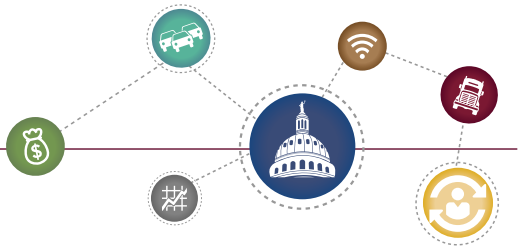
Texas A&M Transportation Institute

Revolutionizing our Roadways

Policy Considerations for Automated Vehicle Testing in Texas



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CONTENTS

TABLES

Revolutionizing our Roadways

Policy Considerations for Automated Vehicle Testing in Texas

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EXECUTIVE SUMMARY

Automated vehicles (AVs) are a rapidly developing transportation technology with the potential to disrupt the transportation system. These vehicles could provide many potential benefits and create some costs for society, although there is significant uncertainty regarding their exact effects due to their limited deployment.

AVs are also a complex technology that, to reach maturity, require testing on public roads. There are nearly an infinite number of situations an AV must safely navigate on real roads, which cannot be effectively simulated. As a result, AV developers must test the software on public roads to ensure the vehicles' efficacy. Because these vehicles are not fully refined and are being tested on public roads, some states have decided to regulate and oversee testing to minimize safety risks for transportation system users. Many states have considered legislation regarding AVs, including both testing and operation, and five have already passed laws. Of these states, two have developed regulations governing their testing on public roads. Several states have also publicly proclaimed their legislative efforts as a means of attracting a growing high-tech industry, although it is unclear if these measures are effective.

Texas may wish to consider legislation and regulations on AVs to ensure the safety of the state's transportation system users, and potentially use such legislation as an implicit means of economic development. Legislation and regulation are not necessarily required, however, and there are potential benefits to taking a "wait and see" approach.

Legislation and regulation is not as simple as a binary, either or decision, however. Legislative measures and regulations vary across states, and there are many different potential policy approaches the state could take. This analysis reviews five salient factors occurring in other states' legislation that might be worth consideration in Texas.

1. Ensuring the safety of road users.
2. Preserving interstate and federal regulatory consistency.
3. Selecting a desired level of regulatory intensiveness.
4. Preserving the AV industry's capacity for innovation.
5. Balancing the social benefits of policy with administrative burden and costs.

This report reviews the legislative and regulatory measures taken around the country and analyzes them to determine similarities and differences. It then discusses the five considerations above and their implications.

Background

Why Might Texas Consider Regulating AV Testing?

Safety

The primary reason the State might want to consider regulating the testing of high-level AVs (NHTSA level 3 or 4) is to ensure the safety of Texans. To successfully develop and refine high-level AVs for public use, manufacturers must test their vehicles on public roads. The reason for this lies in the complexity and randomness of the real world roadway environment. AVs must be programmed and prepared to handle any situation that may arise on the road, which is currently challenging to simulate: an AV must correctly identify a rogue plastic bag as an unthreatening object, and a ball rolling into the street could portend a child is not far behind. Therefore, to ensure their vehicles are adequately prepared for consumer use, AV manufacturers will systematically subject their vehicles to the rigors and unpredictable nature of the real world through on-road testing. This situation presents a potential risk to the State's road users that could warrant State oversight of the AV testing process. An AV being tested on Texas roads would be, by definition, an incomplete and imperfect product. Those imperfections could result in greater safety risks for road users. Legislation and regulation could manage those risks by placing some level of oversight and control over the testing process.

Legislation and regulations could improve safety through a variety of measures. These are discussed in greater depth below, but some high-level protective measures could include the following examples:

- Licensing test drivers to ensure they are capable of safely operating a test vehicle.
- Requiring AVs to have certain components or functionality, like requiring the vehicle to notify the driver when he or she needs to retake control.
- Placing restrictions on the actual testing of AVs, like for example, limiting testing to specific environments, roadway types or designated roadways, or geographic locations.

Implicit Economic Development

A secondary reason that might motivate the State to pass legislation and develop regulations on AVs is for economic development purposes. AV manufacturing and development is a burgeoning tech industry, and developing a legal framework in which AV manufacturers and developers are formally able to legally operate and test their vehicles might induce companies to expand in or relocate to Texas.

Those imperfections could result in greater safety risks for road users. Legislation and regulation could manage those risks by placing some level of oversight and control over the testing process.

Additionally, only four states and the District of Columbia have passed legislation, and of those, only two have developed regulations for AV testing. If Texas passes

NHTSA laid out five levels of automation, ranging from zero to four. Level three and four vehicles are the most advanced, and can drive with little or no human intervention. These vehicles are not yet fully developed, are undergoing testing and development, and are not currently available for retail purchase. For more information, please see the TTI AV Primer, Revolutionizing Our Roadways.

legislation and develops regulations, it could serve as an implicit signal to the industry that the State is in the vanguard of this emerging sector and seeking to foster its growth.

As a note, there is insufficient data to determine the effect of legislative measures on AV industry development. Passing legislation and developing regulations are not a guarantee that the AV industry will locate and operate in Texas. These measures could encourage industry growth, but businesses also consider many other factors when deciding where to locate and operate. For more information on the economic development implications and examples of economic development related to automated vehicles in other states, please see the Appendix.

Why Might Texas Not Want to Regulate AV Testing?

Is It Necessary?

First, it may not be immediately necessary. Other than limited demonstrations, it is not clear that any AV manufacturers are testing their vehicles on public Texas roads. Nevada and California—the states that initially passed legislation and developed regulations—did so (at least partially) out of necessity. These states had AV manufacturers and developers openly testing their vehicles on their public roads, or felt that testing was imminent, and desired to regulate this testing. The authors are unaware of any testing—either imminent or currently occurring—on Texas roads.

