Eno Center for Transportation

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Adopting and Adapting

States and Automated Vehicle Policy

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Special thanks to the Digital Cities Advisory Board.

About Eno and the Digital Cities Project

The Eno Center for Transportation is an independent, nonpartisan think tank that promotes policy innovation and leads professional development in the transportation industry. As part of its mission, Eno seeks continuous improvement in transportation and its public and private leadership in order to improve the system's mobility, safety, and sustainability.

Eno's Digital Cities project is a multi-part research and outreach effort intended to provide a resource for policymakers to understand the technological forces that are shaping our transportation networks.

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Executive Summary

Automated vehicles are challenging the status quo of transportation networks and the policies that support them. The technology is developing quickly and has the potential to make roadways safer, more efficient, and more accessible for Americans. However, commercial deployment is still several years away, and successful implementation is far from guaranteed.

To allow the technology to reach its full potential, governments at all levels need to adapt, especially on the state level. State governments have long played an important role in planning, regulating, and managing roadway networks, however AVs could entirely upend the existing federalist structure. This paper provides guidance on how states should prepare for an automated future by adapting their approach to motor vehicle regulations, infrastructure investment, and research.

Crafting sound policy approaches to AVs is not a straightforward process, as an AV does not have a singular definition. Instead, different "levels of automation" correspond to varying capabilities of the automated system and the role of the human driver. The policy framework directly correspond to the definitions of AVs, particularly in state-level responsibilities such as liability, licensing, and insurance. However, AVs are not commercially available yet and will not be widespread for many years. Planning for something that is not in widespread use, and designing policies to support it, is very difficult.

States have taken one of four approaches to AV policy. A few have fully legalized vehicles without drivers, some have passed laws that expressly permit testing, others have issued direct executive actions, and the rest are either developing laws or are waiting for the market to develop further. This report finds that, while any of these approaches can be effective in the short term, there are some general guidelines that states should follow to avoid regulatory pitfalls, prevent wasted public and private sector investments, and encourage the thoughtful implementation of AVs.

In terms of **AV regulations**, states need to be sure to adhere to consistent definitions. The "levels of automation", as defined by the Society of Automotive Engineers International (SAE), are the national standard and should be worked into all state AV policies. When developing these policies, states should understand legislation or regulatory action alone will not necessarily attract or deter AV testing. An entire ecosystem of engineers, manufacturing plants, and software developers along with good roadways and permissive rules is required to encourage AV testing.

When writing laws or executive orders, states need to be careful not to overdesign reporting requirements for manufacturers and tech firms as they continue to test and deploy AVs. While AV companies are not opposed to obtaining special operating permits or specific driver requirements, states must strike the right balance to avoid onerous bureaucracy or exposure of propriety corporate information. Fully self-driving vehicles are still years away from deployment, but in the meantime states should develop partnerships with AV companies, research groups,

and localities in order to develop specific pilots to better understand the effects of AVs their roads.

States have long been responsible for regulating tort, liability, and insurance for roadway vehicles. AVs could prompt states to redefine some or all of those laws. To prepare, states need to work with the National Highway Traffic Safety Administration (NHTSA) to harmonize tort and liability laws and enable consistent, national safety standards for commercial AV certification. Further, states need to review and update current traffic laws that may directly conflict with the operation of AVs on public roads.

To manage the entire regulatory process, states should form an AV advisory committee that monitors and advises on AV policy. Such an entity should include the variety of public and private sector stakeholders. In consultation with this group, states should create non-binding "statement of principles" for certain AV policies such as privacy, cybersecurity, roadway safety, consumer advocacy, and data sharing.

When it comes to **infrastructure investment,** the most beneficial action states can undertake is to improve roadway state-of-good-repair. Since automated vehicle technology works best on well-maintained and marked roads AV firms are naturally attracted to states with a commitment to fix-it-first. Advanced infrastructure investments, such as vehicle-to-infrastructure (V2I) technologies, could further enhance AV capabilities. However, connected vehicle technology (CV) is unproven and still in testing phases. Instead of committing significant funding to retrofitting their infrastructure, states should initiate tests of CV and V2I applications in order to better understand their potential benefits. In order to **fund** these improvements and other AV infrastructure needs, states should consider developing a road use fee for AVs. States can also experiment with using the fee to manage future demand and mitigate negative externalities.

States should be involved in **AV research** as it pertains to all possible effects of AVs on the broader transportation network. With the private sector leading the way on most AV development, state policymakers should establish themselves as facilitators, by encouraging pilot programs and research efforts at AV testing grounds. States can also fund research to understand how AVs could affect the broader transportation network and incorporate that into state transportation improvement plans.

Finally, states need to prepare for the future impacts of AVs on the **workforce.** With the potential disruptions AVs may have on employment, states should begin to examine and invest in programs that will help retrain workers who have lost jobs to automation. Partnering with universities and the private sector for targeted re-training or career development can enhance early efforts to mitigate job loss and prepare for future workforce challenges.

Sound and consistent policy at the state level will help automated vehicles to navigate safely and seamlessly no matter where they are operating. Policymakers should focus on this harmonization in order to allow AVs to reach their full potential while also maintaining the interests and safety of all road users.

1. Introduction

In the past decade, the automated vehicle (AV) industry has made tremendous technological progress on automated and semi-automated driving features for cars and trucks. Some features, such as lane centering and adaptive cruise control, are available on vehicles today. These advances are already improving safety, and traditional automakers and technology firms alike are promising fully self-driving capabilities within five years.

Meanwhile, state policymakers and transportation departments are planning to adapt policy frameworks to meet the demands and requirements of AVs. This includes updating regulations, making infrastructure investments, and targeting research in a field that is changing rapidly. But sifting through the self-driving vehicle hype to create a policy and investment plan that can adapt to a rapidly-changing environment poses significant challenges for state officials.

The fundamental challenge with AV policy is that the technology is redefining traditional transportation federalism. New stakeholders, business models, and partnerships are upending this structure that currently defines the roles of the federal, state, and local government in surface transportation. With it comes a set of complicated questions. For instance, how do state liability laws assign responsibility if an AV system is involved in a crash? Should state governments invest in a new generation of connected traffic signals? What is the value of states using public funds to research AV development and deployment? How do states with various urban and rural areas, warm and cold climates, and varied driving landscapes adopt policies that meet the needs of their diverse population?

This paper uses a federalist framework to examine three primary policy concerns for state governments: regulations, infrastructure investment and funding, and research and workforce training. The goal is to understand the current state of the industry, review existing and pending policies, and create actionable recommendations for states around the country.

2. Background on AVs

The public policy landscape for automated vehicles is complex and changing rapidly. This presents three major challenges.

First, while AVs are not new, the development approach to them is. With private industry, not government, leading the research and development of the technology, the critical role of policymakers is to continue to foster this innovation while ensuring public safety.

Second, the definition of an AV is not static and is expected to evolve. Currently, the federal government defines “levels of automation” that describe the respective roles and responsibilities of human and AV systems when performing the driving task. While these

established levels provide a useful baseline for categorizing the levels of vehicles autonomy, they also make it difficult to establish regulations and anticipate future developments.

Third, fully automated vehicles do not exist yet. There are some lower level AVs available on the market today (such as Tesla's Autopilot), and there are some higher level AVs in testing or limited pilots (by many major automakers as well as technology firms like Google and Uber). However, experts disagree on when AVs will reach market-ready maturity. Therefore, developing a policy framework for this unproven technology is a daunting task.

2.1 The smart vehicle approach to AVs

Early renderings of driverless vehicles imagined "smart *infrastructure*" networks comprised of roadways and vehicles outfitted with sensors and hardware that would guide automobiles along a programmed path. This vision led to a 1997 demonstration of a vehicle test fleet with operators not using hand or foot controls on 7.6 miles of Interstate 15 in San Diego.[1] While the technology worked successfully, the ambition of achieving driverless cars through smart infrastructure was never realized on a broad scale. This is largely due to the massive, coordinated public and private sector investment that would be needed to outfit millions of miles of roadways and millions of vehicles.

Federal efforts that supported sophisticated research and development such as the U.S. Department of Defense Advanced Research Projects Agency's (DARPA) Grand Challenges (beginning in 2004) and its Urban Challenge (in 2007) played a key role in catalyzing the development of AV technologies and, consequently, the companies and the workforces that support them.[2] Today, automated vehicle technologies are rolling out because of improved systems powerful enough to create "smart *vehicles*" that drive without the need for exterior input or special infrastructure. From a policy standpoint, this means that federal and state governments will play a supporting role in AV deployment, rather than coordinating a widespread investment effort.

