehicle flow
	Vehicle retrieval events / VMT	Vehicle Retrieval Events are instances in which an AV needs to be retrieved from the road by a human operator or a tow truck
Extent of Operations	VMT (driven by driver)	The total miles traveled by the AV fleet with a human driver in control
	VMT (when in passenger service)	The total miles traveled by the AV fleet with a human passenger
	VMT (driven by ADS with driver present)	The total miles traveled by the AV fleet with a safety driver behind the wheel
	VMT (full driverless)	The total miles traveled by the AV fleet with ADS in control without a safety driver present

Table 4. Performance Standards by Phase (SFCTA 2025)

PHASE	TESTING WITH DRIVER	DRIVERLESS PILOT	DRIVERLESS COMMERCIAL			NOTES/JUSTIFICATION
			1	2	3	
Minimum VMT (cumulative)	-	2 million with a safety driver	1 million driverless	2 million driverless	5 million driverless	-
Property damage collisions / 100 Million VMT	132	132	132	132	132	2022 National average property-damage only collision rate
Injuries / 100 Million VMT	75	75	75	75	75	2022 National average traffic injury rate for human drivers
Fatalities / 100 Million VMT	1.33	1.33	1.33	1.33	1.33	2022 National average traffic fatality rate for human drivers, excluding alcohol-impaired drivers
1st-responder obstructions / 100 Million VMT	0	7,000	3,000	400	200	This is equivalent to ~1 event per week
Disengagements / 100 Million VMT	-	500,000	n/a	n/a	n/a	This is equivalent to ~10 events per week
Unplanned stops > 2 minutes / 100 Million VMT	-	500,000	167,000	25,000	12,500	This is equivalent to ~ 10 events per day
Unplanned stops > 15 minutes / 100 Million VMT	-	50,000	17,000	2,500	1,300	This is equivalent to ~1 event per day
Vehicle retrieval events / 100 Million VMT	-	7,000	3,000	400	200	This is equivalent to ~1 event per week

Sources: Property damage-only collisions, fatalities, and injuries are based on the NHTSA Standing General Order database. Overview of Motor Vehicle Traffic Crashes in 2022.

Sever, Tina, and Giuseppe Contissa. (2024). Automated driving regulations – where are we now?

Key Issues

- Responsibility gap in criminal law: Neither human drivers nor ADS neatly satisfy elements of criminal culpability (mens rea, foreseeability).
- Unresolved allocation of fault: Difficult to attribute blame among software, manufacturers, operators, and remote supporters.
- Insufficient legal concepts for non-human actors: Traditional doctrines (negligence, recklessness, intent) do not map to machine decision-making.
- Poorly defined evidentiary frameworks: No standards for what ADS data must be collected or how it must be preserved for investigations.
- Regulatory fragmentation: Wide variation in national and regional AV rules; lack of harmonized international norms.
- Liability regimes not prepared for ML-driven systems: Machine-learning unpredictability challenges standard product-liability constructs.
- Lack of transparency and data access: Proprietary algorithms and data impede fair investigations and judicial review.
- Static regulation vs. evolving technology: Traditional rulemaking processes cannot keep pace with rapid ADS evolution.

Key Recommendations

- Establish Clear, Harmonized Regulatory Frameworks
    - Develop national and international regulatory structures that impose consistent expectations for ADS design, testing, liability, and compliance.
    - Reduce the current patchwork of state- or country-level rules by adopting harmonized definitions, certification procedures, and safety standards for automated driving.
- Create Legal Structures Addressing the “Responsibility Gap”
    - Update criminal and administrative law to explicitly assign responsibility when the “driver” is an automated system rather than a human.
    - Define the legal roles of manufacturers, software developers, fleet operators, and remote supervisors, particularly when no individual human fulfills the traditional elements of mens rea or actus reus.
- Modernize Liability and Accountability Regimes
    - Clarify product-liability standards for automation failures and differentiate between system malfunctions, foreseeable misuse, operator shortcomings, and unforeseeable edge cases.

    - Establish pathways for attributing fault in mixed-fault scenarios where a human occupant, remote supporter, or autonomous system may each contribute to an incident.
- Strengthen Transparency, Data Access, and Evidentiary Requirements
    - Enact rules requiring ADS to retain relevant operational data (before, during, and after crashes) to enable fair investigation and prosecution when needed.
    - Ensure law enforcement, regulators, and courts have access to verifiable high-integrity data records, addressing concerns over proprietary algorithms and data ownership.
- Update Criminal Law Concepts for Non-Human Actors
    - Reevaluate doctrines such as negligence, recklessness, intent, and foreseeability when actions are taken by autonomous systems rather than humans.
    - Consider new legal constructs (e.g., system-level responsibility, organizational mens rea, or statutory liability frameworks) that can operate without traditional human culpability.
- Support Adaptive, Risk-Based Regulation
    - Use phased approval systems, regulatory sandboxes, and continuous monitoring to accommodate rapid technological change and avoid premature locking-in of outdated rules.
    - Encourage evidence-based policymaking supported by real-world testing, crash data, and independent safety assessments.

Report Summary

The article *"Automated driving regulations – where are we now?"* examines the current state of global automated-vehicle regulation and identifies a fundamental tension between the rapid pace of ADS technological development and the slow evolution of legal frameworks. While many jurisdictions have introduced preliminary AV laws, these remain fragmented, inconsistent, and insufficient to address the deeper structural challenges posed by non-human actors performing the dynamic driving task. The authors emphasize that current criminal and administrative liability systems are built on assumptions of human agency—intent, negligence, recklessness, and causation—yet ADS-driven vehicles disrupt these assumptions by shifting responsibility from human drivers to software, algorithms, and corporate entities. This shift creates a "responsibility gap" that neither traditional criminal law nor existing regulatory practices adequately resolve.

