THE NEXT GENERATION OF MOBILITY

A Federal Policy Primer for an Autonomous Future

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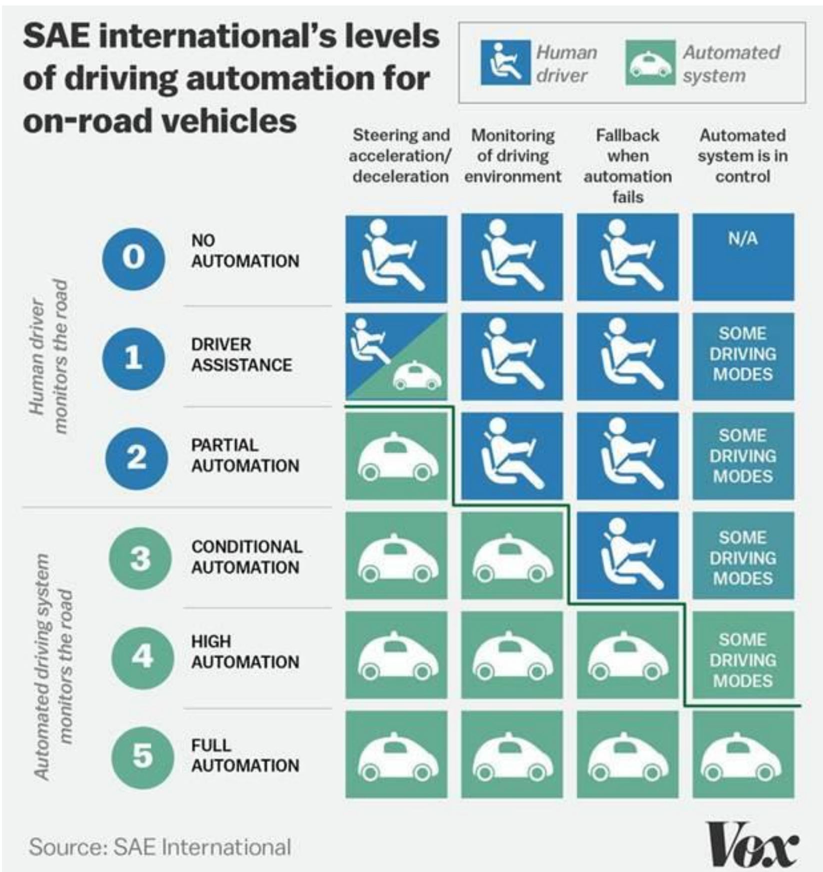
Introduction

The way government funds and plans the nation's transportation system is experiencing unprecedented change. Connected vehicle (CV) and autonomous vehicle (AV) technologies are expected to fundamentally reshape personal, freight, and public transport. Not since the advent of the car and establishment of the Interstate Highway System has the transportation sector been impacted by such disruptive change. The potential benefits to society are immense, but substantial risks exist. As the federal government works to develop a regulatory framework and policies to facilitate market development, this report provides an overview of CV/AV technology, implications, federal actions, and outlook.

Autonomous Vehicles

AV technology spans a wide spectrum of capabilities and vehicle types including low/urban- speed (LSV), passenger, and commercial vehicles. To standardize differences in functionality, the National Highway Traffic Safety Administration (NHTSA) adopted the Society of Automotive Engineers (SAE) International Automation Levels. The SAE automation levels have been widely adopted globally and are critical to understanding federal AV policy and guidance.

SAE International Automation Levels



Source: Vox

Level 1 and 2 autonomous functionalities, such as adaptive cruise control, parking assist, lane centering systems, and automated lighting and braking, are already available on many newer model commercial vehicles. As technology improves and the market matures, some experts anticipate Level 4 functionalities to be available within the next five years and Level 5 functionalities to be a decade away.[1]

Connected Vehicles

CV technologies allow vehicles to communicate with each other and their environments. AVs equipped with CV functionalities are referred to as connected autonomous vehicles (CAVs). While AVs can function without CV technology, doing so can enhance their performance. Because of their ability to share information, AVs with V2V or V2I platforms have increased capabilities which many believe could yield transformational benefits. The different types of CV technologies are listed in the table below:

Vehicle to Vehicle (V2V)	**Vehicle to Infrastructure (V2I)**	**Vehicle to Everything (V2X)**
Allows vehicles to communicate to other vehicles information including speed, location, and traffic	Allows vehicles and infrastructure to communicate information related to traffic signals, lane markings, and other infrastructure.	Allows for connectivity between vehicles and all relevant technologies.