2.2 The multifaceted definition of AVs

An increasing number of features in vehicle models today are automating the driving task, including adaptive cruise control, preemptive braking systems, and parking assist systems.[3] These features, called *automated driving systems* (ADS), correspond to specific "levels of automation" under the National Highway Traffic Safety Administration's (NHTSA) classification system for AVs.[4] As such, an AV is not a single technology – and policymakers have to keep the different levels of automation in mind when thinking about and developing AV policy.

Table 1: NHTSA/SAE Classification System for Vehicle Levels of Automation

Level	Name	Automated System Role	Human Role
0	No Automation	None	All driving functions of the vehicle
1	Driver Assistance	Features such as adaptive cruise control or lane centering to independently assist the driver	Responsible for all core driving functions
2	Partial Automation	Conducts some parts of the driving task, such as steering, acceleration, and deceleration	Responsible for monitoring the external driving environment and ready to take control with or without warning from the system
3	Conditional Automation	Performs most driving functions and monitors the driving environment. May request human driver to intervene for specific driving tasks	Must remain ready to take control and respond appropriately to the AV systems' request to intervene
4	High Automation	Conducts all driving tasks and monitors the driving environment. However, can only operate in certain environments and designed for specific situations, such as a defined route shuttle. No steering wheel, pedals or shifting mechanisms required for a human driver	Human is present but does not need to take back control
5	Full Automation	Conducts all driving functions under all environments without a human driver	Human provides destination or navigation input but does not control the vehicle at any point. Designers may include features such as steering and speed control to allow human operator when system is not engaged

Source: Adapted from SAE Levels of Automation

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2.3 The future of market-ready AV technology

Level 1 vehicles are in wide use today, and vehicles capable of AV Level 2 operation are currently offered by a select number of manufacturers such as Mercedes, BMW, Tesla, Cadillac, and Lexus.[5] As of the release of this publication, there are no market-ready vehicles capable of operating at Levels 3, 4, or 5. Most AV developers believe that the technology will be market-ready in less than five years.[6] Others acknowledge that more testing and supporting policies are needed as the technology matures.[7]

Regardless of when Level 3 or higher AVs will hit the market, the rapid development of AV technology has already started to shift the business models of automotive mobility. Several developers are focusing their initial deployment efforts around a shared fleet model, rather than individual ownership. Some of the first U.S. pilots include Uber's deployment of self-driving fleets in Pittsburgh, San Francisco, and Tempe. General Motors has taken a large financial stake in this model through its partnership with ride-sourcing company Lyft. In order to recover their substantial startup costs, firms could charge for on-demand automated driving services, instead of selling individual vehicles as a traditional one-time purchase. This model would change the interactions between buyers and technology, while also redefining vehicle ownership and liability for crashes or collisions.

Additionally, the shared fleet approach will allow companies to not only retain control of the vehicle for necessary maintenance, but would also allow for a distrustful general

public to gradually become more comfortable with the technology.[8] Policymakers will have to consider both methods as they develop future public policy responses around AVs. The recommendations in this paper can apply to both the private and shared fleet ownership models.

3. Existing state approaches to AV policy

States have taken one of four approaches to AV policy.

First, most **states do not have any regulations or laws that specifically pertain to AVs**. These states are not unaware of the changing environment but are instead working to craft laws and/or waiting to see how the market evolves in the rest of the country. While this leaves any AV subject to existing traffic and motor vehicle laws, it does not explicitly prohibit their operation.

The second approach is from **states that have explicitly expressed interest in AVs** but have not passed any laws directly related to testing and deployment. Through executive orders, states like Arizona have set up self-driving vehicle oversight committees and research teams at their respective state departments of transportation (DOTs). Virginia's governor issued a 2015 "executive proclamation" that supports AV research and the testing conducted in partnership with Virginia Tech. Virginia also created the Virginia Automated 20xx Working Group that brings together state-level policymakers and officials in order to create a strategic plan for AVs in the state.[9] North Dakota established a legislative management study of AVs.[10] These groups work to inform lawmakers and other state officials on when and how to craft state laws or investments for AVs.

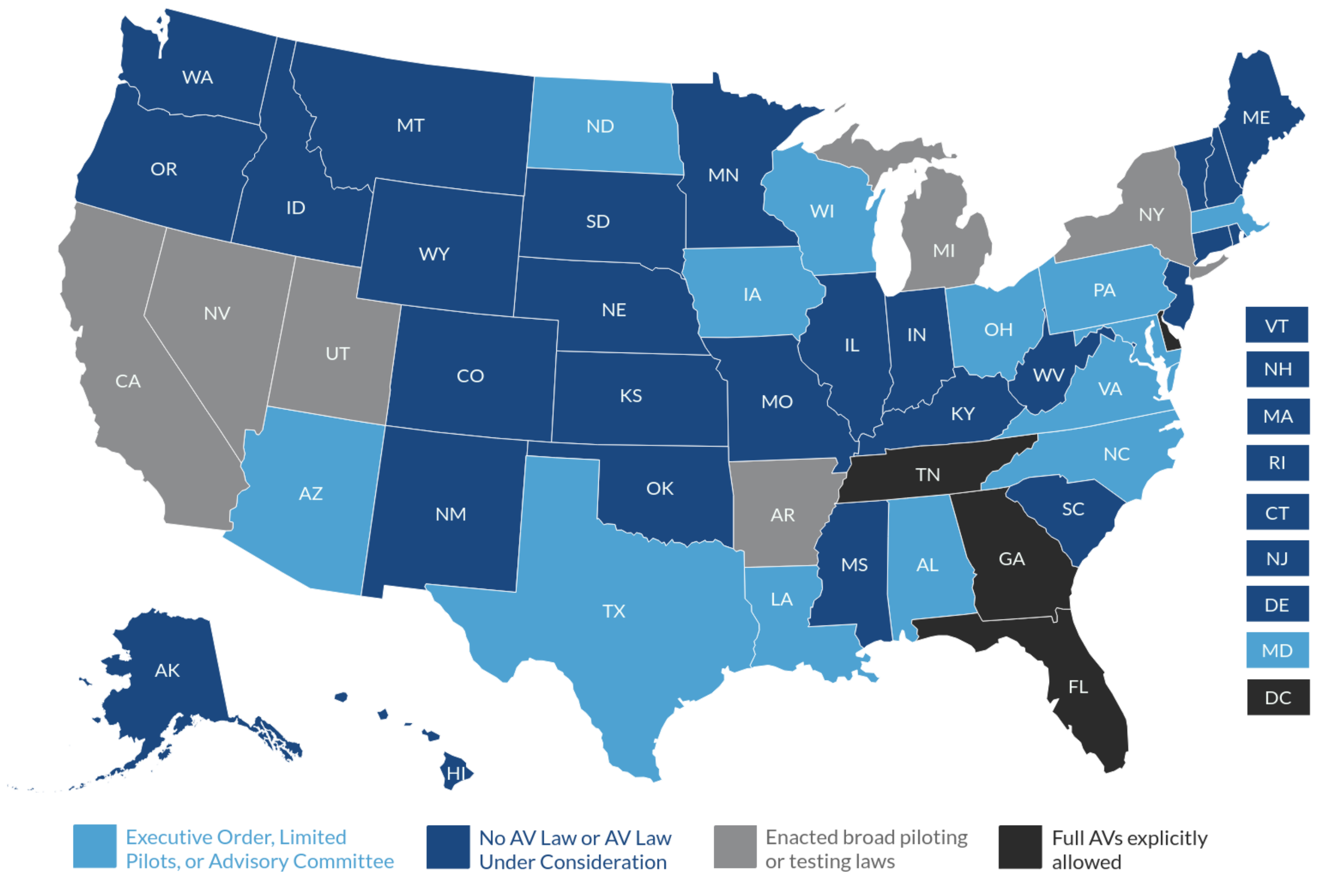
States included in the first two categories have modified their approaches over the course of a few years. Georgia's Joint Autonomous Vehicle Technology Study Committee evaluated the issues facing AV technology through three public hearings involving academics and industry experts. The committee's final 2014 report advised the Georgia state legislature to refrain from passing any legislation until the technology had matured. It stated: "To recommend any changes to our current system at this time would be putting the proverbial cart before the horse."[11] However, the state has since decided to move forward on implementing official AV policies by enacting a law that allows for fully driverless AVs.[12]

The third approach includes **states that explicitly allow for AV testing**. This is most common among states that have AV laws and includes Michigan, California, Utah, Nevada, and Tennessee. The enacted laws vary in scope, rules, and extent, and create a medley of frameworks to which AV testers must adapt. California requires licensing with the state and regular reporting of any system problem or incident. Tennessee set up a framework for the state to begin charging a per-mile fee on AV driving.[13] Michigan passed AV legislation that allows for testing on public roads, truck platooning, and legalized self-driving ridesharing in the state.[14] Utah authorized the state DOT to conduct a connected automated vehicle (CAV) testing program on platooning applications.[15] In most of these cases, AV developers must

obtain a state-approved permit that requires them to report their safety infractions to the state government.