The article argues that a coherent regulatory environment requires harmonized standards, updated legal doctrines, improved data transparency, and clear allocation of responsibility among developers, manufacturers, operators, and automated systems. Without reforms, courts and regulators will face growing challenges in assigning liability, ensuring accountability, maintaining public trust, and supporting safe deployment. The paper concludes that governments must proactively modernize legal frameworks—not only to enable safe AV deployment but also to uphold fundamental principles of justice in a world where automated systems increasingly make operational decisions once reserved for human drivers.

1) Overview of Current Regulatory Landscape
    a) AV regulation remains fragmented across jurisdictions, with multiple national, state, and regional policies lacking harmonization.
    b) Existing regulations often emphasize testing programs, safety drivers, and operational restrictions but do not address deeper liability questions.
    c) International bodies (UNECE, EU, ISO, SAE) have begun developing standards, yet they remain advisory and are implemented unevenly.
2) The Emergence of Non-Human Driving Actors
    a) ADS technologies fulfill many core driving tasks, making the "driver" a software or hardware entity rather than a human.
    b) Traditional traffic law presumes a human actor capable of obeying rules, perceiving hazards, and forming intent, which no longer aligns with ADS operation.
3) The "Responsibility Gap"
    a) Criminal law assigns blame based on human mental states (intent, recklessness, negligence), but ADS cannot possess mens rea.
    b) System failures may arise from complex interactions between sensors, machine-learning models, and environmental conditions, complicating causal attribution.
    c) Manufacturers, developers, and fleet operators may each contribute to risk, yet none neatly fits into traditional criminal categories.
4) Liability and Accountability Challenges
    a) Product-liability law addresses manufacturing defects but struggles with probabilistic or learning-based behaviors inherent in ML.
    b) Determining fault in mixed human-machine interactions (e.g., partial automation, remote monitoring) becomes especially complex.
    c) The absence of mandated data transparency makes post-crash investigations difficult.
5) Regulatory and Criminal-Law Gaps
    a) Current laws lack clear mechanisms for prosecuting harms caused by autonomous systems unless human negligence can be proved.
    b) Some legal systems consider corporate criminal liability, but this may be insufficient or inappropriate for algorithmic decision-making.
    c) Concepts such as foreseeability and reasonableness must be re-examined for non-human agents.
6) Proposed Legal Innovations
    a) Introduce statutory liability frameworks for ADS that do not rely on human mental states.
    b) Define system-level responsibility, enabling accountability for organizational decisions embedded in design, testing, and deployment.
    c) Consider strict-liability models, mandatory insurance schemes, or hybrid fault models that reflect socio-technical complexity.
7) Evidence, Transparency, and Data
    a) ADS should be required to maintain tamperproof logs, enabling investigators and courts to reconstruct events accurately.

b) Clear standards for data retention, access rights, and privacy protection are necessary to support both regulation and justice processes.

8) Adaptive, Risk-Based Regulation
   a) Regulators should adopt flexible frameworks such as sandbox testing, staged approvals, and continuous safety monitoring.
   b) Risk-based approaches allow regulation to align with evolving technical capabilities without stifling innovation.
9) Broader Societal and Ethical Considerations
   a) Public acceptance hinges on clear accountability mechanisms when accidents occur.
   b) Ethical concerns include algorithmic decision-making, transparency, fairness, and potential biases in trained models.

Shladover, Steven. (2016). The Truth About 'Self-Driving' Cars.

Key Recommendations

- Develop comprehensive regulations and standards for self-driving cars.
- Invest in infrastructure improvements to support autonomous vehicles.
- Ensure robust cybersecurity measures to protect against hacking.
- Implement extensive testing and validation procedures.
- Promote collaboration between government, industry, and academia.
- Address ethical and liability issues related to autonomous driving.
- Encourage public education and transparency about the technology.
- Prioritize safety and reliability over speed of deployment.

Report Summary

The report "The Truth About 'Self-Driving' Cars" provides a comprehensive overview of the current state and future prospects of autonomous vehicle technology. It highlights the significant advancements made in recent years while also addressing the myriad challenges that remain. Key areas of focus include the need for robust regulatory frameworks, enhanced safety measures, and public education. The report also delves into the ethical, social, and economic implications of widespread autonomous vehicle adoption, emphasizing the importance of a balanced and thoughtful approach to integrating this technology into society.

2) **Introduction**: Explores the concept of self-driving cars and their potential impact on society.
3) **Technological Landscape**: Discusses the current state of autonomous vehicle technology, including advancements and limitations.
4) **Regulatory Challenges**: Examines the need for new laws and standards to govern the deployment of self-driving cars.
5) **Safety Concerns**: Highlights the importance of ensuring the safety and reliability of autonomous vehicles.
6) **Ethical and Social Implications**: Addresses the broader implications of self-driving cars on employment, urban planning, and societal norms.
7) **Future Prospects**: Looks at the potential future developments in autonomous driving technology and its integration into everyday life.