Potential Benefits

CAVs could benefit the transportation system by enhancing vehicle safety, improving traffic congestion, providing mobility options for underserved populations, and reshaping public spaces. As policymakers and stakeholders anticipate the proliferation of driverless vehicles, critical issues must be addressed to ensure CAV deployment fully realizes its potential and avoids significant risks.

Lawmakers, local leaders, and other stakeholders must build policies around CAVs that help ensure societal, economic, and environmental benefits. A comprehensive policy framework should balance the needs of all users (including pedestrians) while promoting market development.

Safety

CAVs have the potential to improve road safety for drivers, passengers, and pedestrians. For every one person killed in a car crash, eight are hospitalized and another one hundred are treated and released from emergency rooms.[2] In 2016, 37,461 Americans died in vehicle accidents,[3] and 94

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[1] K. Heineke, P. Kampshoff, A. Mkrtchyan, E. Shao, *Self-Driving car technology: When will the robots hit the road?* McKinsey & Company, May 2017, pg. 4.
[2] M. Bertoncello, D. Wee, *Ten Ways Autonomous Driving Could Redefine the Automotive World*, McKinsey & Company, June 2015.
[3] National Highway Traffic Safety Administration, *2016 Fatal Motor Vehicle Crashes: Overview*, DOT HS 812 456, October 2017, Pg. 1.

percent of these crashes were caused by driver error.[4] By removing the 'driver' from the equation, CAVs have the potential to significantly reduce the number of lives lost and people injured in traffic accidents each year.

Connected technology is particularly relevant to the safety benefits of self-driving cars. A NHTSA analysis found that including just two V2V applications – "intersection movement assist" (IMA) and "left turn assist" (ITA) – in a vehicle could lead to a 50 percent reduction in crashes, injuries, and fatalities.[5]

Aside from the loss of life, auto accidents have a substantial economic impact. In 2010, costs associated with vehicle crashes totaled $242 billion and when quality-of-life valuations are considered that figure rises to $836 billion.[6] CAVs not only have the potential to save lives, but to reduce the economic burden of motor vehicle accidents.

While CAV advocates tout numerous safety benefits, policymakers, manufacturers, regulators, and other stakeholders must ensure that CAVs themselves are safe. Some skeptics argue CAV technologies are not yet ready for prime time. They claim certain technologies, such as GPS and LIDAR, do not function properly in all types of weather and there are situations which CAV software cannot anticipate.[7] These issues must be fully addressed as public safety is paramount.

In addition, the transition period during which CAVs will operate alongside human-driven cars and before CAVs reach level 5 autonomy needs to be clarified. The November 2017 crash of a self-driving shuttle in Las Vegas demonstrates the need for policy to guide the interaction of CAVs and human-driven vehicles. A Las Vegas City government representative said of the situation, "The shuttle did what it was supposed to do, in that [its] sensors registered the truck and the shuttle stopped to avoid the accident…Had the truck had the same sensing equipment that the shuttle has the accident would have been avoided."[8] The Las Vegas case illustrates how CAV introduction into the present driving fleet could exacerbate issues.

The March 2018 fatal crash of an autonomous Uber in Tempe, Arizona also raises questions about how semi-autonomous vehicles should be regulated. Some experts have said the back-up human driver in the vehicle should have responded more quickly, while others say the vehicle's sensors should have identified the pedestrian in the road.[9] No matter the explanation, this situation is something lawmakers and other stakeholders should have at the forefront of their minds when drafting policy related to the development and deployment of CAV technology.

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[4] S. Singh, *Critical Reasons for Crashes Investigated in the National Motor Vehicle Crash Causation Survey*, National Highway Traffic Safety Administration, DOT HS 812 115, February 2015, Pg. 1.