Wait and See

A second reason Texas may not wish to pass regulations on AV testing is that the industry is still in a developing state, and with it, the legislative and regulatory environment is also rapidly evolving. Waiting to see how the environment develops might enable the state to pass better refined and targeted measures based on the experiences and lessons learned from other states.

If vehicles are not being tested on Texas roads, there are no safety implications associated with waiting to see.

Federal Regulatory Recommendations

In the summer of 2013, NHTSA released a document on AVs laying out its research agenda, establishing a taxonomical classification system, and proposing recommended guidelines for states wishing to regulate vehicle testing. Recommended regulations consist of several initial principles that should guide all regulations, and a specific regulatory path consisting of four overarching areas, each with additional sub areas. The complete text is available on NHTSA's website (1 p. 10).

NHTSA established a few recommended principles that should guide all regulations (Table 1).

These recommendations are motivated by a variety of factors, including practicality and feasibility, concerns about slowing or stifling industry innovation, ensuring interstate consistency of regulations and standards, and motorist safety. A detailed review of NHTSA's recommendations from the state legislative perspective is provided in the Regulatory Analysis section on page 11 of this report.

Table 1. NHTSA Guiding Regulatory Principles.

States/regulations should	States/regulations should not
• Focus on NHTSA level 3 and 4 vehicles only • Focus on "licensing, driver training, and conditions for operations related to specific types of vehicles" • Ensure that the only people driving test vehicles are employees or "otherwise the agent of" businesses engaged in testing, and the vehicles should only be used for testing purposes	• Permit "operation of self-driving vehicles for purposes other than testing" • Develop detailed regulations on the safety of self-driving vehicles for purposes other than testing • Cover the technical performance of AVs • Develop specific safety standards or regulate AV's technical performance

NHTSA's recommended guiding principles are somewhat detailed, and it is highly recommended that an interested reader refer to the source material conveniently located on NHTSA's website (1). Otherwise, a high-level summary of the guidelines is included in Table 2.

Each of the four sections covers a specific area of regulation, and the subsections highlighted in the components column provide detailed recommendations for implementing agencies and state legislators and decision-makers.

Table 2. Overview of NHTSA's Recommended Regulations.

Section	Components
Licensing drivers to operate self-driving vehicles for testing	• Ensuring the driver understands how to operate a self-driving vehicle
Regulating the testing of self-driving vehicles	• Ensuring on-road testing minimizes risks to other road users • Limiting testing operations to conditions suitable for the capabilities of tested self driving vehicles • Establishing reporting requirements to monitor testing
Establishing basic principles for testing self-driving vehicles	• The transition process from self-driving mode to driver control is safe, simple, and timely • Self-driving test vehicles should have the capability of detecting, recording, and informing the driver that the system of automated technologies has malfunctioned • The installation and operation of any self-driving vehicle technologies does not disable any federally required safety features or systems • Self-driving test vehicles record information about the status of the automated control technologies in the event of a crash or loss of vehicle control
Regulating the operation of self-driving vehicles for purposes other than testing	N/A

Legislative Analysis

Four states (California, Nevada, Florida, Michigan) and the District of Columbia (DC) all passed legislation regarding manufacturer testing and/or private operation of AVs (2) (3) (4) (5) (6). Each state's legislation is unique and there are varying components between each. Some states, for example, explicitly authorize AVs for public use and private testing, while Michigan, for example, is more restrictive—specifically limiting AV use to testing only. Reviewing these states' legislative efforts provides a basis for analysis and a template on which Texas could base any potential legislation.

This analysis divides legislative components into five categories, as seen in Table 3.

Researchers developed matrices of each area for comparative analysis, enabling an easy, visual understanding of similarities and differences between the states. For each matrix, a bolded X signifies that a state has a given legislative component.

The following process and methodology notes should be considered when examining the matrices:

- When legislative language was sufficiently similar that the meanings were essentially the same, the research team combined and streamlined the language for its ease of display in the matrix format.
- Two states developed regulations that added requirements above and beyond those measures mentioned in the legislation. For consistency, those measures are not included in the legislative matrices, but are mentioned in the regulatory analysis section. For example, Nevada did not require an additional event data recorder-like device in their legislation, but did require it in their regulations. As a result, it is not officially included in the legislative matrix, but is discussed in the regulatory analysis section.

Table 3. Organization of Legislative Analysis.

Legislative Categories	Description
Vehicle components	Requirements specific to a vehicle, like specific safety features be built into vehicles
Operational requirements	Requirements on the circumstances under which an AV can legally operate
Operator requirements	Requirements on the human operator of an AV
Vehicle conversion and liability requirements	Requirements on traditional vehicles that are converted to AVs
Mobile communications and data privacy requirements	Requirements on AVs concerning the use of mobile devices and regulations on the use of vehicular data

Vehicle Components

An inspection of the vehicle components table below shows that several of the states had consistent requirements for AVs, with some minor inconsistencies and differences between the states. The measures on which the majority of the states agreed include ensuring that AVs have the following traits:

- A mechanism that allows auto-driving to easily turn on and off.
- A "visual indicator" that indicates when auto-driving is enabled.
- Be able to alert the operator if the auto-driving system failed.
- Meet and comply with all Federal Motor Vehicle Safety Standards (FMVSS).