Conclusion

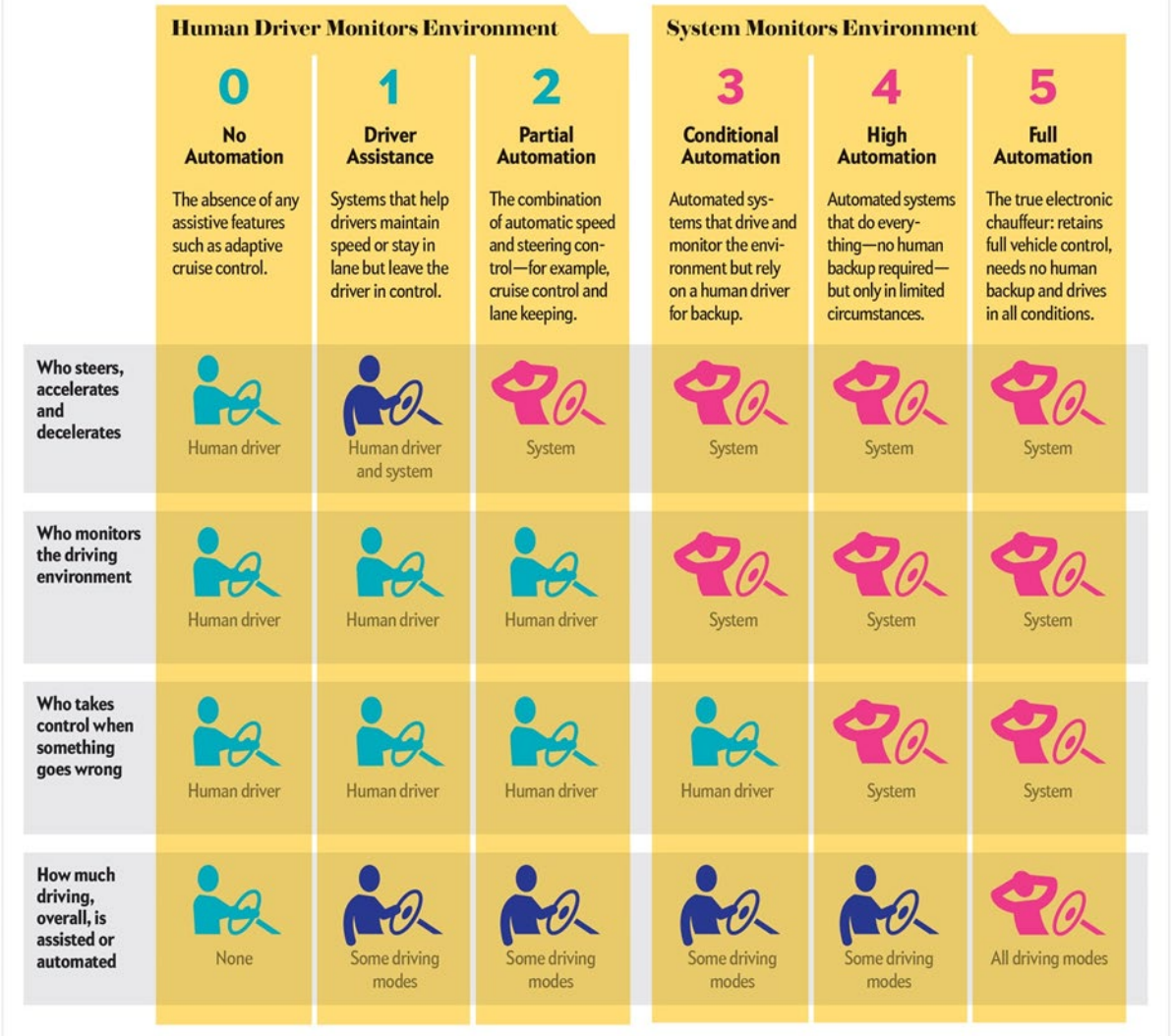
Self-driving cars represent a transformative technology with the potential to significantly alter transportation and urban landscapes. However, realizing this potential requires overcoming substantial technical, regulatory, and societal challenges. The key to successful integration lies in developing comprehensive policies, ensuring rigorous safety standards, and fostering public trust through

transparency and education. As technology continues to evolve, a collaborative effort among all stakeholders will be essential to navigate the complexities and harness the benefits of autonomous driving.

TAXONOMY

The Ladder of Automation

The automotive industry and the media have made a mess of the terminology used to talk about automated driverless systems. The terms "autonomous," "driverless" and "self-driving" obscure more than they illuminate. To clear things up, SAE International wrote definitions, paraphrased here, for different levels of automation and arranged them on a ladder of decreasing reliance on the driver. The hierarchy reveals some surprises. For example, level-four automation is potentially more tractable than level three. Level-five automated systems—electronic chauffeurs that can handle any driving condition with no human input—are decades away.



Shladover, Steven. (2021). ‘Self-Driving’ Cars Begin to Emerge from a Cloud of Hype. Scientific American.

Key Recommendations

- Increase investment in autonomous vehicle technology to improve safety and efficiency.
- Enhance regulatory frameworks to facilitate the integration of self-driving cars into existing transportation systems.
- Foster public-private partnerships to accelerate the development and deployment of autonomous vehicles.
- Prioritize cybersecurity measures to protect autonomous vehicle systems from hacking and other threats.
- Develop robust testing and validation processes to ensure the reliability and safety of self-driving cars.
- Promote public awareness and education about the benefits and limitations of autonomous vehicles.
- Encourage collaboration among industry stakeholders to standardize technologies and protocols.

Report Summary

The article "‘Self-Driving’ Cars Begin to Emerge from a Cloud of Hype" highlights the progress and challenges in the development of autonomous vehicle technology. While initial excitement has given way to more realistic assessments, significant advancements have been made. The potential benefits of self-driving cars include enhanced safety, reduced traffic congestion, and lower transportation costs. However, the industry faces hurdles such as regulatory issues, cybersecurity threats, and the need for widespread public acceptance. Investment from both tech companies and traditional automakers, along with public-private partnerships, is driving the industry forward. Continued advancements in AI and sensor technology are crucial, and rigorous testing is necessary to ensure safety and reliability.