[5] US Department of Transportation, *NHTSA Issues Advance Notice of Propose Rulemaking and research Report on Ground-Breaking Crash Avoidance Technology: "Vehicle-To-Vehicle Communications: Readiness of V2V Technology For Application"*, August 2014, Pg. 1.

[6] L.J. Blincoe, T.R. Miller, E. Zaloshnja, B.A. Lawrence, *The economic and societal impact of motor vehicle crashes, 2010. (Revised)*, DOT HS 812 013, National Highway Traffic Safety Administration, May 2015, Pg. 1.

[7] S. Saripalli, *Redefining 'Safety' for Self-Driving Cars*, The ConversationUS, November 2017.

[8] City of Las Vegas, *Update: Minor Incident Downtown Wednesday Afternoon*, City of Las Vegas Blog, November 2017.

[9] R. Beene, A. Levin, E. Newcomer, *Human Driver Could Have Avoided Fatal Uber Crash, Experts Say*, Bloomberg Technology, March 2018.

Until all vehicles have the same, fully autonomous technology, policymakers, manufacturers, and other stakeholders will need to ensure self-driving cars and human-driven vehicles can co-exist safely.

Environmental Impacts and Congestion

The transportation sector is one of the largest contributors of greenhouse gas (GHG) emissions in the US, accounting for 27 percent of GHG emissions in 2015. [10] CAVs could help to mitigate the negative environmental impacts of transportation in a number of ways. For one, CAVs could lead to smoother traffic flows through more efficient driving, which is enabled by V2X communications and that computers have shown promise of being more skilled drivers than humans. Additionally, because CAVs are more likely to avoid accidents, they can drive closely together in platoons, thereby reducing aerodynamic drag, and be built with lighter and more environmentally sustainable materials.

Efficiency gains and changes to vehicle design can help reduce traffic congestion. A study by the University of Illinois at Urbana-Champaign found that the presence of just one CAV on the road could ease congestion.[11] CAVs have the potential to increase road capacity and reduce the number of vehicles in use.

At the same time, there are a number of risks associated with CAV deployment. More efficient, productive, and safer CAVs could encourage people to take more trips than they would have otherwise resulting in more vehicle miles travelled (VMT). Increased VMT could exponentially increase vehicles on the road, eliminating many touted CAV benefits.

Land Use

CAV deployment will impact the built environment by forcing policymakers to reimagine public and private spaces. CAVs have the potential to limit the need for parking by over 5.7 billion square meters in the US.[12] This means that land normally reserved for parking infrastructure – including garages and curbside parking – could be transformed into living, office, or recreation space and/or dedicated to pedestrians and cyclists. Additionally, given that CAVs are likely to be smaller than human-driven cars and can drive more closely together, the number and size of driving lanes could be reduced, resulting in more space for things like walkways and bike lanes.

On the other hand, CAV deployment could result in urban sprawl generated by increased VMT. If CAVs can make commuting to work, school, or recreation more convenient, they could encourage suburban and rural growth and could conceivable, reduce demand for public transit (or conversely, provide first mile/last mile services to fixed commuter lines such as light rail and subway).

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[10] US Environmental Protection Agency, *Fast Facts on Transportation Gas Emissions*, US Environmental Protection Agency Green Vehicle Guide.
[11] J. Condliffe, *A Single Autonomous Car Has a Huge Impact on Alleviating Traffic*, MIT Technology Review. May 2017.
[12] M. Bertoncello, D. Wee, *Ten Ways Autonomous Driving Could Redefine the Automotive World*, McKinsey & Company, June 2015.