Notably, Michigan and the District of Columbia did not include most of these tenets, although the reasoning for these omissions is not clear. Michigan's legislation, as can be seen by this table and those that follow, was relatively minimal. It avoided placing many specific restrictions on the industry. In contrast, California included several additional vehicle component requirements. These required the AV be able to steer itself

VEHICLE COMPONENTS					
Policy	**California**	**Nevada**	**Florida**	**Michigan**	**District of Columbia**
An AV must have a mechanism with which the operator may easily engage and disengage the autonomous technology.	X	X	X		X
An AV must have a visual indicator inside the cabin to indicate when the autonomous technology is engaged.	X	X	X		
An AV shall be equipped with a means to alert the human operator to take manual control of the AV if a failure of the autonomous technology has been detected and such failure affects the ability of the autonomous technology to safely operate the AV.	X	X	X		
An AV's autonomous technology shall meet Federal Motor Vehicle Safety Standards for the vehicle's model year and all other applicable safety standards and performance requirements set forth in state and federal law and the regulations promulgated pursuant to those laws.	X	X	X		
Autonomous technology shall not make inoperative any Federal Motor Vehicle Safety Standards for the vehicle's model year and all other applicable safety standards and performance requirements set forth in state and federal law and the regulations promulgated pursuant to those laws.	X	X	X		
If the operator does not or is unable to take control of the AV in the case of autonomous technology failure, the AV shall be capable of coming to a complete stop.	X				
An AV shall allow the operator to take control in multiple manners, including, without limitation, through the use of the brake, the accelerator pedal, or the steering wheel, and it shall alert the operator that the autonomous technology has been disengaged.	X				

to a complete stop if a vehicle operator is unable to take control, and an operator to be able to take control from an auto-drive state through multiple means, like using the steering wheel or brakes.

All states except Michigan either explicitly allow the private operation of AVs, or do not specifically ban it.

Operational Requirements

All states except Michigan either explicitly allow the private operation of AVs, or do not specifically ban it. Each state goes about this in a slightly different manner. California, for example, requires a manufacturer that wishes to operate their vehicles for purposes other than testing to submit an application to the DMV certifying the technology meets "certain requirements" that the DMV would develop. As of this writing, the California DMV has not yet publically released the full details of their operational regulations; however, the DMV stated they would be released by January 2015.

Other states authorize the private use of AVs, like in Florida's legislation, which simply states "a person who possesses a valid driver license may operate an autonomous vehicle in autonomous mode" (4). Several states place requirements on the AVs that will be operating on their streets, many of which are discussed in the vehicle conversion section above.

The permissiveness of these regulations is particularly noteworthy due to concerns from the AV industry and the federal government alike. NHTSA expressed "considerable concerns… about detailed state regulation on safety of self-driving vehicles, and does not recommend at this time that states permit operation of self-driving vehicles for purposes other than testing" (1). NHTSA justifies this position by arguing that the technology is not fully developed and is still rapidly evolving; that regulating "the technical performance of automated vehicles is premature at this time"; and "premature regulation can put the brakes on the evolution toward increasingly better vehicle safety technologies."

NHTSA goes on to formally state that while it "does not recommend states authorize self-driving vehicles for purposes other than testing," if a state desires to do so, it recommends that "at a minimum the state should require that a properly licensed driver (i.e., one licensed to drive self-driving vehicles) be seated in the driver's seat and be available at all times in order to operate the vehicle in situations in which the automated technology is not able to safely control the vehicle" (1). California's legislation specifically says the State could authorize driverless AVs, but it reserved the right to require an individual in the driver's seat based on a review of the company's application and the DMV's judgment that a driver is required for safe operation (7).

Also noteworthy, but on the other end of the regulatory spectrum, Michigan is the only state that explicitly restricts AV operation to testing purposes only. The other three states find a middle ground and do not specifically restrict or enable AV operation for purposes other than testing. Aside from specific restrictions on operations, the states also all require—with the exception of the District of Columbia—that testing entities maintain $5 million in insurance, surety bond, or self-insurance with the state. This insurance requirement serves to ensure that testing organizations are sufficiently insured against any damages that might occur as a result of testing.

Aside from specific restrictions on operations, the states also all require—with the exception of the District of Columbia—that testing entities maintain $5 million in insurance, surety bond, or self-insurance with the state.

OPERATIONAL REQUIREMENTS					
Policy	**California**	**Nevada**	**Florida**	**Michigan**	**District of Columbia**
An AV may operate on a public roadway for non-testing purposes if it is capable of operating in compliance with all applicable traffic laws, motor vehicle laws and traffic control devices, and may be subject to additional regulations.	X	X	X		X
The AV testing entity must obtain and maintain $5 million in insurance, surety bond, or proof of self-insurance.	X	X	X	X	
An AV may be operated on a public road for non-testing purposes if the manufacturer submits an application to the DMV and the application is approved.	X				
An AV may be operated or otherwise moved upon a public road by a manufacturer of automated technology solely to transport or test automated technology if the AV displays a special plate approved by the Secretary of State. The organization must satisfy all applicable state requirements in order to conduct testing.				X	

Operator Requirements

All states agree that a test vehicle must have a human operator capable of taking over immediate manual control of the vehicle. Note that this does not necessarily imply that the human operator must be in the driver's seat, or even the vehicle, to take control. The states had unique requirements and minor differences in dealing with this issue. All the states require an individual be present in the vehicle. California requires the operator be in the actual driver's seat. Michigan, Florida, and Nevada require the operator be present in the vehicle and able to take immediate control, but not necessarily in the driver's seat.

Only Nevada and the District of Columbia do not specifically require the operator of a test AV be an employee, contractor, or other person designated by the manufacturer.

OPERATOR REQUIREMENTS					
Policy	**California**	**Nevada**	**Florida**	**Michigan**	**District of Columbia**
An AV may operate on a public roadway for testing purposes if the human operator is capable of taking over immediate manual control of the vehicle.	X	X	X	X	X
An AV may be operated on state roads for testing purposes if the operator is an employee, contractor, or other person designated by the manufacturer of the autonomous technology.	X		X	X	

Vehicle Conversion and Liability Requirements

The states are relatively consistent in terms of liability protection for OEMs for third party conversions, as every state—with the exception of California—grants immunity from liability for damages resulting from such modifications. Each state has minor variations in the language used to describe said immunity, but the core protection remains consistent. Again, California does not provide immunity protection for OEMs from damages that arise as a result of third party modifications.