1) Autonomous vehicle technology is progressing, moving beyond initial hype and demonstrating practical applications.
2) Self-driving cars have potential benefits including improved safety, reduced traffic congestion, and lower transportation costs.
3) Challenges remain, such as regulatory hurdles, cybersecurity risks, and the need for public acceptance.
4) The industry is witnessing significant investments from tech companies and automakers, with public-private partnerships playing a crucial role.
5) Ongoing advancements in artificial intelligence and sensor technology are critical to the success of autonomous vehicles.
6) Comprehensive testing and validation are essential to ensure the safety and reliability of these vehicles.

Conclusion

In conclusion, the journey of autonomous vehicles from hype to practical reality is marked by both significant achievements and ongoing challenges. The potential benefits of self-driving cars are substantial, but realizing these benefits requires addressing regulatory, cybersecurity, and public acceptance issues. The collaboration between technology firms, automakers, and regulatory bodies, coupled with continued innovation in AI and sensor technology, will be essential to the successful integration of autonomous vehicles into our transportation systems. As the technology matures, rigorous testing and validation will ensure that safety and reliability remain paramount.

Shladover, Steven. (2022). Opportunities, Challenges, and Uncertainties in Urban Road Transport Automation.

Key Recommendations

- **Technological Development**: Invest in the advancement of sensor perception, hazard recognition, and prediction software to enhance ADS safety and reliability.
- **Safety Assurance**: Establish comprehensive safety assurance frameworks, including functional safety and verification and validation processes, to earn public trust and regulatory approval.
- **Remote Human Support**: Develop robust remote support systems to manage situations beyond the ADS capabilities.
- **Infrastructure Support**: Enhance both physical and digital infrastructure to facilitate ADS operations in specific locations.
- **Public Education**: Implement educational initiatives to accurately inform the public about ADS safety and benefits.
- **Policy and Regulation**: Develop and harmonize international safety regulations specific to ADS.
- **Collaboration and Coordination**: Promote public–private partnerships and international cooperation for ADS deployment and safety case development.
- **Pilot Programs**: Conduct extensive pilot programs in diverse urban environments to gather real-world data and refine ADS technology.

Report Summary

The paper "Opportunities, Challenges, and Uncertainties in Urban Road Transport Automation" discusses the potential and limitations of ADS in urban environments. Despite significant advancements, ADS technology is not yet ready for widespread deployment due to challenges in sensor perception, hazard recognition, and prediction capabilities. Comprehensive safety assurance frameworks, including functional safety and verification processes, are necessary to earn public trust and regulatory approval. The paper emphasizes the importance of remote human support, infrastructure enhancements, and public education to facilitate ADS deployment. Collaboration among public and private stakeholders and harmonization of international safety regulations are crucial. Extensive pilot programs and future research are needed to resolve current uncertainties and develop robust ADS solutions.

1) **Technological Readiness**: ADS technology is still in its infancy, with significant work needed to achieve robust perception and prediction capabilities.
2) **Safety Assurance**: Comprehensive and scalable methodologies for verifying and validating ADS safety are required.
3) **Remote Human Support**: ADS systems will need occasional human interventions; remote support functions are critical.
4) **Infrastructure Support**: Both physical and digital infrastructure enhancements can facilitate ADS operations.

5) **Public Perception**: Public education and transparent communication are essential for gaining public trust in ADS safety.
6) **Regulatory Frameworks**: Different countries need to develop ADS-specific safety regulations.
7) **Deployment Challenges**: Matching business cases against ODD restrictions and finding profitable locations with sufficient demand density are significant challenges.
8) **Future Research**: Extensive research is needed to resolve uncertainties and develop safety assurance methodologies.

Conclusion

The deployment of ADS in urban environments presents both opportunities and challenges. While the potential benefits of improved safety, reduced congestion, and enhanced efficiency are significant, the technological, regulatory, and public perception challenges are substantial. The current state of ADS technology, coupled with the need for comprehensive safety assurance and robust infrastructure support, suggests that widespread deployment will take time. Public education and transparent communication are essential to gain trust and acceptance. Collaborative efforts among stakeholders and ongoing research are critical to overcoming these challenges and achieving the full potential of urban road transport automation.

Shladover, Steven. (2024). We Need Smarter Driverless Vehicle Regulations More Urgently Than We Need Smarter AI.

Key Recommendations

- **Establish Comprehensive Regulations**: Develop clear and robust regulations specific to driverless vehicles to ensure safety and accountability.
- **Mandate Regular Safety Audits**: Require frequent safety evaluations and certifications for driverless vehicle systems to prevent malfunctions and accidents.
- **Promote Transparency and Data Sharing**: Encourage companies to share data on driverless vehicle performance and incidents to facilitate improvements and regulatory adjustments.
- **Enhance Public Awareness and Education**: Implement educational campaigns to inform the public about the benefits and risks of driverless vehicles.
- **Strengthen Collaboration Between Stakeholders**: Foster collaboration between government agencies, private sector companies, and research institutions to address regulatory challenges.
- **Invest in Infrastructure Upgrades**: Upgrade road infrastructure to support the integration of driverless vehicles, including smart traffic signals and dedicated lanes.
- **Implement Ethical Guidelines**: Develop ethical guidelines to address the moral implications of driverless vehicle decision-making in critical situations.
- **Incentivize Innovation and Compliance**: Offer incentives for companies that comply with regulations and contribute to technological advancements in driverless vehicles.
- **Address Cybersecurity Concerns**: Ensure stringent cybersecurity measures are in place to protect driverless vehicles from hacking and other malicious activities.
- **Monitor Environmental Impact**: Assess and mitigate the environmental impact of driverless vehicles, promoting eco-friendly technologies and practices.

