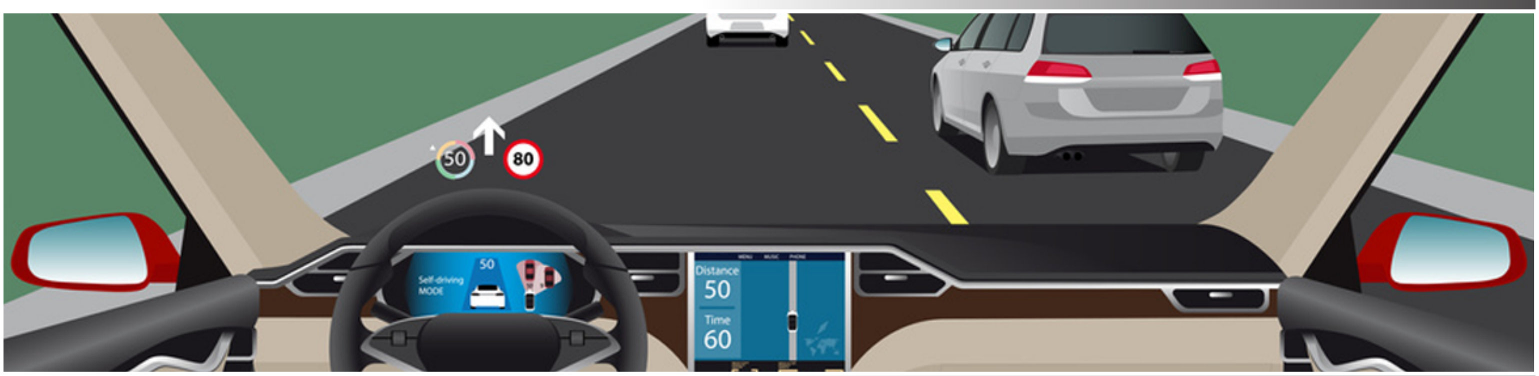
FINAL REPORT OF THE ADVISORY COUNCIL ON CONNECTED AND AUTONOMOUS VEHICLES

ESTABLISHED UNDER EXECUTIVE ORDER 14 SIGNED BY GOVERNOR JOHN C. CARNEY



RESPECTFULLY SUBMITTED TO THE GOVERNOR AND
ALL MEMBERS OF THE 149TH GENERAL ASSEMBLY

SEPTEMBER 2018

GREAT SEAL OF THE STATE OF DELAWARE
LIBERTY AND INDEPENDENCE
1704 • 1776 • 1787

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ACRONYMS

Acronym	Definition
AAMVA	American Association of Motor Vehicle Administration
AASHTO	American Association of State Highway and Transportation Officials
ADS	Automated Driving System
AI	Artificial Intelligence
Auto-ISAC	Auto-Information Sharing and Analysis Center
AVL	Automated Vehicle Location
CAV	Connected and Autonomous Vehicle
CDL	Commercial Driver's License
CES	Consumer Electronics Show
CPU	Consumer Protection Unit
DART	Delaware Authority for Regional Transit
DelDOT	Delaware Department of Transportation
DMV	Division of Motor Vehicles
DOE	Department of Education
DSRC	Dedicated Short Range Communications
ECPA	Electronic Communications Privacy Act
FHWA	Federal Highway Administration
FTC	Federal Trade Commission
HAV	Highly Automated Vehicle
IoT	Internet of Things
ISO	International Standards Organization
ITMS	Integrated Transportation Management System
ITS	Intelligent Transportation Systems
MUTCD	Manual on Uniform Traffic Control Devices
NAIC	National Association of Insurance Commissioners

NAMIC	National Association of Mutual Insurance Companies
NCHRP	National Cooperatives Highway Research Program
NHTSA	National Highway Traffic Safety Administration
OBU	On-Board Unit
OEM	Original Equipment Manufacturers
OHS	Office of Highway Safety
PII	Personally Identifiable Information
RSU	Roadside Unit
SAE	Society of Automotive Engineers
SPaT	Signal Phase and Timing
STAR Campus	Science, Technology, and Advanced Research
TARDEC	Tank Automotive Research Development and Engineering Center
TMC	Transportation Management Center
TRB	Transportation Research Board
UD	University of Delaware
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Everything

MEMBERSHIP

Advisory Council

Member	Organization
Jennifer Cohan (Chair)	Secretary, Delaware Department of Transportation (DelDOT)
Philip Barnes	University of Delaware Institute of Policy Administration
Danielle Brennan	Attorney General
Ruth Briggs King	House of Representatives
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Scott O'Connor (Chair)	Department of Technology and Information (DTI)
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Mark Luszcz	Delaware Department of Transportation (DelDOT)
Reed MacMillan	Dover/Kent Metropolitan Planning Organization
Ed Osienski	House of Representatives
Scott Vien	Division of Motor Vehicles (DMV)

Impacts on Public and Highway Safety Subcommittee	
Member	Organization
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Barzilai Axelrod	Attorney General's Office
Bill Bryson	Delaware Police Chief's Council
Ken Grant	AAA Mid-Atlantic
Mark Luszcz	Delaware Department of Transportation (DelDOT)
Brian Pettyjohn	State Senate
Jana Simpler	Delaware Office of Highway Safety (OHS)
Scott Vien	Division of Motor Vehicles (DMV)
Adam Weiser	AECOM

EXECUTIVE SUMMARY

Under the leadership of Governor Carney, over the past year, the Advisory Council on Connected and Autonomous Vehicles, established through Executive Order 14, met and discussed the varying aspects regarding the deployment of this emerging technology and its potential impacts on our transportation system, economy and citizens. The Advisory Council heard from subject matter experts from across the industry on the opportunities, challenges and best practices on how to encourage the safe manufacturing, development, testing and deployment of connected and automated technologies.

The Advisory Council focused on Promoting Economic Development; Technology, Security and Privacy; Transportation Network Infrastructure; and Impacts on Public and Highway Safety. In addition, the Council, in conjunction with the Department of Insurance, reviewed the potential impacts connected and autonomous vehicles will have on its industry.

The Advisory Council developed a number of recommendations that cross all of the above focus areas. While it was identified that some of the recommendations can be implemented immediately, it was also realized that there is more research to be done on others.

Investing in education and training of our workforce in the varying technologies associated with connected and autonomous vehicles; providing economic incentives for companies that want to test their technology in Delaware; preparing our existing infrastructure; and securing data are just a few of the areas the state should focus.

Lastly, in order to be at the forefront of this emerging industry, Delaware should continue to have a presence at a national level on this topic, as well develop relationships with industry leaders and manufactures.

While Executive Order 14 contemplated that the Advisory Council meeting for one year, it was decided that in order to stay current and move forward with implementing many of these recommendations, that the Advisory Council will continue to meet on a quarterly basis and provide updates on its progress.

BACKGROUND

In September 2017, Governor John Carney signed Executive Order 14 to establish an Advisory Council on Connected and Autonomous Vehicles. This Council was tasked with developing recommendations for innovative tools and strategies that can be used to prepare Delaware's transportation network for connected and autonomous vehicles (CAVs).

CAV technology is predicted to enhance safety on roadways, reduce traffic congestion, and increase mobility. CAVs promise numerous benefits for users, however, there is still much to be learned about their operation and impacts. As these technologies develop globally, it is crucial that Delaware stay at the forefront and prepare for changes to come. This includes considering all aspects of CAV and potential impacts to users and the public.

FIGURE 1: GOVERNOR CARNEY SIGNING EXECUTIVE ORDER 14 ***VIA AAA MID-ATLANTIC***

Council Subcommittees were formed to research and develop recommendations in four areas:

1. Promoting Economic Development
2. Technology, Security and Privacy
3. Transportation Network Infrastructure
4. Impacts on Public and Highway Safety

Connected Vehicles vs. Autonomous Vehicles

CAVs are vehicles that utilize technology to communicate with other vehicles, connected devices, and the transportation system. While sometimes referred to simultaneously in this document under the CAV acronym, it should be noted that there are differences between connected vehicle (CV) and automated vehicle (AV) technologies and the implications each will have to Delaware's ongoing transportation operations.

Connected Vehicles

CV technologies allow vehicles to communicate with each other and the world around them. A "connected vehicle" uses wireless technology to transmit and collect information to and from other vehicles (vehicle-to-vehicle (V2V)), to roadside infrastructure (vehicle-to-infrastructure (V2I)), or to other modes and devices (V2X). This information can be used by transportation agencies to enhance their knowledge of real-time road conditions, as well as generate historic data that will help agencies better plan and allocate future resources. In addition, having a communication medium within the vehicle, connected to the roadside infrastructure, provides the ability for transportation agencies to deliver more detailed, timely, and pertinent information directly to individual vehicles.

While the CV term is most closely associated with the Dedicated Short Range Communications (DSRC) bandwidth (5.9GHz) and basic safety message, the Delaware Department of Transportation (DelDOT) defines the term in a looser, technology-agnostic manner. A CV is inclusive of any vehicle that provides the opportunity to transmit data between itself and another entity whether that be through DSRC, cellular, Wi-Fi, or other methods. This is inclusive of existing technologies, such as the DelDOT mobile application, transit automated vehicle location (AVL) system, and mobile dash camera system. CVs and associated systems, such as Roadside Units (RSUs) and On-Board Units (OBUs), are starting to be deployed utilizing DSRC. At this time, some believe that the next generation of cellular technologies (5G) will someday supplant DSRC as the primary telecommunication protocol for CVs. The implementation of 5G and other CAV telecommunication systems have the potential to improve safety by enhancing data and information exchange between vehicles and infrastructure.

Autonomous Vehicles

AV technologies reside within the vehicle itself and assist with or fully take over driving tasks. AVs are classified by the following six Levels of automation as defined by the Society of Automotive Engineers (SAE) and the National Highway Traffic Safety Administration (NHTSA):

- Level 0 – No Automation. The driver is in complete control of the vehicle at all times.
- Level 1 – Driver Assistance. The vehicle can assist the driver or take control of either the vehicle's speed, through cruise control or its lane position, through lane-keeping assistance, in some situations. The driver must monitor the vehicle and road at all times, with hands on the steering wheel and feet on or near the pedals, and must be ready to take control at any moment.
- Level 2 – Partial Automation. The vehicle can take control of both the vehicle's speed and lane position in certain conditions, for example on controlled access highways. The driver may disengage, with hands of the steering wheel and feet away from the pedals, but must monitor the vehicle and road at all times and be ready to take control quickly at any moment.
- Level 3 – Conditional Automation (limited self-driving). The vehicle can be in full control in certain conditions, monitors the road and traffic, and will inform the driver when he or she must take control. When the vehicle is in control the driver need not monitor the vehicle, road, or traffic but must be ready to take control quickly when informed.
- Level 4 – High Automation (full self-driving under certain conditions). The vehicle can be in full control for the entire trip in these conditions and operates without a driver.
- Level 5 – Full Automation (full self-driving under all conditions). The vehicle can operate without a human driver and need not have human occupants.

NHTSA and SAE refer to vehicles operating at Levels 3-5 as having Automated Driving Systems (ADSs). The American Association of Motor Vehicle Administrators utilizes the term Highly Automated Vehicle (HAV) synonymously with ADS.

				Automated Driving Systems (ADS)		
	Level 0 No Automation	**Level 1 Driver assistance**	**Level 2 Partial automation**	**Level 3 Limited self-driving (conditional automation)**	**Level 4 Full self-driving under certain conditions (high automation)**	**Level 5 Full self-driving under all conditions (full automation)**
Vehicle	No automation.	Can assist driver in some situations.	Can take control of speed and lane position in certain conditions.	Can be in full control in certain conditions and will inform the driver to take control.	Can be in full control for the entire trip in these conditions and can operate without a driver.	Can operate without a human driver and need not have human occupants.
Driver	In complete control at all times.	Must monitor, engage controls, and be ready to take over control quickly at any moment.	Must monitor and be ready to take over control quickly at any moment.	Must be ready to take control quickly when informed.	Not needed	Not needed

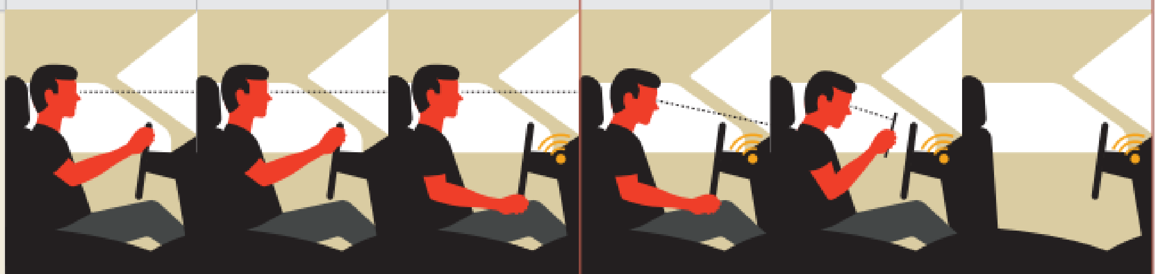


FIGURE 2: LEVELS OF AUTOMATION (GOVERNORS HIGHWAY SAFETY ASSOCIATION)

With AVs, even at Level 5, communication with the outside world in any way is not required for successful operation. In fact, most current AV technologies solely rely on sensors applications located wholly within the vehicle to perform driving functions. In the short term, while AV technology is still in its infancy, CV technologies offer the greatest opportunity to enhance the operations of transportation facilities statewide by providing a mechanism for DelDOT to collect better real time data and disseminate information to motorists in a more effective way. AV technologies, however, offer a significant opportunity to improve highway safety by providing motorists with greater situational awareness and eliminating human error from driving tasks.

Ultimately, it is anticipated that the greatest benefits will be achieved through the combined use of both CV and AV technologies which can seamlessly integrate on-board vehicle operations, alarms, and wayfinding with DelDOT roadway condition data and other traveler information.

CAV System: Vision for the Future

In the short-term, Connected Vehicles should improve highway safety by giving drivers additional information that they do not currently have. However, significant fleet turnover and public sector investment will be required to begin to reap the potential safety benefits of this technology. In the long-term, it is expected that Connected Vehicles will merge with Autonomous Vehicles to create a hybrid CAV. CAVs can be characterized as "transformative" and "disruptive" technologies with myriad impacts on the way we think about and utilize transportation alternatives and on the way we evaluate the risks associated with using these alternatives.

The core of CAV technology is powered by Artificial Intelligence (AI) and high speed communications. AI is already having a significant impact on the insurance industry. Whereas decision-making in the 20th Century was powered by "rules, heuristics or spreadsheets," decision-making is now made better and faster, powered by deep learning involved in AI .

AI in CAVs arguably holds a learning advantage over humans. While a human driver may repeat the same mistakes as millions of drivers before them, a CAV can benefit from the data and experience drawn from thousands of other vehicles on the road.

CAVs will eventually communicate with each other and with the rest of the transportation system through DSRC, Wi-Fi, cellular, or other methods. This means that, not only is the CAV connected to the Internet of Things (IoT), but its passengers are also connected to the CAV, such that data freely flows to and from the CAV, and to and from the passengers riding in it through any mobile devices that the passengers may bring with them on their trip in the CAV. This data can be used to enhance the operation of the transportation system. Increased information can not only help an AV o operate, but it can help human technicians at the Transportation Management Center (TMC) to more quickly and efficiently detect an incident, analyze impacts, develop and deploy solutions, and better prepare for future events. The transportation system as a whole will improve with the additional influx of data from CAVs and continuous communication between mobile devices and roadway infrastructure.

SUBCOMMITTEES

Promoting Economic Development

The mission of the Promoting Economic Development subcommittee is to develop recommendations for innovative tools and strategies that can be used to prepare Delaware's transportation network for CAVs in a way that promotes economic development. The subcommittee focused on three areas: Education; Marketing and Collaboration.

Education

A qualified workforce is essential to any industry and the CAV industry is no exception. The concept of education was discussed and included high school driver's education, Commercial Driver's License (CDL), truck driver training programs, after-market installation and repair technicians, coders, data analytics and perhaps, most urgent, the general public as more commercial vehicles are on the roadways using the advanced technologies.

Marketing

Delaware has a compelling story to tell regarding DelDOT's impressive investment in technology and controlling interest in 90% of roadways, as well as nationally recognized research projects underway in robotics, coding, analytics and pilot deployments.

Collaboration

Delaware has a reputation of being a "state of neighbors" where we work together to make good things happen. We should capitalize on existing collaborations and work to develop more robust collaborations targeting CAVs. Examples include DelDOT's partnership with the University of Delaware (UD) to run an autonomous vehicle pilot on the Science, Technology, and Advanced Research (STAR) Campus, The Mill (co-working space) with support from the State of Delaware is now home to TrafficCast, WhyFly and ZipCode Wilmington (a coding boot camp), and AAA-Mid-Atlantic's partnership with organizations such as Automotive Service Association to develop training programs.

For more information on the Promoting Economic Development Subcommittee refer to Appendix B.

Technology, Security and Privacy

The mission of the Technology, Security and Privacy subcommittee is to identify the Technology, Security, and Privacy issues and opportunities and make recommendation on tools and strategies that are best for Delaware. The subcommittee focused on types of data, data sharing and privacy notices, data ownership, cybersecurity, federal standards and policy, Delaware laws and regulations, and industry standards.

Types of Data

The subcommittee indicated the need to determine what data is needed for CAV development, how data will be stored and accessed, and the minimum amount of data needed to provide CAV functionality. Autonomous vehicles require extensive data to operate effectively and will use devices to collect data, such as GPS for navigation, wheel encoders for monitoring vehicle movement, radar for identifying and tracking, and cameras for color identification. Vehicles can connect to infrastructure through CV technology and devices such as RSUs and OBUs, connected through DSRC, Wi-Fi, or cellular, in order to communicate to DelDOT and to drivers based on roadway information to inform motorists of upcoming conditions. Roadway information, vehicle speed, and volume information is taken into account and collected to warn users and better operate the transportation system. While essential for vehicle and system operations, the collection of data could present security and privacy risks, especially when the data is aggregated and centrally stored.

Data Sharing and Privacy Notices

Delivery of citizen and customer services will require certain data to be shared with service providers such as DelDOT, dealerships, insurance companies, universities, and law enforcement. Today, auto dealers ask the vehicle buyer for permission before collecting their data, either during a sale agreement or via a notice when the owner requests a third-party service in the vehicle, such as on a touchscreen display.

Data Ownership

Ownership of vehicle data is not currently clear – is it owned by the vehicle owner or the automaker or a third party? Third parties could include fleet operators, data carriers, ridesharing providers, and others in the CAV industry. The committee found that answers differ, even *within* the automotive industry.

Infrastructure and Technology

As this technology is implemented, changes will occur, for example to public transportation, and the committee discussed considering partnerships with state services (i.e. Ride-share, Delaware Authority for Regional Transit (DART), etc.) for deliverables. Additionally, Delaware must determine how to maintain state budget revenue streams as funding, economic development, and tax policy changes.

Cybersecurity

The automotive industry is involved in ongoing work to develop cybersecurity standards for autos through SAE and International Standards Organization (ISO). The auto industry also has a cybersecurity protocol called Auto-Information Sharing and Analysis Center (ISAC) which is a forum for the industry to communicate and collaborate on cybersecurity issues.

Federal Standards and Policy

The Electronic Communications Privacy Act (ECPA) is a federal statute that prohibits a third party from intercepting or disclosing communications without authorization. At the federal level, the Federal Trade Commission (FTC) is responsible for consumer protection, including privacy, as well as regulating wireless telecommunications providers that are the current and likely future (5G), data carriers. NHTSA also has a role in protecting consumers, through regulating motor vehicle safety.

Delaware Laws and Regulations

Delaware's laws and regulations were considered, including the Vehicle Data-Reporting Device Law (18 *Del.C.* § 3918) and the Delaware Data Breach Law (6 *Del. C.* § 12B-100 *et. seq.*, effective April 2018). In consultation with legal counsel, subcommittee members considered the impact of these laws on data security and how they apply to data collected from CAVs.

Industry Standards

Private industry developed self-regulatory standards to protect consumer privacy. The most important is the Alliance of Automobile Manufacturers and the Association of Global Automakers who voluntarily agreed to abide by a set of seven "Privacy Principles" for connected vehicles. In the absence of federal and state standards for vehicle data and privacy the Privacy Principles are the automotive industry's self-imposed framework.

For more information on the Technology Security and Privacy Subcommittee refer to Appendix B.

Transportation Network Infrastructure

The mission of the Transportation Network Infrastructure subcommittee is to develop recommendations for innovative tools and strategies that can be used to prepare Delaware's transportation network for CAVs in regards to transportation network infrastructure; inclusive of roadways, bridges, traffic signals, Intelligent Transportation Systems (ITS) devices, telecommunication systems, etc.

The subcommittee focused on the requirements to support CAV and what DelDOT is currently doing.

What is required to support CAV?

The maintenance of roadway infrastructure is what developers of CAV technology have consistently said is the key necessary element for successful deployment. The most beneficial action Delaware can undertake is to maintain and improve roadway state-of-good-repair since automated vehicle technology works best on well-maintained roads with clear lane markings, smooth pavement without potholes, properly functioning and visible traffic signals, and traffic signs that are clearly legible and visible from the roadway. Targeting state-of-good-repair funds to maintain infrastructure that is known to support CAV technology and vehicles will facilitate deployment.

Delaware can also emphasize CAV-friendly roadways in pilot programs.[1] In accordance with CAV-friendly roadways, installing CAV infrastructure at locations with high crash rates, or high-risk areas such as work zones, can be a good place to start implementation of CAV technology. A major component of DelDOT's existing Integrated Transportation Management Systems (ITMS) is Delaware's robust state-owned telecommunications system, which is required to implement and operate the V2I aspect of connected vehicles.

What is DelDOT currently doing?

- Making CAV part of DelDOT's short-term and long-term planning efforts.
- Actively participating in national and regional organizations of transportation officials, that develop transportation policy and conduct research: American Association of State Highway and Transportation Officials (AASHTO), Transportation Research Board (TRB), National Cooperatives Highway Research Program (NCHRP), V2I Deployment Coalition, I-95 Corridor Coalition, National Operations Center for Excellence.
- Maintaining relationships with product manufacturers who make roadway striping and traffic sign films and retro-reflective coverings.
- Coordinating with neighboring States of Maryland and Pennsylvania to share data over dedicated fiber optic networks.
- Continuing to expand its fiber optic and telecommunications network throughout Delaware. DelDOT's fiber connects to and communicates with DelDOT's traffic control devices such as signals, variable message signs, and other ITS devices, as well as to state owned facilities.

[1] Virginia's Automated Corridors include high- quality lane markings as a primary resource for its testing corridor.

- Developing ITMS statewide: traffic signals, variable message signs, roadside detectors, weather stations, etc., which are connected to and controlled from the TMC in Smyrna.
- Monitoring and maintaining its traffic signs, roadway and bridge surfaces, and roadway striping in a state-of-good-repair using in-house and contracted resources.
- Pushing real time traffic data to an extra-net outside the State firewall for consumption by the public and companies wishing to utilize this data for their business purposes. The data includes information on traffic volumes, speeds, and signal timing.

We believe this will encourage the deployment of CAV technology and vehicles in Delaware.

For more information on the Transportation Network Infrastructure Subcommittee refer to Appendix B.

Impacts on Public and Highway Safety

This mission of the Impacts on Public and Highway Safety subcommittee is to consider the implications of CAVs on public and highway safety. The subcommittee discussed the potential benefits and risks of CAV on public and highway safety. Focus areas are categorized as issues for road users, first responders, and DelDOT.

The subcommittee considered the specific implications on public and highway safety in the following areas: road user issues (training, driver's licensing, public education, Original Equipment Manufacturer (OEM) issues, and non-motorized users), first responder issues (Delaware code, law enforcement/first responders), and DelDOT issues (traditional highway engineering and technological DOT issues).

Potential opportunities and risks of CAV on public and highway safety were discussed. Focus areas were categorized as issues for road users, first responders, and DelDOT. Note: the "levels of automation" referenced in this report refer to the six levels (0 through 5) defined by SAE which have been broadly adopted.

Opportunities

According to NHTSA, 37,461 people died due to highway crashes in the U.S. in 2016, and 94% of crashes were primarily due to driver error. In Delaware, there were 120 highway fatalities in 2016 and 118 in 2017. There were also 474 incapacitating injury crashes and 30,100 total crashes in 2017. The estimated cost to society of highway crashes in Delaware in 2017 was over $2.8 billion. According to the Center for Disease Control, "unintentional injuries" were the 4th leading cause of deaths in the U.S. in 2015, and "motor vehicle-related injuries" were the leading cause of death within this category. The potential promise of CAVs is to eliminate crashes due to human error. Many of the following types of crashes may be eliminated or significantly reduced by fully connected and autonomous vehicles: recognition error, including driver's inattention, internal and external distractions, and inadequate surveillance; decision error such as driving too fast for conditions, too fast for a curve, false assumption of others' actions, illegal maneuver and misjudgment of gap or others' speed; performance error such as overcompensation, or poor directional control; and non- performance errors such as falling asleep. The State of Delaware has adopted "Towards Zero Deaths" as the motto of our Strategic Highway Safety Plan, and CAV may be able to significantly help in this effort.

Risks

Autonomous Vehicle technology is currently deployed on certain vehicles available to the public at SAE Level 2, and Level 3 vehicles are expected to be available shortly. There is significant uncertainty regarding the availability of Levels 4 and 5 to the public. Once available, there is a significant amount of time for the fleet to turnover, and customer demand for these higher priced vehicles is uncertain. Risks include:

- Driver complacency induced by “mostly” Autonomous Vehicles (Levels 3 and 4).
- Driver capabilities once the amount of human driving is reduced (Levels 2 through 4), as driving tasks may fall out of practice.
- Significantly increased driver perception/reaction times when transferring from autonomous to human control due to “disengagements” (Levels 1 through 4).
- Lack of public training and understanding of new vehicle features (Levels 2 through 5).
- Mixed fleet interaction (Levels 0 through 5).
- State of technology (all are still “learning as we go”).
- Technology malfunctions.
- Potential short-term increase in crashes due to all of the above, before long- term reductions are realized.
- Ensuring recalls are a priority.
- Artificial Intelligence systems require real world experience to improve.