The fourth approach includes **states that explicitly allow fully automated vehicles** to be deployed beyond the testing phase. Florida was one of the first states to pass an AV policy and, along with Georgia, is one of only two states to specifically allow for the operation of driverless vehicles. Under Florida's current framework, AVs can operate on public roadways without a human physically in the vehicle. The only requirement is that the vehicle is able to inform an operator within the vehicle or via remote that the system has failed and the vehicle software can safely bring itself to a stop. The District of Columbia also allows for fully automated vehicles, but a human operator must be present in the driver seat.[16]

Figure 1: Status of state policies related to automated driving, as of May 2017



Source: National Conference of State Legislatures and individual state legislation[17]

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Just because a state has passed AV legislation does not mean that it is necessarily good for the industry or the general public. Companies developing AVs are worried about the emerging patchwork of regulations at the state and local level, which could thwart the testing and sales of certain types of driverless vehicles across jurisdictions. Moreover, state governments risk investing in technologies that will soon be outdated. Implementing licensing and reporting requirements for AVs requires additional resources on both the public and private sector side. This has been particularly challenging for California, due to the rapid expansion of private

sector AV testing in the state. The resulting financial and personnel burden on the state caused it to propose raising the annual application fees for an AV testing permit from $150 to $3,600 to help cover administrative costs.[18]

States have to maintain a delicate balance: while overreaching policies and excessive regulation could hinder technological innovation, a regulatory vacuum leaves companies uncertain about "the legal environment that awaits their new vehicles."[19]

3.1 The Federal Automated Vehicles Policy Statement

In September 2016, the National Highway and Traffic Safety Administration (NHTSA) released its Federal Automated Vehicles Policy (FAVP) statement.[20] The document was written in consultation with automakers, tech firms, state government officials, and experts in the field. The FAVP establishes a foundation for automated vehicle developers and the federal government to collaborate on developing AV policies but is not binding nor comprehensive.

The FAVP sought to assuage industry concerns surrounding the lack of regulatory certainty for AVs. It provides guidance to manufacturers testing and developing AVs on public roads, clarifies the roles of the federal and state governments in regulating AV operations, and outlines NHTSA's existing and potential enforcement mechanisms. The FAVP is a working document: NHSTA received over 1,100 formal comments and will update it in the coming years.[21]

The document is broken into 4 sections that address NHTSA's authority to enforce federal motor vehicle safety standards (FMVSS), a model state policy, and current and future regulatory tools.[22] The reactions to the FAVP by the AV industry are mostly about the 15-point voluntary safety assessment letter (SAL) presented in the first section of the FAVP. The following summarizes some of the major feedback on the FAVP:

1. Disagreement with the inclusion of Level 2 vehicles in the SAL, which SAE does not categorize as "Highly Automated."[23] Since Level 2 vehicles already operate on roads today, critics argue that this should not be applicable since it will generate additional confusion.
2. Concern that the SAL would force AV developers to share propriety data about their system design to federal regulators. This may include trade secrets and other confidential information that could be subject to public access through Freedom of Information Act (FOIA).
3. Worry that the states formally adopt the NHTSA FAVP policy and render the voluntary guidance mandatory at the state level. AV developers feel that it would be particularly onerous to submit written SAL for each state and would not be conducive to ensuring safe operation, as state agency expertise is traditionally focused on human drivers rather than vehicle design and performance.

4. AV regulations at the state level

The overarching aim of state-level regulations on AVs is to (1) ensure public safety, (2) provide consistent frameworks for developers, and (3) create an environment where rules can adapt to the unknown future outcomes. Given that AVs are still in development phase, there is no "one size fits all" approach to state-level AV regulations. Some states might choose to pass laws, others might choose to take executive actions, and others will prefer to not take any steps. While there can be pitfalls in any of these methods, state governments must decide what is right for their own constituents. The following items outline specific steps or considerations for any state-level approach.

4.1 Consider that legislation or regulatory action will not necessarily attract or deter AV testing

States are feeling pressure to proactively pass AV laws that govern the safety and regulatory environment in which the technology would operate. A primary impetus for these statutes is to promote AV testing and development in order to bolster an AV economy in their state. While AV laws intend to help create a more consistent and welcome environment for AV developers, three examples below demonstrate how they might not achieve their stated purpose.

While establishing AV policies may not have been of existential importance for Michigan's auto industry, it did provide companies with the regulatory certainty to expand their AV testing and deployment operations in the state. Governor Rick Snyder used his 2013 State of the State Address to draw attention to the need for state AV policies.[24] He cited other AV legislation that had already been passed by California, Florida, and Nevada, to spur Michigan to pass a bill so as not to lose competitive ground with those states. Governor Snyder subsequently signed Michigan's first AV laws later that year.

But even without the laws, Michigan has long been a natural home for researching and testing advanced driving technologies. Not only are the largest U.S. automakers in Detroit, but the state's geographic diversity, four seasons, and diversity of urban and rural conditions allow manufacturers and tech firms to explore the full range of challenges for AVs. Ford, GM, and Toyota were conducting automated vehicle research in the state before the passage of its first AV policies in 2013.[25]

In contrast, Tennessee legislators saw a need to establish policies that would accommodate the future testing and deployment of AVs. State senator Mark Green led the effort to pass AV legislation in July 2016. He hoped that this would create new business opportunities for the auto manufacturers that have plants in the state.[26] It is too early to determine whether the AV law has attracted investment, yet no major companies have announced a movement of AV research and development to Tennessee.

California has rigorous permitting and reporting requirements for AVs, but that has not deterred multiple companies from continuing to test vehicles. As of March 2017, 22 different firms have registered to test AVs, even though they are subject to an extensive list of reporting requirements. For example, in December 2016, Uber announced the launch of its Self-Driving Uber service in San Francisco.[27] Uber stated that the service utilizes semi-automated vehicles that are continuously monitored by a human operator, arguing that its vehicles are not included under California's reporting requirements. However, the department of motor vehicle's general counsel informed the firm that its self-driving Ubers fall within the state's legal definition of automated vehicle technology – and therefore must be registered before testing.[28] Uber was ordered to cease operations immediately and apply for an AV tester permit before conducting any future operations on public roads. The company refused to comply, which resulted in the state revoking the registration of its 15 self-driving vehicles. Uber moved the test vehicles to Arizona, which explicitly permits AV testing and does not have reporting requirements.[29] However, within a few weeks Uber had applied for and received permits, and moved two of its test vehicles back to San Francisco.[30]

States like Virginia chose not to adopt formal legislation on AVs or testing. Virginia's governor created the Virginia Automated Corridors and Virginia Connected Corridors program to develop, test, and deploy AV technologies. The automated corridors program is in partnership with the Virginia Department of Transportation, Department of Motor Vehicles, Transurban (a private highway operator), HERE (a private high-definition mapping company), and Virginia Tech. The corridors designate 70 miles of interstates and arterials in the Northern Virginia region and include two test-track environments as for AV testing. AV developers can test on Virginia roadways without additional permits or special licenses, as long as a driver remains in the vehicle. [31]

Establishing automated vehicle laws will not necessarily attract high-tech companies and jobs to a state. Despite copying portions of California's AV laws, Tennessee does not (yet) have a robust AV testing industry in the state. Nor do burdensome reporting requirements prompt companies to leave a particular state. California and Michigan have unique competitive advantages on the national stage including varied climates, a skilled workforce, high-tech industries that already existed in each state, and hundreds of academic institutions. The technology is still in development and, despite its high visibility in the media, it remains both geographically and financially concentrated in Michigan and on the West Coast.

State Action Item:

Make sure testing AVs is not only allowed, but also that it fosters the development of an entire ecosystem of automakers and/or tech firms, research institutes, and localities engaged in the field. Also, states have an advantage when they collaborate with their neighbors. Although there is a competitive nature in state-level AV policy, each state will be more attractive to AV development if there are fewer regulatory hurdles at their borders.

4.2 Adhere to consistent definitions

SAE and NHTSA have adopted a classification scheme for defining AVs and their system capabilities. However, states have also created their own unique definitions for AVs that are inconsistent with these definitions, causing confusion. For example, Michigan defined an "automated motor vehicle" as any motor vehicle with automated technology installed that allows it to be operated without any control or monitoring by a human driver. Vehicles with active safety or operator assistance systems like adaptive cruise control, lane-keeping assistance, and lane departure warnings were not included in Michigan designation unless one or more of those technologies allowed the vehicle to operate itself without control or monitoring by an operator.