Report Summary

In the rapidly evolving landscape of driverless vehicle technology, the need for smarter regulations has become more urgent than the demand for further advancements of AI. Current regulatory frameworks are insufficient to manage the complexities and risks associated with autonomous vehicles. This article highlights the critical areas where regulations must be strengthened, including safety audits, data transparency, public education, and collaboration among stakeholders. Additionally, investments in infrastructure, stringent cybersecurity measures, and ethical guidelines are essential to ensure the safe and responsible deployment of driverless vehicles. By prioritizing these regulatory improvements, we can enhance public trust and foster innovation in this transformative sector.

1) The article stresses the urgent need for smarter regulations for driverless vehicles over advancements in AI technology.
2) Current regulations are inadequate to address the complexities and risks associated with driverless vehicles.

3) There is a pressing need for a comprehensive regulatory framework to ensure safety, accountability, and public trust.
4) Key areas of focus include safety audits, data transparency, public education, and stakeholder collaboration.
5) Infrastructure improvements and cybersecurity measures are essential to support the safe deployment of driverless vehicles.
6) Ethical considerations and environmental impact must be integrated into the regulatory approach.

Conclusion

In conclusion, the successful integration of driverless vehicles into our transportation system hinges on the development and implementation of smarter regulations. These regulations must address safety, accountability, transparency, and ethical concerns while fostering collaboration among all stakeholders. Infrastructure upgrades and robust cybersecurity measures are also vital to support this technological advancement. By focusing on these regulatory priorities, we can ensure the safe, efficient, and responsible deployment of driverless vehicles, ultimately benefiting society as a whole.

Stantec and Applied Research Associates (ARA). (2020). Impacts of Automated Vehicles and Shared Mobility on Transit and Partnership Opportunities.

Key Recommendations

- Establish Comprehensive Partnerships:
    - Develop and promote partnerships between public transit agencies and private mobility providers to enhance first/last mile connectivity.
    - Encourage collaboration with various stakeholders, including human service agencies, to address mobility deserts and underserved populations.
- Update Regulatory Frameworks:
    - Revise definitions of "public transportation" in federal, state, and local legislation to include on-demand and shared AV services.
    - Ensure AV services comply with ADA requirements and other relevant safety and operational standards.
- Infrastructure Development:
    - Plan and implement mobility hubs at transit stations to support AVs and other shared mobility services, incorporating necessary infrastructure such as charging stations and dedicated lanes.
    - Invest in accessible built environments to ensure seamless integration of AV services for all users, including those with disabilities.
- Enhance Equity and Accessibility:
    - Focus on equitable service delivery by addressing the needs of low-income, unbanked, and rural populations through subsidies and alternative access methods like SMS text services and mobility kiosks.
    - Promote universal design principles in AV development to accommodate users with diverse needs.
- Develop and Implement MaaS:
    - Create integrated MaaS platforms that combine various transportation modes into a single, accessible service with fare integration and user-friendly interfaces.
    - Address potential negative implications of MaaS on the environment, health, and equity through conscientious planning and regulation.
- Address Workforce Implications:
    - Prepare for workforce transitions by developing training programs for new roles in the AV ecosystem, such as safety operators and technicians.
    - Engage labor unions and consider labor agreement implications to protect existing jobs and facilitate smooth transitions.
- Continued Research and Development:
    - Identify and fill research gaps in areas such as AV safety scenarios, data sharing models, and social impacts of AV deployment.

- Develop performance metrics for evaluating the effectiveness of AV and shared mobility partnerships.

Report Summary

The report "Impacts of Automated Vehicles and Shared Mobility on Transit and Partnership Opportunities" explores the evolving landscape of shared mobility and the role of AVs in enhancing public transportation. It examines the potential benefits and challenges of integrating AVs with transit systems, emphasizing the importance of strategic partnerships, governance, and infrastructure planning. Key focus areas include first/last mile connectivity, equitable access, workforce implications, and the need for updated regulatory frameworks. The report underscores the necessity of continued research to address the gaps and develop best practices for successful implementation.

1) Paper Areas of Focus
   a) Partnerships: Exploring how partnerships can complement public transportation and support first/last mile deployments.
   b) Regulatory Definitions: Discussing the evolving definitions of “public transportation.”
   c) Equity and Accessibility: Evaluating the needs of underserved populations and ensuring inclusive mobility solutions.
   d) MaaS: Assessing the opportunities and challenges of integrating multiple transportation modes into a single service.
   e) Workforce Implications: Considering the impact of automation on the transit workforce.
   f) Universal Design: Addressing ADA requirements and promoting universal design for accessible transportation.
2) Summary of Findings
   a) Partnership Potential: AV partnerships can enhance shared mobility options and improve transit connections, especially in underserved areas.
   b) Mobility Hubs: Early planning for mobility hubs is crucial for integrating AVs with public transit.
   c) Regulatory Updates: Definitions of public transportation need updating to accommodate new partnership models and services.
   d) First/Last Mile Services: AVs can effectively bridge the gap for first/last mile connections, improving overall transit efficiency.
   e) Equity and Accessibility: Policies must ensure equitable access to AV services, with a focus on the needs of various user groups.
   f) MaaS Implementation: MaaS can significantly improve urban mobility if implemented equitably and efficiently.
   g) Workforce Transition: Automation will shift employment roles, requiring new skills and training programs.
3) Research Reviewed
   a) The report reviews a wide range of studies, demonstrating a strong cross-sector interest in maximizing the effectiveness of transit through AV and shared mobility partnerships. It highlights:

b) Mobility Hubs: Examples from cities like Minneapolis and San Diego show the benefits of integrating multiple transportation modes.
c) Multimodal Connections: AV transit can provide key links for multimodal transportation, improving overall connectivity.
d) First/Last Mile Deployments: Various pilots demonstrate the potential of AVs for first/last mile solutions.
e) Governance: Effective governance structures are essential for successful public-private partnerships.
f) Complementarity with Transit: AV services can complement existing transit services, enhancing overall mobility.