For more information on the Public and Highway Safety Subcommittee refer to Appendix B.

DEPARTMENT OF INSURANCE

The Department of Insurance conducted separate research and developed a report seeking to identify insurance issues and opportunities concerning the deployment of CAVs and to make recommendations concerning tools and strategies that are best for Delaware consumers and insurance markets.

The advent of CAVs will likely have a transformative impact on our society, with vehicle ownership and its associated risk being just a small part of a larger cultural shift. New entrants into the mobility provider sector, and new providers of insurance products will likely result in a confluence of disruptors.

In a May 2018 issues analysis, the National Association of Mutual Insurance Companies (NAMIC) opined:

> The development and deployment of proven, safe ADS will require significant technological advances, revisions to the regulatory paradigm, and the active participation of far more than just the auto manufacturers and technology companies.
>
> The potential of technology to move the needle on crash statistics is extraordinary; however, there will still be crashes, especially in an environment where autonomous vehicles continue to share the road with human drivers…
>
> The critical issues related to passenger safety, liability, and compensation after a crash require that insurance companies are included in the development, deployment, regulation and use of ADS.
>
> Consumers will continue to look to property/casualty insurers to provide them with the protections they have come to expect as this new frontier of automotive products and services evolves.

Accordingly, it is critically important for all stakeholders in the insurance arena, including regulators, consumers, and participants in insurance markets, to have a seat at the CAV table. It is not enough to understand CAV technology itself. Rather, regulators, consumers and insurance marketplace participants should also be able to understand the risks associated with CAV technology and the insurance products being designed and deployed to insure against those risks.

The Delaware Department of Insurance has identified opportunities and risks related to their research, as well as potential legislation to consider as this technology becomes more prevalent, all of which can be found in the Department's entire report listed in Appendix C.

ADVISORY COUNCIL RECOMMENDATIONS AND FINDINGS

The following recommendations were developed by each of the subcommittees based on discussion of opportunities and risks associated with CAV development in Delaware. *All recommendations are intended for Governor Carney and the State of Delaware unless otherwise noted using an (*) to indicate a recommendation to a specific agency or group:*

General Recommendations

1. Include the topic of CAV in the next version of the Delaware Strategic Highway Safety Plan. This strategic plan is a state-wide coordinated safety plan that provides a comprehensive framework to reduce fatalities on Delaware's roadways. The plan's lead agencies include DelDOT, the Delaware Office of Highway Safety (OHS), and Delaware State Police. An update of the plan is scheduled for the year 2020 and the topic of CAV should be integrally included in the next version of this plan.
2. Continue Advisory Council and the various subcommittee meetings on a regular basis after the initial report is submitted to the Governor. The Public and Highway Safety Subcommittee in particular should pursue initiatives as appropriate based on the approval of the full Advisory Council; to include staying abreast of federal guidance and regulations and providing feedback as appropriate to our federal partners. Updates to the Governor should be provided on an annual basis.

Data Collection and Ownership

3. Monitor discussion, activities of standards organizations (SAE, ISO, etc.), and court decisions around data ownership.
4. Define clear use cases for collecting Personally Identifiable Information (PII).
5. Collect the least amount of PII necessary to accomplish the goals of the use case.
6. Keep PII for the shortest time necessary to accomplish the goals of the use case and anonymize the PII appropriate for the case.
7. Identify what additional transportation data needs to be shared publicly to support CAV and the methods of sharing the data.

Data Privacy

8. Encrypt (or apply current best practice for anonymization) PII and non-public data collected during transmission and at rest.
9. Anonymize network-wide trajectory data, which can be used to inform transportation and land-use planning decisions.
10. Separate CAV data into PII and non-PII when storing.
11. Take steps to address *current* privacy challenges in vehicles.
12. Establish a partnership with other states, business partners and NHTSA to collaborate on cybersecurity policies and best practices.

Infrastructure and Technology

13. Establish additional resources through the Capital Transportation Plan to continue and enhance these efforts.

14. Create a technology oversight board comprised of state, federal, academic, and non-profit and private sector entities to monitor future CAV technologies and how future technologies will affect the State of Delaware.
15. Coordinate with surrounding states on CAV technology standards to maintain consistency as the regulatory environment develops nation-wide.
16. Consider partnering with public transit providers to leverage CAV technology to provide enhanced mobility to stakeholders with limited mobility, including senior citizens and those who utilize paratransit services.
17. Stay abreast of the latest state of the practice, and continue discussions with OEMs and related groups, associated with potential infrastructure enhancements that will improve/enhance the performance of CAV (e.g., changes in signing, striping, surface smoothness, etc.). (*DelDOT**)
18. Continue the expansion and improvement of the ITMS, including: continuation of build out of state telecommunications network and fiber optic network, continuation of ITS deployment, and begin Phase 1 of deployment of V2I systems, with initial focus on traffic signals. (*DelDOT**)
19. Support the emergence of 5G and/or other similar technologies, and by extension the potential improvements in CV, by issuing permits to small cell companies per state code, regulations, and standard procedures. The council is not directly recommending use of a specific type of infrastructure at this point, however members suggest expansion of CAV infrastructure occur in all areas. (*DelDOT**)
20. Evaluate and prepare Delaware's roadways for CAV communication networks including data collection, data management, and back office systems that support the large amounts of data that CAVs generate and CAV mobility applications demand.
21. Incorporate CAV technology and devices into DelDOT's project development process including:
    a. Types of infrastructure to include: conduit, poles, communication lines
    b. Identifying the CAV stakeholders to coordinate with
22. Evaluate and update DelDOT's construction contract specifications as they relate to CAV technology.
23. Incorporate CAV technologies into Delaware's state vehicle fleet as vehicles are replaced with new ones. Driver assist technology based on connections from the vehicle to infrastructure as well as high levels of autonomy should be considered for inclusion in the state fleet. Features like vehicle connectivity, automatic emergency braking, blind spot monitoring, and advanced cruise control can help to both prevent collisions and pilot new technologies.
24. Evaluate the need for new legal authorities related to:
    a. State procurement of proprietary and sole source products and services
    b. Placement of privately owned CAV devices in the public rights of way
    c. Impacts of local land use and zoning controls on placement of CAV technology along roadsides, in towns and neighborhoods
    d. Testing of CAV devices and vehicles on public roadways

Education and Training

25. Develop a constructive, living communications plan to inform citizens on data being collected by CAVs, its use and storage. The plan is intended to be updated regularly to reflect new developments in data collection, use, and storage.
26. Consider a joint DelDOT-Consumer Protection Unit (CPU) large-scale public education campaign to inform Delawareans about the privacy landscape of CAVs and cybersecurity risks. Different categories of

information may require different levels of education. Target training on cybersecurity risks, such as social engineering concerns.

27. Recommend that manufacturers allow CAV owners to opt-in to data collection rather than have data collected by default and disclose use of data to CAV customers during the registration period.
28. Review the 2017 Government Accountability Office (GAO) Report on vehicle data privacy.
29. Hire a consultant to develop recommendations and a plan to incorporate those recommendations for CAV education into Delaware's Driver Education and Defensive Driving Programs. At a minimum, the plan would include information on the levels of automation, the capability of ADS with a focus on the process of disengagement, and awareness of CAVs when encountered on the road. The hired consultant should work closely with the Department of Education (DOE), OHS, and the Division of Motor Vehicles (DMV) to develop the plan.
30. Update the Delaware Driver Manual to include information on CAV consistent with the recommendations and plan developed for Delaware's Driver Education and Defensive Driving Programs.
31. Hire a consultant to develop and update content for a web site and other promotional materials (e.g., brochures) to educate the public on CAV. It is recommended that there be one consolidated web site covering issues from all state agencies. Individual agency web sites should link to the main state web site. The consultant would rely on the Advisory Council on Connected and Autonomous Vehicles for content.
32. Investigate the feasibility of developing regulations related to public training that should be required for new car dealers, used car dealers, rental car companies, and commercial vehicle dealers for their customers related to CAV technologies and features included within their vehicles.
33. Create an industry task force to develop curriculum for Delaware Training Providers to teach the skills necessary to develop, manufacture, maintain and repair the sophisticated hardware, software and security systems that are critical components of CAVs and to make recommendations regarding potential Center of Excellence training facility, similar to Flight Safety International, that includes the most appropriate equipment, machinery and/or simulation laboratories.
    a. Advocate for CAV-related experiential learning opportunities for K-12 students in Delaware's public schools (i.e., encourage and celebrate schools that allow trade groups to engage with students) as well as adult learners through Department of Education and Department of Labor-approved workforce training providers.

Economic Development Opportunities

34. Initiate new pilots of DSRC and 5G wireless CAV technologies, particularly when a private entity is willing and able to support the pilot financially.
35. Evaluate CAV's potential impacts on existing sources of transportation revenue
36. Evaluate new transportation funding needs created by CAV, such as enhanced maintenance standards.
37. Evaluate potential transportation revenue sources created by CAV.
38. Aggressively promote DelDOT's ownership of and extensive investment in sensors and infrastructure in over 90% of the state's roadways; and continue to make investments in new CAV related infrastructure/data needed to fill the gap in order to deploy significant CAV projects.
    a. Feature Delaware's new Angel Investor Tax Credit and the Department of State, Division of Small Business' Business Finder Fee Tax Credit that offers a potential tax credit incentive for companies that help to recruit other companies to relocate to Delaware and create new jobs.

   b. Ensure Delaware is "Open for Business" – with a commitment to fostering an enterprise-friendly business environment to encourage private sector investment and entrepreneurial activity in the CAV space.
   c. Continue to take an active role in ensuring that CAV related technologies and opportunities will provided equitable access in transportation, jobs, education/training, etc. across the State of Delaware through collaborations among various stakeholder organizations [example: expansion of CAV shuttle services to provide services to people with disabilities in rural, urban, and suburban communities].

39. Seek opportunities to demonstrate CAV technology throughout Delaware to increase awareness and acceptance. Encourage, support and celebrate those opportunities and pilot projects that demonstrate safe deployment of technology that target high-need populations such as congested roadways during peak beach season, senior citizens living in rural communities with limited access to dependable and innovative transportation solutions, etc.
    a. Develop and execute a strategic plan for attracting OEMs and/or private industry to build a Center of Excellence for CAVs in Delaware.
40. Develop financial incentives in order to attract new CAV technology-related companies, especially those focusing in robotics, sensors, and software development, to encourage and attract businesses to locate in Delaware.
41. Encourage the creation of CAV focused co-working spaces, collaborative lab spaces, or makerspace settings that encourage innovation through collaborative design and development and access to specialized equipment; and, provide networking and collaboration initiatives that bring small businesses and entrepreneurs together with large companies and universities.
42. Create educational and networking opportunities for stakeholders and the general public to discuss and learn about CAV technology. The emphasis would be on ensuring safety and building support for the deployment of this technology. Other components would include social media, public service announcements, talking points, posters, op-eds, videos, etc.
    a. Acknowledge and begin planning for the potential job displacement that current and future technological advancements will create for workers in the transportation sector and related industries. (*Department of Labor**)
    b. Encourage Delaware's elected and appointed officials to adopt public policy that encourages and supports the development of the technology (i.e., robotics, software/coding, sensors, security technologies, etc.) that are necessary to grow this industry, maintain public safety and protect personally identifiable data. This effort must take a balanced approach that encourages private investment and recognizes that providing private sector access to existing CAV related infrastructure/data is an extremely compelling economic driver.
43. Evaluate impacts to DelDOT's workforce:
    a. Jobs created: installation & maintenance techs, electrical engineers, computer engineers, communication engineers.
    b. Specialized training needs
    c. Specialized credentialing needed to work in certain fields and with certain sensitive and secure facilities and data.

State and Federal Policy

44. Hire a consultant to conduct a comprehensive review of relevant state code, regulations, and policy. This review should focus on the safe and allowable operations of CAVs in Delaware. The review should include a review and recommendations in at least two distinct areas: 1) The driver/operator's responsibility in monitoring and controlling vehicles that are semi-autonomous, and 2) what laws, regulations, and/or processes should be in place to allow fully autonomous/driverless vehicles, while still keeping regulations at a minimum as to not discourage the use and testing of CAVs. This task should also include the following items:
    a. Propose definition of terms for use in state code and regulations, including "driver," "autonomous driving systems," "platooning," etc.
    b. Review state code to determine if additional laws are needed related to new restrictions or penalties related to CAV, such as "inappropriate use of autonomous driving systems."
    c. Thorough review of other state laws, regulations and national guidance regarding CAV, to understand best practices and develop recommendations for Delaware. In addition to a general review on this matter, a specific topic that should be addressed is the potential requirement of all vehicles on public roadways requiring a licensed driver, at this time. State code is currently silent on this issue. The subcommittee generally believes this is a good requirement, with the need for exceptions. Exceptions could include driverless platooning under certain circumstances, or certain types of vehicles that are specifically approved for driverless testing in certain areas or along certain roadways. This task should develop recommendations for this topic.
    d. Research the potential for implementing a registration process so relevant state agencies can be aware of AVs operating in Delaware.
45. Monitor CAV policy development at the national, state and municipal levels across the country and in neighboring states. Review need for regulatory policy establishing traffic safety standards in support of CAV infrastructure placement in the right-of-way, such as:
    a. Minimization of roadside obstructions (i.e., non-proliferation of poles) posing dangers to errant vehicles;
    b. Setting restrictions on size and weight of CAV devices and infrastructure placed in the right-of-way;
    c. Requirements for breakaway features;
    d. Setting horizontal and vertical clearances from travel lanes, bike lanes, sidewalks, etc.

Industry Collaboration and Participation

46. Continue to participate in national and regional organizations of transportation, officials that develop transportation policy and conduct research: AASHTO, TRB, NCHRP, V2I Deployment Coalition, I-95 Corridor Coalition, National Operations Center for Excellence.
47. Develop and/or maintain relationships with:
    a. OEMs
    b. Public utilities and telecommunication companies who are deploying technologies in support of CAV such as 5G.
    c. University researchers (we do this already, but should be expanding this to new areas we haven't coordinated with before)

   d. Dover Air Force Base and Military researchers and implementers of CAV such as the US Army Tank Automotive Research Development & Engineering Center (TARDEC).
   e. Shipping and logistics companies
   f. Software companies
   g. Developers of artificial intelligence. DelDOT is presently implementing/testing a Federal Highway Administration (FHWA) sponsored AI-based Traffic Operation Expert System in the I95/US40/DE1 area.
   h. Other government entities at the federal, state and municipal levels working on CAV policy like emergency planners, 911 centers, other TMCs, etc.
   i. School Districts
48. Collaborate with neighboring states. Although there is a competitive nature in state-level CAV policy, each state will be more attractive to CAV development if there are fewer regulatory hurdles at our borders.
49. Establish CAV testing and deployment grounds in partnership with Delaware's universities, military bases, municipalities, industrial zones, and/or privately-managed roadways.
50. Coordinate with high schools, colleges, universities, to educate the future work force to develop CAV technology and infrastructure.
51. Complete the AASHTO Signal Phase and Timing (SPaT) Challenge.

Potential State Legislation

The Advisory Council recognizes that the federal government, in particularly the Federal Trade Commission (FTC), might be the lead agency when dealing with privacy issues for a national standard.

1. Consider support of federal legislation for automakers to provide “plain language” consent forms to owners, especially at the point of sale. Use clear, plain language to articulate to consumers what data will be collected, the purpose of the data being collected, how the data will be stored, for how long the data will be stored, and how the data the will be protected.
2. There was unpassed legislation in the 149th General Assembly (Biometric Privacy Protection Bill and Geolocation Privacy Protection Bill – HB350). DelDOT should communicate with sponsors and co-sponsors to evaluate whether it would be appropriate and feasible to integrate CAVs into these Acts if they are reworked and reintroduced in the future.
3. Consider state legislation requiring used vehicle dealers, private sellers, rental car providers to wipe vehicle data clean before resale.
4. Consider legislation that encourages and supports the development of the technology (i.e., robotics, software/coding, sensors, security technologies, etc.) that is necessary to grow this industry, maintain public safety and protect personally identifiable data. This effort must take a balanced approach that encourages private investment and recognizes that providing private sector access to existing CAV related infrastructure/data is an extremely compelling economic driver.
5. To the extent that the private companies developing CAVs may need to rely on privately-owned CAV infrastructure in the roadside to make these vehicles function safely and efficiently, Delaware may need to provide some ability for accommodation of privately-owned infrastructure in the State’s rights of way. Currently, only DelDOT, public utility companies, and small wireless telecommunication companies have codified rights to be accommodated in the right-of-way.
6. Delaware may need pre-emption of local land use and zoning controls on placement of CAV infrastructure along roadsides in towns and neighborhoods.
7. Consider legislation to establish safety standards requiring owners of all standing CAV infrastructure to utilize appropriate security and access control methods as a minimum to control who can access, where, when, and how.
8. State policy should encourage CAV technology to support a robust state of good repair program, targeted to improve roadway safety and traffic operations including within work zones.
9. Delaware Code should encourage all companies manufacturing and/or operating such vehicles on Delaware’s roadway to collect and share data regarding roadway and traffic conditions. Having access to such data will enable DelDOT to monitor vehicle speed, location, trajectory, and operational variables such as congestion and delay. It would enable better management of traffic flow with the ability to address specific problems in real-time such as adjusting signal timings or identify potholes and similar vehicular hazards.
10. Since much of the CAV technology is proprietary, Delaware should evaluate whether new legal authorities related to State procurement of proprietary and sole source products and services are needed, especially for publicly-owned CAV infrastructure.
11. Research potential legislation to allow platooning on controlled access highways as current Delaware law prohibits truck convoys [21 Del. C. §4126 (10)].
12. Reexamine parts of Title 18 to redefine automobiles and automobile insurance requirements, including minimum limits, who must have insurance, etc.

13. Require that the CAV-testing entity provide evidence of the entity's ability to satisfy a judgment or judgments for damages for personal injury, death, or property damage caused by a CAV, whether that evidence is in the form of an instrument of insurance, a surety bond, or proof of self-insurance. Additionally, it would be appropriate to suspend permission to test if the entity fails to comply with the State insurance or driver requirements. The entity should provide sufficient amount of evidence to ensure safety while not stifling creativity or innovation.
14. Consider enacting filing requirements that are worded to adjust for the use of new data and predictive modeling such as the legislation enacted by New Hampshire by amending 18 Del.C. 2305(a)(1), which currently provides that, "Rates shall be made in accordance with the following provisions: (1) Manual, minimum, class rates, rating schedules or rating plans shall be made and adopted, except in the case of specific inland marine rates on risks specially rated; . . ."
15. Consider adopting the NAIC Insurance Data Security Model Law as a Delaware Statute.
16. As the NAIC drafts model laws and regulations, consider adopting them as appropriate for Delaware.
17. Consider expanding Public – Private Partnership opportunities to foster CAV development.

OVERVIEW OF PRESENTATIONS AND REPORTS

1. Current Assessment of the Transportation Network and CAV in Delaware
   Presenter: Gene Donaldson, DelDOT
   Date: November 16, 2017
   Gene Donaldson, TMC Operations Manager, gave an overview of Delaware's unique ability to implement CAV technologies, given DelDOT's ownership of 90% of roads and most traffic signals in the state. Also, the agency operates the transit system and tolls making it truly multimodal. Delaware employs an Integrated Transportation Management System (ITMS) that integrates operations and planning with the three critical functions of monitoring, control, and information. DelDOT has developed an ITMS Strategic Plan and is deploying ongoing projects involving CV technologies. Projects include the development of Connected Vehicle Enabled Weather Responsive Traffic Management (CV-WRTM), participation in the Signal Phase and Timing (SPaT) Challenge, Artificial Intelligence/Machine Learning in TMC operations, and implementation of a Dilemma Zone warning system.

2. National/Regional Perspective on CAV
   Presenter: Ian Grossman, American Association of Motor Vehicle Administration (AAMVA)
   Date: November 16, 2017
   Ian Grossman reviewed the approach AAMVA is taking as CAV technology develops, focusing on considerations specific to vehicles, driver licensing, administrative considerations, and enforcement. AAMVA strongly recommends manufacturers and industry users follow NHTSA's automated driving systems voluntary guidance documents. Common themes in CAV development throughout various states include discussion around limited restrictions vs. granting permission, insurance requirements, program oversight, regulations, incident reporting, and human driver presence. As CAV technology develops there is an ongoing need for a balance between promoting consistency and encouraging innovation.

3. DelDOT's Integrated Transportation Management System (ITMS)
   Presenter: Gene Donaldson, DelDOT
   Date: December 21, 2017
   Gene Donaldson presented the Council with information regarding DelDOT's recently updated ITMS Strategic Plan, which includes discussion of CAV in Delaware. DelDOT is currently collecting large amounts of data to facilitate the design, planning, management, and operation of its ITMS, working towards an ultimate goal of developing a predictive and adaptive transportation management system. With the help of AI and machine learning, this predictive system can achieve goals of improving safety, decreasing congestion, decreasing energy consumption, and enhancing mobility. Gene Donaldson demonstrated DelDOT's interactive map on the agency's website which, along with the Strategic Plan, forms the foundation of CAV development in Delaware.

4. University of Delaware's role in CAV Development
   Presenter: Philip Barnes, University of Delaware Institute of Public Administration
   Date: December 21, 2017
   Phil Barnes presented the Council with an update on what UD is working on in regards to the development of CAV technology, specifically in research, planning, policy, and public education. The importance of gaining public acceptance of this technology and mitigating uncertainty, fear and misconception was

emphasized. UD researchers have developed a Smart City model that displays seamless acceleration and deceleration of autonomous vehicles. Future developments by UD include: increased focus on smart cities and supported research, development of a UD Data Science Institute as a big data research hub, demonstration of an autonomous shuttle on campus, and the Biden Institute as a foundation for research into smart cities, public policy, and engineering for CAV.

5. UBER's Role in the Development of Autonomous Vehicles
   Presenter: Shari Shapiro, UBER
   Date: January 18, 2018
   Shari Shapiro gave an overview of the status of UBER's work in developing autonomous vehicles. UBER is testing self-driving vehicles with passengers on public roads, focusing on area including safety, scalability, mapping, hardware, vehicle programs, and operations. Economic development opportunities and policies to improve AV utilization may include increased jobs for engineers and operators, deploying road/congestion pricing, urban high-occupancy vehicle (HOV) lanes, and smart pricing for off-street and curbside parking. Benefits of self-driving vehicles were reviewed and include improved safety, increased efficiency, decreased congestion, beneficial environmental impacts, urban development opportunity, and increased accessibility.

6. Connected and Autonomous Vehicle Insights from the 2018 Consumer Electronics Show (CES)
   Presenter: Ken Grant, AAA Mid-Atlantic
   Date: February 15, 2018
   Key takeaways from the 2018 CES were presented by Ken Grant: connected and autonomous vehicles are anticipated to be on the roads much sooner than expected and the public acceptance of this technology is associated with increased education. Attendees had the ability to ride in AAA's Level 4 self-driving shuttle with an operator present. The vehicle relied on traffic signals and LiDAR to function and operated at 20 mph. The shuttle was rated by riders and received a 4.8 out of 5-star rating. The crash that occurred on the day of the shuttle launch during this event was not caused by the automated shuttle but by a delivery driver who made an illegal turn. Other companies operated autonomous vehicles for attendees at CES; this contributed to decreased fear amongst the public.

7. Toyota's Perspective in CAV Development
   Presenter: Ed Bradley, Toyota
   Date: March 15, 2018
   A high level overview from Toyota's perspective on CAV development was presented to the Council. Toyota's approach includes focus on risk mitigation and avoidance, and use of sensors, precision mapping, and DSRC to increase safety and mobility while reducing environmental impacts. Toyota vehicles in Japan are enabled with optional DSRC connectivity and are testing V2I applications such as intersection turn assist, red light caution, signal timing, and an eco-approach. V2V applications are also being tested and include cooperative adaptive cruise control and emergency vehicle notifications. Toyota supports V2V current and future federal regulations including DSRC regulations, SAE and IEEE standards, 5.9 GHz spectrum, and support of aftermarket devices that meet appropriate standards. Challenges to deployments include adoption of this technology from a technical standpoint, left turns across traffic, changes to road markings, all weather driving, and police/fire/crossing-guards/traffic officers.

8. Automated Driving Systems (ADS) Equipped Vehicles
   Presenter: Anne Marie Lewis, Ph.D., Alliance of Automobile Manufacturers
   Date: April 19, 2018
   Anne Marie Lewis provided the Council with information regarding the development and status of ADS. Vehicles equipped with ADS include GM Cruise AV, Smart Vision EQ 2030, and the Toyota e-Palette Concept Vehicle. It was predicted that by 2055 full fleet conversion will occur so that all vehicles will be equipped with Level 5 autonomy. Four trends, non-reliant on each other, are occurring to influence the modern auto industry: automation, connectivity, ridesharing, and electrification. There are also considerations to infrastructure that are important to the development of CAVs – consistency with the Manual on Uniform Traffic Control Devices (MUTCD) and digital infrastructure can provide benefits to communication and sharing information. Review of federal activity regarding ADS-equipped vehicles was given and included NHTSA meetings, FHWA meetings, and legislation created.