Tennessee's law defines "autonomous technology" (a different term than Michigan) as systems with the capability to drive a motor vehicle without the active physical control or monitoring by the operator. It breaks down autonomous technology into two types: Operator-Required Autonomous Vehicle (ORAV) and Non-Operator Required Autonomous Vehicle (NORAV), and necessitates each type to receive state certification before testing.[32]

The differences in these definitions create confusion and apprehension among AV developers as they work to create vehicles that can cross state boundaries. The NHTSA/SAE classification provides a uniform system for designating the levels of vehicle automation, which allows lawmakers and regulators to precisely define how their rules apply to different automated systems, rather than trying to recreate categories that might not line up in other jurisdictions. As they relate to public policy, the NHTSA/SAE definitions might change along with the development of technology, but there are substantial benefits to using consistent designations for AVs.

State Action Item:

Adopt the current (and future) NHTSA/SAE AV definitions, and use them when developing AV policies.

4.3 Be careful not to overdesign reporting requirements for AV testing and deployment

Since AVs of Level 3 and higher are still in the development phase, regulations within existing state legislation target the testing of vehicles. In an attempt to ensure that these test vehicles are abiding by a standard of safety, some state AV laws require testers to get state permits and report to the state before, during, and/or after testing. Not every state has the same requirements, and overdesign of the reporting requirements can both dissuade widespread testing and create problems when test vehicles cross state boundaries. While this is an annoyance during testing, it will be problematic for future commercial applications.

In California, each AV must be registered and permitted with the state's department of motor vehicles (DMV) prior to operation on public roads. Registration documents must include a written description of the automated technology and features integrated into the vehicle, as well as the range of its automated capabilities. California DMV established fees to recover the costs of processing initial applications and renewals, requesting additional vehicles and/or test drives, and modifying an existing permit.[33]

Under California's enacted regulations, only employees, contractors, or other persons designated by the AV manufacturer can conduct the tests. The regulations require manufacturers to develop and maintain training programs for their AV test drivers. A human operator must also remain in the driver's seat to monitor the safe operation of the vehicle and immediately take over control in the event of a system failure or another emergency. Furthermore, each AV must have a data recording system that captures and stores sensor data for at least 90 seconds before a collision. This data must be stored in a read-only (un-editable) format for a minimum of three years after the date of a collision. Prior to testing AVs in California, manufacturers must also obtain an instrument of insurance in the amount of $5,000,000.

During testing, the regulations require manufacturers to record every instance of disengagement of the automated system (i.e. when the AV system is turned off and control is handed back to the human operator), as well as collisions. The California DMV makes these "disengagement reports" publicly available online.[35] These reports summarize disengagements, including the total number and the circumstances surrounding them. The DMV website published 2016 disengagement reports for 11 AV developers, including GM, Mercedes, and Tesla, each with hundreds of individual instances.[36]

Similar to California, manufacturers in Tennessee are permitted to test ORAVs on public streets and highways after obtaining a permit from the Department of Safety. In fact, aside from their inconsistent definitions of AVs, portions of Tennessee's 2016 laws that relate to AV testing are identical to California's 2012 AV laws. As in California, if any company were to begin testing in the state, it would need to obtain a permit from the state and verify that its AVs are capable of safe operation. By copying California's legal language, Tennessee facilitated the consistency of requirements for testing and reporting, but this does not mean that all states will take the same approach.

Michigan has similar (but not identical) testing laws to California and Tennessee. Manufacturers are required to submit proof of insurance and obtain special license plates from the state prior to testing AVs. Throughout testing, an employee of the manufacturer must be either present in the vehicle or monitoring it remotely and be prepared to immediately take over control.[37] Furthermore, the regulations exempt AV operators from the statewide prohibition on using cell phones while operating a motor vehicle, opening up a future where humans are freed from driving.

The rules in Arizona for AV testing are simpler and much more permissive than in California, Tennessee, and Michigan. While Arizona has not enacted any AV legislation, a 2015 executive order directs the department of transportation, department of safety, and all other state agencies to "undertake all necessary steps to support the testing and operation" of AVs. The order outlines several "rules" for AV testing and operation, including that the vehicles can only be operated by an employee of the AV developer (with a valid driver's license), who is responsible for and must monitor the vehicle's movement. The AV developer must have a proof of financial responsibility and the DOT director can add additional rules necessary to allow testing on public roadways.

While the AV industry has helped to create state AV laws and regulations, it does not always support the outcome. The Coalition for Safer Streets, an industry-led AV advocacy group, expressed concerns over the requirement in California and other states for manufacturers to submit annual reports on every single unplanned disengagement of the automated system.[38] But the private AV industry is not opposed to states requiring permitting or reporting, particularly in the case of collisions. Documenting and publishing every disengagement is over reporting, especially since the disengagement reports do not provide the public with much information into how safely or unsafely the vehicles are operating on roadways.

Manufacturer applications in California must certify that its AV is equipped with the following features:

1. An easily-accessible mechanism to engage and disengage the AV system
2. A visible display inside the vehicle that indicates when the AV system is engaged or disengaged
3. An alert system that notifies the operator when a system failure is detected
4. Mechanisms for mitigating risk in the event of a system failure that either:
    - Allows the operator to immediately take manual control of the vehicle; and/or
    - Stops the vehicle when the driver does not or cannot take control in the event of an emergency
5. A failure alert system that allows the driver to take immediate manual control in more than one way (e.g., using the brake, accelerator, or steering wheel).[34]

State Action Item:

Design balanced reporting and permitting requirements that meet state needs for transparency and safety, but are not overly burdensome on AV testers. There is no rule of thumb on whether states should require AV testers to obtain a permit or submit reports to state officials. The AV industry is not opposed to testing permits and reporting, so long as the process is not too bureaucratic, cumbersome, or reveals proprietary corporate information.

4.4 Work with NHTSA to harmonize current and future tort/liability and ensure consistent, national safety standards for commercial AV certification.

More than 40,000 fatalities and 4.6 million nonfatal injuries occur annually on U.S. roads.[39] Automobile collisions are one the major leading causes of death in the United States, which has significantly higher car crash fatality rates than other high-income countries.[40] Of the thousands of traffic deaths each year, 94 percent are attributable to human error.[41] And while humans might drive while distracted, intoxicated, or fatigued, computers do not, and they are capable of 360-degree awareness and much faster response times.[42]

Eno's 2017 *Beyond Speculation* report discusses how it is currently impossible to prove that AV systems are definitively safer than human drivers, but the early results are promising.[43] For policymakers, the issues that surround how to certify automated driving systems, assign liability for collisions, and insure against damages in a driverless or quasi-driverless world are some of the most challenging to address. For instance, driving liability currently applies to the operator of the vehicle, which has always meant the human behind the steering wheel. Now, experts are suggesting that this risk should shift from the human driver to software developed by the vehicle manufacturer and technology providers.[44]

States are starting to lay a legal and liability framework to address AVs. For example, California proposed a rule in 2015 that would require AVs to have manual controls and a licensed driver in the vehicle, indicating consistent reliance on a human controller and implying that liability will stay with the *human driver*. However, this requirement poses a conflict with many AV developers' goal to eventually have fully self-driving vehicles without steering wheels or any manual controls at all. Recognizing this, California released a revised version of the proposed regulation in March 2017 that would allow vehicles to operate without a human operator.[45]

Additionally, Michigan limits the liability of manufacturers and subcomponent system suppliers for damages caused by a third party converting a vehicle to be automated.[46]

Manufacturers are further released of liability for damages resulting from converting a vehicle to be automated, unless there was a defect present when the vehicle was manufactured. In 2016, Florida passed the first legislation that legalizes fully automated vehicles on public roads without a driver being present. This indicates that Florida intends for the *self-driving technology* to be held liable in the case of an accident.

NHTSA, not individual states, should be responsible for certifying the technology used to drive AVs to ensure that they can safely operate in the conditions for which they are designed. Creating mandatory state-based safety assessments for commercial-ready vehicles would be overly burdensome on the emerging industry. For example, if every state required a safety assessment letter (which NHTSA current requests as part of its voluntary policy statement), the industry could quickly get bogged down in reporting for 50 states. State governments have a role in ensuring that AVs meet safety standards and follow the rules of the road, but regulating safety at the state level requires careful action and harmonization with federal guidelines.

State Action Items:

Allow NHTSA to regulate the certification of commercially-ready AV technologies.

Continue to lead in states' traditional regulatory areas such as licensing of human drivers, enforcing traffic laws, and regulating insurance and liability. States should assign crash liability to whatever (human or machine) is responsible for the driving task if there is an at-fault collision. AV developers should assume full liability in the case of a crash during testing. And AV firms should have insurance requirements for when their software is operating the vehicle.