Mobility

CAVs have the potential to expand mobility for the disabled and the elderly. Policymakers, transit providers, and other stakeholders must work together to ensure CAV access is equitable.
The disabled and those unable to independently travel by vehicle stand to benefit from self-driving cars – if those vehicles meet their particular access needs. Being driverless solves one problem, but if the vehicle does not easily accommodate the needs of the disabled rider, its usefulness to the disabled user will be limited. While public transportation must comply with the Americans with Disabilities Act (ADA), the same is not true for individual vehicles. Given the capabilities of CAVs, appropriately designed vehicles could help bridge the transportation gap for the more than 53 million Americans with a disability.[13] A report by the Ruderman Family Foundation found that "mitigating transportation related obstacles for individuals with disabilities would enable new employment opportunities for approximately 2 million individuals with disabilities and save $19 billion annually in healthcare expenditures from missed medical appointments."[14] With 49 million Americans are over the age of 65,[15] CAVs could also provide an expanded roster of mobility options for the elderly and help them to age in place, remain an integral party of society, and continue to contribute to the economy.

Policymakers and other stakeholders have an opportunity to guide autonomous policies to produce better outcomes for the country's disabled and elderly populations.

Policy Considerations

Private vs. Shared Use Models

CAV deployment is often described using heaven and hell scenarios. In the heaven scenario, CAVs reduce GHG emissions, ease traffic congestion, and result in innovative land use policies. In the hell scenario, however, they increase emissions, exacerbate traffic congestion, and amplify urban sprawl. The heaven and hell scenario is often correlated with private vs. shared use CAV deployment.

Encouragingly, developers seem to be leaning towards a shared use model. Ford plans to release a fully autonomous vehicle intended for ride sharing by 2021,[16] and the company announced in September 2017 that it will partner with the ride-sharing company Lyft.[17] General Motors, which

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[13] National Highway Safety Administration, *Automated Vehicles for Safety*, NHTSA; US Department of Transportation.
[14] H. Claypool, A. Bin-Nun, J. Gerlach, *Self-Driving Cars: The Impact on People with Disabilities*, The Ruderman Family Foundation & Securing America's Future Energy, January 2017. Pg. 4.
[15] National Highway Safety Administration, *Automated Vehicles for Safety*, NHTSA; US Department of Transportation.
[16] The Ford Motor Company Media Center. *Ford Targets Fully Autonomous Vehicle for Ride Sharing in 2021*; *Invests In New Tech Companies, Doubles Silicon Valley Team*, 2016.
[17] J. Bhuiyan, *Ford's partnership with Lyft finally gives it a clear plan for self-driving cars*, September 2017, Recode.

also partners with Lyft, has produced its first round of autonomous Chevy Bolts.[18] Meanwhile, Uber has pursued CAV pilot projects in Pittsburgh, San Francisco, and Tempe.[19] These pilot projects are now halted following the recent Uber AV crash in Tempe which resulted in the death of a pedestrian.

Some transportation planners believe conventional vehicles should be replaced by urban/low speed vehicles in constrained use urban environments to make last mile trips clear, safer, and more affordable. A smaller fleet of urban speed vehicles could offer an alternative for more rapid deployment of CAV technology.

While CAV manufacturers appear willing to develop shared use CAV applications, it may be difficult to convince individuals to give up their cars. Policymakers and other stakeholders must consider how to best guide the industry so the potential benefits of CAVs can be fully realized, and a ‘hell’ scenario can be avoided.

Infrastructure and Infrastructure Financing

Only 6 percent of urban transportation plans consider CAVs and their effects, according to a 2015 National League of Cities (NLC) analysis.[20] This is a low number considering CAVs will need a modern infrastructure plan. CAVs will need a predictable driving environment including uniform lane striping and signage; smart infrastructure – including street lights, traffic signals, roads, parking spots, and pavement markings complete with sensors; and broadband and spectrum to support V2V and V2I applications. Lawmakers at the local, state, and federal level will need to work alongside manufacturers to create an infrastructure that reflects and supports the needs of driverless and connected vehicles. Manufactures will also need to share data with local and state governmental bodies to ensure they understand the type of infrastructure that needs to be built or retrofitted to maximize CAV potential.

A *Governing* analysis found 25 of the largest US cities raised nearly $5 billion in fiscal year 2016 from “parking-related activities, camera and traffic citations, gas taxes, towing, and vehicle registration and licensing fees.”[21] Widespread CAV use could impact these traditional local revenue streams and, depending on how CAVs change travel demand and vehicle ownership, state and federal budgets could also be negatively affected.