Michigan takes an additional step in granting immunity from civil liability to automated technology manufacturers and subcomponent system producers from third party conversions. The important distinction is that only vehicle manufacturers, but not technology manufacturers or subcomponent system producers, receive immunity in other states. Michigan chose to extend that immunity to technology manufacturers as well, which covers a wide variety of entities involved in the development of automated technologies that support a final AV product.

Each state has minor variations in the language used to describe said immunity, but the core protection remains consistent.

Finally, the District of Columbia takes the unique position that any vehicle conversions had to be on model year vehicles 2009 and newer, or those built within four years of the conversion date.

VEHICLE CONVERSION AND LIABILITY					
Policy	**California**	**Nevada**	**Florida**	**Michigan**	**District of Columbia**
The original manufacturer of a vehicle converted by a third party into an AV shall not be liable in legal action brought against the original manufacturer by any person injured due to an alleged vehicle defect caused by the conversion of the vehicle, or by the installation or modification of AV equipment, unless the alleged defect was present in the vehicle as originally manufactured.		X	X	X	X
A manufacturer of automated technology is immune from civil liability for damages that arise out of any modification made by another person to a motor vehicle or an automated motor vehicle, or to any automated technology.				X	
A subcomponent system producer is not liable in a product liability action for damages resulting from the modification of equipment installed by the subcomponent system producer to convert a vehicle to an automated motor vehicle unless the defect from which the damages resulted was present in the equipment when it was installed by the subcomponent system producer.				X	
The conversion of vehicles to AVs shall be limited to model years 2009 or later or vehicles built within 4 years of conversion, whichever vehicle is newer.					X

Mobile Communications and Data Privacy Requirements

Both Nevada and Florida revised their statues to exempt AV operators from restrictions on the use of mobile devices while the vehicle is in operation. Michigan also revised its mobile device use law, but only to allow AV operators to use wireless devices if the device operates or programs the automated vehicle.

California includes the unique language on data privacy in their legislation. The state mandates AV manufacturers disclose and describe the information collected by autonomous technology. California also crafted very specific language which requires AVs have a separate device that functions similarly to, but is distinct from, an event data recorder: the device must record the autonomous system information for 30 seconds preceding a crash and preserve it for three years.

As a part of Nevada's regulatory package, the state also requires AVs to have a data storage mechanism that can capture and store vehicle sensor data that is able to be extracted and downloaded by an external device for up to three years after an accident to help with providing forensic crash reconstruction.

MOBILE COMMUNICATIONS AND DATA PRIVACY REQUIREMENTS					
Policy	**California**	**Nevada**	**Florida**	**Michigan**	**District of Columbia**
It is legal for an operator to use a cellular phone or other handheld wireless communication device if the motor vehicle is being driven autonomously through the use of artificial intelligence software.		X	X		
It is legal for an operator to use a cellular phone or other handheld wireless communication device if the individual who is using the device is doing so in order to operate or program the operation of an automated motor vehicle while testing the automated motor vehicle.			X	X	
The manufacturer of the autonomous technology installed on a vehicle shall provide a written disclosure to the purchaser of an AV that describes what information is collected by the autonomous technology equipped on the vehicle.	X				
An AV must have a separate mechanism, in addition to, and separate from, any other mechanism required by law, to capture and store the autonomous technology sensor data for at least 30 seconds before a collision occurs while the vehicle is operating in autonomous mode. The autonomous technology sensor data shall be captured and stored in a read-only format by the mechanism so that the data is retained until extracted from the mechanism by an external device capable of downloading and storing the data. The data shall be preserved for three years after the date of the collision.	X				

REGULATORY ANALYSIS

Introduction

Regulations on AV testing codify a state's enabling legislation, provide a precise explanation for how a state intends to execute its oversight, and describe how those subject to the regulations can comply. The two states with regulations thus far—California and Nevada—directed their respective DMVs to develop the necessary regulations.

The following subsections first review and describe each state's regulations to provide context for the reader, and second, analyze the regulations to determine the level of interstate consistency. This analysis limits its focus to describing and comparatively analyzing the states' regulations; a more thorough or quantitatively-based analysis would require information that is not currently available. The analysis focuses primarily on a state's adherence to the NHTSA recommended regulations.

The reason for focusing on adherence to the NHTSA guidelines is due to industry fears of interstate regulatory inconsistency, which industry members feel could slow AV innovation and development. In previous interviews, AV industry representatives stated that one of their largest concerns was that an inconsistent "tapestry" of state regulations would make it very difficult to develop and eventually bring AVs to market (8).

The NHTSA recommendations in this analysis serve as a base case on which the analysts determine regulatory consistency. This analysis does not presume the NHTSA regulations are preferable to other state approaches and makes no statements about their efficacy in comparison to alternative approaches; it simply uses them as an illustrative and analytical tool to demonstrate interstate regulatory consistency, or lack thereof. As an important note—and to be fair to Nevada—their DMV completed their regulations before NHTSA put forward its recommended regulations.

The two states with regulations thus far—California and Nevada—directed their respective DMVs to develop the necessary regulations.

The scope of this analysis stays within the bounds of NHTSA's guidelines since *AV testing* for levels 3 and 4 has a minimal role in improving mobility, shaping urban form, or affecting the allocation of public goods in our communities. Large-scale *AV deployment*, perhaps decades from now, may require a comprehensive set of regulations to govern the far-reaching implications across many areas of society. As a result, this analysis does not consider issues related to regulating the implementation of AVs and is limited to regulations on companies testing AVs on public roads.

Regulatory Overview

California

California Department of Motor Vehicles (DMV) is tasked with developing testing regulations by September 2014, releasing draft iterations for public comment throughout this past year. In addition to testing regulations, California will be the first state to release public operation regulations for widespread deployment by January 2015. Regulations for public operation of autonomous vehicles are expected to be released for public comment and consequent adoption just before January 2015.