Work with NHTSA and neighboring states to ensure that the liability definitions have few discrepancies.

4.5 Review and update current traffic laws

Current state and local laws can conflict directly with the nature of AVs. Take, for example, Falls Church, Virginia, where the vehicle code reads: "No person shall operate a motor vehicle upon the streets of the city without giving full time and attention to the operation of the vehicle".[47] This well-intended traffic code, which is common in cities, is in direct conflict with the ultimate goal of AV developments: to reduce the need for humans to drive.

Eventually all states and localities will need to consider how their current traffic laws work within driverless vehicle capabilities and update them accordingly. Examples include:

1. Talking on a hand-held cell phone while driving is banned in 15 states and texting while driving is banned in 48 states.[48] As written, these laws would still not allow for phone use even if the vehicle were driving itself, defeating one of the largest benefits of Level 4 and 5 AVs.
2. Every state is responsible for licensing drivers, and almost every state requires that a licensed driver be present and operating the vehicle when it is in use. But if there is a driverless fleet of vehicles, there might not be a need for any person, licensed or not, to be in the vehicle or control.
3. Many states have regulations about leaving vehicles unattended, including those that are idling. From a legal standpoint, this means that a person would need to "attend" to the vehicle at all times, which would not be required in Level 4 or 5 operation. Some states, like Virginia, caveat this and prohibits vehicles to be unattended only if "it constitutes a hazard in the use of the highway."[49]

These laws need to be reconciled with the changing nature of self-driving capabilities. By doing so, states can preemptively address concerns rather than letting case law – through a series of court cases across the country – determine the final outcome. According to some experts, it is not certain that a legal interpretation of existing laws would yield a favorable outcome for the AV industry, inciting a push for proactive policymaking when at all possible.[50] But repealing all existing traffic safety laws does not make sense either: human drivers should always have to abide by sensible traffic safety regulations, and updates should apply only to certified AV systems.

Tennessee's 2016 AV law begins to address some of the legal conflicts with AV driving. First, the law preempts localities from enacting policies that ban the operation of AVs, either intentionally or unintentionally. Further, the law allows AV operators to use electronic display screens only when the automated mode is engaged.[51]

State Action Item:

Identify current state and local laws that might be in conflict with the capabilities of future commercial-ready AVs. Proactively modify those laws so that they allow for permitted or certified AV systems, while still requiring safe human operation.

4.6 Authorize specific pilot programs

Testing of advanced AV capabilities, particularly those without human drivers, requires special authorizations that allow for them to pilot on public roadways. While self-driving vehicles are still years away from full deployment, cities across the world have initiated pilot programs for AV shuttles and testing for true driverless vehicles.

On September 29, 2016, California Governor Jerry Brown signed AB 1592 into law, which authorizes the Contra Costa Transportation Authority (CCTA) to conduct a pilot project for testing automated vehicles without human operators.[52] Prior to testing, the CCTA and/or the private entity conducting the test must submit a detailed description of the program to the California DMV. The program description must certify that the vehicle has been tested under controlled conditions to ensure it is capable of safe operation. Furthermore, the City of San Ramon and other local authorities with jurisdiction over the testing area must approve of the testing, environmental, traffic, and speed conditions under which the AV will operate. The law restricts the vehicles to operating at less than 35 miles per hour and only within the designated areas and weather conditions.

Similarly, Michigan's AV laws allow companies to launch an on-demand AV network, but a company must self-certify its ownership of all vehicles in the participating fleet and that they are equipped with (a) an automated driving system, (b) automatic crash notification technology, and (c) a data recording system that records the automated driving system's status as well as speed, direction, and location before a crash. They are also required to maintain incident reports and provide the Department of State and NHTSA with periodic summaries pertaining to the safety and efficacy of travel of the participating fleet.

Michigan has several additional minimum standards that AV developers must meet prior to beginning their pilot. This includes self-certifying that they have logged at least 1,000,000 miles of driving with the automated driving system engaged, self-certifying that they meet all Federal Motor Vehicle Safety Standards (FMVSS), and providing proof of insurance for no less than $10,000,000. To prevent local barriers to entry, cities are prohibited from imposing a local fees or regulations on AV pilot projects until after December 21, 2022.

For freight applications, Michigan companies are able to capitalize on AV capabilities by operating platoons on streets or highways for entities, provided that they submit plans for general platoon operations with the state police department and state transportation department. If neither department rejects those plans within 30 days, the entity is allowed to initiate platooning tests and demonstrations.[53]

State Action Item:

Allow specific pilot programs for driverless AV testing through partnerships with AV developers, localities, and research groups.

4.7 Form an AV advisory committee

Regardless of whether they pass AV laws or not, states are setting up stakeholder working groups that are monitoring and advising on AV policy. For example, in August 2015 Arizona Governor Doug Ducey issued an executive order establishing a Self-Driving Vehicle Oversight Committee under the Office of the Governor. The committee is comprised of governor-appointed representatives from the governor's office, the University of Arizona, and Arizona's Departments of Transportation, Public Safety, and Insurance.[54] This committee advises other public agencies on how to advance the testing and operation of AVs in the state.[55]

A number of other states have adopted a similar approach in establishing AV task forces, including Pennsylvania and Michigan, that are comprised of officials from a variety of public agencies whose operations may be affected by AVs.[56] Michigan established the Council on Future Mobility to recommend statewide policy changes and updates on an annual basis. The governor appoints individuals representing interests in local government, business, research, and technological leaders in AV development. The legislature also appoints representatives of the majority and minority parties from each chamber. State legislatures such as Georgia and Alabama have also established internal study committees.

State Action Item:

Create AV advisory committees of no more than 30 people that includes representatives from state government offices, local government, auto manufacturers, AV technology firms, safety advocates, public transit industry, trucking industry, taxi industry, and other relevant experts. States should rely on industry associations or rotating seats to ensure that group sizes are manageable yet include perspectives from different organizations in the industry.

4.8 Create "statements of principles" for outstanding AV issues

Commercially-ready AVs present new challenges for policymakers in areas such as privacy, data sharing, consumer advocacy, roadway safety, and cybersecurity. For example, AVs will collect and potentially store highly detailed data about consumers' travel patterns. This creates public concern about data ownership, privacy, and access to the data in the case of a collision. AVs could also be hacked, and malicious access could be detrimental to the safety of the occupants and others on the roadway. In a recent survey, more than 70 percent of U.S. citizens indicated that they were "very concerned" or "moderately concerned" with AV system security from hackers.[57] Nearly the same amount voiced concern about privacy of location and destination tracking data.[58]

Meanwhile, AVs will operate on roadways shared by pedestrians, bicyclists, motorcyclists, the people with disabilities, transit vehicles, and other users. Not only do people inside and outside of the vehicle need to be safe, but consumers need to understand the capabilities and limitations of the technology in their vehicles. Finally, AVs need public roadways to operate, and the public could benefit from the reams of data that AVs produce.

AVs are still very much in their development phases, and it will be several years until the industry and the public fully understands what the implications are for data, cybersecurity, and safety. However, given the wide attention on AVs, states can demonstrate to the public and to the AV industry that they are taking these issues seriously by giving policymakers the flexibility to adapt in an unknown future.

State Action Item:

Develop nonbinding "statements of principles" that address the following topics:

1. **Privacy.** States need to clearly delineate expectations about data ownership and access to the data in the case of a collision. Manufacturers must protect the privacy of the vehicle owners and companies should not be allowed to distribute personally identifiable information about vehicle owners or occupants without their approval and knowledge.
2. **Cybersecurity.** States need to proactively define AV developers' limited liability for crashes that result from a security breach, and ensure that all AV developers are taking cybersecurity seriously.
3. **Roadway safety.** States should emphasize that AVs must be able to recognize, yield to, and share the roadway with all users of the roadway.
4. **Consumer advocacy.** Consumers need to be aware of what their vehicle is capable of and what is it not. States can set principles for consumer information for new and used cars with AV features. In addition, consumers should be informed of data ownership rules prior to purchasing an AV.
5. **Data sharing.** Creating initial guidelines for data sharing can set the stage for future data sharing agreements that can bring benefits to both public sector agencies and private companies.

5. State AV infrastructure investment and funding

AV technology and public roadways are intrinsically linked. Although the technological development has been a private sector effort, successful deployment requires access to good public roadways, traffic signals, and signage that create a workable driving environment. Given that current roadways, intersections, and signage were built to accommodate human drivers, pedestrians, and cyclists, this infrastructure will need to be adapted and improved in a way that will make all users safer.