Therefore, policymakers at all levels of government must consider how to pay for some current and new infrastructure. Examples of innovative financing models include VMT fees, AV user fees, the expansion of state infrastructure banks, and increased utilization of public-private partnerships (P3s). In addition to traditional transportation infrastructure financing, innovative financing approaches will need to be pursued for widespread CAV adoption.

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[18] General Motors Corporate Newsroom, G*M Produces First Round of Self-Driving Chevrolet Bolt EV Test Vehicles*, 2013.

[19] P. Lewis, G. Rogers, S. Turner, *Beyond Speculation: Automated Vehicles and Public Policy; An Action Plan for Federal, State, and Local Policymakers*, May 2017, Eno Center for Transportation, Pg. 6.

[20] N. DuPuis, C. Martin, B. Rainwater, *City of the Future: Technology & Mobility*, National League of Cities Center for City Solutions and Applied Research, 2015, Pg. 7.

[21] M. Maciag, *How Driverless Cars Could Be a Big Problem for Cities*, August 2017, Governing.

Data

The proliferation of CAVs will result in a large amount of useful and important data on congestion, traffic patterns, mobility, and infrastructure. The data generated will be of tremendous value to a number of stakeholders including the manufacturer, the vehicle owner, and local, state, and federal governments. Who has access to this data, how it is used, and how it is stored are questions the federal government will need to address.
While the Driver Privacy Act designates data collected by a vehicle's event data recorder (EDR) as the property of the vehicle owner, it does not touch upon the kind of data and information that will be collected by CAVs and how or if it should be shared. The sharing of data between manufacturers and the government could help to maximize the potential of CAVs. Data collected by manufacturers could be useful for monitoring traffic and congestion, public utilities, road safety, and infrastructure. Local and city governments in particular will want access to this information to better serve the needs of their constituencies.

The National Association of City Transportation Officials' (NACTO) 2016 Statement on Automated Vehicles called for policy that would encourage modernizing traffic data and supported implementing data sharing requirements for new vehicle technology: "Public policies should foster open data platforms that enable robust private innovation to better serve transportation customer needs, while reducing aggregate social and environmental costs and inequities through a regulated utility model framework."[22] Collaboration between the public and private sector will be key to reaching an agreement on data sharing.

Cybersecurity

As vehicles are programmed to connect to the internet, each other, and their environment they become increasingly vulnerable to hacking. Digitally connected devices in vehicles can serve as an entry way for cybercriminals, who could theoretically use the devices to hack into the vehicle and disable the engine, brakes, and other features, steal personal and financial information, or even disrupt smart infrastructure systems. The consequences of such disruptions range from financial loss to loss of life.

So-called 'white hat hackers,' who work to expose technology vulnerabilities before malicious hackers do, have exposed the vulnerabilities of various aspects of automated driving systems (ADS). In 2015, hackers broke into a 2014 Jeep Cherokee's digital system through the internet.[23] Chrysler has since fixed the problem, but the implications of the incident – including the fact that malicious hackers could have manipulated the vehicle's brakes and steering wheel – remain.

Both policymakers and the auto industry are taking CAV cybersecurity seriously. The automotive industry created the Automotive Information Sharing and Analysis Center (Auto-ISAC) to share best safety practices, and policy guidelines released by NHTSA in 2017 included vehicle

[22] National Association of City Transportation Officials, *NACTO Policy Statement on Automated Vehicles*, NACTO, June 2016, pg. 2.
[23] A. Greenberg, *Hackers Remotely Kill a Jeep on the Highway – With Me In It*, Wired, July 2015.