4) Further Research Opportunities
a) Investigating the impact of current public transportation definitions.
b) Developing best practices for public-private partnerships.
c) Evaluating MaaS models and their implementation.
d) Studying the workforce impacts of AV deployment.
e) Conducting a literature synthesis on universal design for transportation.

Conclusion

The integration of AVs and shared mobility with public transit presents significant opportunities to enhance urban mobility, reduce congestion, and improve accessibility. Strategic partnerships, updated regulatory frameworks, and focused infrastructure development are essential for realizing these benefits. Continued research and proactive planning will ensure that these innovations contribute positively to the transportation ecosystem, addressing the needs of all users and fostering sustainable urban development.

United Nations Economic Commission for Europe (UNECE). (September 2019-November 2025). Working Party on Automated/Autonomous and Connected Vehicles (GRVA)

The Framework establishes a unified approach for the United Nations World Forum for Harmonization of Vehicle Regulations (WP.29) to regulate SAE Level 3+ automated/autonomous vehicles. It defines the key safety principles, regulatory priorities, and work plan needed to ensure consistent and safe deployment across contracting countries under both the 1958 and 1998 Agreements.

Timeline of major milestones from UNECE's work on the international regulatory framework for automated/autonomous driving systems (ADS), followed by key planned deliverables for the next 2-3 years:

Date	Milestone	Significance
2019	Adoption by Working Party on Automated/Autonomous and Connected Vehicles of the "Framework Document on Automated/Autonomous and Connected Vehicles (FDAV)". (UNECE)	Provides the foundational vision, safety-first principle, and structure for subsequent regulatory work.
Nov 2021	Revised FDAV document published. (UNECE)	Reflects evolution of approaches, emerging technologies, and provides updated guidance.
2022	FDAV publication ("Framework Document …" Feb 2022) made publicly available. (UNECE)	Gives states, industry and infrastructure stakeholders a clearer reference.
2024	Entry into force (or adoption) of new regulation for driver-controlled assistance systems (DCAS) under GRVA. (mistergreen.nl)	This regulation serves as a "bridge" from ADAS toward full automation.
June 26, 2024	UNECE press conference on "Regulating autonomous vehicles: international developments". (UNO G Newsroom)	Public signaling that the regulatory regime is advancing toward full ADS.
2025–2026 (Underway)	Document: "GRVA priorities and activities in 2026 (Draft)", Sep 2025. (UNECE)	This signals the expectation of major deliverables within this timeframe.

Key Recommendations

- Adopt performance-based, technology-neutral regulatory requirements to allow innovation while ensuring consistent safety outcomes.
- Require clear definition of the ODD for every ADS, including environmental, geographic, and operational limits.

- Ensure ADS can detect failures and execute a safe fallback (Minimum Risk Manoeuvre) whenever the system or conditions exceed its operating capabilities.
- Mandate robust validation and testing using a multi-pillar approach that combines simulation, track testing, and real-world evaluation.
- Implement strong cybersecurity and secure software-update processes to protect vehicles throughout their lifecycle.
- Require effective Human-Machine Interface (HMI) and driver monitoring for systems where human takeover may be needed.
- Establish data recording requirements (event detection and response (EDR)/Data Storage System for Automated Driving (DSSAD)) to capture system status, driver involvement, and relevant events for crash investigation and regulatory oversight.

Guiding Principles

- Performance-based, technology-neutral regulation
- Support innovation while ensuring safety and security
- Leverage existing standards and avoid duplication
- Cross-coordination across multiple expert working groups
- Annual review and update of the framework

Core Regulatory Priorities

- System Safety - ADS must comply with traffic rules and avoid unreasonable safety risks while in automated mode.
- Failsafe Response - Vehicles must detect failures or ODD exit conditions and execute a Minimum Risk Manoeuvre (MRM).
- HMI - Includes driver engagement monitoring, clear take-over requests, and external HMI for communicating vehicle status to other road users.
- Object and Event Detection and Response (OEDR) - ADS must detect and appropriately respond to objects/events expected within the ODD.
- ODD - Manufacturers must document operating constraints (road types, speeds, geography, weather, lighting).
- Validation for System Safety - A systems-engineering-based validation approach covering:
    - Hazard analysis and risk assessment
    - Behavioral competencies
    - Crash-avoidance performance
    - Fallback strategies
    - Validation should use simulation, test-track, and real-world testing.
- Cybersecurity - Robust protection against cyber threats; manufacturers must show cybersecurity incorporated into design, testing, and lifecycle management.

- Software Updates (including OTA) - Updates must be secure, traceable, and maintain functional safety.
- Data Recording (EDR/DSSAD) - Vehicles must record data needed to identify system behavior and status before/after crashes.

Appendix B. Report of Traffic Accident Involving an Autonomous Vehicle (OL 316)

https://www.dmv.ca.gov/portal/file/report-of-traffic-accident-involving-an-autonomous-vehicle-ol-316-pdf/

STATE OF CALIFORNIA
DMV
Department of Motor Vehicles

DMV USE ONLY
AVT NUMBER
NAME

REPORT OF TRAFFIC COLLISION INVOLVING AN AUTONOMOUS VEHICLE

Instructions: Please print within the spaces and boxes on this form. If you need to provide additional information on a separate piece of paper(s) or you include a copy of any law enforcement agency report, please check the box to indicate "Additional Information Attached."