5.1 Invest in improving roadway state of good repair

As the technology currently exists, AVs are limited to operating on well-maintained roads with clear lane markings.[59] AV developers are not counting on massive, coordinated public investment for full functionality of their systems. Instead they are developing advanced methods that work within the existing roadway environment. Thus, maintaining traditional infrastructure that serves all road users—regardless of levels of automation or connectivity—remains the best use of public funds.

To this end, states that employ a "fix it first" approach to infrastructure investment will likely prove to be both prudent and cost-effective in the long run. By prioritizing maintenance of existing roads and infrastructure, a state will be able to ensure the long-term health of its transportation network.

Initial investment to assist AV development can be straightforward and easy to implement. In addition to clear lane markings, pavement should be uniform and without potholes, traffic signals should be functioning properly and easily visible, and signs should be clearly legible and visible from the roadway.[60] Federal funding programs should encourage these investments both for the benefit of current road users and in anticipation of future AV deployments.

However, it is unrealistic to expect states to update every roadway to have very high quality pavement, signage, and striping. AVs need to be able to operate safely regardless of the road condition, but targeting state of good repair funds to roadways with safety problems, or to high-risk areas such as work zones, can be a good place for states to start. States can also emphasize AV-friendly roadways in pilot programs: for example, Virginia's Automated Corridors include high-quality lane markings as a primary resource for its testing corridor.[61]

State Action Item:

Use AVs as a way to galvanize support for a robust state of good repair program, targeted to unsafe roadways and work zones across the state.

5.2 Pilot connected vehicle projects

Although connected vehicles and automated vehicle are fundamentally different things, many in the industry believe that AVs must be connected in order to speed the deployment and unlock the full benefits of driverless technology.[62] Connected vehicles (CV) are those that have the ability to communicate with each other (via vehicle-to-vehicle communication, or V2V) and with infrastructure (through vehicle-to-infrastructure communication, or V2I). CV technology communicates directly with other vehicles and infrastructure about vehicle data related to speed, location, trajectory, and other operational variables, potentially enabling better management of traffic flow with the ability to address specific problems in real-time.

The U.S. DOT believes that this technology (with 100 percent market penetration) has the possibility to eliminate 80 percent of unimpaired crash scenarios that could save tens of thousands of lives each year.[63] The agency is currently supporting connected vehicle pilots whose goal is to better understand how best to implement this technology in a variety of scenarios across the country.

States, universities and localities are already testing CV capabilities on public roadways. In 2016, the City of Sunnyvale, California entered into a partnership with Nissan, Savari, and U.C. Berkeley to install V2X-enabled roadside units across nearly 4.5 square miles and three public intersections. Sunnyvale intends to use information collected through this test program to optimize traffic light timing.[64]

The Virginia Connected Corridors initiative facilitates the real-world application and deployment of connected vehicle technology. The state is using more than 60 roadside equipment units and is implementing connected applications using the corridor, including traveler information, enhanced transit operations, lane closure alerts, and work zone and incident management.[65]

In Michigan, the Ann Arbor Connected Vehicle Test Environment (AACVTE) began when U.S. DOT and the University of Michigan Transportation Research Institute (UMTRI) launched its predecessor, the Safety Pilot Model Deployment in 2012. This three-year, $30 million research project included over 2,800 vehicles and 73 lane miles of connected infrastructure along the roadway.[66] In the coming years, AACVTE will expand this deployment by leveraging funds from the Federal Highway Administration, the state of Michigan, academic institutions, the City of Ann Arbor, and the private sector. The larger deployment will amount to a 27-square mile test zone throughout the City of Ann Arbor, including 45 street locations, 12 freeway sites, and up to 5,000 equipped vehicles.[67]

Broader investments in smart infrastructure for automated vehicles were not included in Michigan's 2015 infrastructure plan, despite the state's ongoing CV pilot.[68] In 2013, the Michigan Department of Transportation (MDOT) released its Intelligent Transportation System Architecture and Deployment Plan. The plan indicated that the benefits of ITS

deployment have yet to be known and did not provide a discrete set of recommendations or priorities for implementation.[69]

The challenge for policymakers is that the underlying technology in CV capabilities could change. For now, CVs rely on dedicated short range communications (DSRC) as the means to transmit data. Some industry observers predict that 5G cellular technology will overtake DSRC, potentially rendering initial investments obsolete.[70] Virginia Governor McAuliffe signed legislation that allows private companies to install 5G technology on existing structures on public roadways.[71] But since the technology is still in the development phase, states are rightly reluctant to find significant resources to fund broad deployment of CV systems.

State Action Items:

Initiate pilots of DSRC and 5G wireless CV technologies, particularly when a private entity is willing and able to support the pilot financially.

Incorporate CV and AV technologies into state vehicle fleets as states turnover those vehicles and purchase new ones. Features like vehicle connectivity, automatic emergency braking, blind spot monitoring, and advanced cruise control can help to both prevent collisions and pilot new technologies.

5.3 Consider developing a per-mile AV fee in concert with the federal government

The infrastructure costs associated with the operation of AVs presents a substantial funding need. Between the maintenance of public roadways and the potential loss of revenue (fuel taxes, parking, and traffic tickets) states and cities will have significant financial burden to address. Auspiciously, AV technology provides an opportunity to implement a straightforward Vehicle Miles Traveled (VMT) fee.

Eno's 2017 *Beyond Speculation* report details why and how the federal government should develop a $0.01 per mile charge on automated driving.[72] Companies are laying the groundwork to charge consumers by trip or by the mile, allowing for easy administration of such a fee at the government level. The next step is for state and local governments to take advantage of this to help fund their own public infrastructure investments.[73] Further, states could design an AV VMT fee to account for differences in vehicle types, occupancy levels, congestion, and other variables.

Tennessee passed a law that would specifically charge a VMT for AVs at a rate of $0.01 per mile for two axle vehicles and $0.026 per mile for more than two axles. Although it has yet to

be implemented, the state will divide the revenue generated from the charge between the state general fund, state highway fund, counties, and localities according to a statutory formula.[74]

While Tennessee is the first state to legislate an AV-specific VMT fee, this is the start of a larger trend. Oregon completed a pilot project that tested replacing the state gasoline tax with a VMT charge. The federal government is also interested in encouraging VMT fees: the 2015 Fixing America's Surface Transportation (FAST) Act set aside $95 million for VMT research.[75] The United States Department of Transportation can use this money to begin testing a VMT fee system for AVs before they become more prevalent on the roadways.

AV developers are not necessarily against implementing a VMT fee on their vehicles. Policymakers need to be mindful of market distortions related to a VMT fee, and should consider using discounts or other incentives to encourage the beneficial adoption of AV technology.

State Action Item:

Research different approaches to implementing and using a VMT fee on AVs as a way to (1) create a new revenue stream for state transportation investment and (2) encourage the responsible use of AVs on public roadways.

6. State funded AV research and workforce training

6.1 Foster the creation of testing grounds

The development of AV technologies has largely been led by the private sector and university research, with a combination of public and private funding.

Universities play a helpful role in piloting AV deployment in a variety of environments. At Santa Clara University, for example, local startup Auro Robotics is conducting a first-of-its-kind deployment of low-speed automated shuttles on a university campus. The pilot program, which began in November 2016, is not subject to California's motor vehicle laws since it is operated on university grounds. This project is part of the university's wider program to convert its roads and parking spaces to bicycle and pedestrian-friendly paths, and is expected to provide valuable insights into how AVs can expand mobility options and share roads with pedestrians and bicyclists. The pilot is authorized to operate for segments of a few months at a time, after which the university decides on extensions – as well as whether Auro Robotics can remove its human backup drivers to make the shuttles fully automated.[76]

The University of Michigan Mobility Transformation Center (MTC) is the result of a public-private research and development partnership that has attracted partners from industry, government, and universities alike. MTC's stakeholders and partners collaborate in

interdisciplinary research of the technical, environmental, and policy issues pertaining to AVs.[77] One of the most publicized centers for AV research is MTC's Mcity, which is designed to simulate an urban environment for testing in all four seasons. Tests conducted at Mcity provide auto manufacturers and academics with a laboratory to experiment with different safety and design approaches for dynamic driving conditions. This includes preparing for interactions with pedestrians and cyclists, city intersections where views may be obstructed by buildings, and adverse weather conditions.[78] Michigan also amended state laws to authorize the creation of the American Center for Mobility at Willow Run, an old factory site, to conduct AV research and education.

Alternatively, some states like Ohio and countries like Singapore and China have created mixed-traffic "AV Zones" or "AV corridors" in industrial parks or managed freeways that serve to imitate the broad array of potential driving conditions without necessitating the construction of a new testing facility.[79] Virginia's Automated Corridors use existing highways to study, test, and deploy AVs.[80]

State Action Item:

Establish AV testing grounds in partnership with universities, military bases, localities, industrial zones, and/or privately-managed roadways.