9. Regional Governmental Perspective on CAV Development
   Presenter: Don Hannon, Council of State Governments Eastern Regional Conference (CSG/ERC)
   Date: June 21, 2018
   Don Hannon provided the Council with regional, governmental perspective of northeastern states on CAV developments. There are existing regulations across the nation regarding CAV technology – 41 states have legislation related to CAV, 29 states have issued laws, and 7 states have issued executive orders. An overview of federal and northeastern state activity in CAV development was given, and common issues were presented. Issues include the question of requiring a physically present operator, developing special rules to ensure safe testing and operations, special training/certifications for AV operators, hand-held devices, and AV corridors. Moving forward it will important to understand the following concepts: electric vehicles and AVs go hand in hand, utilizing university research is a beneficial tool, connectivity is an important enhancement to autonomy, reporting must be transparent, and safety must be balanced with everything. From a Delaware-specific perspective, goals must be defined and it will be important to identify what developments can attract AV industry leaders to Delaware.

10. National Automobile Dealers Association Perspective on CAV Development
    Presenter: Jason Walsh, Delaware Automobile and Truck Dealers Association (DATDA)
    Date: June 21, 2018
    Jason Walsh indicated that consumer perspective is an aspect of CAV research that is often overlooked. It is important to identify what consumers think and want, and to measure predictions. Focus groups were surveyed and key findings concluded that the majority of people still want to own their own vehicles, even given the safety, convenience, and money savings of an autonomous ride-sharing opportunity, and that their time is more valuable than money. Research has also been developed on the amount people drive (e.g. vehicle miles traveled) however not a lot focuses on how people are using their cars. Some may take small trips more often while others take long trips. Identifying how people value their time can identify more benefits to AVs.

APPENDICES

a. Executive Order 14
b. Subcommittee Final Reports
c. Department of Insurance Report
d. Presentations and Reports
e. Meeting Agendas and Minutes

APPENDIX A: EXECUTIVE ORDER 14

STATE OF DELAWARE

EXECUTIVE DEPARTMENT
DOVER

EXECUTIVE ORDER
NUMBER FOURTEEN

TO: HEADS OF ALL STATE DEPARTMENTS AND AGENCIES

RE: ESTABLISHMENT OF THE ADVISORY COUNCIL ON CONNECTED AND AUTONOMOUS VEHICLES

WHEREAS, connected and autonomous vehicles are becoming more prevalent and have the potential to radically transform how the world works, plays and lives; and

WHEREAS, vehicle-to-vehicle and vehicle-to-infrastructure technologies are being developed by every automotive manufacturer; and

WHEREAS, the economic impact of this new mobility opportunity could mean a better quality of life for Delawareans and spur businesses; and

WHEREAS, Delaware is uniquely able to be an early adopter in the connected and automated vehicle space due to its robust telecommunications system, the Delaware Department of Transportation's ("DelDOT") multi-modal mission, the State's ownership and operation of over 90% of the roads and traffic signals, and its culture of innovation; and

WHEREAS, Delaware has continually upgraded and invested in its telecommunications and IT systems over the last 20 years, including DelDOT's Integrated Transportation Management System (ITMS); and

WHEREAS, Delaware should be a proving ground for manufacturers of connected and autonomous vehicles as well as the Intelligent Transportation System's technology infrastructure that will be required; and

WHEREAS, there is a need to evaluate the impact this emerging technology will have on public safety, cyber security, legal issues, privacy and the design and construction of the transportation network; and

WHEREAS, it is important to review Delaware laws relating to the regulation of connected and autonomous vehicles and their drivers, and how the laws relate to the rules of the road, in order to remove barriers to entry for companies interested in participating in the new era of transportation.

NOW, THEREFORE, I, JOHN C. CARNEY, by virtue of the authority vested in me as Governor of the State of Delaware, do hereby declare and order the following:

1. The Advisory Council on Connected and Autonomous Vehicles is hereby established. The Advisory Council shall consist of no less than 19 members:

   (a) The Secretary of the Delaware Department of Transportation ("DelDOT");

   (b) The Director of the Division of Small Business, Development and Tourism Office;

   (c) The Secretary of Delaware Safety & Homeland Security ("DSHS);

   (d) The Attorney General of Delaware;

   (e) The Chief Information Officer of the Department of Technology and Information;

   (f) The Director of the Delaware Division of Motor Vehicles ("DMV");

   (g) Two Representatives appointed by the Speaker of the House;

   (h) Two Representatives appointed by the President Pro Tempore of the Senate;

   (i) The Chairperson of the Delaware Automobile and Truck Dealers' Association;

   (j) A Representative of the American Automobile Association (AAA) Mid-Atlantic;

   (k) The Delaware Insurance Commissioner;

   (l) The President of the Alliance of Automobile Manufacturers;

   (m) The President of the Delaware Motor Transport Association;

   (n) The Director of the University of Delaware Institute for Public Administration;

   (o) The Chair of the Wilmington Metropolitan Area Planning Council;

(p) The Chair of the Dover/Kent Metropolitan Area Planning Council;

(q) The Sussex County Administrator; and

(r) Such other persons as the Governor may from time to time appoint.

2. Members serving by virtue of position may appoint a designee to serve in their stead and at their pleasure.

3. Additional members may be appointed by and serve at the pleasure of the Governor. The Governor may appoint a chairperson from among the members.

4. DelDOT shall provide staff and fiscal support to the Advisory Council as part of DelDOT's ongoing responsibility.

5. The Advisory Council is tasked with developing recommendations for innovative tools and strategies that can be used to prepare Delaware's transportation network for connected and autonomous vehicles. The Advisory Council shall make recommendations regarding at least the following subject areas:

(a) Promoting economic development;

(b) Technology, security and privacy;

(c) Transportation network infrastructure; and

(d) Impacts on public and highway safety.

6. The Advisory Council shall provide a report of its activities and any recommendations within one year of the signing of the Executive Order to the Governor and General Assembly.

APPROVED this 5th day of September, 2017

____

Governor

ATTEST:

____

Secretary of State

APPENDIX B: SUBCOMMITTEE FINAL REPORTS

Subcommittee Membership

- Chair: Robert McCleary, Chief Engineer, DelDOT
- Brian Pettyjohn, State Senator, 19th District
- Edward Osienski, State Representative, 24th District
- Ruth Briggs King, State Representative, 37th District
- Reed Macmillan, Executive Director, Dover/Kent MPO
- Scott Vien, Director, Delaware DMV
- Mark Luszcz, Chief Traffic Engineer, DelDOT
- Gene Donaldson, Manager, DelDOT Traffic Management Center

Mission of the Subcommittee

Develop recommendations for innovative tools and strategies that can be used to prepare Delaware's Transportation Network for Connected and Autonomous Vehicles (CAV) in regards to Transportation Network Infrastructure; inclusive of roadways, bridges, traffic signals, ITS devices, telecommunication systems, etc.

Areas of Focus/Discussion

Please list the areas the Subcommittee focused on and what were the outcomes for each.

1. **What is required to support CAV?**

   a. Much is still unknown, but maintenance of roadway infrastructure is what developers of CAV technology have consistently said is the key necessary element for the successful deployment. It will require access to good public roadways, traffic signals, roadway striping and signage that create a workable driving environment.

   b. At this time, the most beneficial action Delaware can undertake is to maintain and improve roadway state-of-good-repair since automated vehicle technology works best on well-maintained roads with clear lane markings, smooth pavement without potholes, properly functioning and visible traffic signals, and traffic signs that are clearly legible and visible from the roadway.

c. Targeting State of Good Repair funds to maintain infrastructure that is known to support CAV technology and vehicles. Delaware can also emphasize CAV-friendly roadways in pilot programs, for example: Virginia's Automated Corridors include high-quality lane markings as a primary resource for its testing corridor.

d. Installing CAV infrastructure at locations with high crash rates, or high-risk areas such as work zones, can be a good place to start implementation of CAV technology.

e. Robust State-Owned Telecommunications Systems are required for the V2I aspect of Connected Vehicles.

2. What is DelDOT currently doing?

a. DelDOT is making CAV part of DelDOT's short-term and long-term planning efforts.

b. DelDOT participates in national and regional organizations of transportation, officials that develop transportation policy and conduct research: AASHTO, TRB, NCHRP, V2I Deployment Coalition, I-95 Corridor Coalition, National Operations Center for Excellence.

c. DelDOT maintains relationships with product manufacturers who make roadway striping and traffic sign films and retro-reflective coverings.

d. DelDOT currently coordinates with neighboring States of Maryland and Pennsylvania to share data over dedicated fiber optic networks.

e. DelDOT continues to expand its fiber optic and telecommunications network throughout Delaware. DelDOT's fiber connects to and communicates with DelDOT's traffic control devices such as signals, variable message signs, and other ITS devices, as well as to state owned facilities.

f. DelDOT continues to develop Integrated Transportation Management Systems (ITMS) statewide: traffic signals, variable message signs, roadside detectors, weather stations, etc., which are connected to and controlled from the Transportation Management Center (TMC) in Smyrna.

g. DelDOT monitors and maintains its traffic signs, roadway and bridge surfaces, and roadway striping in a state of good repair using in-house and contracted resources.

h. DelDOT pushes real time traffic data to an extra-net outside the State firewall for consumption by the public and companies wishing to utilize this data for their business purposes. The data includes information on traffic volumes, speeds, and signal timing. We believe this will encourage the deployment of CAV technology and vehicles in Delaware.

Stakeholders
Please list the outside stakeholders impacted by the work/topics of the Subcommittee. 1. GPS Navigation Companies (TomTom, OnStar, Garmin, Magellan, HERE/NavTech) 2. Freight/Logistics Companies (UPS, FedEx, DHL, Royal Truck & Equipment) 3. Traffic Control Device Manufacturers (3M, Siemens) 4. Public Utilities (DPL, DEC, Verizon) 5. Telecommunications Co.'s (Verizon Wireless, T-Mobile, Sprint, Mobilitie, Crown Castle) 6. OEM's (Tesla, Toyota, Ford, GM, Nissan, BMW, Mercedes, Volvo, Local Motors) 7. Software Co.'s (Waymo, Intel, Uber, Tesla, IAI) 8. US Military (DAFB, Army-TARDEC) 9. FHWA (Turner Fairbanks Highway Research Center) 10. AASHTO CAV Committee 11. Surrounding States (PA, MD, NJ, VA) 12. State's with CAV Testing Programs (California, Arizona, Nevada, Michigan, Pennsylvania, Florida) 13. Municipalities with CAV Testing Programs (Pittsburgh, PA; Ann Arbor, MI; Chandler, AZ; Scottsdale, AZ; Miami, FL; The Villages, FL 14. Delaware School Districts 15. DEMA 16. County Agencies (911 Centers, Land Use)
Recommendations to the Advisory Council
Opportunities: Please list the opportunities the Subcommittee has identified for the State related to the Subcommittee's Mission. 1. CAV's have the potential to make roadways safer, more efficient, and more accessible for Delawareans. 2. CAV and V2I could help optimize transportation corridor capacity by coordinating transportation operations in response to fluctuations in roadway network supply and demand. This is possible because vehicle data offers a new source of highly detailed, real-time and historical information for each corridor. 3. Deployment of CAV technology may be used as a means to supplement or replace fixed traveler information infrastructure (e.g., overhead sign structures, dynamic message signs, lane use

signs, regulatory signs, wayfinding signs, etc., reducing sign clutter and the overall cost to operate and maintain roadways.)

4. Coordinate with high schools, colleges, universities, to develop the future work force to develop CAV technology and infrastructure.

Risks: Please list any risks the Subcommittee has identified for the State related to the Subcommittee's mission.

1. CAVs are not commercially available yet and will not be widespread for many years.
2. Successful implementation is far from guaranteed.
3. Planning for something that is not in widespread use, predicting its future needs, and designing policies to support it, is very difficult.
4. Early implementation of CAV infrastructure might lead to wasted public and private sector investments if the technology we invest in now is not adopted as the standard.
5. Many unknowns as it relates to traffic operations. It is difficult to predict how people will actually behave in response to access to CAV. Some experts predict it will encourage more cars on the road and increased traveling/commuting distances if driver fatigue is no longer a concern.

Recommendations:

Short Term (1 to 3 years)

a. Monitor CAV policy development at the national, State and municipal levels across the country and in neighboring States. Review need for regulatory policy establishing traffic safety standards in support of CAV infrastructure placement in the ROW, such as:
    i. Minimization of roadside obstructions (i.e., non-proliferation of poles) posing dangers to errant vehicles;
    ii. Setting restrictions on size and weight of CAV devices and infrastructure placed in the ROW;
    iii. Requirements for breakaway features;
    iv. Setting horizontal and vertical clearances from travel lanes, bike lanes, sidewalks, etc.
b. Continue to participate in all groups noted in Item 2.b.
c. Develop and/or maintain relationships with:

i. OEM’s such as Toyota, GM, Ford, Local Motors, etc.

ii. Public utilities such as telecommunication companies who are deploying technologies in support of CAV such as 5G.

iii. University researchers (we do this already, but should be expanding this to new areas we haven’t coordinated with before)

iv. DAFB and Military researchers and implementers of CAV such as the US Army Tank Automotive Research Development & Engineering Center (TARDEC).

v. Shipping and logistics companies like FedEx, UPS, DHL, Amazon

vi. Software companies like Google, Apple, etc.

vii. Developers of artificial intelligence. DelDOT is presently implementing/testing a FHWA sponsored artificial intelligence (AI) based Traffic Operation Expert System in the I95/US40/DE1 area.

viii. Other government entities at the Federal, State and municipal levels working on CAV policy like emergency planners, 911 centers, other TMC’s, etc.

ix. School Districts

d. Delaware needs to collaborate with neighboring States. Although there is a competitive nature in State-level CAV policy, each State will be more attractive to CAV development if there are fewer regulatory hurdles at our borders.

e. Establish CAV testing grounds in partnership with Delaware’s universities, military bases, municipalities, industrial zones, and/or privately-managed roadways.

f. Complete the AASHTO signal phasing and timing challenge.

g. Coordinate with high schools, colleges, universities, to develop the future work force to develop CAV technology and infrastructure.

h. Evaluate impacts to DelDOT’s workforce:

i. Jobs created: installation & maintenance techs, electrical engineers, computer engineers, communication engineers.

ii. Specialized training needs

iii. Specialized credentialing needed to work in certain fields and with certain sensitive and secure facilities and data.

Medium Term (3 to 5 Years)

i. Build out DelDOT's fiber optic network

j. Identify what additional transportation data needs to be shared publicly to support CAV and the methods of sharing the data.

k. Evaluate the need for new legal authorities related to:

   i. State procurement of proprietary and sole source products and services

   ii. Placement of privately owned CAV devices in the public rights of way

   iii. Impacts of local land use and zoning controls on placement of CAV technology along roadsides, in towns and neighborhoods

   iv. Testing of CAV devices and vehicles on public roadways

l. Evaluate and prepare Delaware's roadways for CAV communication networks including data collection, data management, and back office systems that support the large amounts of data that CAVs generate and CAV mobility applications demand.

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

Long Term (5 to 10 Years)

n. Incorporate CAV technology and devices into DelDOT's project development process including:

   i. Types of infrastructure to include: conduit, poles, communication lines

   ii. Identifying the CAV stakeholders to coordinate with

o. Evaluate and update DelDOT's construction contract specifications as they relate to CAV technology.

p. Evaluate CAV's potential impacts on existing sources of transportation revenue

q. Evaluate new transportation funding needs created by CAV, such as enhanced maintenance standards.

r. Evaluate potential transportation revenue sources created by CAV.

s. Incorporate CAV technologies into the State vehicle fleet as vehicles are replaced with new ones. Driver assist technology based on connections from the vehicle to infrastructure as well as high levels of autonomy should be considered for inclusion in the State fleet. Features like vehicle connectivity, automatic emergency braking, blind spot monitoring, and advanced cruise control can help to both prevent collisions and pilot new technologies.

Potential State Legislation
Did the Subcommittee identify any potential State legislation what would be needed to successfully implement a connected and autonomous vehicle network? 1. To the extent that the private companies developing CAVs may need to rely on privately-owned CAV infrastructure in the roadside to make these vehicles function safely and efficiently, Delaware may need to provide some ability for accommodation of privately-owned infrastructure in the State's rights of way. Currently, only DelDOT, public utility companies, and small wireless telecommunication companies have codified rights to be accommodated in the right-of-way. 2. It may be beneficial to consider Public – Private Partnership opportunities to foster CAV development. 3. Delaware may need pre-emption of local land use and zoning controls on placement of CAV infrastructure along roadsides in towns and neighborhoods. 4. Consider legislation to establish safety standards requiring owners of all standing CAV infrastructure to utilize appropriate security and access control methods as a minimum to control who can access, where, when, and how. 5. State policy should encourage CAV technology to support a robust state of good repair program, targeted to improve roadway safety and traffic operations including within work zones. 6. Delaware Code should encourage all companies manufacturing and/or operating such vehicles on Delaware's roadway to collect and share data regarding roadway and traffic conditions. Having access to such data will enable DelDOT to monitor vehicle speed, location, trajectory, and operational variables such as congestion and delay. It would enable better management of traffic flow with the ability to address specific problems in real-time such as adjusting signal timings or identify potholes and similar vehicular hazards. 7. Since much of the CAV technology is proprietary, Delaware should evaluate whether new legal authorities related to State procurement of proprietary and sole source products and services are needed, especially for publicly-owned CAV infrastructure. 8. We may need legislation to allow platooning on controlled access highways as current Delaware law prohibits truck convoys [21 *Del. C.* §4126 (10)].
Topics for Future Discussions
Please list any topics identified by the Subcommittee that will need further discussion either by the Subcommittee or the Advisory Council.

Analysis and Recommendations

1. Development of minimum roadway infrastructure maintenance standards necessary to support CAV.
2. Budgeting for public highway infrastructure maintenance to support CAV. This should include working with our Federal partners to encourage Federal funding programs on roadway maintenance for the benefit of current road users and in anticipation of future CAV deployments.
3. Who and how will we continue to monitor development of CAV in Delaware.
4. Traffic Control Device (TCD) Needs and Potential Changes – are any changes in TCD's required or beneficial to the deployment of Autonomous Vehicles? As of now, there is no answer to this question. We need to keep on top of this.
5. Long-Term – Consideration of changes in basic road geometry, CAV lanes, CAV roadways, etc. Not much we can do in this area right now.
6. Long-Term – Reduction or elimination of TCD's
7. NHTSA Regulations Effective Date: The Agency is proposing that the effective date for manufacturers to begin implementing new V2V requirements on all new light vehicles would be two model years after the final rule is adopted, with a three year phase-in period to accommodate vehicle manufacturers' product cycles. Assuming a final rule is issued in 2019, this would mean that the phase-in period would begin in 2021, and all vehicles subject to that final rule would be required to comply in 2023.
8. The underlying technology in CAV capabilities could change. For now, CVs rely on dedicated short range communications (DSRC) as the means to transmit data. Some industry observers predict that cellular technology will overtake DSRC, potentially rendering initial investments obsolete.

Subcommittee Meeting Dates

- List the dates of when the Subcommittee met.

  Meetings were held: 02/01/2018, 03/01/2018, 4/5/2018 (no Quorum), 5/8/2018, 6/7/2018, 7/5/2018.

Subcommittee Membership
• Chair: Captain Glenn Dixon, Delaware State Police • Barzilai Axelrod, Attorney General's Office • Chief Bill Bryson, Delaware Police Chief's Council • Mark Luszcz, Delaware Department of Transportation (DelDOT) • Brian Pettyjohn, State Senate • Cathy Rossi, AAA Mid-Atlantic • Jana Simpler, Office of Highway Safety (OHS) • Scott Vien, Division of Motor Vehicles (DMV) • Adam Weiser, AECOM
Mission of the Subcommittee
Consider the implications of Connected and Autonomous Vehicles (CAV) on public and highway safety.
Areas of Focus/Discussion
• Please list the areas the subcommittee focused on and what were the outcomes for each. **Summary of Areas of Focus**: Potential benefits and risks of CAV on public and highway safety. Focus areas are categorized as issues for road users, first responders, and the Department of Transportation. Note: the "levels of automation" referenced in this report refer to the six levels (0 through 5) defined by the Society of Automotive Engineers (SAE) which have been broadly adopted. A summary of the levels is available online: https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety. **Discussion:** • **Opportunities:** According to the National Highway Traffic Safety Administration (NHTSA), 37,461 people died due to highway crashes in the U.S. in 2016, and 94% of crashes are primarily due to driver error. In Delaware, there were 120 highway fatalities in 2016 and 118 in 2017. There were also 474 incapacitating injury crashes and 30,100 total crashes in 2017. The estimated cost to society of highway crashes in Delaware in 2017 was over $2.8 billion. According to the Center for Disease Control, "unintentional injuries" were the 4th leading cause of deaths in the U.S. in 2015, and "motor vehicle-related injuries" were the leading cause of

death within this category. The potential promise of Connected and Autonomous Vehicles is to eliminate crashes due to human error. Many of the following types of crashes may be eliminated or significantly reduced by a fully connected and autonomous vehicles: **recognition error**, which included driver's inattention, internal and external distractions, and inadequate surveillance; **decision error** such as driving too fast for conditions, too fast for the curve, false assumption of others' actions, illegal maneuver and misjudgment of gap or others' speed; **performance error** such as overcompensation, or poor directional control; and **non-performance errors** such as falling asleep. The State of Delaware has adopted "Towards Zero Deaths" as the motto of our Strategic Highway Safety Plan, and CAV may be able to significantly help in this effort.

- **Risks:**
  - Connected vehicles are just starting to be manufactured. Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communications and applications are in their infancy. In the short-term, Connected Vehicles should improve highway safety by giving drivers additional information that they do not currently have. However, significant fleet turnover and public sector investment will be required to begin to reap the potential safety benefits of this technology. In the long-term, it is expected that Connected Vehicles will merge with Autonomous Vehicles to create a hybrid Connected & Autonomous Vehicle.
  - Autonomous Vehicle technology is currently deployed on certain vehicles available to the public at Level 2, and Level 3 vehicles are expected to be available shortly. There is significant uncertainty regarding the availability of Levels 4 and 5 to the public. Once available, there is a significant amount of time for the fleet to turnover, and customer demand for these higher priced vehicles is uncertain. Risks include:
    - Driver complacency induced by "mostly" Autonomous Vehicles (Levels 3 & 4).
    - Driver capabilities once the amount of human driving is reduced (Levels 2 through 4), as driving tasks may fall out of practice.
    - Significantly increased driver perception/reaction times when transferring from autonomous to human control due to "disengagements" (Levels 1 through 4).
    - Lack of public training and understanding of new vehicle features (Levels 2 through 5).
    - Mixed fleet interaction (Levels 0 through 5).
    - State of technology (all are still "learning as we go").
    - Technology malfunctions.

- Potential short-term increase in crashes due to all of the above, before long-term reductions are realized.
- Ensuring recalls are a priority.
- Artificial Intelligence systems require real world experience to improve.

The subcommittee considered the specific implications on public and highway safety in the following areas: road user issues (training, driver's licensing, public education, Original Equipment Manufacturer (OEM) issues, and non-motorized users), first responder issues (Delaware code, law enforcement/first responders), and Department of Transportation (DOT) issues (traditional highway engineering and technological DOT issues). The recommendations, potential legislation, and future topics for discussion generated through the consideration of these topics based on the various levels of automation are included later in this report.

Stakeholders

- Please list the outside stakeholders impacted by the work/topics of the subcommittee.

All road users: motor vehicle drivers and passengers, private and commercial; transit users; pedestrians; bicyclists.

Legislators, law enforcement, first responders (fire, EMS), insurance industry, OEMs, OHS, DelDOT/DMV.

Recommendations to the Advisory Council

1. Hire a consultant to do a comprehensive review of relevant state code, regulations, and policy. This review should focus on the safe and allowable operations of Connected and Autonomous Vehicles (CAV) in Delaware. The review should include a review and recommendations in at least two distinct areas: 1) The driver/operator's responsibility in monitoring and controlling vehicles that are semi-autonomous, and 2) what laws, regulations, and/or processes should be in place to allow fully autonomous/driverless vehicles, while still keeping regulations at a minimum as to not discourage the use and testing of AVs. This task should also include the following items:

    a. Propose definition of terms for use in state code and regulations, including "driver," "autonomous driving systems (ADS)," "platooning," etc.

    b. Review state code to determine if additional laws are needed related to new restrictions or penalties related to CAV, such as "inappropriate use of autonomous driving systems."

    c. Thorough review of other state laws, regulations and national guidance regarding CAV, to understand best practices and develop recommendations for Delaware. In addition to a general review on this matter, a specific topic that should be addressed is the potential requirement of all vehicles on public roadways requiring a licensed driver, at this time. State code is currently silent on this issue. The subcommittee generally believes this is a good requirement, with the need for exceptions. Exceptions could include driverless platooning under certain circumstances, or certain types of vehicles that are specifically approved for driverless testing in certain areas or along certain roadways. This task should develop recommendations for this topic.

   d. Research the potential for implementing a registration process so relevant state agencies can be aware of Autonomous Vehicles (AVs) operating in the State.

2. The following recommendations are related to training and education:

   a. Hire a consultant to develop recommendations and a plan to incorporate those recommendations for CAV education into Delaware's Driver Education and Defensive Driving Programs. At a minimum, the plan would include information on the levels of automation, the capability of ADS with a focus on the process of disengagement, and awareness of CAVs when encountered on the road. The hired consultant should work closely with the Department of Education (DOE), the Office of Highway Safety (OHS), and the Division of Motor Vehicles (DMV) to develop the plan.

   b. Update the Delaware Driver Manual to include information on CAV consistent with the recommendations and plan developed for Delaware's Driver Education and Defensive Driving Programs.

   c. Hire a consultant to develop and update content for a web site and other promotional materials (e.g., brochures) to educate the public on CAV. It is recommended that there be one consolidated web site covering issues from all state agencies. Individual agency web sites should link to the main state web site. The consultant would rely on the Advisory Council on Connected and Autonomous Vehicles for content.

   d. Investigate the feasibility of developing regulations related to public training that should be required for new car dealers, used car dealers, rental car companies, and commercial vehicle dealers for their customers related to CAV technologies and features included within their vehicles.