- Write **unk (for unknown)** or **none** in any space or box when you do not have the information on the other party involved.
- Give insurance information that is complete and which correctly and *fully* identifies the **company** that issued the insurance policy or surety bond, or whether there is a certificate of self-insurance.
- Place the National Association of Insurance Commissioners (NAIC) number for your Insurance or Surety Company in the boxes provided. The NAIC number should be located on the proof of insurance provided by you company or you can contact your insurer for that information.
- Identify any person involved in the accident (driver, passenger, bicyclist, pedestrian, etc) that you saw was injured or complained of bodily injury or know to be deceased.
- Record in the PROPERTY DAMAGE line any damage to telephone poles, fences, street signs, guard post, trees, livestock, dogs, buildings, parked vehicles, etc., including a description of the damage.
- Once you have completed this report, please mail to: Department of Motor Vehicles, Autonomous Vehicles Branch, 2415 1st Avenue, MS D405, Sacramento, CA 95818

SECTION 1 — MANUFACTURER'S INFORMATION

MANUFACTURER'S NAME			AVT NUMBER
BUSINESS NAME			TELEPHONE NUMBER ( )
STREET ADDRESS	CITY	STATE	ZIP CODE

SECTION 2 — ACCIDENT INFORMATION/VEHICLE 1

DATE OF ACCIDENT	TIME OF ACCIDENT ☐ AM ☐ PM	VEHICLE YEAR	MAKE	MODEL
LICENSE PLATE NUMBER	VEHICLE IDENTIFICATION NUMBER			STATE VEHICLE IS REGISTERED IN
ADDRESS/LOCATION OF ACCIDENT	CITY	COUNTY	STATE	ZIP CODE

Vehicle was: ☐ Moving ☐ Stopped in Traffic

Involved in the Accident: ☐ Pedestrian ☐ Bicyclist ☐ Other _____

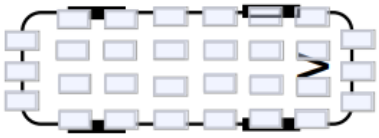
NUMBER OF VEHICLES INVOLVED

DRIVER'S FULL NAME (*FIRST, MIDDLE, LAST*)	DRIVER LICENSE NUMBER	STATE	DATE OF BIRTH
INSURANCE COMPANY NAME OR SURETY COMPANY AT TIME OF ACCIDENT	POLICY NUMBER		
COMPANY NAIC NUMBER	POLICY PERIOD FROM _____ TO _____		

Describe Vehicle Damage

☐ UNK ☐ NONE ☐ MINOR
☐ MOD ☐ MAJOR

Shade in Damaged Area



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SECTION 3 — OTHER PARTY'S INFORMATION/VEHICLE 2

VEHICLE YEAR	MODEL	
LICENSE PLATE NUMBER	VEHICLE IDENTIFICATION NUMBER	STATE VEHICLE IS REGISTERED IN

Vehicle was: ☐ Moving ☐ Stopped in Traffic **Involved in the Accident:** ☐ Pedestrian ☐ Bicyclist ☐ Other _____ NUMBER OF VEHICLES INVOLVED

DRIVER'S FULL NAME (*FIRST, MIDDLE, LAST*)	DRIVER LICENSE NUMBER	STATE	DATE OF BIRTH
INSURANCE COMPANY NAME OR SURETY COMPANY AT TIME OF ACCIDENT	POLICY NUMBER		
COMPANY NAIC NUMBER	POLICY PERIOD FROM _____ TO _____		

☐ **Additional information attached.**

SECTION 4 — INJURY/DEATH, PROPERTY DAMAGE

NAME (*FIRST, MIDDLE, LAST*)

ADDRESS	CITY	STATE	ZIP CODE

CHECK ALL THAT APPLY ☐ Injured ☐ Deceased ☐ Driver ☐ Passenger ☐ Bicyclist ☐ Property

NAME (*FIRST, MIDDLE, LAST*)

ADDRESS	CITY	STATE	ZIP CODE

CHECK ALL THAT APPLY ☐ Injured ☐ Deceased ☐ Driver ☐ Passenger ☐ Bicyclist ☐ Property

PROPERTY DAMAGE

PROPERTY OWNER'S NAME		TELEPHONE NUMBER ( )
STREET ADDRESS	CITY	STATE ZIP CODE
WITNESS NAME		TELEPHONE NUMBER ( )
STREET ADDRESS	CITY	STATE ZIP CODE
WITNESS NAME		TELEPHONE NUMBER ( )
STREET ADDRESS	CITY	STATE ZIP CODE