6.2 Fund research to understand how AVs could affect the broader transportation network and incorporate findings into state transportation improvement plans

While the private sector has invested their resources into AV technology, universities can play an increasingly important role in understanding how AVs will integrate into the transportation system. This includes how AVs will interact with built environments, pedestrians, bicyclists, public transit, motorcycles, and every other roadway user.

Testing centers, technology research, and other innovative investments can help understand and accelerate deployment so the general public can gain from the safety, environmental, and social benefits that AVs can provide. In 2014, The Virginia Tech Transportation Institute received a federal grant for $25 million to research safety protocols for AVs. The study looks at AVs electronics and potential cybersecurity risk, along with human interaction and reliability aspects of AVs.[81]

State Action Item:

Fund research at universities to understand the potential short-, medium-, and long-term effects of AVs on the transportation network, including the environment, social equity, and economic vitality.

Revise state research procurement methods so that the results keep pace with the rapid development of AV technology. Procurement for research should target outcomes, rather than specific processes, for developing the research.

Include AVs in long-range state transportation plans, not as a given outcome, but a potential scenario to anticipate.

6.3 Invest in programs that develop the future workforce

By their nature, AVs pose a threat to thousands of driver jobs across the country. Jobs like bus drivers, delivery drivers, postal services, and truck drivers represent almost 4 million jobs spread out across the country.[82] But when, if, and how automated driving systems will affect industry workers or replace humans behind the wheel is widely debated. Lower level automation (Level 3), for example, could significantly reduce crashes, affecting the 915,000 workers employed in auto repair and maintenance jobs in the U.S.[83]

The threat of substantial job losses or economic disruption, however, is a long way off. In the short and medium term, automation can help address some of the serious problems associated with professional driving. For example, the trucking industry is grappling with a shortage of drivers. Automated trucks could create much safer and enjoyable jobs for the workforce, first by avoiding collisions and eventually by allowing truckers to avoid sitting for extended periods of time. More flexible work hours and technology-based driving might also attract younger workers. Similar workforce improvements apply to public transit and taxi workers.

The rise of AVs could also lead to the creation of new industries and new occupations. Examples of new industries that could emerge include maintenance workers for AV vehicles, remote operators for fleets of AVs, and individuals who will educate consumers, policymakers, and car distributors on the functions and limitations of AVs.

This is not the first time that technology has disrupted regional economies. A state like Virginia once relied on coal miners, manufacturing in tobacco, furniture, and textiles to drive the state's economy. When those jobs disappeared, the state adapted and reinvented itself by incentivizing the growth of its tech industry – as it might need to do with automated vehicles.

State Action Item:

Form partnerships with universities and the private sector to implement targeted retraining or career development programs that proactively address and prepare for the adverse effects of automation.

Work with academic institutions to retrain workers whose jobs may be lost to automation.

7. Conclusion

States have an important role to play in the advancement of AV technologies. With so much at stake, states can proactively begin to prepare their policy frameworks to accept testing on public roadways and eventual commercial deployment in a safe and effective manner. There is no single approach to achieving this, but several short-term steps are important for states to prepare their departments, their roadways, and their citizens for an automated future.

Endnotes

1 Novak, M., "The National Automated Highway System That Almost Was", *Smithsonian Magazine,* 2013.

2 Crane C. et al, "Lessons Learned at the DARPA Urban Challenge," Florida Conference on Recent Advances in Robotics, 2008; Urmson C., Whittaker, W., "Self-Driving Cars and the Urban Challenge," IEEE Intelligent Systems, Vol. 23 No. 2. 2008.

3 Casey, M., "Want A Self-Driving Car? Look on the Driveway", Fortune, 2014.

4 National Highway Traffic Safety Administration, "Federal Automated Vehicles Policy Statement", US Department of Transportation, 2016.

5 Connor, A., "Semi-Autonomous Cars Bring the Self-Driving Car Closer to Reality", Gear Patrol, 2015.

6 Abkowitz, A., "Baidu Plans to Mass Produce Autonomous Cars in Five Years", Wall Street Journal, 2016; and Sage, A., Lienert, P., "Ford Plans Self-Driving Car for Ride Share Fleets in 2021", Reuters, 2016; Thompson, C., "The Self-Driving Ford is Coming", Business Insider, 2016; Chafkin, M., "Uber's First Self-Driving Fleet Arrives in Pittsburgh This Month", Bloomberg, 2016; Stoll, J., "GM Executive Credits Silicon Valley for Accelerating Development of Self-Driving Cars, The Wall Street Journal, 2016; Yadron, D., "Two Years Until Self-Driving Cars are on the Road – is Elon Musk right?", The Guardian, 2016; Halleck, T., "Google Inc. Says Self-Driving Car Will Be Ready By 2020", International Business Times, 2015; Litman, T., "Autonomous Vehicle Implementation Predictions: Implications for Transport Planning", Victoria Transport Policy, 2017; Expecting Level 4&5 Automation: National Association of City Transportation Officials, "NACTO Policy Statement on Automated Vehicles", 2016; IHS Markit, "IHS Clarifies Autonomous Vehicle Sales Forecast – Expects 21 Million Sales Globally in the Year 2035 and Nearly 76 Million Sold Globally Through 2035", 2016; ABI Research, "Car OEMs Target 2021 for Rollout of SAE Levels 4 and 5 of Autonomous Driving", 2016; Juniper Research, "Self-Driving Car Production to Hit 14.5 Million A Year By 2025", Clean Technica, 2016; Stepp, Erin, "Three-Quarters of Americans "Afraid" to Ride in a Self-Driving Vehicle", American Automobile Association Newsroom, 2017.

7 Caddy, B., "Toyota to Launch First Driverless Car in 2020", Wired, 2015; and Yoshida, J., "Why Autonomous Cars Are 'Absolutely Not Ready'", EE Times, 2016.

8 Stepp, Erin, "Three-Quarters of Americans "Afraid" to Ride in a Self-Driving Vehicle", American Automobile Association Newsroom, 2017.

9 Office of Governor Terry McAuliffe, "Virginia Executive Proclamation: Support for Virginia Tech Transportation Institute and Automated and Autonomous Vehicles", Commonwealth of Virginia, 2015.

10 Weiner, G., Walker Smith, B., "Automated Driving: Legislative and Regulatory Action", The Center for Internet and Society, 2017.

11 Reynolds, M., "A State-By-State Guide To Driverless Car Regulations" Law360, July 20, 2016.

12 Georgia General Assembly, "SB 219 Motor Vehicles; definitions; operation of motor vehicles with automated driving systems on certain public roads; provide", 154th General Assembly, 2017.

13 Tennessee Senate, "S.B. 1561 - Act to amend Tennessee Code Annotated, Title 47;Title 54, Chapter 1; Title 55 and Title 67, relative to autonomous vehicles", Tennessee 110th General Assembly, 2016.

14 Bhuiyan, J., "Michigan Just Became the First State to Pass Comprehensive Self-Driving Regulations", *Recode*, 2016.

15 Weiner, G., Walker Smith, B., "Automated Driving: Legislative and Regulatory Action", The Center for Internet and Society, 2017.

16 Reynolds, M., "A State-By-State Guide To Driverless Car Regulations" Law360, July 20, 2016.

17 NCSL. "Self Driving Vehicles Enacted Legislation". Legislative Database. National Conference of State Legislatures. March 21, 2017.

18 State of California, Department of Motor Vehicles, "Initial Statement of Reasons, Title 13, Division 1, Chapter 1, Article 3.7 – Testing of Autonomous Vehicles, Article 3.8 – Deployment of Autonomous Vehicles", 2017.

19 Vlasic, B., "U.S. Proposes Spending $4 Billion on Self-Driving Cars", *The New York Times,* 2016.

20 NHTSA Federal Automated Vehicle Policy Statement, 2016

21 See: eRulemaking Program Management Office, Docket ID: NHTSA-2016-0090, National Highway Traffic Safety Administration, U.S. Department of Transportation, 2017

22 Eno Center for Transportation, Beyond Speculation: Automated Vehicles and Public Policy, 2017.

23 See: Table 1

24 Snyder, R., "Michigan Gov. Rick Snyder's 2013 State of the State Speech" *Governing*, January 16, 2013.

25 *Lexus USA Newsroom,* "Toyota Motor Corp. and Lexus Showcase Advanced Active Safety Research Vehicle at CES", January 7, 2013.

26 Harris, A., "Sen. Mark Green Wants Tennessee to Lead in Auto Innovations" *Arizona Republic*, January 27, 2016

27 Levandowski, A., "San Francisco, Your Self-Driving Uber is Arriving Now" *Uber Newsroom*, December 14, 2016.

28 State of California, Department of Motor Vehicles "To Anthony Levandowski, Uber Advanced Technology Center" Scribd., December 14, 2016.