3. The following recommendations are related to highway infrastructure. To continue and enhance these efforts, additional resources should be established through the Capital Transportation Plan.

   a. Delaware Department of Transportation (DelDOT) to stay abreast of the latest state of the practice, and continue discussions with Original Equipment Manufacturers (OEMs) and related groups, related to potential infrastructure enhancements that will improve/enhance the performance of CAV (e.g., changes in signing, striping, surface smoothness, etc.).

b. DelDOT to continue the expansion and improvement of their Integrated Transportation Management Systems (ITMS), including: continuation of build out of state telecommunications network, continuation of Intelligent Transportation Systems (ITS) deployment, and begin Phase 1 of deployment of Vehicle to Infrastructure (V2I) systems, with initial focus on traffic signals.

c. Connected Vehicles and associated systems (such as Roadside Units) are starting to be deployed utilizing Dedicated Short Range Communications (DSRC). At this time, some believe that the next generation of cellular technologies (5G) will someday supplant DSRC as the primary telecommunication protocol for Connected Vehicles. DelDOT should support the emergence of 5G and/or other similar technologies and by extension the potential improvements in Connected Vehicles, by issuing permits to small cell companies per state code, regulations, and standard procedures. The implementation of 5G and other CAV telecommunication systems have the potential to improve safety by enhancing data and information exchange between vehicles and infrastructure. The committee is not directly recommending use of a specific type of infrastructure at this point, however members suggest expansion of CAV infrastructure occur in all areas.

4. The Delaware Strategic Highway Safety Plan is a state-wide coordinated safety plan that provides a comprehensive framework to reduce fatalities on Delaware's roadways. The plan's lead agencies include the Delaware Department of Transportation, the Delaware Office of Highway Safety (OHS), and Delaware State Police. An update of the plan is scheduled for the year 2020. The topic of CAV should be integrally included in the next version of this plan.

5. The Advisory Council and the various sub-committees should continue to exist and meet on a regular basis after the initial report is submitted to the Governor. The Public and Highway Safety Subcommittee in particular should pursue initiatives as appropriate based on the approval of the full Advisory Council; to include staying abreast of federal guidance and regulations and providing feedback as appropriate to our federal partners. Updates to the Governor should be provided on an annual basis.

Potential State Legislation

- Did the subcommittee identify any potential state legislation what would be needed to successfully implement a connected and autonomous vehicle network?

Nothing specific is recommended at this time. Additional review of state code is recommended per Item 1 in the “Recommendations” section of this report.

Topics for Future Discussions

- Please list any topics identified by the subcommittee that will need further discussion either by the subcommittee or the Advisory Council.

Funding for training and equipment for Delaware State Police and local police agencies related to vehicles' "black box."
Subcommittee Meeting Dates
• January 8, 2018 • February 2, 2018 • March 9, 2018 • April 13, 2018 • May 23, 2018 • June 6, 2018 • June 25, 2018

Subcommittee Membership
• Chair: Patty Cannon, Division of Small Business, Development & Tourism • Co-Chair: Steve Chillas, Delaware OMB-Contracting • Ruth Briggs King, Speaker of the House Representative • Jim Lardear, AAA Mid-Atlantic • Al McGowan, TrafficCast • Ed Osienski, Speaker of the House Representative • Brian Pettyjohn, State Senate • William Pfaff, Sussex County • Colton Phillips, DelDOT Planning • Mark Thompson, WhyFly • Scott Vien, Division of Motor Vehicles (DMV)
Mission of the Subcommittee
Develop recommendations for innovative tools and strategies that can be used to prepare Delaware's transportation network for connected and autonomous vehicles in regards to promoting economic development.
Areas of Focus/Discussion
Education: A qualified workforce is essential to any industry and the Connected & Autonomous Vehicle industry is no exception. The concept of Education was inclusive of high school Drivers Education, CDL Truck Driver Training Programs, After-market Installation & Repair Technicians, Coders, Data Analytics and perhaps, most urgent, the general public as more commercial vehicles are on the roadways using the advanced technologies. Marketing: Delaware has a compelling story to tell regarding DelDOT's impressive investment in technology as well as controlling interest in 90% of roadways, as well as nationally recognized research projects underway in robotics, coding, analytics and pilot programs. Collaboration: Delaware has a reputation of being a "state of neighbors" where we work together to make good things happen. We should capitalize on existing collaborations and work to develop more robust collaborations targeting Connected and Autonomous Vehicles. Examples include DelDOT's partnership with UD to run a piloting an autonomous vehicle on the STAR Campus, The Mill (co-working

space) with support from the State of Delaware is now home to TrafficCast, WhyFly and ZipCode Wilmington (a coding boot camp), and AAA-Mid-Atlantic's partnership with organizations such as Automotive Service Association to develop training programs.

Stakeholders

DelDOT, DE Department of Labor, DE Department of Education, DE Governor & General Assembly, Local Governments & Municipalities within the State of Delaware, DE Prosperity Partnership, DE Division of Revenue, DE Division of Small Business

AAA Mid-Atlantic, Uber, Lyft, OEMS, DTCC, DE State University, University of DE, Delaware Truck Drivers Association, DE Automotive Service Association, TrafficCast, WhyFly, OEMs

Recommendations to the Advisory Council

1. Aggressively promote DelDOT's ownership of and extensive investment in sensors and infrastructure in over 90% of the state's roadways; and CONTINUE to make investments in new CAV related infrastructure/data needed to fill the gap in order to deploy significant CAV projects.
   Feature Delaware's new Angel Investor Tax Credit and the Department of State, Division of Small Business' Business Finder Fee Tax Credit that offers a potential tax credit incentive for companies that help to recruit other companies to relocate to Delaware and create new jobs.
   http://delcode.delaware.gov/sessionlaws/ga149/chp244.shtml
   http://delcode.delaware.gov/title30/c020/sc10/index.shtml
   Ensure Delaware is "Open for Business" – with a commitment to fostering an enterprise-friendly business environment to encourage private sector investment and entrepreneurial activity in the CAV space.
   Continue to take an active role in ensuring that CAV related technologies and opportunities will provided equitable access in transportation, jobs, education/training, etc. across the State of Delaware through collaborations among various stakeholder organizations [example: expansion of CAV shuttle services to provide services to people with disabilities in rural, urban, and suburban communities].
2. Create an industry task force to develop curriculum for Delaware Training Providers to teach the skills necessary to develop, manufacture, maintain and repair the sophisticated hardware, software and security systems that are critical components of Connected and Autonomous Vehicles and to make recommendations regarding potential Center of Excellence training facility, similar to Flight Safety International, that includes the most appropriate equipment, machinery and/or simulation laboratories.
   Advocate for Connected and Autonomous Vehicle-related experiential learning opportunities for K-12 students in Delaware's public schools. (i.e., encourage and celebrate schools that allow trade groups to engage with students) as well as adult learners through Department of Education and Department of Labor approved Workforce Training Providers.
3. Seek opportunities to demonstrate connected and autonomous vehicle technology throughout Delaware to increase awareness and acceptance. Encourage, support and celebrate those opportunities and pilot projects that demonstrate safe deployment of technology that target

high-need populations such as congested roadways during peak beach season, senior citizens living in rural communities with limited access to dependable and innovative transportation solutions, etc.

Develop and execute a strategic plan for attracting Original Equipment Manufacturers &/or private industry to build a Center of Excellence for Connected and Autonomous Vehicles in Delaware, similar to Ford's Center of Excellence in Manufacturing at St. Claire College (Ontario, Canada) - Ford contributed $3 million toward the $15,000,000 project. https://corporate.ford.com/innovation/autonomous-2021.html as well as potential existing institutional partners (i.e., DTCC, UD, DESU, Flight Safety International, DE River & Bay Authority, etc.)

4. Encourage the creation of CAV focused Co-working spaces, collaborative lab spaces, or maker space settings that encourage innovation through collaborative design and development and access to specialized equipment; and, provide networking & collaboration initiatives that bring small businesses and entrepreneurs together with large companies and universities.
5. Create educational and networking opportunities for stake holders and the general public to discuss and learn about Connected and Autonomous Vehicle Technology. The emphasis would be on ensuring safety and building support for the deployment of this technology. Other components would include social media, Public Service Announcements, Talking Points, Posters, OpEds, Videos, etc.

Acknowledge and begin planning for the job displacement that current and future technological advancements will create for workers in the transportation sector and related industries. (Department of Labor)

Encourage Delaware's elected and appointed officials to adopt public policy that encourages and supports the development of the technology (i.e., robotics, software/coding, sensors, security technologies, etc.) that are necessary to grow this industry, maintain public safety and protect personally identifiable data. This effort must take a balanced approach that encourages private investment and recognizes that providing private sector access to existing CAV related infrastructure/data is an extremely compelling economic driver.

Potential State Legislation

- Did the subcommittee identify any potential state legislation what would be needed to successfully implement a connected and autonomous vehicle network?

Legislation that encourages and supports the development of the technology (i.e., robotics, software/coding, sensors, security technologies, etc.) that are necessary to grow this industry, maintain public safety and protect personally identifiable data. This effort must take a balanced approach that encourages private investment and recognizes that providing private sector access to existing CAV related infrastructure/data is an extremely compelling economic driver.

Topics for Future Discussions

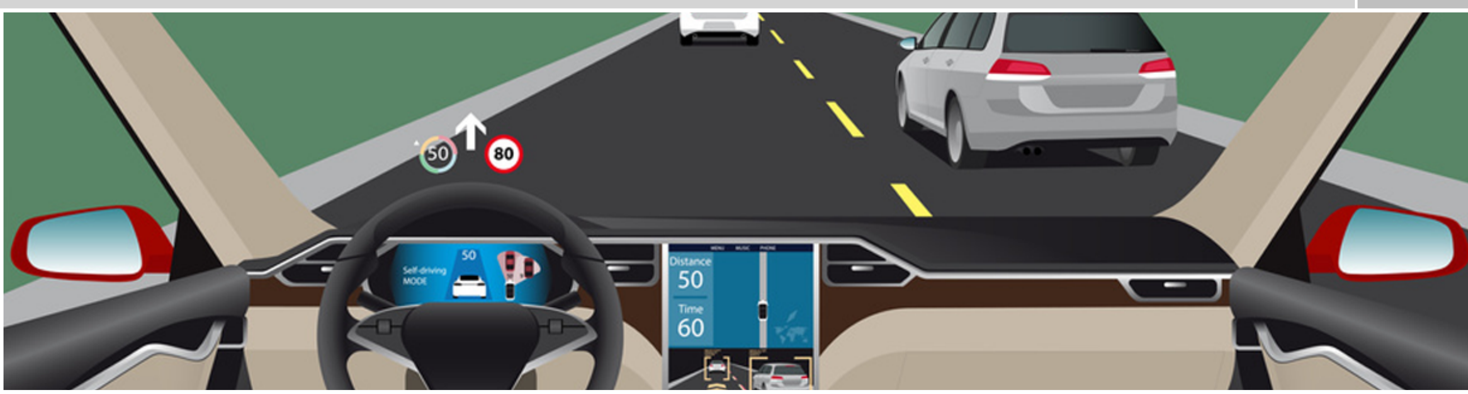
The sub-committee expressed a sense of urgency regarding the immediate need for curriculum development related to Connected & Autonomous Vehicles and they remain hopeful that the discussions will continue to drive Delaware’s CAV initiatives forward beyond the life of this advisory council. Ideally, future discussions will be a catalyst for action on the recommendations contained within

this report.
Subcommittee Meeting Dates
• January 8, 2018 • February 15, 2018 • May 24, 2018 • June 21, 2018 • July 19, 2018

2018

Final Report & Recommendations

Subcommittee on Technology, Security & Privacy



Delaware Advisory Council on Connected and Autonomous Vehicles

7/31/2018

Table of Contents

Introduction

In September 2017, Governor John Carney signed Executive Order 14 to establish an Advisory Council on Connected and Autonomous Vehicles. This Council was tasked with developing recommendations for innovative tools and strategies that can be used to prepare Delaware's transportation network for connected and autonomous vehicles (CAVs).

Connected and autonomous vehicle technology is predicted to enhance safety on roadways, reduce traffic congestion, and increase mobility. CAVs promise numerous benefits for users, however, there is still much to be learned about their operation and impacts. As these technologies develop globally, it is crucial that Delaware stay at the forefront and prepare for changes to come. This includes considering all aspects of CAV and potential impacts to users and the public.

Council Subcommittees were formed to research and develop recommendations in four areas:

1. Promoting economic development
2. **Technology, security and privacy**
3. Transportation network infrastructure
4. Impacts on public and highway safety

This report focuses on research and recommendations developed by the **Subcommittee on Technology, Security and Privacy**. This subcommittee consisted of 13 members from state agencies, academia, and the private sector. Committee members self-divided into one of three workgroups: technology, security or privacy. Each workgroup researched and identified issues and developed recommendations.

The subcommittee met monthly from December 2017 to July 2018 and discussed key issues, stakeholders, opportunities and risks, and potential legislation related to technology, security and privacy and the development of CAV technologies in Delaware. The subcommittee also brought in experts to help inform their discussions. Much of the meeting time was spent in workgroups discussing impacts and recommendations. Although each workgroup developed thoughts and ideas individually, there was overlap between topics discussed and thoughts presented. The subcommittee, as a whole, combined these thoughts and ideas to establish a final set of recommendations.

Subcommittee on Technology, Security & Privacy

Membership

- Philip Barnes, University of Delaware Institute of Public Administration (UD IPA)
- Scott Clapper, Division of Motor Vehicles (DMV)
- Aleine Cohen, Department of Justice (DOJ)
- Jim Garrity, Diamond Technologies
- Renee Gibson, Alliance of Automobile Manufacturers
- Ken Grant, AAA Mid-Atlantic
- Leslie Ledogar, Delaware Department of Insurance
- Li Wen Lin, Delaware Department of Transportation (DelDOT)
- Scott O'Connor, Department of Technology and Information (DTI)
- Brian Pettyjohn, State Senate
- Todd Reavis, Delaware Department of Transportation (DelDOT)
- Shari Shapiro, UBER
- Elayne Starkey, Department of Technology and Information (DTI), Chair
- Sergeant Steve Yeich, Delaware Information and Analysis Center (DIAC)

Mission

The purpose of the subcommittee is to identify the Technology, Security, and Privacy issues and opportunities and make recommendation on tools and strategies that are best for Delaware.

Stakeholders

- Citizens
- Government entities
- External partners
- Educational institutions
- Vendors
- DelDOT (Transportation Management Center & Delaware Transit Corporation)
- Delaware Department of Justice (Consumer Protection Unit)
- State and local law enforcement
- Delaware Department of Technology and Information
- American Civil Liberties Union (ACLU) of Delaware
- Auto Alliance and Global Automakers
- Delaware Automobile and Truck Dealers Association
- Wireless Carriers (Verizon, AT&T, etc.)
- Infotainment (Sirius, Pandora, etc.)

Meeting Dates

- December 21, 2017
- January 18, 2018
- February 15, 2018
- March 15, 2018
- April 19, 2018
- May 17, 2018
- June 21, 2018
- July 19, 2018

Discussion Topics

The individual workgroups discussed various topics that fall under technology, security and privacy as they relate to connected and autonomous vehicles. Although workgroups developed ideas individually, there was overlap in topics discussed. Notable areas of focus included data ownership, data usage, vehicle data privacy, infrastructure for CAV technology, funding and economic development, existing privacy law and policies, data collection policies, cyber security, and physical security threats.

Types of Data

A major discussion topic was vehicle data, including data collection, data types and uses, ownership, sharing, and data storage and access. The subcommittee indicated the need to determine what data is needed for CAV development, how data will be stored and accessed, and the minimum amount of data needed to provide CAV functionality.

Autonomous vehicles require extensive data to operate effectively and will use devices to collect data, such as GPS for navigation, wheel encoders for monitoring vehicle movement, radar for identifying and tracking, and cameras for color identification.   While essential for vehicle operations, the collection of data could present security and privacy risks, especially when the data is aggregated and centrally stored (Bloom et al., 2017).

A Government Accountability Office (GAO) 2017 report entitled "Vehicle Data Privacy: Industry and Federal Efforts Under Way, but NHTSA Needs to Define Its Role" identified two broad categories of data:

1. Vehicle performance data including geolocation, speed, acceleration/deceleration, tire pressure, odometer, seatbelt use, emissions, airbag deployment, transmission/engine performance, and vehicle service history; and
2. Personal owner information including physical addresses, email addresses, phone numbers, and interactions with in-vehicle displays/infotainment, biometric data, and personal communications (voice commands, text messages, etc.) (GAO, 2017, Figure 4).

Personally identifiable information (PII) may be collected to enhance and personalize the CAV experience.   Information on vehicle owner preferences, behavior, and biometric data could be collected and be linked to an individual. As CAV technology develops using variations of data types, it is important that Delaware develop an understanding of all possible scenarios regarding data collection, location, stewardship, and retention.

Data Sharing and Privacy Notices

CAV data will be incredibly valuable to many, whether it is for emergency communication, transportation planning, research and development, or marketing. (GAO, 2017 p. 13). Delivery of citizen and customer services will require the data to be shared with service providers such as DelDOT, dealerships, insurance companies, universities, and law enforcement. (GAO, 2017 pgs. 14-15).

Today, auto dealers ask the vehicle buyer for permission before collecting their data, either during a sale agreement or via a notice when the owner requests a third-party service in the vehicle, such as on a touchscreen display. The GAO (2017, p. 22) report notes that:

> [S]ome consumers do not take the time to read notices, decreasing their ability to provide fully informed consent. In another example, four experts mentioned the multiple decisions and corresponding large amount of paperwork required for buying a vehicle as factors that would make it less likely for a consumer to thoroughly read the privacy notice.

Even if a vehicle owner reads the privacy notices, they may have a difficult time understanding them because "none of the automakers' written notices were in plain language" (GAO, 2017, p. 17). Privacy notices contain ambiguous language which may give automakers latitude to share data for "legitimate business purposes" (GAO, 2017). Currently, vehicle owners are given little control over the degree of data sharing. They have the option to agree to data sharing and receive vehicle services, or they opt-out of sharing and vehicle services entirely. There are few options besides all-in or all-out. (GAO, 2017).

Data Ownership

Data ownership was a major discussion topic throughout committee meetings. Ownership of vehicle data is not currently clear – is it owned by the vehicle owner or the automaker or a third party? Third parties could include fleet vehicles, data carriers, ridesharing providers, and others in the CAV industry. The committee found that answers differ, even *within* the automotive industry. The GAO (2017, pgs. 13-14) interviewed automaker representatives and found the following:

> [Auto makers] differed on who owns data collected from their connected vehicles. Specifically, 7 told us ownership of these data is legally unclear or they do not yet have a position. Of the remaining automakers, 3 said the vehicle owner owns the data, but the automaker has a license to use them; 2 said the automaker owns the data, and 1 said the automaker owns anonymized data and the customer owns personal data (e.g., data tied to a vehicle identification number).

It is anticipated that future court decisions will likely settle the data ownership question. Currently, the Driver Privacy Act of 2015 provides that information collected by Event Data Recorders (EDRs) belongs to the owner or lessee of the vehicle and restricts data retrieval from EDRs. In the future, vehicle data collected by CAV systems will be tremendously valuable. One estimate notes that vehicle data could be a $450 to $750 billion dollar industry by 2030 (Bertoncello et al., 2016). However, ownership of the data will come with associated safeguarding duties and responsibilities, which may decrease the desirability of legally owning the data.

Infrastructure & Technology

The subcommittee discussed infrastructure as it relates to CAV technology. Development of a plan or proposal to support the addition of necessary technology infrastructure and to consider the growth of technology and infrastructure will be required. As this technology is implemented, changes will occur, for example to public transportation, and the committee discussed considering partnerships with state services (i.e. Ride-share, Delaware Authority for Regional Transit (DART), etc.) for deliverables. Additionally, Delaware must determine how to maintain state budget revenue streams as funding, economic development, and tax policies change.

Cybersecurity

Security threats were discussed at length, including both physical and cybersecurity threats, such as hacking and commandeering of vehicles in order to cause harm. The automotive industry is involved in ongoing work to develop cybersecurity standards for autos through Society of Automotive Engineers (SAE) and International Standards Organization (ISO). The auto industry also has a cybersecurity protocol called Auto-Information Sharing and Analysis Center (ISAC) which is a forum for the industry to communicate and collaborate on cybersecurity issues. The focus of Auto-ISAC (2018) is "security by design, risk assessment and management, threat detection and prevention, instant response, collaboration, and governance and awareness."

Federal Standards & Policy

Federal standards and policies that protect privacy were researched by the committee. The Electronic Communications Privacy Act (ECPA) is a federal statute that prohibits a third party from intercepting or disclosing communications without authorization. The subcommittee also sought to understand the exceptions, such as the long-standing exception for vehicles grounded in the Fourth Amendment of the United States Constitution that allows law enforcement officials to stop and search a vehicle based on probable cause without having to secure a warrant from a judge. Here, an outstanding question is whether the vehicle exemption applies to data (Castro et al., 2018).

At the federal level, the Federal Trade Commission (FTC) is responsible for consumer protection, including privacy, as well as regulating wireless telecommunications providers that are the current and likely future (5G), data carriers. The National Highway Traffic Safety Administration (NHTSA) also has a role in protecting consumers, through regulating motor vehicle safety. NHTSA has broad enforcement authority to take action that preserves the safety of motor vehicles operated on public roadways, including defect and recall authority. NHTSA did issue a recall in 2015 for a cybersecurity issue affecting 1.4 million vehicles.

ISO 27000 Family of Standards and NIST standards such as 800-63 (Digital Identity Guidelines), 800-183 (Network of Things), and 800-160 (Systems Security Engineering) all provide critical guidance on the security and handling of sensitive data.

Delaware Laws & Regulations

In addition to federal standards, Delaware's laws and regulations were considered, including the Vehicle Data-Reporting Device Law (18 *Del.C.* § 3918) and the Delaware Data Breach Law (6 *Del. C.* § 12B-100 *et. seq.*, effective April 2018). In consultation with legal counsel, subcommittee members considered the impact of these laws on data security and how they apply to data collected from CAVs.

Other relevant State legislation includes the Delaware Online Privacy and Protection Act, which requires businesses to post their privacy policy for online use and the Delaware Privacy Protection Act and the Geolocation Privacy Protection Act, which protects certain biometric and location data under the regulatory authority of the Consumer Protection Unit (CPU) of the Delaware Department of Justice (DOJ). This bill, HB350 in the 149th General Assembly, did not make it out of committee but may be reintroduced or reworked in the future. The CPU is responsible for fraud prevention in the state and is the government unit most likely to become involved in privacy issues. DelDOT is currently collecting Bluetooth data to measure travel times and must abide by State data protection policies such as the Delaware Information Security Policy and the Cloud Security Policy.

Industry Standards

Private industry developed self-regulatory standards to protect consumer privacy. The most important is the Alliance of Automobile Manufacturers and the Association of Global Automakers who voluntarily agreed to abide by a set of seven "Privacy Principles" for connected vehicles. These principles are as follows: (1) transparency, (2) choice, (3) respect for context, (4) data minimization, de-identification & retention, (5) data security, (6) integrity & access, and (7) accountability. In the absence of federal and state standards for vehicle data and privacy, The Privacy Principles are the automotive industry's self-imposed framework. Vehicle owners' privacy in the United States are therefore governed primarily by the voluntary Privacy Principles and not by FTC or NHTSA regulation.

Other Discussion Topics

Additional privacy issues related to CAVs were identified. Beyond the owner concerns already discussed, additional passengers in CAVs may not know their data is being collected, and they may not have consented to having their data collected like the vehicle owner.

Data retention, transfer, and disposal issues arise during the transfer or sale of a vehicle. For example, in the used car market, the previous owner's data (home address, phone contacts, text messages, driving patterns, app history, etc.) may be stored in a vehicle. If the data is not deleted before sale, the new owner may have access to the previous owner's data and personal information.

Opportunities & Risks

The subcommittee identified potential opportunities in CAV development and their associated risks. These technologies have the capability to provide a multitude of opportunities to reduce congestion, and increase safety and mobility in Delaware.

Opportunities

CAV systems provide an opportunity for value creation and revenue growth for the State and private entities and the subcommittee recognizes that DelDOT's current Integrated Transportation Management System (ITMS) infrastructure positions Delaware well for future CAV innovation. Potential revenue streams include partnerships with private sector entities who can acquire data as a result of CAV technology.

An additional advancement opportunity can be created by partnering with public transit providers to enhance mobility for travelers with physical limitations, including those who use Paratransit services and the elderly.

Concerns over privacy-related issues are not speculative or based on long-term projections for autonomous vehicle deployment – connected vehicles are on the road now. Delaware can get ahead of the CAV policy curve if it takes proactive steps to address *current* privacy challenges in vehicles.

Anonymized network-wide trajectory data can be used to inform transportation and land-use planning decisions, which provides DelDOT with an opportunity to improve transportation planning and operations.

Risks

Consumer unease with vehicle data collection, targeted advertising, and data misuse is a concern. Public acceptance of CAV technology is already low and anecdotes or examples of perceived privacy violations could heighten public sentiment against CAVs and delay deployment. AAA's 2018 survey shows that 82% of Delawareans surveyed are "very concerned" or "somewhat concerned" about the security of data sent to and from CAVs. These conditions indicate that the public acceptance environment is fragile. Citizens need clear, plain language for what data will be collected, the purpose of the data being collected, how the data will be stored and secured, for how long and how the data will be retained.