☐ **Additional information attached.**

SECTION 5 — ACCIDENT DETAILS - DESCRIPTION

☐ Autonomous Mode ☐ Conventional Mode

☐ **Additional information attached.**

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ITEMS MARKED BELOW FOLLOWED BY AN ASTERISK (*) SHOULD BE EXPLAINED IN THE NARRATIVE							
	WEATHER (MARK 1 to 2 ITEMS)	VEH 1	VEH 2	**MOVEMENT PRECEDING COLLISION**	VEH 1	VEH 2	**OTHER ASSOCIATED FACTOR(s)** (MARK ALL APPLICABLE)
	A. CLEAR	X	X	A. STOPPED	X		A. CVC SECTIONS VIOLATED
	B. CLOUDY			B. PROCEEDING STRAIGHT		X	CITED ☐ YES ☐ NO
	C. RAINING			C. RAN OFF ROAD			
	D. SNOWING			D. MAKING RIGHT TURN			
	E. FOG/VISIBILITY			E. MAKING LEFT TURN			
	F. OTHER			F. MAKING U TURN			B. VISION OBSCUREMENT ☐
	G. WIND			G. BACKING			C. INATTENTION* ☐
	LIGHTING			H. SLOWING/STOPPING			D. STOP & GO TRAFFIC ☐
	A. DAYLIGHT			I. PASSING OTHER VEHICLE			E. ENTERING/LEAVING RAMP ☐
	B. DUSK – DAWN			J. CHANGING LANES			F. PREVIOUS COLLISION ☐
	C. DARK–STREET LIGHTS	X	X	K. PARKING MANUEVER			G. UNFAMILIAR WITH ROAD ☐
	D. DARK – NO STREET LIGHTS			L. ENTERING TRAFFIC			H. DEFECTIVE WEH EQUIP
	E. DARK–STREET LIGHTS NOT FUNCTIONING*	X		M. OTHER UNSAFE TURNING			CITED ☐ YES ☐ NO
	ROADWAY SURFACE			N. XING INTO OPPOSING LANE			
	A. DRY	X	X	O. PARKED			I. UNINVOLVED VEHICLE ☐
	B. WET			P. MERGING			J. OTHER* ☐
	C. SNOWY – ICY			Q. TRAVELING WRONG WAY			K. NONE APPARENT ☒
	D. SLIPPERY (MUDDY, OILY, ETC.)			R. OTHER*			L. RUNAWAY VEHICLE ☐
	ROADWAY CONDITIONS (MARK 1 TO 2 ITEMS)			**TYPE OF COLLISION**			
	A. HOLES, DEEP RUT*			A. HEAD-ON			
	B. LOOSE MATERIAL ON ROADWAY			B. SIDE SWIPE			
	C. OBSTRUCTION ON ROADWAY*			C. REAR END	X	X	
	D. CONSTRUCTION – REPAIR ZONE			D. BROADSIDE			
	E. REDUCED ROADWAY WIDTH			E. HIT OBJECT			
	F. FLOODED*			F. OVERTURNED			
	G. OTHER*			G. VEHICLE/PEDESTRIAN			
	H. NO UNUSUAL CONDITIONS	X	X	H. OTHER*			

SECTION 6 — CERTIFICATION

I certify (or declare) under penalty of perjury under the laws of the State of California that the foregoing is true and correct.

I further certify that I am the authorized Administrator of the program for the above named employer.

PROGRAM DIRECTOR/AUTHORIZED REPRESENTATIVE PRINTED NAME AND TITLE	TELEPHONE NUMBER
Zachary Askew - Program Manager, Regulatory Compliance	( )
SIGNATURE	**DATE SIGNED**
X	11/26/2025

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Appendix C. California Public Utilities Commission (CPUC) AV Program Quarterly Reporting

The templates below provide guidance on the submission of the required quantitative data. The current templates are available at: https://www.cpuc.ca.gov/regulatory-services/licensing/transportation-licensing-and-analysis-branch/autonomous-vehicle-programs/quarterly-reporting

Quarterly Deployment Data Reporting Templates

- Trip-Level
  - Carrier ID number
  - Ride ID of Trip
  - Waybill Number of Trip
  - TripStartDate
  - TripReqRequesterTract
  - TripReqRequesterZip
  - TripFulfilled
  - ReasonUnfulfilled
  - VIN
  - VehicleFuelType
  - VehicleWAV
  - NumberPassengers
  - TripAcceptDate
  - TripPickupDate
  - TripDropoffDate
  - VMTP1: Vehicle miles traveled since the last trip while the vehicle is neither carrying passengers nor en route to picking up a passenger ("Period 1 VMT").
  - VMTP2: Vehicle miles traveled between the point where the vehicle was when it accepted a trip to the point where it picked up the passenger ("Period 2 VMT").
  - VMTP3: Vehicle miles traveled between the pick-up point and the drop-off point ("Period 3 VMT").
  - EVMT: Electric Vehicle Miles Traveled over entire trip (i.e., aggregate over all periods for Waybill1).
  - PassengerMilesTraveled
  - PickUpTract
  - DropOffTract
  - PickUpZip
  - DropOffZip
  - WAVReq
  - PoolRequest
  - SharedProvided

    - FaredRide
    - RideIDMilesTraveledP23
    - RideIDMilesTraveledP3
- Month-Level
    - TCPID
    - Year
    - Month
    - TotalTrips
    - TotalWaiting
    - TotalVMTPeriod1
    - TotalVMTPeriod2
    - TotalVMTPeriod3
    - TotalVMTZEV
    - TotalPassengersCarried
    - TotalPMT
    - TotalWAVsAvail
    - TotalWAVsRequested
    - TotalWAVsDeclinedUnavail
    - TotalWAVsFulfilled
- Monthly Tract
    - TCPID
    - Year
    - Month
    - Tract
    - TripsStart
    - TripsEnd
- Incidents-Complaints
    - Total and by actor: A single collision may be counted in more than 1 field if multiple actors were involved. If multiple of a single type of actor was involved (e.g., 2 pedestrians), count only once. Do not double count AV occupants as pedestrians.
    - By damage caused, property or injury/fatality
    - Time of collision
    - Time of collision during pick-up/drop-off (PUDO) at curb or in travel lane
    - Types of complaints
        - law enforcement, harassment, assault
        - safety, PUDO, accessibility, WAV, customer service, others
    - Payouts if known
- Incidents-Location
    - Tract
    - CollisionsAll
    - CollisionsPUDO

    - PUDOTravelLane
- Chargers
- Charging Sessions

Carriers are also required to submit narrative responses, as described in D.20-11-046 (as modified by D.21-05-017) Ordering Paragraphs 5(k)(iv) and Appendix A. These should be submitted as a searchable electronic Word document, PDF, or similar file alongside the numerical data.