Nationwide, stakeholders are following the development of California's testing and deployment regulations as they will most likely influence other states' statutes and code. In particular, automotive manufacturers have declared they would like to see uniformity throughout states and do not anticipate calling for federal legislation unless there are significant differences in state rules that inhibit product development or innovation. California's approach to testing regulations could be considered an administratively low-burden strategy for the DMV. Allowing manufacturers to self-certify vehicles and drivers removed some of the administrative burden from the state. There are disagreements between the DMV, manufacturers, and dealers on the capacity drivers must have in order to operate autonomous vehicles and which institution(s) should enforce such standards. Consumer privacy groups insist the DMV slow the development of deployment regulations to allow testing results to accrue and be analyzed properly before embarking on widespread public use. Deployment regulations will most likely face a higher level of opposition during the public comment phase than did testing regulations. It remains to be seen whether all parties can come to consensus.

Nevada

Nevada became the first state in the United States to adopt testing regulations for autonomous vehicles in 2012. The DMV developed regulations thanks to state enabling legislation in 2011, later amended in 2013 for minor inconsistencies. The DMV collaborated with Google, automobile manufacturers, testing professionals, insurance companies, universities, and law enforcement officials in developing testing regulations with safety as their foremost priority. Self-driving vehicles are distinguished in Nevada by a red license plate with an infinity symbol on its left side.

Nevada divides applicable regulations to "licensees" into two sections – one for authorized test drivers, the other for autonomous vehicle certification facilities—since both are categorized as "licensees" of the DMV, unlike California.

Regulatory Analysis

This subsection analyzes regulations in the only two states with existing AV regulations for testing purposes—Nevada and California. The analysis focuses primarily on how well the states adhere to the set of recommended regulatory guidelines NHTSA published in 2013. These recommended regulations provide a template for states to follow if they choose.

NHTSA focuses on three categories:

- Licensing drivers.
- Governing testing.
- Basic principles for testing AVs.

Each category has associated strategies and regulations. The analysis below explains these categories, and describes the associated strategies and regulations under each. It then assesses how closely Nevada and California's regulations adhered to these recommendations.

Licensing Test Drivers to Operate AVs

NHTSA's first category centers on ensuring drivers understand how to safely operate self-driving vehicles. Recommended regulations include:

- Adding AV endorsements for driver licenses.
- Establishing driver certification programs for manufacturers.
- The state's DMV vetting and approving the certification courses provided by manufacturers.

LICENSING DRIVERS *Ensure that the driver understands how to operate a self-driving vehicle safely*		
Regulation(s)	**California**	**Nevada**
i. Driver's license endorsements		X
ii. Prerequisites: certification by manufacturer	X	X
iii. Certification course should be submitted to the state DMV for approval	X	

California

California does not require AV drivers to seek additional driver license endorsements from the DMV. Drivers, however, must seek a 3-year Autonomous Vehicle Testing (AVT) operator permit from the manufacturer conducting testing of autonomous vehicles. Manufacturers wishing to test autonomous vehicles must apply to the DMV on an annual basis with their AVT program, the amount of vehicles, and corresponding fees of $150 for 1-10 vehicles (for up to 20 drivers) and $50 (for each additional set of 1-10 vehicles) with 1-20 drivers. The DMV approves or denies applications within 10 days of receipt, informing rejected manufacturers of their application deficiencies and allowing a 'reasonable period of time' for the manufacturer to correct their application.

Nevada

Similar to California, two of the three recommended regulations under driver licensing are covered, albeit, not the same two regulations. Unlike California, Nevada requires an additional driver license endorsement, categorized as a "G" endorsement for driving autonomous vehicles on public roadways. Nevada also requires certification by manufacturer or an autonomous vehicle testing facility licensed to test the vehicles before the sale by an authorized dealer in the state. Nevertheless, a state issued "G" endorsement for drivers authorizes the testing of the autonomous technology even if certificates of compliance have not been issued from the AV testing facility.

Nevada also does not require a certification course for AV manufacturers, but imposes standards (covered under "regulating testing") on vehicle testing facilities, in addition to demonstrating that the vehicle operator(s) possess the necessary knowledge and expertise to ensure the safety of AV. The applicant will have to allow inspection of the autonomous certification facility before approval is granted.

Governing Testing of AVs

The second category focuses on regulating testing with three overarching NHTSA strategies, each with their particular regulations:

1. Minimize risk to other road users.
2. Limit testing operations to roadway, traffic, and environmental conditions suitable for autonomous vehicles.
3. Establish reporting requirements to monitor the performance of AV technologies during testing.

In order to achieve their first strategy of *minimizing risk* to other road users, states are recommended to adopt the following four rules.

1. Vehicle simulation/testing in autonomous mode must go without incident before seeking license.
2. Agreed upon data from previous testing should be required to ensure state officials have appropriate information when assessing certification permits.
3. Drivers should be properly licensed, seated, and present in the driver's seat at all times when the vehicle is engaged to be ready to take control, if necessary.
4. Manufacturers should submit a safety plan to state authorities on how they will minimize risk to other road users.

For the second strategy to *limit testing operations to suitable conditions*, NHTSA recommends three additional rules to limit testing operations to conditions suitable for autonomous vehicles.

1. Manufacturers should inform the state of the operating conditions under which they wish to test, and then demonstrate their vehicles are capable of operating in these conditions with limited driver intervention.
2. States should consider limitations on the conditions in which a vehicle may be operating in autonomous mode.
3. States should require manufacturers designate the operating conditions for which the vehicle can operate, like a limited access highway.

Only one regulation is proposed for the final strategy, establish reporting requirements in monitoring the performance of autonomous vehicle technology. States are encouraged to require manufacturers to submit "certain information" to the state. The rule encourages states to take a proactive role in determining information they believe will be valuable for future policy evaluation.