Consumers are frequently unaware of what data is already being collected by the CAV industry and what additional use of the data is possible when multiple data streams are combined. For example, the Privacy Principles (see Industry Standards section above) state that automakers can share geolocation, biometric, and driver behavior data with third-party service providers without owner consent, if those parties only utilize it for service provision AND those third-party privacy practices are consistent with the notices that automakers have provided (Alliance, 2014, p. 9). This is an issue when third-party providers subcontract and share the data with their fourth-party providers (and so on). Like the child's game of "Telephone", the standards and procedures by which the data is governed will likely diverge from the original as it moves through the subcontractor chain.

There is a risk that the current practice of automotive industry self-regulatory action (see Industry Standards section above) may experience a conflict of interest between sufficient data and consumer privacy safeguards on the one hand, and on the other, the incentive to capture a share of the emerging multi-billion dollar market for vehicle data (Bertoncello et al., 2016).

It may be some time before the market decides the best way to transmit data. There are multiple technology options such as 5G and Dedicated Short Range Communications (DSRC), some of which are still emerging, so the risks are unknown.

Summary of Recommendations to the Advisory Council

Final Recommendations

The following recommendations to the Advisory Council were developed by the subcommittee based on discussion of opportunities and risks associated with CAV development in Delaware:

Data Collection & Ownership

1. Monitor discussion, activities of standards organizations (SAE, ISO, etc.), and court decisions around data ownership
2. Define clear use cases for collecting Personally Identifiable Information (PII).
3. Collect the least amount of PII necessary to accomplish the goals of the use case.
4. Keep PII for the shortest time necessary to accomplish the goals of the use case and anonymize the PII appropriate for the case.

Data Privacy

5. Encrypt (or apply current best practice for anonymization) PII and non-public data collected during transmission and at rest.
6. Anonymize network-wide trajectory data, which can be used to inform transportation and land-use planning decisions.
7. Separate CAV data into PII and non-PII when storing.
8. Take steps to address *current* privacy challenges in vehicles.
9. The State of Delaware should establish a partnership with other states, business partners and the National Highway Traffic Safety Administration (NHTSA) to collaborate on cybersecurity policies and best practices.

Infrastructure & Technology

10. Create a technology oversight board comprised of state, federal, academic, and non-profit and private sector entities to monitor future CAV technologies and how future technologies will affect the State of Delaware.
11. Coordinate with surrounding states on CAV technology standards to maintain consistency as the regulatory environment develops nation-wide.
12. Consider partnering with public transit providers to leverage CAV technology to provide enhanced mobility to stakeholders with limited mobility, including senior citizens and those who utilize Paratransit services.

Education & Training

13. Develop a constructive, living communications plan to inform citizens on data being collected by CAVs, its use and storage.
14. Consider a joint DelDOT-Consumer Protection Unit (CPU) large-scale public education campaign to inform Delawareans about the privacy landscape of CAVs and cybersecurity risks. Different categories of information may require different levels of education. Target training on cybersecurity risks, such as social engineering concerns.

15. Recommend that manufacturers allow CAV owners to opt-in to data collection rather than have data collected by default and disclose use of data to CAV customers during the registration period.
16. Recommend the Advisory Council thoroughly review the 2017 Government Accountability Office (GAO) Report.

Potential State Legislation[1]

The subcommittee recognizes that the federal government, in particularly the Federal Trade Commission (FTC), might be the lead agency when dealing with privacy issues for a national standard. However, we have identified some options for the Council to consider.

1. Consider legislation for automakers to provide "plain language" consent forms to owners, especially at the point of sale. Use clear, plain language to articulate to consumers what data will be collected, the purpose of the data being collected, how the data will be stored, for how long the data will be stored, and how the data the will be protected.
2. There was unpassed legislation in the 149th General Assembly (Biometric Privacy Protection Bill and Geolocation Privacy Protection Bill – HB350). DelDOT should communicate with sponsors and co-sponsors to evaluate whether it would be appropriate and feasible to integrate connected and automated vehicles into these Acts if they are reworked and reintroduced in the future.
3. Consider requiring used vehicle dealers and private sellers to wipe vehicle data clean before resale.

Conclusion

The subcommittee on Technology, Security, and Privacy discussed key issues, stakeholders, opportunities and risks, and potential legislation related to the development of CAV technologies in Delaware. The thoughts and ideas discussed during the committee meetings were summarized and developed into recommendations to the Advisory Council on Connected and Autonomous Vehicles.

Although there are significant benefits to CAV advancement, associated risks need to be considered. Enhanced connectivity allows for socially beneficial outcomes, but also opens the door to security threats, such as hacking and unintended release of personal information. There are many unknowns surrounding the future of this technology, especially as it relates to data collection, sharing, and storage. Technology, security and privacy are all very important topics to consider as Delaware moves forward in implementing connected and autonomous vehicle technologies.

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[1] *The proposed legislation provided by the subcommittee is not an endorsement of the legislation by the Deputy Attorney General assigned to the subcommittee, the Attorney General, or the Department of Justice. The proposed legislation was discussed at client request by a Deputy Attorney General of the Department of Justice in accordance with the powers, duties, and authority of the Department of Justice under 29 Del. C. § 2504(8). The Attorney General is an elected officer under Article III, § 21 of the Delaware Constitution of 1897 as amended.*

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APPENDIX C: DEPARTMENT OF INSURANCE REPORT

2018

Report & Recommendations

Subcommittee on Insurance Issues

Delaware Advisory Council on Connected and Autonomous Vehicles

7/31/2018

Table of Contents

I. Introduction

A. Background

The advent of connected and autonomous vehicles (CAVs) will likely have a transformative impact on our society, with vehicle ownership and its associated risk being just a small part of a larger cultural shift. New entrants into the mobility provider sector, and new providers of insurance products will likely result in a confluence of disruptors.

In a May 2018 issues analysis, the National Association of Mutual Insurance Companies (NAMIC) opined:

> The development and deployment of proven, safe automated driving systems (ADS) will require significant technological advances, revisions to the regulatory paradigm, and the active participation of far more than just the auto manufacturers and technology companies.
>
> The potential of technology to move the needle on crash statistics is extraordinary; however, there will still be crashes, especially in an environment where autonomous vehicles continue to share the road with human drivers. . . .
>
> The critical issues related to passenger safety, liability, and compensation after a crash require that insurance companies are included in the development, deployment, regulation and use of ADS.
>
> Consumers will continue to look to property/casualty insurers to provide them with the protections they have come to expect as this new frontier of automotive products and services evolves.

(Karol, 2018, p. 2).

Accordingly, it is critically important for all stakeholders in the insurance arena, including regulators, consumers, and participants in insurance markets, to have a seat at the CAV table. It is not enough to understand CAV technology itself. Rather, regulators, consumers and insurance marketplace participants should also be able to understand the risks associated with CAV technology and the insurance products being designed and deployed to insure against those risks.

The Delaware Insurance Commissioner is a named member of the Advisory Council on Connected and Autonomous Vehicles (the Council), established by Governor John Carney through Executive Order (EO) No. 14 (September 5, 2017). At its December 2017 meeting, the Council recognized the need for a separate chapter in its final report that specifically addresses the insurance aspects of CAVs and requested that the Insurance Commissioner draft that chapter.

To accomplish that task, the Insurance Commissioner first convened an Autonomous Vehicles Insurance Task Force in February 2018, during which a variety of stakeholders identified key issues, opportunities, risks, and potential legislation related to the effect of CAVs on insurance in Delaware. Delaware Department of Insurance (Department) staff then conducted an extensive literature review of issues related to CAV insurance.

Finally, Department staff participated in the following events to learn from key, prominent thought leaders in the insurance arena:

- The relevant subcommittee meetings of the National Association of Insurance Commissioners (NAIC) Spring meeting in Milwaukee, Wisconsin (March 24-27, 2018);
- The NAIC Insurance Summit Center for Insurance Policy Research (CIPR) Innovation Program (June 19-21, 2018);
- The U.S. Department of Transportation Federal Highway Administration's National Dialogue on Highway Automation workshops in Washington, DC (March 1, 2018) and in Philadelphia, Pennsylvania (June 26-27, 2018); and
- The Automated Driving Systems Conference in Washington, DC (June 19-20, 2018).

This chapter is not intended to be the final word on the insurance implications of CAV deployment. Rather, it is about preparing for its potentialities by establishing a foundation and a framework upon which future discussion and decision making may occur. The Department recognizes that this is a constantly changing area in which all of us will continue to adapt and evolve.

B. Subcommittee Membership

The Insurance Commissioner appointed Leslie W. Ledogar, Esq., the Department's Regulatory Specialist, as Insurance Subcommittee Chair and chapter author. Other members of the Subcommittee on Insurance include:

- The Honorable Trinidad Navarro, Insurance Commissioner;
- Tanisha Merced, Deputy Insurance Commissioner;
- Frank Pyle, Director of Consumer Protection and Enforcement ;
- Michael Gould, Manager of Consumer Services Investigations and Market Regulation: Property & Casualty; and
- Gene Reed, Deputy Receiver, Rehabilitation & Liquidation Bureau.

C. Subcommittee Mission

The mission of the Council's Insurance Subcommittee is to identify insurance issues and opportunities concerning the deployment of CAVs and to make recommendations concerning tools and strategies that are best for Delaware consumers and insurance markets.

D. CAV Insurance Issue Stakeholders

The following is a non-exhaustive list of stakeholders in the CAV/insurance arena:

- Citizen consumers of automobile insurance;
- Small and large business owners in the fleet transportation and trucking industries;
- Insurers and re-insurers, including InsurTech innovators and non-insurance companies who are considering entering the insurance market place for the first time;
- Vendors such as insurance producers and adjusters;
- Government entities;

- Academia;
- Automobile and truck manufacturers; and
- The legal community.

E. Topics of Research

The Department's research focused on the following areas:

- Understanding connected and autonomous vehicles (CAVs);
- Understanding regulatory authorities over CAVs;
- Identifying the impacts of CAVs on the insurance industry;
- Understanding how data generated by automobiles, including CAVs, is used;
- Understanding cyber security and CAVs;
- Understanding budgetary impacts from possible shifts in premium tax revenues; and
- Tracking and reporting on the progress of the National Association of Insurance Commissioners (NAIC) through its position papers/model legislation and Federal/state legislation on insurance products that involve CAV insurance.

This chapter is organized into sections that discuss each of these research areas, followed by sections that discuss future opportunities and risks related to the Subcommittee's mission.

II. Understanding connected and autonomous vehicles (CAVs).

CAVs can be characterized as "transformative" and "disruptive" technologies with myriad impacts on the way we think about and utilize transportation alternatives and on the way we evaluate the risks associated with using these alternatives. The transition of transportation and economic systems to include CAVs will likely be both "significant and long lasting" (Barnes, 2017, p. 4).

<u>The "Autonomous" in CAVs</u>

CAVs are classified by the following six Levels of automation (Barnes, 2017, p. 9) (National Highway Traffic Safety Administration, 2017, p. 4):

- Level 0 – No Automation (The human driver controls all aspects of the car);
- Level 1 – Driver Assistance (An automated system on the vehicle can sometimes assist the human driver conduct some parts of the driving task);
- Level 2 – Partial Automation (An automated system on the vehicle can conduct some parts of the driving task, which the human continues to monitor the driving environment and performs most of the driving task);
- Level 3 – Conditional Automation (An automated system can conduct some parts of the driving task and monitor the driving environment in some instances, but the human driver must be ready to take back control when the automated system requests);
- Level 4 – High Automation (An automated system can conduct the driving task and monitor the driving environment, and the human need not take back control, but the automated system can operate only in certain environments and under certain conditions); and

- Level 5 – Full Automation (the automated system can perform all driving tasks under all conditions that a human driver could perform them).

Some of the ways in which CAVs interact with each other and their surroundings are illustrated in Figure 1 below.

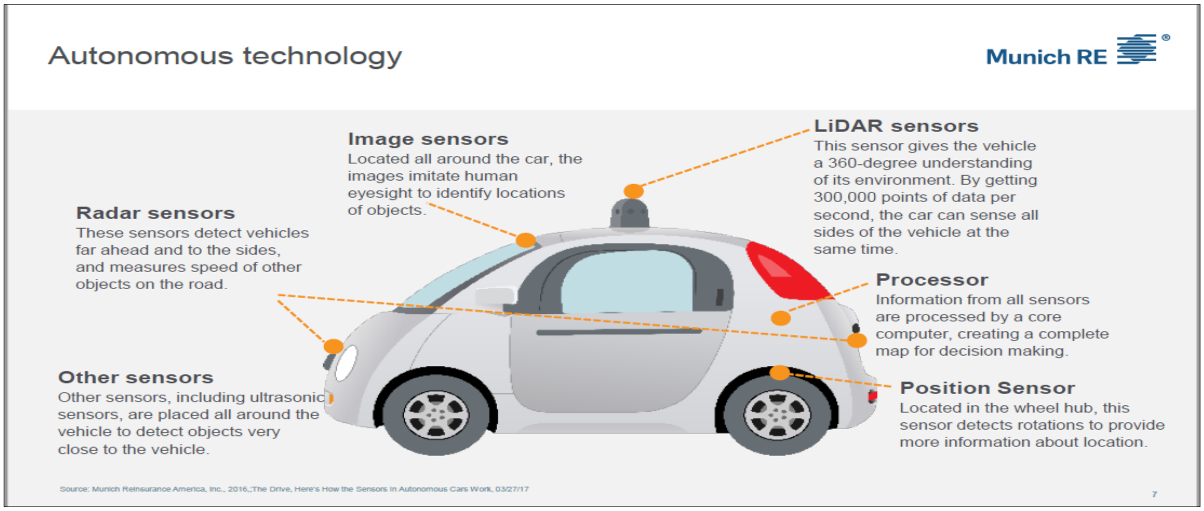


Figure 1. Autonomous Technology (Brunette, 2018).

<u>The "Connected" in CAVs</u>

The main premise of a CAV is that it is an integral part of the Internet of Things (IoT). From Wikipedia, the "IoT" is:

> [T]he network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these things to connect and exchange data, creating opportunities for more direct integration of the physical world into computer-based systems, resulting in efficiency improvements, economic benefits, and reduced human exertions. . . .


Figure 2. The IoT (Wilgengebroed).

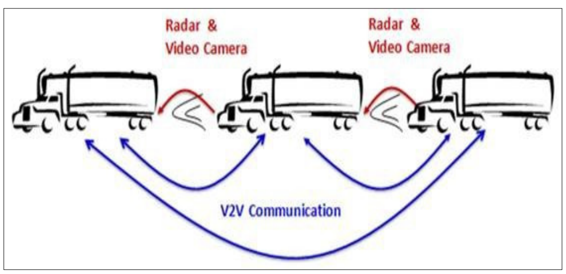
> The IoT involves extending internet connectivity beyond standard devices, such as desktops, laptops, smartphones and tablets, to any range of traditionally dumb or non-internet-enabled physical devices and everyday objects. Embedded with technology, these devices can communicate and interact over the internet, and they can be remotely monitored and controlled (Various, 2018).

The processor in the CAV is powered by Artificial Intelligence (AI) (see Figure 1 above). While AI is discussed further below, suffice it to say that AI is already having a significant impact on the insurance industry. Whereas decision-making in the 20th Century was powered by “rules, heuristics or spreadsheets,” decision-making is now made better and faster, powered by deep learning involved in AI (U.S. Department of Transportation, 2016, p. 5) .

AI in CAVs arguably holds a learning advantage over humans. While a human driver may repeat the same mistakes as millions of drivers before them, a CAV can benefit from the data and experience drawn from thousands of other vehicles on the road (U.S. Department of Transportation, 2016).

CAVs will eventually communicate with each other and with the rest of the transportation system through Designated Short Range Communications across an exclusive 5G bandwidth (Gould, 2018). This means that, not only is the CAV connected to the IoT, but its passengers are also connected to the CAV, such that data freely flows to and from the CAV, and to and from the passengers riding in it through any devices that the passengers may bring with them on their trip in the CAV.

Additionally, trucks and cars can and are being redesigned to travel in “platoons.” According to a USDOT fact sheet, platooning involves the use of cooperative adaptive cruise control (CACC) that enables heavy trucks to drive safely and smoothly at significantly shorter gaps than they can under conventional manual driving.



The CACC system uses forward-looking radar sensors and electronic actuation of engine and brakes of the conventional ACC system but adds 5.9 GHz Dedicated Short Range Communications (DSRC) vehicle-to-vehicle (V2V) communications, enabling the implementation of a higher performance vehicle-following controller (USDOT, 2018).

Figure 3. Truck Platooning (USDOT, 2018)

Even with its purported safety advantages, connectivity also raises access issues. Access to the Nation’s transportation infrastructure is currently largely free (with the exception of certain stretches that require the payment of tolls). With the advent of the necessary connectedness, it may become likely that free access to that transportation infrastructure may become a thing of the past, just as free access to communication lines such as telephone and television have become a thing of the past, and shifting accessibility to only those who can afford it. Additionally, the sale of 5G bandwidth may cause bandwidth providers (for example, Verizon, AT&T, Comcast, etc.) to reimagine themselves as mobility providers, thereby edging out the traditional automobile manufacturer. With that comes an opportunity for bandwidth providers to also reimagine themselves as mobility insurance providers.

III. Understanding regulatory authorities over CAVs

Both the Federal government, through the National Highway Traffic Safety Administration (NHTSA), and State governments, have jurisdiction over CAVs. NHTSA is responsible for regulating the safety, design, and performance aspects of motor vehicles and motor vehicle equipment, while the individual States are responsible for regulating the human driver and vehicle operations, including:

- Licensing human drivers and registering motor vehicles in their jurisdictions;
- Enacting and enforcing traffic laws and regulations;
- Conducting safety inspections, where States choose to do so; and
- **Regulating motor vehicle insurance and liability.**

(National Highway Traffic Safety Administration, 2017, pp. ii, 20)(emphasis added).

On the Federal legislative front, two bills have been introduced, but neither has been enacted. The Senate's AV START Act (S.1885), which passed the Senate Commerce Committee by voice vote on October 4, 2017 and may come to a vote on the Senate floor in the summer of 2018:

- Preempts states from regulating the design and performance of CAVs;
- Includes a provision for the development of Federal guidelines (which are different from enforceable regulations); and
- Requires each manufacturer to develop, maintain, and execute a written plan for identifying and reducing cybersecurity risks to CAVs.

The SELF DRIVE Act (H.R.3388), which is a version of the Senate Bill 1885, passed the House unanimously. Although similar to the Senate bill in that it preempts state regulation of the design and performance of CAVs, the House bill would also:

- Enable the Federal Department of Transportation to grant automakers exemptions from federal motor vehicle safety standards, through a phased approach that would begin with 25,000 exemptions in the first year and increase to 100,000 by the third year;
- Require manufacturers to demonstrate that their CAVs are as safe as or safer than traditional vehicles; and
- Allow states to maintain control over the registration and licensing of autonomous vehicles, in addition to overseeing crash investigations, safety inspections, and traffic laws.

A July 11, 2018 *Los Angeles Times* article reports that some Federal lawmakers and consumer advocates have expressed concern that these bills would "fail to protect passengers from hackers . . . [and], lack a standard 'vision test' to ensure that computer vision systems can properly perceive and react to unexpected obstacles, much in the way that passing a vision test is required to obtain a driver's license" (Fawcett, 2018). Additionally, some Senators are concerned that the bills "indefinitely preempt state and local regulations, even if federal safety standards are never developed" (Fawcett, 2018).

At the state level, most states that have enacted legislation focus on allowing vehicles to be tested under certain circumstances (for example, requiring a driver/tester behind the wheel at all times) (Brunette, 2018). Arguably, in states with no legislation or regulations, CAVs could be deployed unfettered.

The following figure shows in which states some form of legislation has been enacted, in which states the respective Governors have issued an executive order (Delaware is one of these states), and in which states federal proving grounds for CAVs are located.

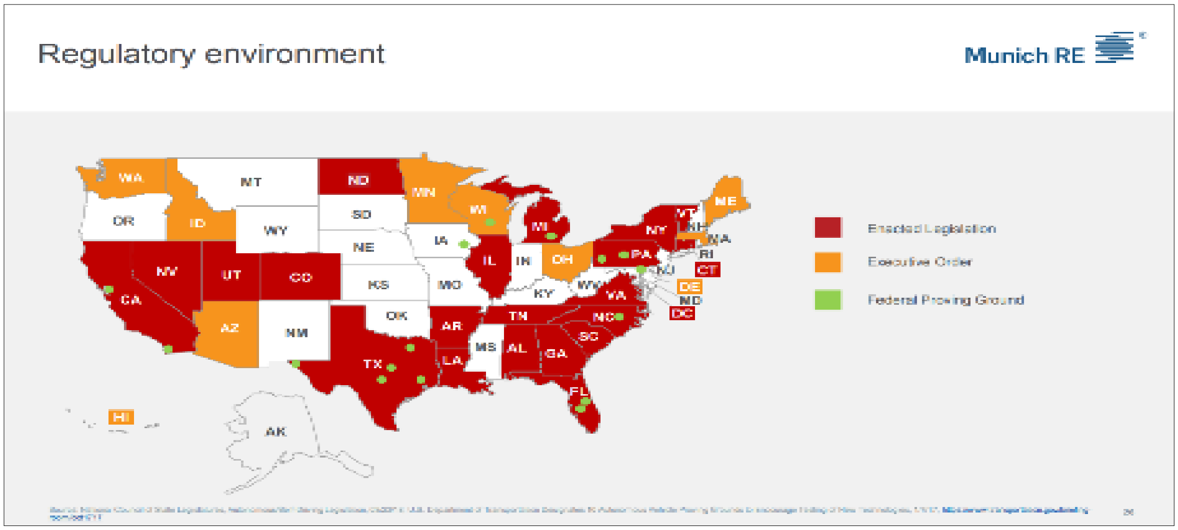


Figure 4. State regulatory environment (Brunette, 2018)

The following table, excerpted from a Council of State Governments blog (Slone, 2017) and from the National Conference of State Legislatures (NCSL) Autonomous Vehicles State Bill Tracking Database (NCSL, 2018), shows that 14 states passed legislation that addresses autonomous vehicle policy in some way, while other states' legislation is pending.

2017 - 2018 State Legislative Activity		
Issue addressed	States that enacted laws in 2017	What the Legislation does
Truck Platooning	Arkansas, California, Georgia, Nevada, North Carolina, South Carolina, Tennessee and Texas Pennsylvania (pending)	Allows truck platooning or testing on roads in those states.
Pre-Emption of Local Regulation	Colorado, Illinois, New York, North Carolina, Tennessee, Texas	Enacted measures that seek to pre-empt local regulation of autonomous vehicles and/or put a state government agency in charge.
Pilot Program	Connecticut, Missouri (pending), New Jersey (pending), Pennsylvania (pending) (States whose pilot programs failed to pass include Arizona, California, Georgia, Indiana)	Enacted legislation to establish a pilot program for up to four municipalities to test fully autonomous vehicles on public roads.
Licensing, Registration & Insurance	Georgia, Tennessee (pending) Utah (failed) (No Fault insurance failed in Florida, strict liability pending in New York)	Exempts a person operating a vehicle with an automated driving system engaged from the requirement of holding a driver's license and specifies conditions that must be met for a vehicle to operate without a human driver present, including insurance and registration requirements.
Autonomous Vehicle Act	Illinois (pending), Massachusetts	Creates the Autonomous Vehicle Act,

	(pending) Failed - Georgia	provides that an automated driving system equipped vehicle may drive or operate upon the highways of the State with the automated driving system engaged for testing, a transportation service, or any other use, regardless of whether a human operator is physically present in the vehicle, and provides for liability for incidents involving such systems.
Studies and Advisory Panels	North Dakota, Vermont, Delaware, Washington, Wisconsin,	Varies

From the particular standpoint of insurance legislation, since the passage of the McCarran-Ferguson Act in 1945 (15 U.S.C. § 1, et seq.), the regulation and supervision of the insurance industry rests with the States, except in instances where federal law specifically supersedes state law (Klein, 2014, p. 115).

As a result, each state has its own Department of Insurance, which is overseen by an official who is either elected by the citizens of that state (as in Delaware), or appointed by the Governor of that state. That official is charged with overseeing:

- The solvency of insurance companies doing business in that state;
- The insurance rates charged by those companies for policies written in that state; and
- The market practices of those insurance companies doing business in state, including the protection of consumers (Klein, 2014, p. 2).

Insurance Commissioners are assisted in their regulation of insurance companies by a "substantial institutional framework that has been developed over the years" (Klein, 2014, p. 2). That framework includes "laws, regulations, policies, procedures, personnel, knowledge and physical facilities designed to oversee this important financial industry" (Klein, 2014, p. 2). Additionally, the National Association of Insurance Commissioners (NAIC) "plays a central role in state regulators' efforts to coordinate, strengthen and streamline their oversight of the insurance industry" (Klein, 2014, p. 3).

The NAIC Insurance Availability and Affordability Task Force (the Task Force) conducted a study some years ago in which it concluded that "some urban areas have significant insurance market problems and inadequate availability, leading to high costs in urban areas for low-income drivers." (NAIC Insurance Availability and Affordabilty (EX3) Task Force, 2014, p. 9) The same concerns will arguably arise with the pricing of CAVs and associated insurance products.

The Task Force developed a continuum of potential remedial measures for state insurance regulators to fit the specific circumstances in their respective markets. It organized the continuum of policy options based on the degree of intervention in the market required by each:

- Limited market intervention – maximizes reliance on and facilitates the exercise of market forces in resolving urban insurance problems;
- Moderate Market intervention – Sets standards and safeguards but still emphasizes market forces to determine the prices and amount of insurance available in different areas;

- Extensive market intervention – contemplates a much more restrictive approach in which there is significantly less room for market forces to determine prices and products and the actions of insurers and agents would be highly constrained or subject to mandates in order to achieve specific public policy objectives; and
- Public provision of insurance – would reject reliance on and supplement or supplant, the private market to provide insurance.