29 Kim, E. Carson B., “Uber Caves after DMV Gives its Self-Driving Cars the Death Blow in California” *Business Insider*, December 21, 2016.
30 Associated Press, “It’s Official: Uber Self-Driving Cars are Allowed to Come Back to California Roads” *Business Insider*, March 8, 2017.
31 Virginia Tech Transportation Institute, “Virginia Tech Transportation Institute and Partners Unveil Virginia Automated Corridors”, Virginia Polytechnic Institute and State University, 2015.
32 Tennessee Senate, “S.B. 1561 - Act to amend Tennessee Code Annotated, Title 47;Title 54, Chapter 1; Title 55 and Title 67, relative to autonomous vehicles”, Tennessee 110th General Assembly, 2016.
33 Application processing fees are as follows: $150 for the processing of initial applications for up to 10 AVs and 20 test drivers; $50 to submit application addenda for an additional 1 to 10 vehicles and 1 to 20 drivers; $70 for changes and modifications to an issued Manufacturer’s Testing Permit. See: State of California Department of Motor Vehicles, “Application Requirements for Autonomous Vehicle Tester Program”, 2017
34 State of California, Department of Motor Vehicles. “Testing of Autonomous Vehicles”, 2017
35 State of California, Department of Motor Vehicles, Report of Traffic Accident Involving an Autonomous Vehicle, Form OL 316., October, 2013.
36 State of California Department of Motor Vehicles, “Autonomous Vehicle Disengagement Reports 2016”, 2016.
37 State of Michigan, “Enrolled Senate Bill No. 995” 98th Legislature, Regular Session, 2016.
38 Kyrouz, M. “Industry Comments to NHTSA’s Federal Automated Vehicle Policy.” Medium, January, 2017.
39 39 National Safety Council, “ NSC Motor Vehicle Fatality Estimates”, 2017.
40 40 Sauber-Schatz, E. Ederer, D. Dellinger, A. Baldwin, G “Vital Signs: Motor Vehicle Injury Prevention – United States and 19 Comparison Countries”, Centers for Disease Control and Prevention, Jul. 08, 2016.
41 Clamann, M., Aubert, M., Cummings, M., “Evaluation of Vehicle-to-Pedestrian Communication Displays for Autonomous Vehicles”, Duke University, 2016.
42 42 Ng, A., Lin, L., “Self-Driving Cars Won’t Work Until We Change Our Roads – And Attitudes”, Wired, Mar. 15, 2016.
43 Eno, Beyond Speculation, 2017
44 Insurance Information Institute, “Self-Driving Cars and Insurance”, July, 2016.
45 Reuters, “New California Law Allows Test of Autonomous Shuttle with No Driver”, *Fortune,* 2016.
46 Ibid
47 Falls Church Virginia Code of Ordinances, § 46.2-103. Sec. 26-18.
48 Insurance Institute for Highway Safety; Highway Loss Data Institute “Distracted Driving: Cellphones and Texting” March, 2017.
49 Virginia Code § 46.2-1209 Unattended or Immobile Vehicles, Generally.
50 Reynolds, M.,“A State-by-State Guide to Driverless Car Regulations”, Law360, July 20, 2016.
51 Tennessee Senate, “S.B. 2333 – Act to amend Tennessee Code Annotated, Title 55, Chapter 8, Part 1, relative to motor vehicles equipped with autonomous technology”, Tennessee 109th General Assembly, 2016.
52 California General Assembly “A.B. 1592 – Act to add and repeal Section 38755 of the Vehicle Code, relating to autonomous vehicles”, 2016.
53 State of Michigan, “Enrolled Senate Bill No. 995” 98th Legislature, Regular Session, 2016.
54 Arizona Department of Transportation, “Arizona Self-Driving Vehicle Oversight Committee”, 2016.
55 Arizona Exec. Order No. 2015-09: Self-Driving Vehicle Testing and Piloting in the State of Arizona; Self-Driving Vehicle Oversight Committee. August 25, 2015.
56 Pennsylvania Department of Transportation, “Pennsylvania Takes Steps to Lead on Autonomous Vehicle Development, Testing With Newly Established Task Force, Legislation”, June 1, 2016; Michigan Department of Transportation “Michigan Connected and Automated Vehicle Working Group” July 26, 2016.
57 Schoettle, B. Sivak, M. “A Survey of Public Opinion about Autonomous and Self-Driving Vehicles in the U.S., the UK, and Australia” University of Michigan Transportation Research Institute. UMTRI-2014-21. July, 2014.
58 Ibid
59 Truett, R., “The Other Bump on Path to Driverless Cars: Crumbling Roads” *Automotive News*, August 30, 2016.
60 Sorokanich, R., “6 Simple Things Google’s Self-Driving Car Still Can’t Handle”, *Gizmodo*, 2014.
61 Virginia Tech Transportation Institute, 2015; Further, in 2016 U.S. DOT awarded Virginia with a $165 million FASTLANE grant to deliver the Atlantic Gateway Project, a multimodal project to modernize the road and rail infrastructure along the I-95 corridor. Part of this project includes building pavement for autonomous vehicle enhancement, which will provide the infrastructure to test and deploy driverless vehicles. Coy, B. “Governor McAuliffe Announces Virginia’s Selection for $165 Million FASTLANE Grant to Deliver the Atlantic Gateway Project.” Virginia DOT Press Release, July 5, 2016.

62 Viereckl, R., Ahlemann, D., Koster, A., Hirsh, E., Kuhnert, F., Mohs, J., Fischer, M., Gerling, W., Gnanasekaran, K., Kusber, J., Stephan, J., Crusius, D., Kerstan, H., Warnke, T., Schulte, M., Seyfferth, J., Baker, E., "Connected car report 2016: Opportunities, risk, and turmoil on the road to autonomous vehicles", Strategy&, 2016.
63 Freidman, D., "V2V: Cars Communicating to Prevent Crashes, Deaths, Injuries", U.S. Department of Transportation FastLane, 2016.
64 Yoshida, J., "Is Car-to-Car Talk Done Deal in US?" *EETimes,* March 29, 2016.
65 Virginia Tech Transportation Institute, "Virginia Connected Corridors", Virginia Polytechnic Institute and State University, 2017.
66 AACVTE, "About Ann Arbor Connected Vehicle Test Environment (AACVTE)", University of Michigan Transportation Research Institute, 2017.
67 Office of the Assistant Secretary for Research and Technology, "Ann Arbor Connected Vehicle Test Environment (AACVTE)", U.S. Department of Transportation, Undated.
68 Gallagher, J., "Why We Aren't Ready for Self-Driving Cars – Yet", *Detroit Free Press*, January 7, 2017.
69 The Center for Automotive Research "MDOT ITS Investment Plan" Michigan Department of Transportation, September 2013.
70 Daniels, G. "Connected cars could drive the need for 5G technologies." TelecomTV, 2015.
71 Virginia General Assembly "S.B. 1282 – Wireless communications infrastructure; procedure for approved by localities", 2017.
72 Eno, Beyond Speculation, 2017.
73 Eno, Beyond Speculation, 2017.
74 Tennessee Senate, "S.B. 1561 - Act to amend Tennessee Code Annotated, Title 47;Title 54, Chapter 1; Title 55 and Title 67, relative to autonomous vehicles", Tennessee 110th General Assembly, 2016.
75 Federal Highway Administration, "Fixing America's Surface Transportation Act or 'FAST Act' – Funding", U.S. Department of Transportation, 2017.
76 Said, C. "Self-Driving Shuttle Loops Around Santa Clara University Campus", *San Francisco Chronicle*, December 31, 2016.
77 Mobility Transformation Center, "FAQ" University of Michigan. Undated.
78 Mobility Transformation Center, "Mcity", University of Michigan. Undated.
79 Christ, G., "Self-driving truck hits the road in Ohio, state investing $15 million in autonomous vehicle corridor", *The Plain Dealer via Cleveland.Com*, 2016; Chen, Z., He, F., Yin, Y., "Optimal design of autonomous vehicle zones in transportation networks", Transportation Research Part B: Methodological, Volume 99, 2017.
80 Virginia Tech Transportation Institute, 2015.
81 Virginia Tech Transportation Institute, "Transportation Institute Awarded $55 Million in Federal Contracts on Truck Safety, Automated Vehicles", Virginia Polytechnic Institute and State University, 2014.
82 Tracy, S., "Autonomous Vehicles Will Replace Taxi Drivers, That's Just the Beginning", The Huffington Post, 2015.
83 Bureau of Labor Statistics, "Automotive Industry: Employment, Earnings and Hours", U.S. Department of Labor, 2017.

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