REGULATING TESTING *Ensuring on-road testing minimizes risks to other road users*		
Regulation(s)	**California**	**Nevada**
i. Vehicle testing in self-driving mode without incident before seeking license		
ii. Data from previous testing		X
iii. Plan from firm(s) on minimizing safety risks to other road users		X
iiii. NHTSA recommends states require a properly licensed driver be seated in the driver's seat ready to take control.	X	
Limit testing operations to roadway, traffic, and environmental conditions suitable for self-driving vehicles		
i. Self-driving vehicle manufacturers inform the state of the operating conditions they wish to test. Firms should supply states with test data or other information to demonstrate their vehicles are capable of operating in these conditions with limited driver intervention.	X	X
ii. States are encouraged to consider appropriate limitations on the conditions in which a vehicle may be operated in self-driving mode.		X
iii. Regulations could designate the operating conditions for which the self-driving vehicle is designed for such as a limited access highway.		X
Establish reporting requirements to monitor the performance of self-driving technology during testing		
i. To expand the body of data and support research concerning self-driving vehicles, states are encouraged to require firms testing self-driving vehicles to submit to the state certain information	X	

Basic Principles for Testing AVs

NHTSA outlines two strategies, with five total regulations under this section. The first strategy recommends four regulations to ensure that the *process for transitioning from self-driving mode to driver control is safe, simple, and timely*. The four regulations under the first strategy combine to suggest a driver familiar with the vehicle's automated systems be in the vehicle at all times in order to retake control by immediately overriding its automated features, and the vehicle must be able to alert the driver when control should be retaken.

BASIC PRINCIPLES FOR TESTING SELF-DRIVING VEHICLES *Ensure that the process for transitioning from self-driving mode to driver control is safe, simple, and timely*		
Regulation(s)	**California**	**Nevada**
i. A driver familiar with the particular vehicle's automated systems is necessary to ensure that a failure of the system does not put other road users at risk.	X	X
ii. A regulation may require the driver be able to retake control of the test vehicle by immediately over-riding, such as pressing a button located within the driver's reach	X	X
iii. Automated functions should defer to the driver's input by allowing the driver to retake control by using the brakes, accelerator, or the steering wheel.	X	
iiii. The vehicle should alert the driver when he/she must take control of the vehicle		X
Test vehicles should be able to detect, record, and inform drivers of system malfunction		
i. Self-driving test vehicles operating on the road should have the capability of detecting that their automated vehicle technologies have malfunctioned or are operating in a degraded state, and informing the driver in a way that enables the driver to regain proper control		X

The second strategy holds one regulation *recommending test vehicles should be able to detect, record, and inform drivers of system malfunction*. It requires the test vehicle be capable of detecting malfunctioning technologies operating in a degraded state and properly informing the driver in a way that enables him/her to regain proper control.

Other Regulations

California and Nevada's DMV also established regulations not covered in the preceding review. They deal with procedural rules for financial responsibility, revocations, or appeals and reinstatement processes. For example, manufacturers must comply with a $5 million insurance or surety bond as evidence of financial responsibility in both states. Manufacturers can appeal refusals, suspensions, or revocations of test permits by requesting a hearing for within 60 days in California or 30 days in Nevada and complying with the DMV's recommendations before any suspensions may be lifted.

Other miscellaneous rules include:

- Manufacturers in California must obtain a non-repairable vehicle certificate if disposing of the autonomous vehicle to ensure the vehicle is not retitled, resold, and ownership of the vehicle is transferred to an auto dismantler.
- Autonomous vehicles in California may also be donated to a museum, educational, or research institution for display or further study.
- Prospective autonomous vehicle operators applying for a test permit must be enrolled in California's Employer Pull Notice Program before being approved by a certified AVT program. This statewide program provides employers with a comprehensive driver record to assess AV operators appropriately.
- Finally, AV title transfers require recipients hold a valid autonomous vehicle manufacturer test permit from the DMV.

Policy Considerations for AV Testing Legislation and Regulations

The preceding sections review the legislative and regulatory approaches other states have taken. If the state decides it needs to regulate AV testing on public roads, there are many things the state might want to consider.

Since it would be impossible to know or discuss all the factors the state might take into account, this analysis will review and discuss a few salient considerations. Again, this list does not presume to comprise all the things the state might consider, but instead reviews select relevant and salient points related to AV legislation and regulations. These considerations include:

- Safety.
- Interstate and federal regulatory consistency.
- Innovative flexibility.
- Regulatory intensiveness.
- Administrative burden and cost.

Safety

AV technology is evolving rapidly, with multiple vendors using competing approaches. Given the wide-ranging demands of maneuvering a vehicle in traffic under a variety of conditions, developers are expected to desire on-road testing, and there do not appear to be any significant current barriers in Texas law to such testing. Other states have passed laws or adopted regulations to address public concerns regarding the testing of driverless, connected, or otherwise technologically advanced vehicles in a real-world environment. Such measures include requirements similar to those seen in the table below.

Table 4. Example Safety Requirements.

Policy/regulatory area	Example Requirements
Vehicle component requirements	• The AV must be capable of safely transferring control to a driver in the event of an emergency through numerous specific ways (e.g. applying the brake, grabbing the steering wheel, etc.) • The vehicle must be consistent with FMVSS and not make any FMVSS inoperative • AVs must have custom event data recorder hardware • The vehicle must have a visual indicator showing when the vehicle is in automated mode. • The DMV must develop a certification program for test vehicles and drivers to ensure they meet certain minimum standards
Operational requirements	• Permit vehicles to operate for testing purposes only • Regular reporting of occasions where the AV had to leave automated mode erroneously or for emergency purposes • $5 million of insurance covering vehicle testing • Limit testing to specific geographic regions, roadway types, or road segments
Operator requirements	• Vehicle operators undergo training through a licensing program • Vehicle operators must not only be present in the vehicle, but physically seated in the driver's seat and able to take over in case of emergencies

Interstate and Federal Regulatory Consistency

A second factor the state may wish to consider is how well legislation and regulations adhere to previously developed legislation and regulations, as well as NHTSA's AV testing recommendations (1). The rationale behind this consideration is that, in previous interviews, one of the largest issues concerning AV manufacturers and developers is that an inconsistent patchwork of legislation and regulations would develop (8). Such a system would make it difficult and costly for AV refinement and manufacturing, and the industry fears this would decrease innovative capacity.