(NAIC Insurance Availability and Affordabilty (EX3) Task Force, 2014, p. 6).

From the Summary, "The Task Force's opinion was that regulators should apply tools least intrusive to market intervention to address market failures, although it was stressed that the states could choose different measures from different levels along the continuum based on the particular circumstances with in their own state" (NAIC Insurance Availability and Affordabilty (EX3) Task Force, 2014, p. 6). A similar approach could be taken to help ensure the availability and affordability of CAVs and those insurance products that emerge to meet the needs of CAV users and owners.

As will be discussed further in the next section, insurance regulators are just beginning to evaluate the impact of CAVs on the insurance industry. It is important for the developers of CAV technology and insurance regulators to engage in a robust and ongoing dialogue with each other so that both increase their understanding of the technology, its risks and how to insure against those risks.

IV. Identifying impacts of CAVs on the insurance industry and insureds

Everyone in society is effected by risk. Risk "arises when there is the possibility of more than one outcome and one of those possible outcomes has negative consequences" (Klein, 2014, p. 1). To reduce the impact of a particular risk, individuals or firms may choose to transfer and diversify their risk by pooling their resources to cover their individual losses. In other words, "members of the group exchange a smaller, more certain financial contribution (the insurance premium) against a larger, uncertain loss (such as the loss of a car in an automobile accident)" (Klein, 2014, p. 6). In this way, insurance has an "important and pervasive role in the economy that is vested with public interest" (Klein, 2014, p. 1).

Some insurance industry analysts predict that, with the advent of technology generally, and CAVs in particular, the "core business models for traditional automobile insurance carriers may be under threat of obsolescence, with automobile manufacturers potentially becoming a viable alternative to cover driving risk" (KPMG Insurance Task Force, 2017, p. i).

This prediction rests on the premise that the following three disrupters to the auto insurance marketplace are likely to converge to make what one analyst calls "the perfect storm" (KPMG Insurance Task Force, 2017, p. 19):

- Increases in auto safety, which will significantly reduce accident frequency and accident severity, will result in less driving exposure to cover, and therefore, the size of the traditional auto insurance industry may shrink (KPMG Insurance Task Force, 2017, pp. 19-23);

- Auto manufacturers may be able to take market share away from insurers (KPMG Insurance Task Force, 2017, pp. 23-29); and
- Mobility-on-demand and ride sharing (transportation network companies) have spawned new business models that focus on fleets of vehicles rather than on individual car ownership (KPMG Insurance Task Force, 2017, p. 31), and that focus on non-traditional mobility providers such as the providers of bandwidth (Gould, 2018).

Disrupter 1. – A Shrinking Auto Insurance Sector

The demand for automobile insurance is reportedly decreasing due to reductions in accident frequency and accident severity. The effects of employing driver assist technology (automation levels 1 and 2) are reportedly resulting in a significant reduction in accident frequency, with a potential of a 90 percent reduction in accident frequency by 2050. Accident severity is also likely to fall, particularly for property damage, such that total losses from car accidents could fall by roughly 63 percent. (KPMG Insurance Task Force, 2017, pp. 19-23)

The likely rise in loss severity may offset reductions in accident frequency and severity. With the advent of CAVs, loss severity will likely rise due to the increased cost of vehicles equipped with autonomous technology (property damage) and rising health care costs (bodily injury) (KPMG Insurance Task Force, 2017, pp. 19-23).

Annual miles driven may see a slight increase as fleets of vehicles will be deployed frequently (in contrast with a privately owned vehicle that is parked in a lot or garage for most of the day), and as those who cannot drive take advantage of autonomously piloted vehicles to get around (KPMG Insurance Task Force, 2017, pp. 19-23).

However, as NAMIC points out:

> The elimination of certain human errors does not tell us anything about the introduction of computer, sensor, or software error. Safe [CAVs] will require a substantial amount of specialized software, sensors, controllers, and actuators to collectively perform without error the large universe of operations that human drivers perform, or at least as well as those human drivers. The bar for performance has been set high: human drivers average 3.4 million vehicle hours (390 years of non-stop driving) between fatal crashes and 61,400 vehicle hours (7 years of non-stop driving) between injury crashes.

(Karol, 2018, p. 3).

Another cause of shrinkage in the auto insurance industry is automation in general. This is because application (AP) designers are rapidly entering the insurance marketplace in the space commonly referred to as "InsurTech. Everything from applying for and writing an insurance contract to claims processing and settlement are being scrutinized by AP designers.

For example, InsurTech startups are disrupting the way coverage is delivered and claims are processed. As a result, one company, Allstate Corp. reported that it has cut 550 auto adjusters because technological advancements made their jobs unnecessary, causing the company to invest $40 million to help retrain its employees for a changing economy (Mathis, 2018).

The challenge for regulators will be to keep up with AP development to ensure that insurance policies are properly underwritten and claims are settled fairly. Additionally, new entrants into the InsurTech space have demonstrated a lack of understanding of the regulatory underpinnings of offering insurance (A.M. Best Company, Inc., 2018, p. 7). Regulatory oversight at the beginning of the process may be preferable to regulation in hindsight.

Three states, Idaho, Connecticut and South Carolina, are active in regulating InsurTech. Regulators from each state reported on their approaches at the NAIC Insurance Summit CIPR Innovation Program (Ledogar, 2018). To summarize:

> Idaho. Idaho's legislature has given the Idaho Department of Insurance (IDI) the authority to waive regulatory requirements for innovators who agree to innovate in a so called "regulatory sandbox." The IDI has been working closely with Idaho's Global Insurance Accelerator, which provides InsurTech innovators with seed capital, office space, and mentoring by insurance professionals. If the innovation fails to protect consumers, the IDI has the authority to shut the product down and require that premiums be refunded. If the product proves viable while in the sandbox, the IDI may then require the innovator to enter the official regulatory space by filing the requisite rate filings and register as an official insurance company.
>
> Connecticut – Connecticut reported that insurance is a key part of the State's larger economic plan to engage the technology sector. The Connecticut Insurance Department (CID) reportedly fosters innovation from the standpoint of providing InsurTech innovators access to its InsurTech Hub. The Hub is an accelerator where mentors, investors, regulators, and innovators can partner to quickly and efficiently evaluate an InsurTech concept. CID encourages companies to talk to the regulators early in the development phase of a proposed insurance product, and also emphasizes consumer protection by making sure that consumers know that the product they are purchasing is in the testing phase. Because Hartford Connecticut is the seat of many traditional insurance companies, traditional carriers and tech startups are reportedly able to have active discussions in real time.
>
> South Carolina. The South Carolina Department of Insurance (SCDI) reportedly utilizes its regulatory discretion within its existing regulatory framework to allow innovators to identify regulatory barriers to implementing their new and innovative ideas, and to work with the SCDI to remove those barriers. Under this approach, the SCDI maintains a watchful eye, but is open to using its regulatory flexibility to encourage the development of innovative insurance products.

Disrupter 2. Shifting Liability

With the advent of CAVs, liability for incidents will likely shift (Barnes, 2017, pp. 13-14). Currently, all state laws assume that a human will get a license and that a human is going to drive a car, but this approach is already evolving.

In February 2016, the National Highway Traffic Safety Administration told Google that its self-driving system could be viewed as a driver under existing regulations, even though it stopped short of allowing Google to remove the steering wheel from its car (Golson, 2018).

During the transition from partially to fully autonomous vehicles, if the vehicle is operated manually and driven for personal use only, there will still be a need for personal auto insurance. However, if the vehicle is operated autonomously, the technology manufacturer would be liable for covering losses, since the software, not the person, is driving. Personal comprehensive coverage would also be necessary for damage to the vehicle that results without any driver or technology error (KPMG Insurance Task Force, 2017, p. 33).

The "next generation" legal analysis of culpability from accidents will therefore likely move from the consumer to the auto manufacturer. As that occurs, liability constructs will gradually shift from duty, breach and causation to distinguishing between whether it was the human or the technology that was in control of the vehicle at the time of the accident (Cole, 2016, p. 9).

A shift in risk from consumers to manufacturers will likely consolidate risk exposure by providing insurance to both the driver and the manufacturer (KPMG Insurance Task Force, 2017, pp. 19-23).

Recognizing that the average individual is not financially equipped to deal with a multiparty suit against major manufacturers (Brunette, 2018), at least three automobile manufacturers have already announced that they will accept liability. Volvo Car Group was one of the first companies to announce that it would accept liability whenever one of its vehicles is involved in an accident and the vehicle is in autonomous mode (KPMG Insurance Task Force, 2017, p. 6). Mercedes and Google have also made similar moves (KPMG Insurance Task Force, 2017, p. 11).

Cole and McCullough, in their piece for the *Journal of Insurance Regulation*, point out that, "[p]hysical damage coverage may become mandatory, given the potential costs of repairs to expensive, critical systems that would need to get vehicles back on the roadway. An alternative would be to require 'critical repair' coverage to be included in the purchase costs of vehicles" (Cole, 2016, p. 9).

Additionally, the need for uninsured motorist coverage may become obsolete if the manufacturer is absorbing the risk (Cole, 2016, p. 9). Moreover, GAP insurance,[1] currently required on some automobile loans and leases, may no longer be needed if liability shifts from the traditional auto insurance model to a products liability model.

The insurance community is also discussing a no-fault approach to assigning financial responsibility for CAVs involved in accidents (Zmud, undated, p. 22). The no-fault approach allows accident victims to recover damages from their auto insurer without having to make a claim against the other driver who was involved in the accident or that driver's insurer.

No-fault insurance would likely clarify liability, and depending on the statutory language, reduce or eliminate manufacturer liability. However, the concept of no-fault insurance may be opposed by members of the plaintiffs' bar because it may reduce access to the court system and prevent suits against otherwise culpable motorists and manufacturers (Zmud, undated, p. 22).

[1] GAP insurance is the difference between the actual cash value of a vehicle and the balance still owed on the financing (car loan, lease, etc.) at the time of an accident. GAP coverage is mainly used on new and used small vehicles (cars and trucks) and heavy trucks.

Some other possible alternatives to existing personal liability auto insurance include:

- Converting all auto insurance coverage from third party to first party insurance;
- Designing insurance products for pedestrians; and
- Christine Kogut's SPLASh Pool (Supplier Product Liability Autonomous Share) pool, where the carmaker would assume all the product liability risk for accidents and stemming from the autonomous technology and cede the risk to the SPLASh pool (Brunette, 2018).

Last but not least, traditional insurers will have to reevaluate their legal strategy to address the shift in exposures, including the ways in which claims are investigated and processed and how the core concepts of reservation of rights and subrogation fit in to overall legal strategies (KPMG Insurance Task Force, 2017, p. 11). Insurers will also have to reevaluate underwriting criteria. Although traditional criteria such as the number and kind of accidents an insured has had, the miles driven annually and where the car is garaged may still apply, the make, model and style of car may become more important factors in underwriting the risks associated with CAV mobility (Cole, 2016, p. 9).

At the end of the day, whatever the model(s) adopted, the decisions concerning allocating risk will likely fundamentally inform the nature of the exposure and thus the coverage for that exposure, well into the future. (Gould, 2018)

Disrupter 3. Mobility on Demand

Shared mobility may reduce the demand for personal automobile ownership, and therefore the need to purchase personal auto insurance. Additionally, the shift to fleets of vehicles will likely shift the insurance product mix from personal insurance lines to commercial lines, and, as discussed above, will likely shift driving risk away from both the individual and fleet owners and towards the auto manufacturers (KPMG Insurance Task Force, 2017, pp. 19-23).

The following is a non-exhaustive list of insurance products that are emerging to insure against risks associated with ride hailing/sharing:

- Pay-as-you-go – ride share/hailing/robo-taxi models;
- Usage-based insurance;
- Insurance that is included with the purchase of the vehicle;
- Fleet and individual products;
- Subscription based products; and
- Innovation in "InsurTech" products – InsurTech companies are exploring avenues that large insurance firms have less incentive to exploit, such as offering ultra-customized policies, social insurance, and using new streams of data from internet-enabled devices to dynamically price premiums according to observed behavior.

Note that if the vehicle is used for both commercial and personal use, as is the case with mobility-on-demand, the same personal comprehensive and collision coverages would be necessary as when the vehicle is operated for personal use. However, commercial coverage would be required when the vehicle is operated for business purposes (driving customers and accepting fares), with a possible hybrid form of collision and comprehensive insurance being developed to accommodate this business model (KPMG Insurance Task Force, 2017, p. 33).

V. Understanding how data generated by automobiles, including CAVs is used

Data collection is not new. Since the 1960s, vehicles have been equipped with diagnostic systems and "event data recorders" that capture accident data (Holley, 2018).

What is new, however, is that auto manufacturers are currently collecting large amounts of data concerning individual drivers and their driving habits. Using these data, companies are able to determine such things as where the driver shops, what are her/his daily commuting habits, how often s/he wears a seatbelt, and what the driver was doing moments before an accident.

Additionally, the data being collected no longer stays with the car. Those data can be distributed electronically via the Internet of Things (IoT). (Holley, 2018)

The troves of data currently collected by onboard computers using AI will increase exponentially as vehicles move closer to full autonomy. Those data can be characterized into three broad categories:

- Driving data – information generated by the vehicle such as speed, breaking, acceleration, etc.'
- Activity data – what the passengers are doing and saying during the ride; and
- Environmental data – data on the vehicle externalities such as weather, road conditions, location, etc.

(KPMG Insurance Task Force, 2017, p. 12).

Data are invaluable to the understanding of broad risk exposure as well as risk exposure from a particular policy holder. Companies can "reap significant benefits from analyzing this information by being better able to assess and underwrite risk, process claims, and prevent fraud" (KPMG Insurance Task Force, 2017, p. 12).

Additionally, data collection can be used to outsource customer preferences and for the "greater good," such as to improve transportation, reduce emissions and save lives with automatic crash detection (Holley, 2018).

Processing big data through the use of AI can also help bring different levels of transparency to policy writing and claims processing. By disclosing to the policy holder the predictors used in pricing models, insurers can nudge consumers into engaging in preventative behaviors. When a consumer understands the predictors that an insurance company uses to price a policy and what they, as a consumer, can do to lower their premium, it is increasingly likely that accident prevention can help reduce loss incidents (A.M. Best Company, Inc., 2018, p. 5).

When an accident does occur, AI can help with the analysis of the claim. The result is that we can have an automated claims system where claims can be evaluated and paid in a matter of seconds not weeks.

As Best Analytics states, "The advancement in predictive analytics has already improved the accuracy of risk pricing and has the potential to prevent future losses by enhancing loss control and risk management practices. It is also being used in fraud detection and for more targeted marketing" (A.M. Best Company, Inc., 2018, p. 5).

However, using big data and predictive analytics is not without its challenges. For example, boundaries concerning the legality, nature and extent of collecting and analyzing policyholder personal data gleaned from third party sources such as search engines and social media are beginning to be set through litigation. (A.M. Best Company, Inc., 2018, p. 5) (*See e.g.* Carpenter v. United States, 585 U.S.__, 6/22/2018, in which the US Supreme Court held that police will generally need a warrant for sustained cellphone location information). Other issues concerning personal privacy are discussed in the chapter of this report prepared by the Subcommittee on Technology, Security & Privacy.

Additionally, regulators have already begun to express concern about the use of more advanced underwriting tools as a disguise for impermissibly profiling certain demographic groups (A.M. Best Company, Inc., 2018, p. 5). The inability of regulators to know exactly what data are going into the models due to its sheer volume will represent a challenge to ensuring that the data are not used by insurers to create unfairness in pricing or access to insurance, each of which could pose a real potential for consumer harm. If regulators cannot understand what data form the basis of insurance rates, it is correspondingly unlikely that the consumer will understand exactly how their individual insurance score is calculated (Ledogar, 2018).

In anticipation of the rapid development of risk predicting algorithms that use big data and AI, some states have already enacted laws directed towards insurers that are worded to adjust for the use of big data in predictive modeling. For example, New Hampshire requires that:

> Every insurer shall file with the commissioner every manual, **predictive models or telematics models or other models** that pertain to the formulation of rates and/or premiums, minimum premium, class rate, rating schedule or rating plan and every other rating rule, and every modification of any of the foregoing which it proposes to use (emphasis added).

(*See NH Rev. Stat.* § 412:16-II (2016)).

Delaware currently regulates the use of telematics in private passenger vehicle insurance issued to individual policyholders primarily for personal, family or household purposes. The statute, which was approved on May 8, 2014:

- Requires an insurer seeking to install a data-reporting device in a private passenger vehicle, or seeking to use a previously installed device for the purpose of obtaining data, to inform the policyholder of such installation or use of the data that may be obtained by the insurer from such device, and how the installation or use and removal or discontinuation of such device can affect the cost of insurance coverage;

- Prohibits an insurer from installing or using a data reporting device in a private passenger vehicle unless an insured listed as the policyholder consents to such installation or use;

- Requires that the disclosure of any nonpublic personal information and any nonpublic confidential information collected by a vehicle data reporting device be governed by 18 *Del.C* § 535 (which governs the privacy of consumer and financial and health information and how, when and where such information may be disclosed) and its associated regulation at 18 *DE Admin. Code* §§ 904-1.0 – 904-16.0;

- Requires that any private passenger vehicle insurance rating plan that uses data obtained by a vehicle data-reporting device be subject to the Department's rate setting statute at 18 *Del.C.* § 2501 *et seq.* and the implementing regulations at 18 *Del. Admin. Code* §§ 1902-1.0 – 1902.6.0; and

- Defines a data reporting device as any device that is capable of maintaining, transmitting, or storing, a vehicle's telematics and driving data.

(*See* 18 *Del.C.* § 3918). Note that the statute does not apply to policies issued to commercial entities or individuals who obtain insurance products or services for business, commercial or agricultural purposes.

VI. Understanding Cyber Security and CAVs

As previously discussed, CAVs are connected to each other and to the IoT, and where there is connectivity, there is the possibility of a data breach. In fact, the cyber vulnerability of CAVs has been identified as one hurdle to full implementation because it is real, as demonstrated by the successful 2015 hack of a driving Jeep by researchers who were located 10 miles away from the CAV they hacked (Brunette, 2018).

Unlike most hacking today, malicious cyber interference with a driverless automobile could result in serious personal injury and property damage. At present, there is little financial motive to hack into cars, but this may change with the advent of ransomware and more widespread deployment of CAVs. "State-sponsored cyberattacks causing mass disruption to critical transportation infrastructure, as well as potentially mass casualties, are also a matter that transportation officials rightfully take very seriously. . . " (Peterson, 2017).

The top cyber threats are socially engineered malware, password phishing attacks, unpatched software, social medial threats, advanced persistent threats, and vendor insecurity (Schmoyer, June 19, 2018). Just as any of these methods can be utilized to bring down an individual company's internet infrastructure, so too can they be used to disrupt CAV networks.

The NHTSA recognized this vulnerability, and released cybersecurity guidelines in October of 2016. Auto manufacturers are also stepping up to the plate. For example, Volkswagen partnered with tech companies to create new cybersecurity firm, CYMOTIVE Technologies, in September 2016 to help it address this threat (Brunette, 2018).

Aon Inpoint, a data analytics, engagement and consulting team, has found that over the past five years, cyber premiums across all business lines saw the most significant growth at 23% annually. Aon Inpoint predicts that by 2021, worldwide premiums will be worth $4 billion, which represents a compound annual growth rate of 14.1%. This growth is attributed to a broad based trend of putting a greater value on intangible assets, such as cyber and intellectual property (Heft, 2018). In fact, companies large and small have elevated cyber security from being "just an IT issue" to being a major component of corporate risk management. Individual end users are also becoming increasingly aware and educated about the threat of cyber breaches in their daily lives, and the advent of CAVs has brought this topic front and center.

Currently, CAV manufacturers appear to be focusing consumer education campaigns devoted to convincing regulators and the public at large that CAVs are safe, but the insurance companies and insurance regulators know that this is a transitory issue which demographic changes will soon enough elucidate. The other two areas of focus are connectivity and payments and many diverse stakeholders are needed at the table before we will be able to gain a full understanding of these issues. (Gould, 2018)

The European Union's General Data Protection Regulation (GDPR), effective May 25, 2018, represents a significant shakeup in privacy protections because it gives European citizens more control over their online information. (Rodriguez, 2018) Companies are also required to report any data breach within 72 hours and must be able to provide their European customers with a copy of their personal data and to be able to delete those data at customer request. Non-compliance can lead to fines of four percent of annual global revenues (A.M. Best, 2018).

The GDPR is likely to have a global impact because it applies to all companies that do business with Europeans, and most deeply affecting those business sectors that collect large amounts of customer data (Rodriguez, 2018) such as the insurance. A particular challenge to compliance with the GDPR is the way that the GDPR has been incorporated into the laws of individual EU member states, but this has reportedly also lead to heightened pre-event planning and training, increasing the overall level of preparedness. (A.M. Best, 2018)

NAIC's Innovation and Technology Task Force's Cybersecurity Working Group (also discussed in the next section) recently disbanded after adopting its model cyber security law. From the NAIC press release:

> The National Association of Insurance Commissioners adopted the Insurance Data Security Model Law [On October 24, 2017] during a joint meeting of the Executive (EX) Committee and Plenary. The model law, adopted during National Cybersecurity Awareness Month, creates rules for insurers, agents and other licensed entities covering data security, investigation and notification of breach. This includes maintaining an information security program based on ongoing risk assessment, overseeing third-party service providers, investigating data breaches and notifying regulators of a cybersecurity event (NAIC, 2017).

The Department will evaluate the model law in the coming months, including compatibility with Delaware's recently updated Data Breach Law, 6 *Del. C.* § 12B-100 *et seq.*, which requires that:

> Any person who conducts business in this State and owns, licenses, or maintains personal information shall implement and maintain reasonable procedures and practices to prevent the unauthorized acquisition, use, modification, disclosure, or destruction of personal information collected or maintained in the regular course of business (*see* section 12B-101); and
>
> Any person who conducts business in this State and who owns or licenses computerized data that includes personal information shall provide notice of any breach of security following determination

of the breach of security to any resident of this State whose personal information was breached or is reasonably believed to have been breached, unless, after an appropriate investigation, the person reasonably determines that the breach of security is unlikely to result in harm to the individuals whose personal information has been breached (*see* section 12B-102).

In the meantime, on September 22, 2017, the Department released "Universally Applicable Bulletin No. 3," which requests insurers to notify the Department of a data breach or other disclosure of confidential consumer information (see https://insurance.delaware.gov/wp-content/uploads/sites/15/2017/09/Universally-Applicable-Bulletin-003.pdf).

VII. Understanding State budgetary impacts from possible shifts in premium tax income revenues

The largest source of revenue collected by the Department is the insurance premium tax, most of which is deposited directly into the General Fund. The remaining portion of that tax revenue is distributed to volunteer fire companies, the City of Wilmington Fireman's Pension Fund, ambulance service providers throughout the State, and the Police Pension Fund (*see* 18 *Del.C.* Chapter 7).

According to Department records, the auto premium tax has generated an average of 15%, or $1 million of the total annual insurance premium taxes paid into the State coffers over each of the past 10 years. To the extent that we see disruptions in the types of auto insurance products offered, we may see a gradual decrease in the auto premiums generated, which, in turn, will decrease the amount of taxes generated by those premiums.

However, two factors concerning the amount of premiums generated may offset each other. On the one hand, the reduction in the number of accidents will lower expected losses. There is thus the potential for savings pass through to consumers as lower premiums, which will result in lower premium taxes.

On the other hand, the increase in replacement value of vehicles due to the added expense of the CAV technology will likely have an upward effect on premiums and therefore an upward effect on premium taxes (Ramsey, 2017, p. 17). The surcharge placed on the vehicle for the CAV technology itself will likely initially be $10,000, but will likely fall to around $3,000 as the technology advances and is more universally deployed (Barnes, 2017, p. 11).

Shifts in auto premium tax collected, to the extent that they occur, will likely not be immediate. Between now and full deployment, automobiles with various levels of autonomy will be sharing the road, with sales of CAVs likely beginning within the next five to ten years (Barnes, 2017, p. 10). Some analysts predict that 50 percent of all vehicles sold in 2040 would be CAVs, and that by 2060, nearly all of the vehicles in the marketplace would be CAVs (A.M. Best Company, Inc., 2018, p. 6). However, "widespread ownership of these vehicles will probably take much longer because of increased costs, regulations, and [lack of] public acceptance" (A.M. Best Company, Inc., 2018, p. 6).

That said, revised ways of thinking about mobility are already emerging. For example, by 2025, self-driving taxis could be commonplace. Additionally, renting someone else's car while they are not using it is on the horizon (Insurance Journal, 2018).

Esurance researchers believe that once driverless ridesharing is widely accessible, two-car households might be willing to go to just one car and some urban one-car households might drop their cars entirely, thereby saving families more money in transportation costs (Insurance Journal, 2018) and in insurance costs. If this phenomenon occurs as predicted, families would need to purchase less auto insurance, which would exert corresponding downward pressure on insurance premiums and therefore on the insurance premium tax collected.

Additionally, with the exponentially greater interest in cyber insurance discussed elsewhere in this chapter, decreases in auto premium tax may be offset by increases in the tax on cyber insurance premiums. Another variable that may have an upward effect on premium tax collected may be an increase in taxes generated from the anticipated influx of new, non-traditional insurers into the insurance marketplace. Taxing mechanisms will likely need to be restructured to ensure that they apply to these new entities.

Accordingly, it is too early to tell what effect, if any, will result from shifting demands on automobile insurance premiums generated because we do not yet fully understand what new entities will enter the insurance market place or what products they intend to offer. Until we come to conclusions about who will be paying the premium tax and how many companies and consumers will be affected, we will not be able to accurately assess impacts on the State’s revenue stream or revenue sources.