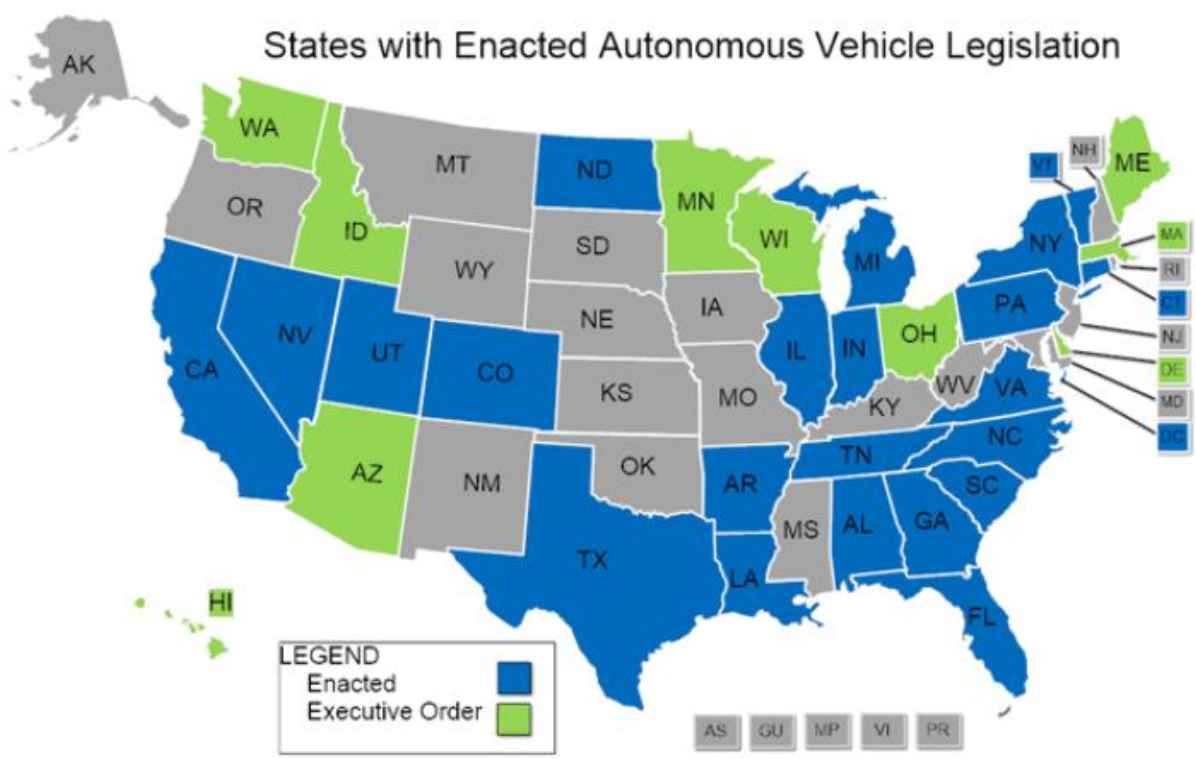
cybersecurity in its 12 priority safety design elements. Additionally, federal legislation has been introduced to address the threat of cybersecurity. The SELF DRIVE Act, passed by the House of Representatives, requires AV and ADS manufacturers to create a cybersecurity policy, designate a lead cybersecurity employee, establish a process for limiting access to ADSs, and have employee cyber security training and supervision procedures. The AV START Act, passed by the Senate Commerce Science, and Transportation Committee, contains similar provisions.

Current Regulatory and Legislative Landscape

State Legislation & Regulation

Traditionally, the federal government has regulated the vehicle while states have regulated the driver. CAVs have the potential to disrupt this delineation of responsibilities by making the vehicle the driver. Given the void of federal CAV legislation, many states have instituted their own regulations.

According to the National Conference of State Legislatures (NCSL), 22 states have enacted legislation related to CAVs, while the governors of another 10 have issued executive orders related to CAVs. A map of states with enacted CAV legislation is included below:



Source: National Conference of State Legislatures

A patchwork of state regulations and laws has appeared in the absence of any federal CAV legislation. This is concerning to CAV manufacturers that wish to sell and operate their vehicles across state lines. As the federal government develops CAV legislation, a careful balance must be struck between federal and local jurisdiction.

Federal Regulation

The US Department of Transportation (USDOT), through NHTSA, has released two federal guidance documents on CAV technologies. The first, *the Federal Automated Vehicles Policy* (FAVP) was issued in September, 2016 under the Obama administration and the second, the *Automated Driving Systems 2.0: A Vision for Safety* (ADS 2.0), was released a year later in September, 2017 under the Trump administration. USDOT anticipates publishing annual updates to the regulatory framework, and work on ADS 3.0 is already underway.