To address this concern and aid states in developing legislation and regulations for AV testing, NHTSA developed a recommended regulatory framework for states. Texas may wish to consider this framework as a means of increasing interstate and federal regulatory consistency. Comparing any proposed regulations against other states' would also help to minimize inconsistencies.

There is an additional way that Texas could maintain interstate regulatory consistency: the State could pursue a policy consistent with 46 of 50 states by not passing legislation or developing regulations on AV testing. Such an approach would not result in inconsistent regulations, as it would not result in new conflicting regulations.

Regulatory Intensiveness and Flexibility for Innovation

In its regulatory recommendations, NHTSA points to the difficulty states are likely to face when balancing competing priorities, noting that states "must appropriately balance the need to ensure motor vehicle safety with the flexibility [for the AV industry] to innovate." As noted above, increases in safety regulations are generally presumed to increase safety, but an overabundance of regulations could stifle the AV industry's innovative capabilities.

The following hypothetical example of safety regulations illustrates this point. A state might wish to license and require specific training of AV test drivers, which is a policy idea that other states have considered. However, if a state required extensive and unprecedented amounts of training or placed unreasonably high requirements on the test drivers, such a regulation would likely make the costs of testing high, reduce the pool of potential test drivers, and make testing difficult to accomplish. States may wish to consider how regulatory intensiveness might affect innovative flexibility and safety when crafting public policy.

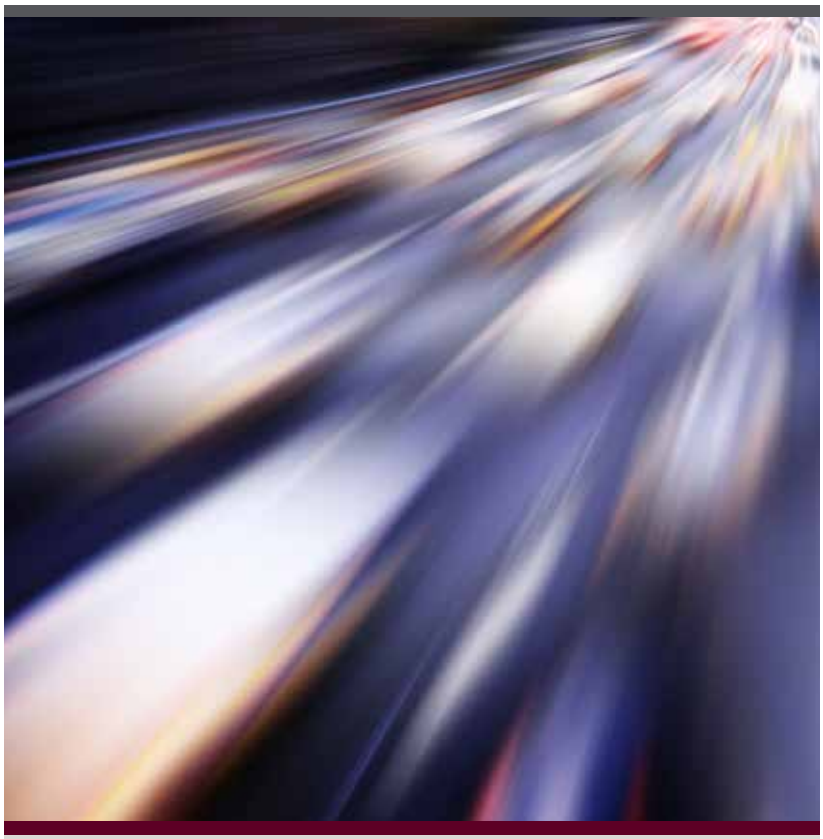
Administrative Burden and Cost

While not expected to be a costly endeavor, variations in regulatory intensiveness could result in higher administrative burden and costs. For example, developing an original certification and licensing process for AV test drivers could result in higher costs than a system that uses the existing licensing process. The state might wish to develop a novel system, although this might result in increased costs and administrative burden.

While not expected to be a costly endeavor, variations in regulatory intensiveness could result in higher administrative burden and costs.

As a potential option, the State could charge a fee to drivers applying for licenses and companies applying to test in Texas to offset some or all of the system costs. The costs to develop and implement similar regulatory programs in other states are unknown, but the California DMV stated in its regulatory Final Statement of Reasons that the adopted regulations would result in:

- No costs or savings to any state agency.
- No costs to any local agency or school district.
- No other discretionary cost or savings to local agencies.
- No costs or savings in federal funding (9).



CONCLUSION

AVs are a rapidly developing technology that could potentially provide many benefits but will require concerted and coordinated action to fully realize the potential of automated driving. Refining these vehicles requires testing on public roads, and several states have already passed legislation and developed regulations governing AV testing.

The State of Texas must first decide if legislation and/or regulations are a desirable option. Legislation and regulation could protect the public from unrefined and untested automated vehicles being tested on public roads, and provide an implicit signal to the industry that the State is welcoming the AV industry and testing. There are also potential benefits to waiting to see how the technology develops and is regulated, and it is not clear that such measures are immediately necessary.