VIII. Track and report on the progress of the National Association of Insurance Commissioners (NAIC) on position papers/model legislation and Federal/state legislation on insurance products that involve CAV insurance.

Three NAIC task forces and working groups are examining issues that are germane to the CAV discussion.

<u>Innovation and Technology (EX) Task Force.</u>

Autonomous vehicles fall under the purview of the Property and Casualty Insurance (C) Committee’s Innovation and Technology (EX) Task Force. The charge of this task force is to, “Discuss regulatory issues that arise with the development of autonomous vehicles; study and, if necessary, develop recommendations for changes needed to the state-based insurance regulatory framework; and consider development of a white paper or model legislation, if necessary.”

Big Data Working group

The concept of "Big Data" is being explored by the NAIC Big Data Working group as it applies across all insurance lines. Recommendations from this group's work will likely impact the collection, handling and storage of data collected from CAVS.

With the exception of prohibiting any risk classification from being based upon race, creed, national origin, or the religion of the insured, the models do not prescribe what data cannot be used for rating. Delaware's insurance laws were recently amended by HS1for HB80 concerning prohibiting certain risk classifications from being used in the setting of auto insurance rates, but otherwise, the same conclusion holds for Delaware.

Cybersecurity Working Group

NAIC's Innovation and Technology Task Force's Cybersecurity Working Group recently completed its task of addressing the issues surrounding cybersecurity risks and cyber risk management. At the October 24, 2017 meeting, the NAIC adopted the Insurance Data Security Model Law. The model law creates rules for insurers, agents and other licensed entities covering data security, investigation and notification of breach. This includes maintaining an information security program based on ongoing risk assessment, overseeing third-party service providers, investigating data breaches and notifying regulators of a cybersecurity event.

IX. Opportunities and Risks Related to the Subcommittee's Mission

A. Opportunities

The Department has identified the following as opportunities related to the Subcommittee's mission:

- Create a regulatory environment in which InsurTech innovators can discuss their proposed products with the Department on the front end of product development – possibly collaborate with other branches of Delaware State government that are already establishing a "tech-friendly" business atmosphere in Delaware.
- Consumer Protection and Education
  - Ensure that consumer protection keeps pace with changes in the marketplace and that consumers have information and education needed for informed decision making.
  - Work with governments, insurance companies and simulation software companies to understand the capabilities of autonomous vehicles and the risks/rewards posed by their deployment (includes both road test and simulation to understand a vehicle's basic roadworthiness).
  - Collaborate with fellow state regulators, members of the insurance industry and other stakeholders to ensure that newly minted insurance products are reliable, safe, and provide adequate coverage for consumers.
- Track NAIC model legislation and regulations and determine suitability for the Delaware Code and Administrative Code, respectively.
- Build the Department's talent pool with employees who understand how to use big data in underwriting so that the Department can accurately evaluate new products as they are presented, and accurately answer customer calls and complaints.

- Ensure that the Department understands the business models of new entrants into the mobility service sector and the insurance sector, including mega non-insurance companies that already are in the home like Amazon and Verizon, and that these new entrants understand what is involved in providing insurance to the public.
- Work with industry to develop a certification program where the requisite level of properly installed safety technology could result in a premium discount.

B. Risks

The Department has identified the following risks related to the Subcommittee's mission:

- A lack of legislation can and may result in the deployment of CAVs in Delaware without proper safeguards.
- Companies who have access to data about consumers, including insurance companies, are able to easily control their interactions with consumers, including using those data to the company's advantage, and to the possible disadvantage of the consumer.
- Overpromising on the rate of technology deployment and what the technology can and cannot do may lead to unsafe and unsatisfied consumers (Ramsey, 2017).
- Revenues from tax premiums may decrease, although this decrease may be offset by increases in taxes collected on premiums written on other insurance products.
- The development of new insurance products by innovators who are not currently in the insurance business may result in products being offered that are not truly insurance and that do not provide consumers with the protections they thought they were purchasing. As a result, consumers may find themselves under or uninsured at the time an accident occurs.
- The sheer quantity of data generated may result in premiums being written and coverage offered that is inaccurate or discriminatory. There should be a process by which consumers can understand what data is being utilized and for what purpose, and a mechanism that allows consumers to correct inaccuracies that is similar to the dispute mechanism currently available by which consumers may correct inaccuracies in their credit scores.

X. Potential State Legislation

- Reexamine parts of Chapter 18 to redefine automobiles and automobile insurance requirements, including minimum limits, who must have insurance, etc.
- If Delaware determines to allow CAV testing in this state, require that the testing entity provide evidence of the entity's ability to satisfy a judgment or judgments for damages for personal injury, death, or property damage caused by a CAV, whether that evidence is in the form of an instrument of insurance, a surety bond, or proof of self-insurance. Additionally, it would be appropriate to suspend permission to test if the entity fails to comply with the State insurance or driver requirements.
- Consider enacting filing requirements that are worded to adjust for the use of new data and predictive modeling such as the legislation enacted by New Hampshire by amending 18 *Del.C.* 2305(a)(1), which currently provides that, "Rates shall be made in accordance with the following provisions: (1) Manual, minimum, class rates, rating schedules or rating plans shall be made and adopted, except in the case of specific inland marine rates on risks specially rated; . . ."

- Consider adopting the NAIC Insurance Data Security Model Law as a Delaware Statute.
- As the NAIC drafts model laws and regulations, consider adopting them as appropriate for Delaware.

XI. Conclusion

As responsibility for executing driving decisions shifts from driver to vehicle, the risk against which insurance is written will shift concurrently away from driver liability and toward manufacturer (product) liability. Responsibility will remain with the states to regulate these products, but how they will be underwritten is to be determined and will vary by jurisdiction. From policy to procedures, there will be myriad new opportunities and challenges, both for the Department and the State at large, as Delaware moves forward in implementing connected and autonomous vehicle technologies.

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APPENDIX D: PRESENTATIONS & REPORTS

Delaware Connected and Autonomous Vehicles

November 16, 2017

Delaware Department of Transportation

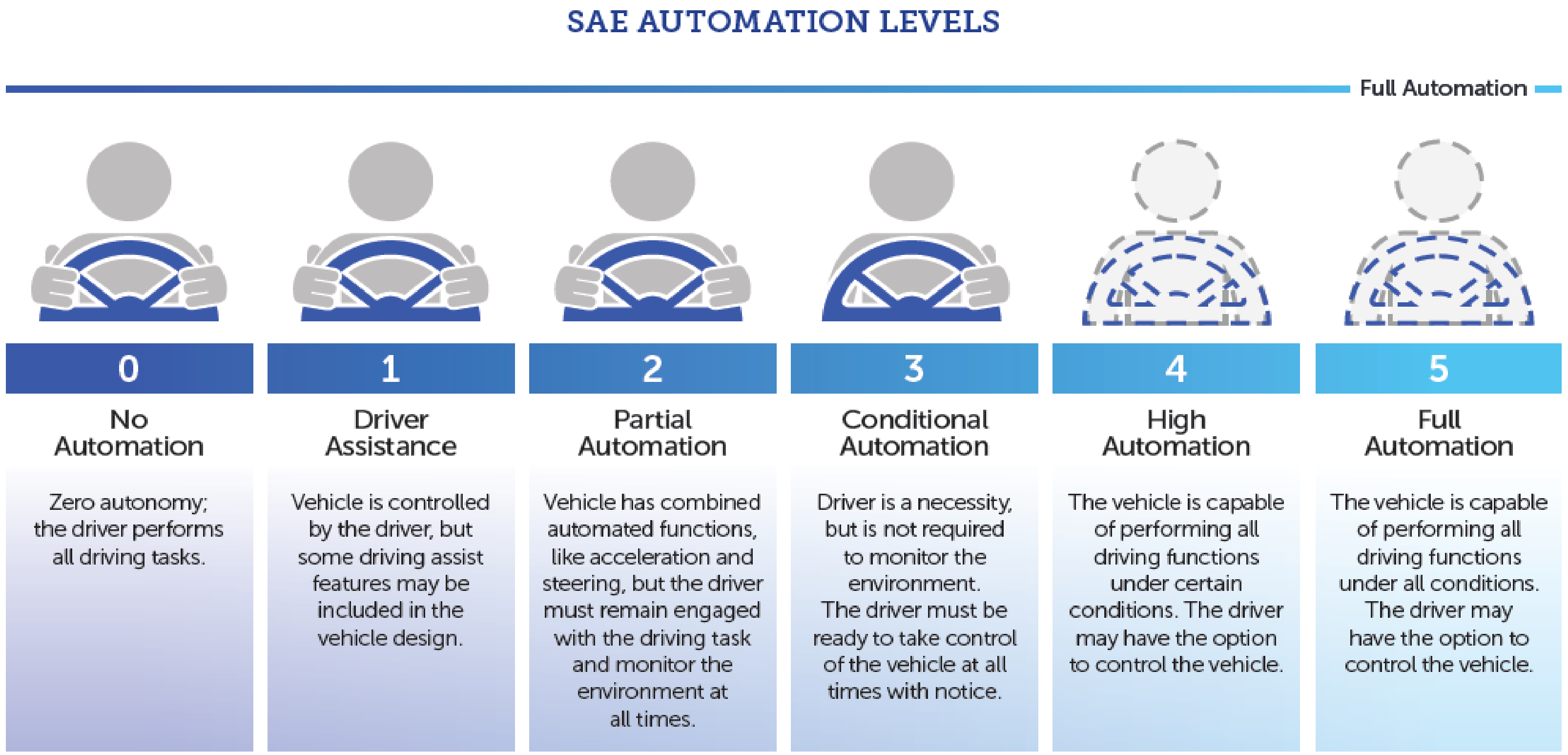
Department Wide Look

- Nearly every DelDOT division will be effected and has a role in the developing CAV conversation
  - Passenger vs. Driver
  - Narrower lanes
  - More capacity
  - ITMS
- DelDOT formed an internal committee with every division represented
  - Held first meeting in December 2016
  - 1/4ly meetings
  - Purpose, begin the discussion and understand everyone's role within the Department
    - Understand what each division has been working on toward CAV
    - CAV is too big to develop in a silo
    - Identify any barriers to CAV in Delaware
- Ensure we create an environment in DE that opens the door for this quickly evolving…life-changing technology

How is DelDOT Unique?

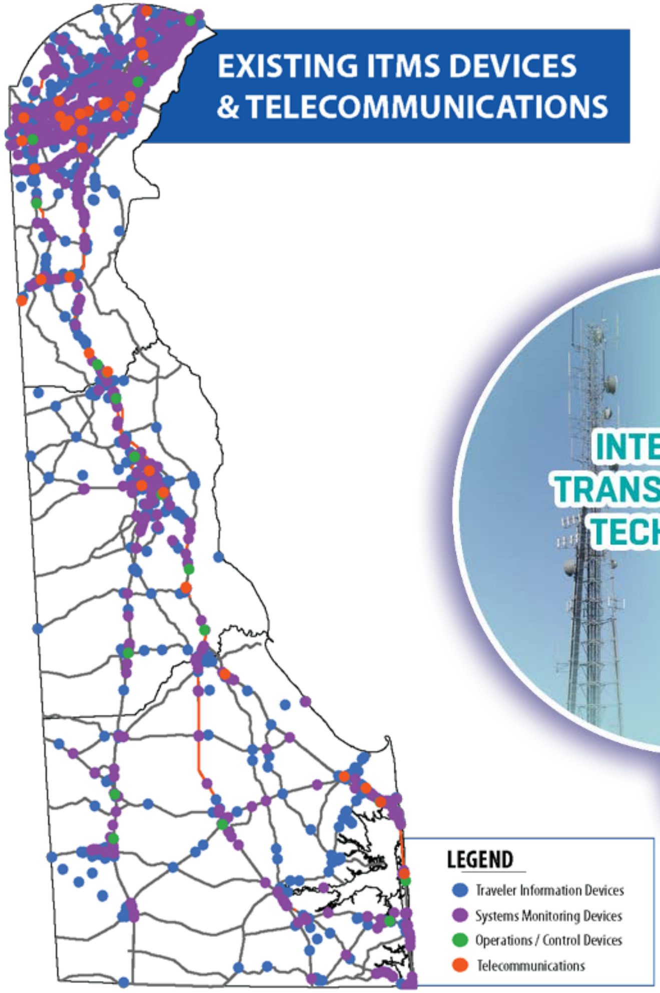
- Owns 90% + of roads
- Owns most traffic signals
- Operates the transit system
- Operates the tolls
- Truly multimodal
- Integration of planning and operations

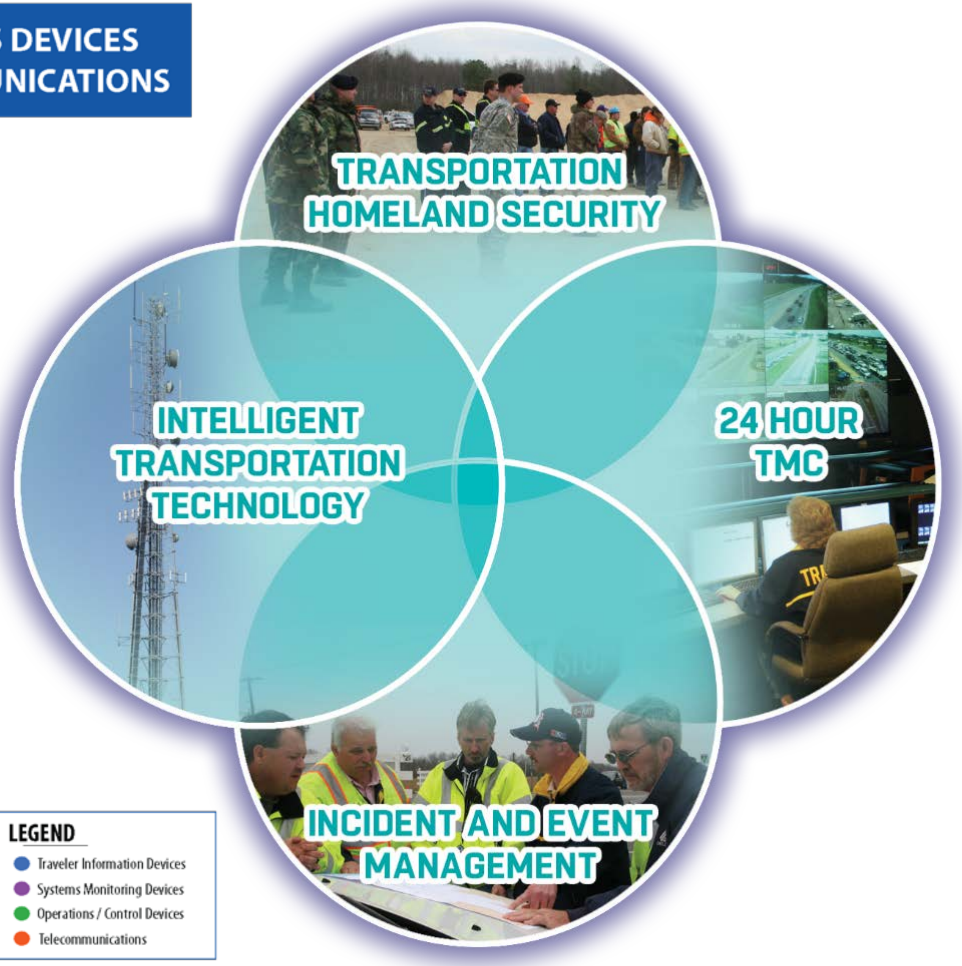
What is an Autonomous Vehicle?



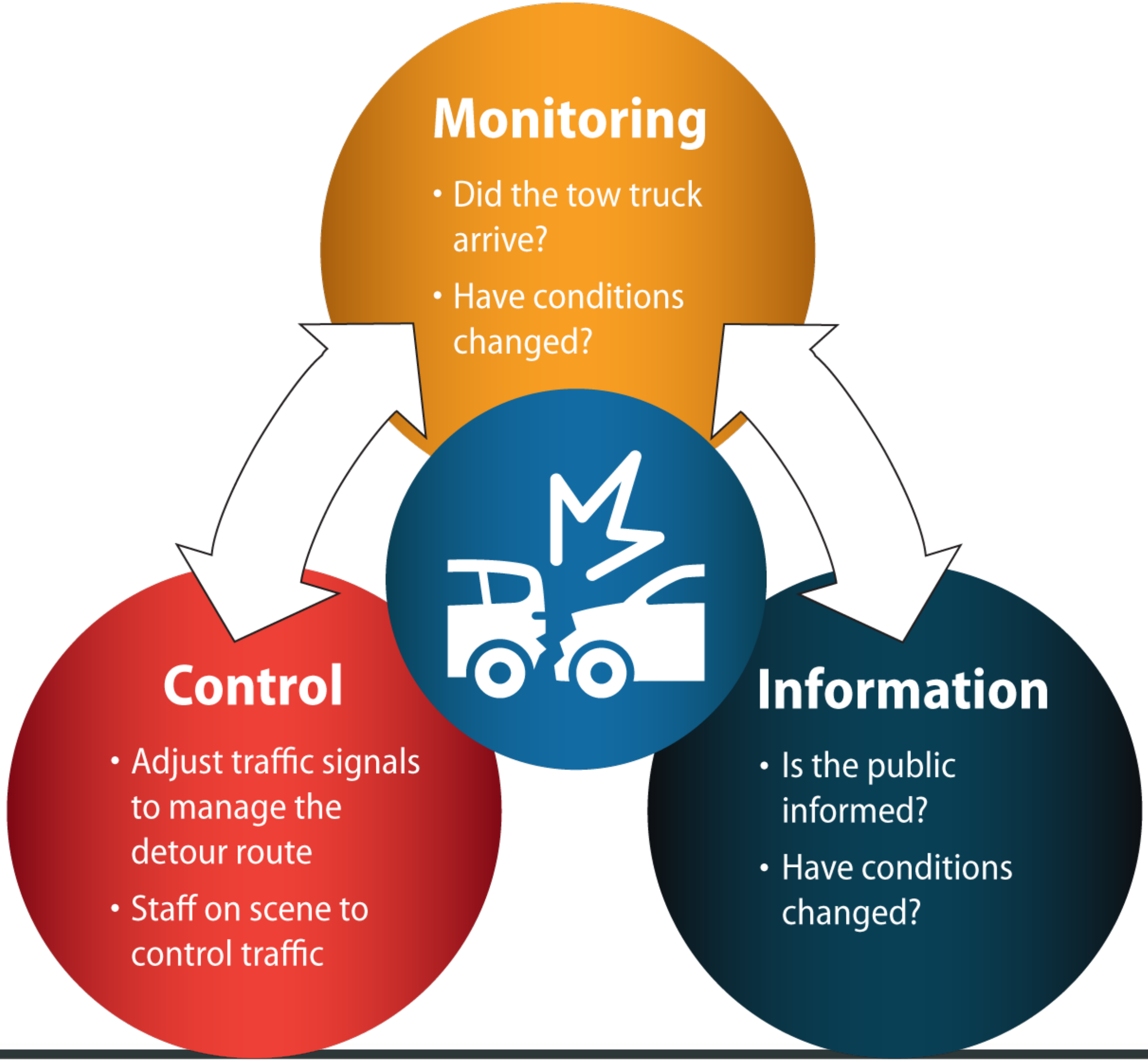
Automated Driving Systems 2.0: A Vision For Safety

Integrated Transportation Management System

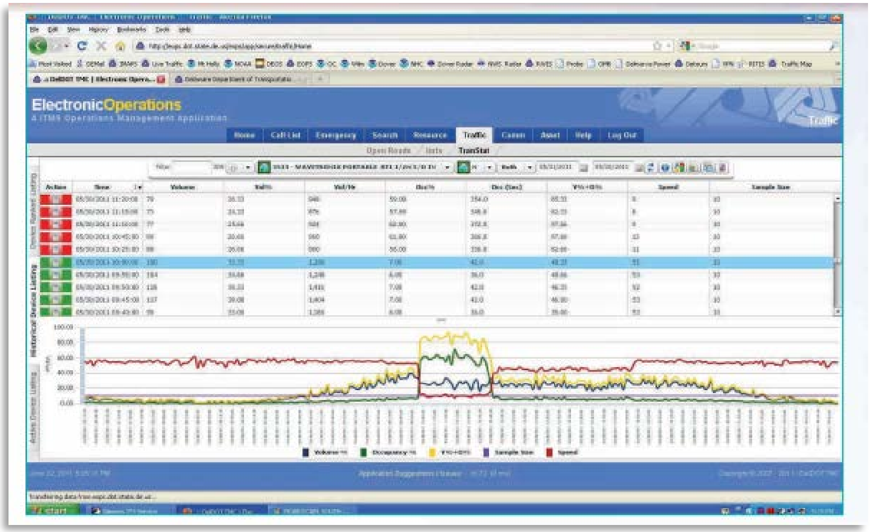




Three Critical Functions of ITMS



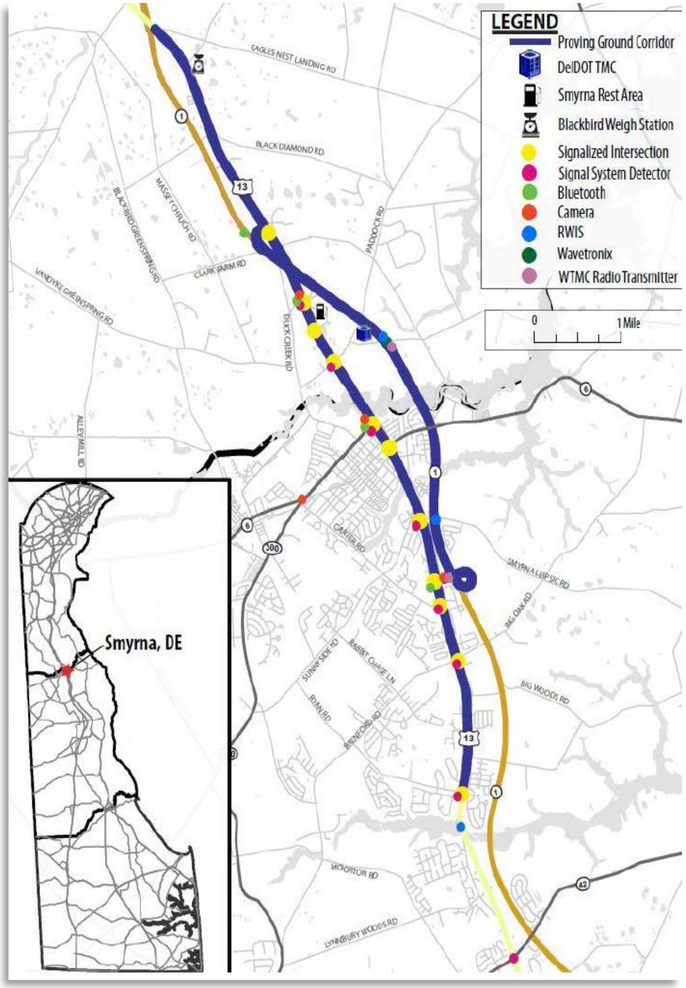
Integration of Operations and Planning



DelDOT ITMS Strategic Plan

- 2017 update to the ITMS Strategic plan
- Addresses Connected and Autonomous Vehicles

Smart Delaware: The Next Phase of ITMS



Ongoing Projects

- Connected Vehicle Enabled Weather Responsive Traffic Management (CV-WRTM)
- US 13 Technology Proving Ground
- Signal Phasing and Timing (SPaT) Challenge
- Machine Learning/Artificial Intelligence – Automating TMC Operations
- Dilemma Zone

DMV's Role

- Currently no law or regulation to prevent or enable the operation of a CAV in Delaware
  - As we progress through this process, that will be an area of focus
- The CAV conversation is rightfully a ***vehicle*** centered conversation
  - Historically the federal government has taken the lead a responsibility for regulating vehicle safety at the manufacturer level
  - States focus on the operation of those vehicles and ensuring they continue to operate safely
- Can't lose sight of the ***driver*** impact of CAVs
  - Will we need new levels of graduated driver licenses?
  - Specialized training?