The FAVP, crafted with input from a wide variety of stakeholders, was divided into four sections:

- Vehicle Performance Guidance for Automated Vehicles
- Model State Policy
- NHTSA's Current Regulatory Tools
- Modern Regulatory Tools

ADS 2.0 is divided into two sections: voluntary guidance and technical assistance to states. Both the FAVP and ADS 2.0 take a similar approach to the division of federal and state regulatory responsibilities. ADS 2.0, like the FAVP, suggests current regulatory responsibilities – in which the federal government regulates motor vehicles and motor vehicle equipment, and state governments manage the driver – should remain the same.

ADS 2.0 states USDOT should maintain responsibility over the nation's infrastructure system, interstate motor carriers, commercial vehicle drivers, and registration and insurance requirements. The policy also "allows DOT alone to regulate the safety design and performance aspects of ADS technology."[24]

Another important element of the ADS 2.0 policy is its best practices for state legislatures. These include providing a 'technology-neutral' environment, providing licensing and registration procedures, providing reporting and communications methods for public safety officials, and reviewing traffic laws and regulations that may serve as barriers to AVs.

ADS 2.0 is similar to FAVP, but is generally considered to be less strict with regard to regulations and places an emphasis on the voluntary aspects of the guidelines. ADS 2.0 also modifies the 15-point safety assessment letter (SAL) included in the FAVP, by suggesting CAV entities submit a 12-point safety self-assessment instead.

[24] US Department of Transportation National Highway Safety Administration, *Automated Driving Systems 2.0: A Vision for Safety*, September 2017, Pg. 20.

Some safety advocates believe USDOT is taking a backseat approach to regulating CAVs, and say that while the agency should not be picking winners and losers, it has a vested interest in and responsibility for public safety.

Transportation Secretary Elaine Chao recently announced at a Listening Summit on automated vehicle policy that ADS 3.0 could be released as early as summer 2018. According to statements made by USDOT officials at the Summit, the policy will be multimodal in focus and reflect a 'one DOT approach.'

Federal Legislation

On September 6, 2017 the US House of Representatives passed its first piece of AV legislation, the Safely Ensuring Lives Future Deployment and Research in Vehicle Evolution (SELF DRIVE) Act, H.R. 3388. The SELF DRIVE Act seeks to outline a clear federal regulatory path for developing, testing, and deploying AVs.

The Senate Commerce, Science, and Transportation Committee passed its own AV legislation, the American Vision for Safety Transportation through Advancement of Revolutionary Technologies (AV START) act on October 4, 2017.

The Eno Center for Transportation published a side-by-side comparison summary of the two bills. It is publicly available here.

Federal Legislation Concerns

While the AV START Act was meant to be considered under a fast-track process, a group of Senators are stalling the bill. They are demanding changes to the legislation including a sunset of its preemption provisions, a limit on safety exemptions, stronger privacy and security protections, and regulation of partially as well as fully autonomous vehicles.

These Senators are not the only ones who have concerns about the bill. Some state and local governments, as well as associations including Transportation for American (T4) and NACTO are apprehensive of the bill's state preemption provisions. They argue the bill will allow for the development, testing, and deployment of CAVs on local and state road without giving local and state governments any authority over them.

Such groups are also concerned the bill does not make sufficient data available to transportation agencies. Associations like NACTO and T4 believe that data sharing requirements are necessary for local governments to protect public safety, adapt their infrastructure, and manage their assets and investments.

Consumer advocates are concerned the exemption language in the bill is too broad and could allow vehicle manufacturers to bypass normal safety components like airbags, endangering pedestrians, passengers, and drivers.

Conclusion

We will likely see increased federal action on CAVs in 2018. Informal preconference meetings have begun in the House and Senate to reconcile differences in the AV START and SELF DRIVE Acts, which indicates legislation could pass. Additionally, the USDOT is expected to continue expanding its role in AV development. The agency’s 3.0 guidance will go beyond AV design and performance to address actual implementation of autonomous driving technologies. The pace of CAV innovation is not likely to slow for decades. Successful adoption will require sound transportation planning and effective public policies to manage safe deployment.

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