If Texas decides that a law should be passed, there are many legislative and regulatory aspects to consider, from requiring specialized vehicle components, to developing licensing and AV testing oversight programs, to limiting where and how testing might occur. This report reviews many of the aspects that the State may wish to consider and discusses how previous states have handled such issues. It discusses five salient factors that the state might wish to consider if it passes legislation and develops regulations:

- Ensuring the safety of road users.
- Preserving interstate and federal regulatory consistency.
- Selecting a desired level of regulatory intensiveness.
- Preserving the AV industry's capacity for innovation.
- Balancing the social benefits of policy with administrative burden and costs.

Appendix – Economic Development in Automated Vehicle Industries

As automobile and technology companies develop and test automated vehicle technologies, several states have passed or considered automated vehicle legislation. Uncertainty about the technology's legal and regulatory status has been described by industry representatives as a hurdle.

Toyota's Director of Technology and Innovation Policy said, "Until we know what the rules of the road will be it's hard to move forward" (10). In contrast, Google, a company that has invested in testing automated vehicle technology, actively supported and contributed to the successful legislation efforts in Nevada and California (11). Some states passed legislation and regulations on automated vehicle testing with the stated intent of generating economic growth.

Michigan

The state of Michigan is actively pursuing automated vehicle industries through legislative action and economic development policies. Michigan policy makers and economic developers see the state's established industry clusters as an asset the state can leverage to improve its standing as a leader in automotive technology. A 2008 Center for Automotive Research report suggested the state should pursue strategic development of new information technology jobs by linking them to the existing automotive technology resources. According to the report, Michigan has a competitive advantage in research engineering in the automotive sector with almost 70% of North American automotive research and development and over 70,000 high-tech workers (12).

Michigan is one of five states and the District of Columbia to pass legislation on the testing or operation of automated vehicles. Supporters of the bills, including the governor, publically stated that the legislation is intended to stimulate automated vehicle industries in the state. Passed in late 2013, Michigan Senate Bills 169 and 663 allow testing of automated technologies on public roadways and protect automakers from liability. Michigan Senator Mike Kowall, who introduced the bills, sees the legislation as economic development for the state, stating the legislation is "really a huge economic development bill…This is going to have an effect of attracting new companies and building upon existing companies that are already here" (13). According to Senator Kowall, Governor Snyder of Michigan was interested in the 2013 legislation "to establish Michigan as a leader in the automated vehicle technology, mostly to attract jobs stemming from this developing industry" (14). In addition to the legislative measures, economic development policies, and programs are also being developed to encourage the industry.

Cluster strategies and public-private partnerships are being implemented by economic development organizations to support an automated vehicle industry in Michigan. A grant from the Michigan Economic Development Corporation (MEDC) helped to establish the Michigan Automated Systems Collaborative (MASC), a strategic partnership to support development of automated systems and related robotic technologies including the goal to "establish and maintain Michigan's leadership in automated vehicle technology" (15). The Detroit Regional Chamber implemented an economic development initiative, called MICHAuto, "dedicated to promoting, retaining and growing the automotive industry in Michigan" (16). A MICHAuto automated vehicle event in 2013 was described by program manager Rob Luce as an event "to focus on how Michigan can capitalize on its existing automotive assets to ensure that this technology is developed and integrated here, versus in Silicon Valley or Germany or Asia" (17).

Government, industry, and university partners have joined forces in several economic development initiatives to promote automated vehicle technology.

In 2012, the US DOT-funded and University of Michigan-led Connected Vehicle Safety Pilot Model Deployment project was launched, testing thousands of vehicles with connected vehicle technology on public roads in the state. Major carmakers provided vehicles and may seek to benefit from the opportunity to be involved in testing that will inform future vehicle regulatory decisions. As a result of the state's testing, vehicle technology companies in Michigan may benefit, and several new companies relocated to the area as a result (11).

In 2014, the University of Michigan's Mobility Transformation Center (MTC) launched a 32-acre automated and connected vehicle technology test site with the support of US DOT and the Michigan DOT. The project has engaged industry partners including Ford, GM, Toyota, Bosch and Econolite, who will each commit $1 million over three years to support the center's programs (18). The university location offers access to its incubator space, which supports business start-ups and other economic development (19). The test bed is expected to feed data to US DOT that will inform federal policy decisions on automated vehicle technology (20). The testing sites and projects are supported by government sponsors and economic development corporations because they are seen as regional investments with the potential to draw in new businesses, build companies, and create more jobs.

Florida

Florida Governor Rick Scott publically stated that he believes automated vehicles will generate new jobs for the state (21). Florida's legislation, which allows automated vehicle testing on public roads, has sparked interest from governments, universities, and industry partners. An Automated Vehicle Institute was launched by the Center for Urban Transportation and Research (CUTR) at the University of South Florida. The Institute then partnered with the Tampa Hillsborough Expressway Authority (THEA) on a vehicle test site (22).

The Lee Roy Selmon Expressway in Tampa, Florida, was designated as one of ten nationwide test sites for the study of automated vehicles. Brad Stertz, of Audi of America, said that the testing will "call attention to the way Florida is approaching its laws dealing with this new frontier" (23). Joe Waggoner, head of THEA, contends that this will give the region access to the businesses, automakers, and researchers who are interested in this new technology, saying, "We want to know what it takes and be a part of it" (24).

Iowa

In July 2014, Johnson County, Iowa, became the first municipality to officially encourage automated vehicle testing as an economic development initiative. The Johnson County Board of Supervisors unanimously passed a proclamation "encouraging autonomous vehicle testing as a public safety and economic development initiative" (25).

In contrast to the states that have passed specific legislation on automated vehicles, Iowa is advertising its lack of restrictive legislation on the testing or operation of automated vehicles on public roads. Advocates also argue that the state boasts a less burdensome regulatory environment than some other states and a unified network of interested stakeholders. The University of Iowa, including the National Advanced Driving Simulator and clusters of advanced vehicle and technology companies, offer a foundation for automated vehicle research in the region. Officials are even considering certifying roadways that can accommodate automated vehicle testing (26).

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