DMV's Role

- The transition from now to a world where CAVs are common place will be the most challenging
  - Driver skills needs will vary depending on the level of automation
  - Driver trust of CAVs sharing the road will require time and education
  - DMV's regulatory responsibilities will evolve
- We remain engaged in the national conversation
  - Active members of AAMVA
  - Chief of Vehicle Services is a sitting member of the Autonomous Vehicles Information Sharing Group

American Association of Motor Vehicle Administrators

Automated Vehicles

November 16, 2017

Ian Grossman, AAMVA

American Association of Motor Vehicle Administrators

Overview

1. AAMVA Automated Vehicle Working Group
2. NHTSA Automated Vehicle Policy 2.0
3. Federal Legislation
4. State Approaches

Autonomous Vehicle Working Group Update

The AVWG The Working Group established fall 2014

Focusing on issues impacting testing and deployed vehicles:

- Drivers: Education, Testing, Licensing
- Vehicles: Permits, Registration and Title
- Law Enforcement: Concerns & Challenges

"Jurisdictional Guidelines for the Safe Testing and Deployment of Highly Automated Vehicles"

Report Outline
4 Sections

1. Introduction
2. Vehicle Classification, Terms and Technologies
3. Guidelines
4. Next Steps

Key Elements for State Use

SAE International Classifications, Terms, and Definitions

Concise summary of guidelines for jurisdictions:

- Administration
- Vehicle
- Driver
- Law Enforcement

Administrative Considerations

- Establish a lead agency and stakeholder committee
- Develop a strategy for addressing testing and deployment
- Examine laws and regulations in order to address unnecessary barriers
- Establish statutory authority
- Use NHTSA's guidance and this report to frame regulations

American Association of Motor Vehicle Administrators

Vehicle Considerations

- Application and permit to test AVs
- Automated Vehicle identification on registrations, titles and MCOs
- Use of standard license plates
- Insurance for testing and deployed vehicles

Driver Licensing Considerations

- Defines and discusses driver and passenger roles
- Driver license requirements for testing vehicles
- Driver training for consumers purchasing deployed vehicles
- Driver Training for Motor Vehicle Agency Examiners, Driver Education Programs and Private Instructors
- Driver License Skills Testing
- Endorsements and Restrictions not recommended

Enforcement Considerations

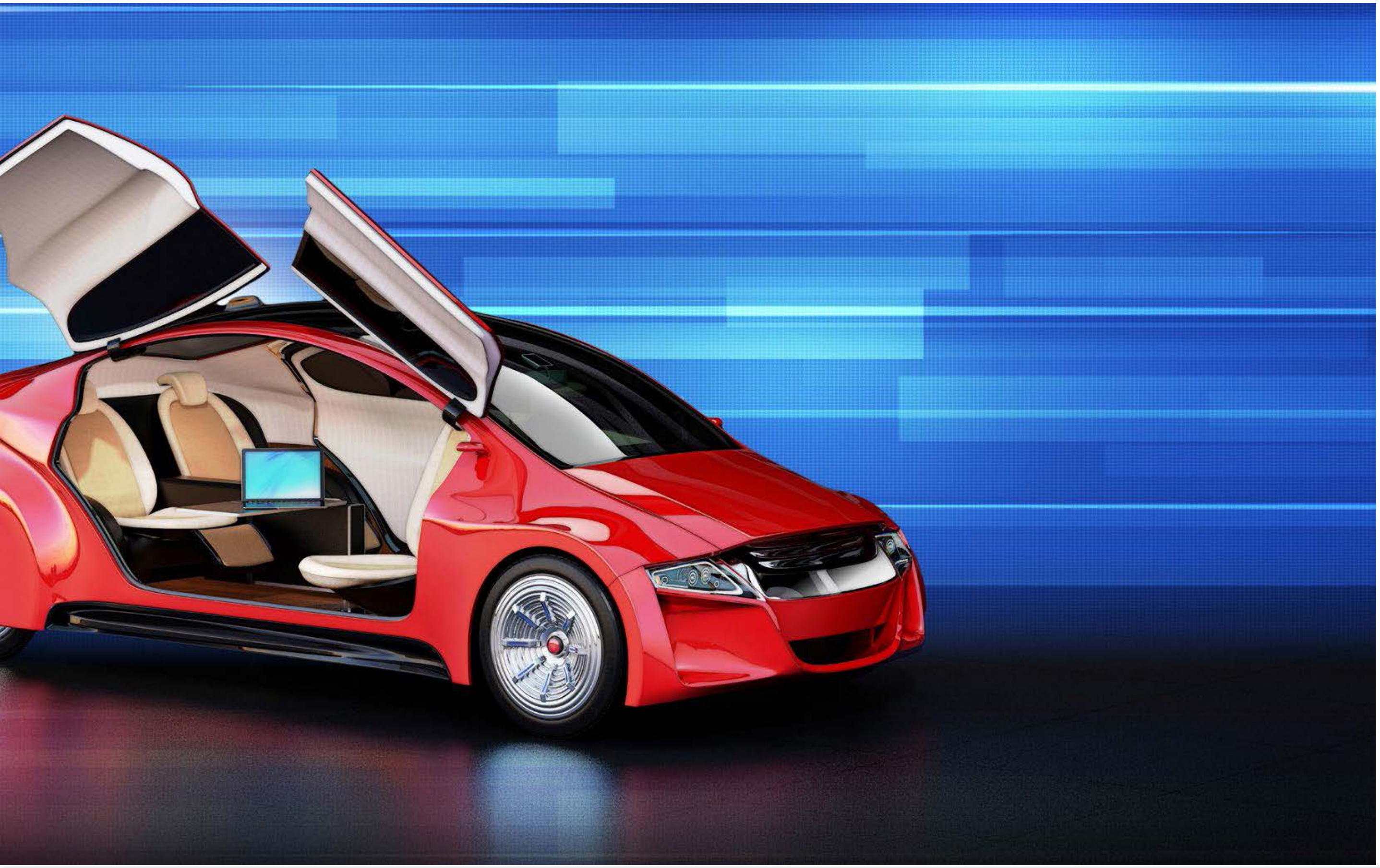
- Crash and incident reporting
- Criminal Activity
- Distracted Driving
- Enforcement of Permit Conditions
- Establishing Operational Responsibility
- First Responder Safety
- Law Enforcement/First Responder Training
- Response to Emergency Vehicles, Manual Traffic Controls and Atypical Road Conditions
- System Misuse and Abuse

NHTSA Vision for Safety

AUTOMATED DRIVING SYSTEMS 2.0

A Vision for Safety

Published September 12, 2017



Contains Two Sections:

1. Voluntary Guidance; and
2. Technical Assistance to States

NHTSA Automated Driving Systems 2.0

Section 1: **Voluntary Guidance;** *12 safety elements*

1. System Safety
2. Operational Design Domain
3. Object and Event Detection and Response
4. Fallback (Minimal Risk Condition)
5. Validation Methods
6. Human Machine Interface
7. Vehicle Cybersecurity
8. Crash Worthiness
9. Post Crash ADS Behavior
10. Data Recording
11. Consumer Education and Training
12. Federal, State, and Local Laws

The purpose of the Voluntary Guidance is to help designers of ADSs analyze, identify, and resolve safety considerations prior to deployment using their own, industry, and other best practices. Provide as public information. NHTSA approval not required.

NHTSA Automated Driving Systems 2.0

Section 2: Technical Assistance to States

- Federal and State Regulatory Roles
- Best Practices for Legislatures
- Best Practices for Highway Safety Officials
- Permission for Entities to Test ADSs on Public Roadways
- Specific Considerations for ADS Test Drivers and Operations
- Considerations for Registration and Titling
- Working with Public Safety Officials
- Liability and Insurance

A central repository of NHTSA resources will be maintained at:
www.nhtsa.gov/technology-innovation/automated-vehicles

Federal Legislation - House

HR 3388 – The SELF DRIVE Act

- Preemption based on whether or not it is "an **unreasonable** restriction on the design, construction, or *performance* of HAVs.
- Does detail a list of protected state interests and authorities.
- States may not prescribe any performance standards unless the standard is identical to a federal standard (FMVSS).
- Passed House under suspension of the rules by voice vote on September 6th.

Federal Legislation - House

HR 3388 – The SELF DRIVE Act

- Language includes a rulemaking requiring the submission of a safety assessment certification to DOT.
- Until the rulemaking takes place, safety assessment letters shall be submitted to NHTSA in accordance with federal guidance.
- The Act states that DOT may not condition deployment or testing of HAVs on review of the safety assessments.
- Manufacturers responsible for developing a cybersecurity plan for HAVs.

Federal Legislation - Senate

S. 1885 – AV START Act

- Prescribes preemption based on the specific subject matters relative to a safety evaluation report.
- However, the issue of what constitutes “vehicle performance” remains.
- Precludes states from issuing DLs in any manner that “discriminates on the basis of disability.”
- Mandates the submission of a safety evaluation report to DOT on prescribed subject areas.
- Passed the Senate Committee on Commerce, Science and Transportation on October 4th.

Federal Legislation - Senate

S. 1885 – AV START Act

- AAMVA has joined the following groups to form a coalition of State-based interests regarding HAVs:
  - National Governors Association
  - National Conference of State Legislatures
  - National Association of Counties
  - U.S. Conference of Mayors
  - National League of Cities
  - American Association of State Highway Transportation Officials
  - Governors Highway Safety Association
  - National Association of City Transportation Officials

Different State Approaches

- Granting permissions (such as permits to test) vs. limited restriction (testing not allowed on specific road types)
- Some require insurance up to $5 million per company (per incident)
- Program oversight varies between DOT, DMV, and Governor's office
- Regulations varies between statute, regulations, and executive order
- Incident reporting
- Most states require a human to be behind the wheel; soon to change

American Association of Motor Vehicle Administrators

Automated Vehicles

November 16, 2017

Ian Grossman, AAMVA

Smart Delaware

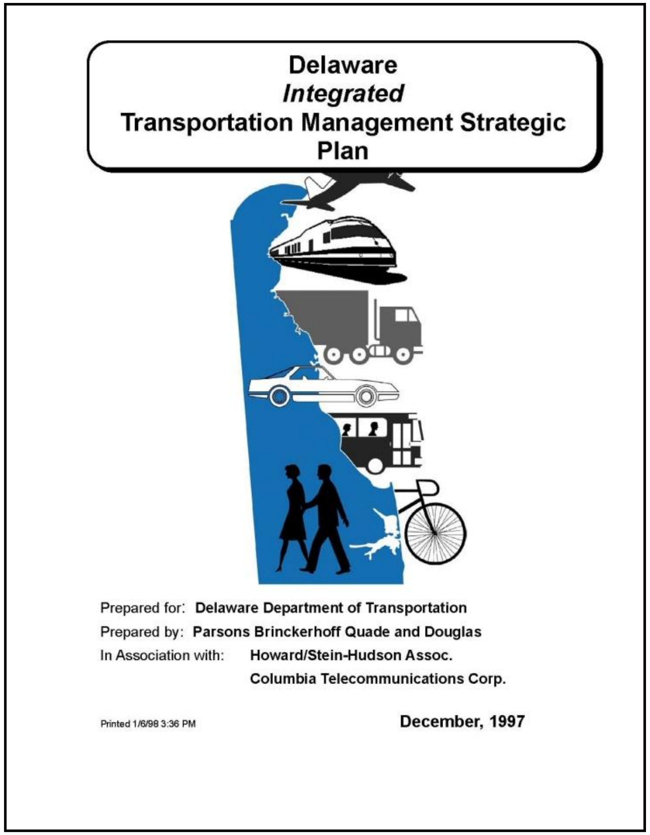
Delaware's Integrated Transportation Management System

Gene Donaldson, DelDOT

Delaware Department of Transportation

Integrated Transportation Management Strategic Plan (1997)

- Required a foundation for a shared mission and vision between all of Delaware's Transportation Management System stakeholders.
- The plan defined Delaware's Transportation Management:
  - Mission
  - Vision
  - Goals
  - Strategies for Implementation
- Defined a Statewide Transportation Management Program managed from a central transportation management center (TMC).



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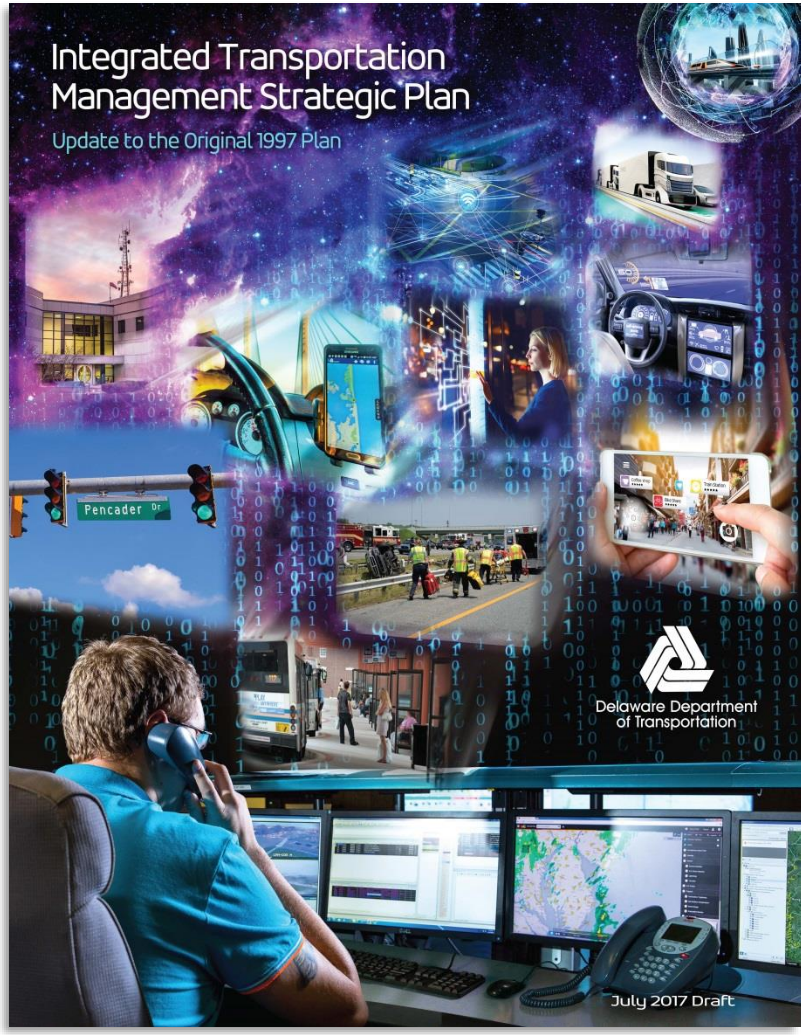

How is DelDOT Unique?

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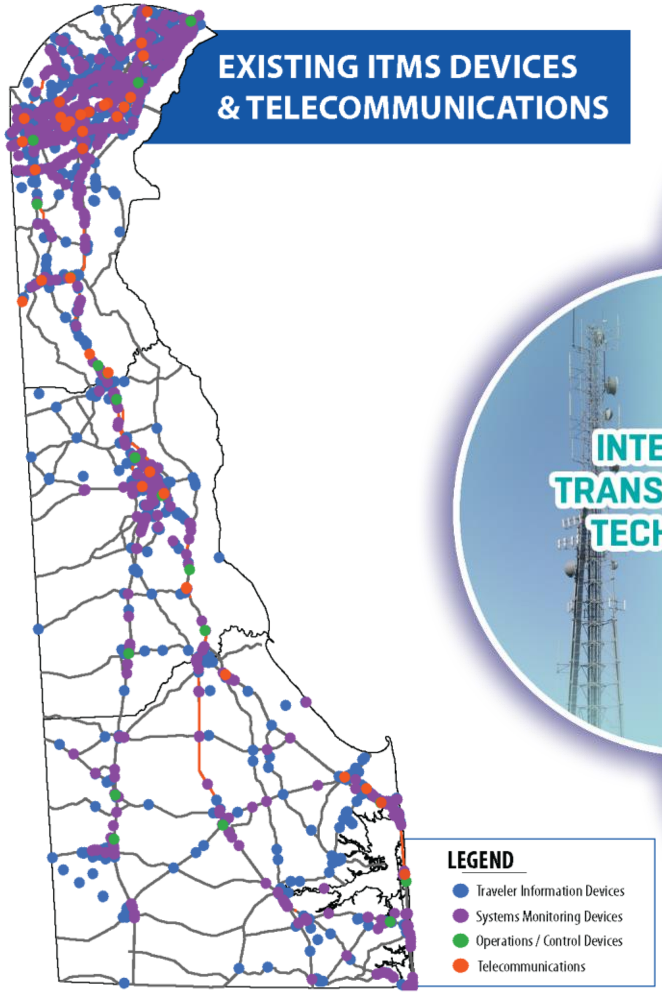
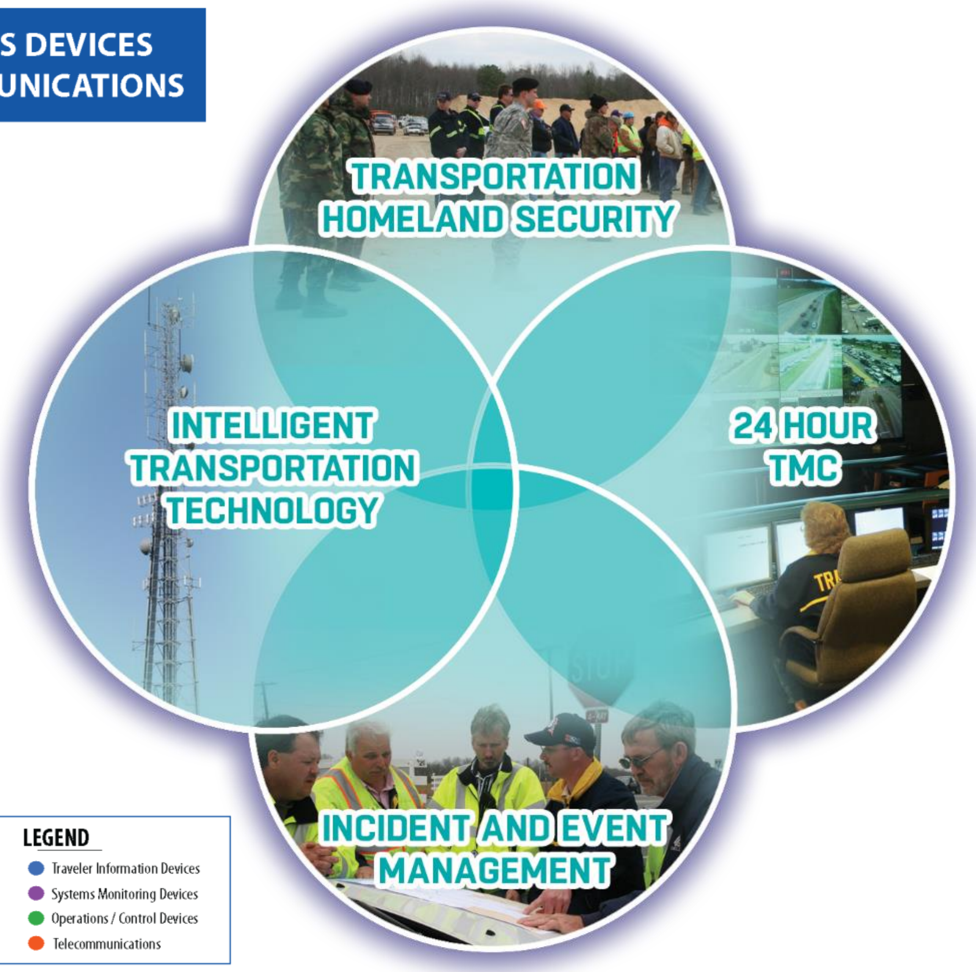
Integrated Transportation Management System





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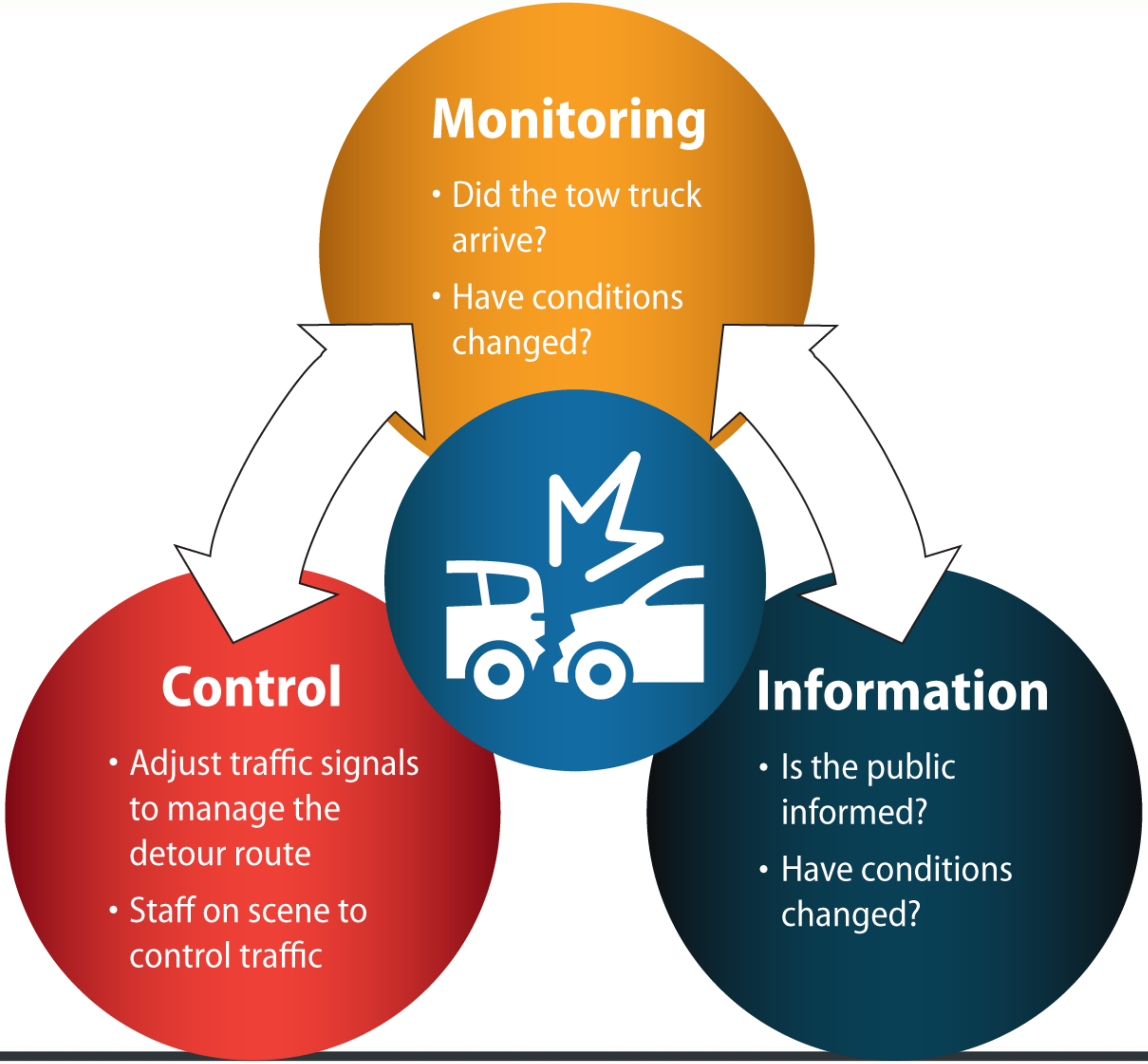

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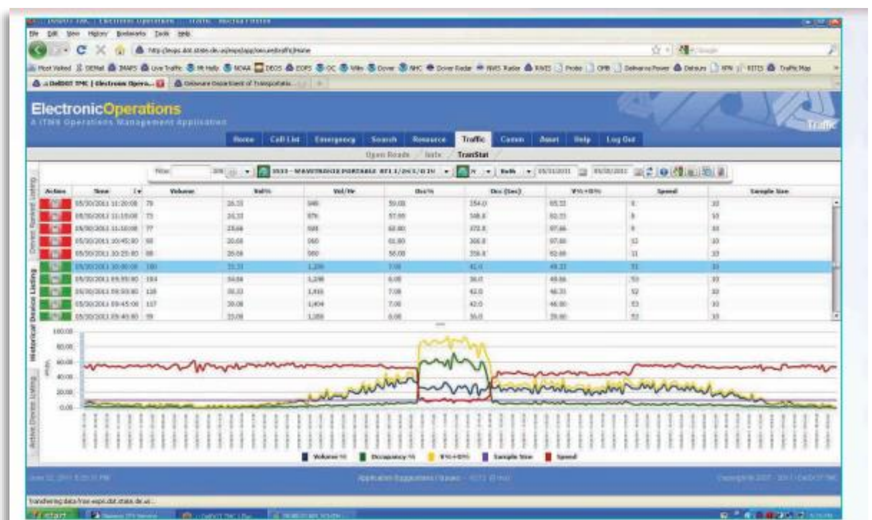


Smart Delaware: The Next Phase of ITMS

- A constant data-exchange between all modes
- Efficient transportation management decisions
- Reduced accidents, less congestion, reduced energy consumption, fewer emissions and improved travel times
- Enhanced mobility for all

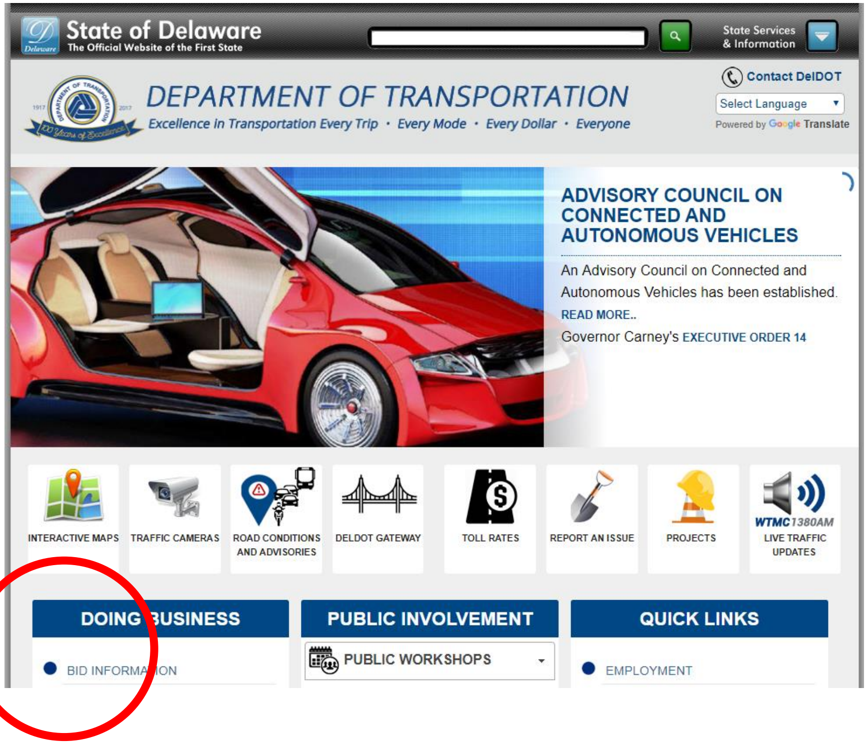
USDOT Smart City Expected Outcomes:
improve safety * enhance mobility * enhance ladders of opportunity * address climate change

What Can We Leverage?

- Existing Telecommunications Network
- Existing Delaware Transit Corporation Integration
- Existing Traffic Signal and ITS Device Integration into TMC
- Mobile App Download on the App Store GET IT ON Google play

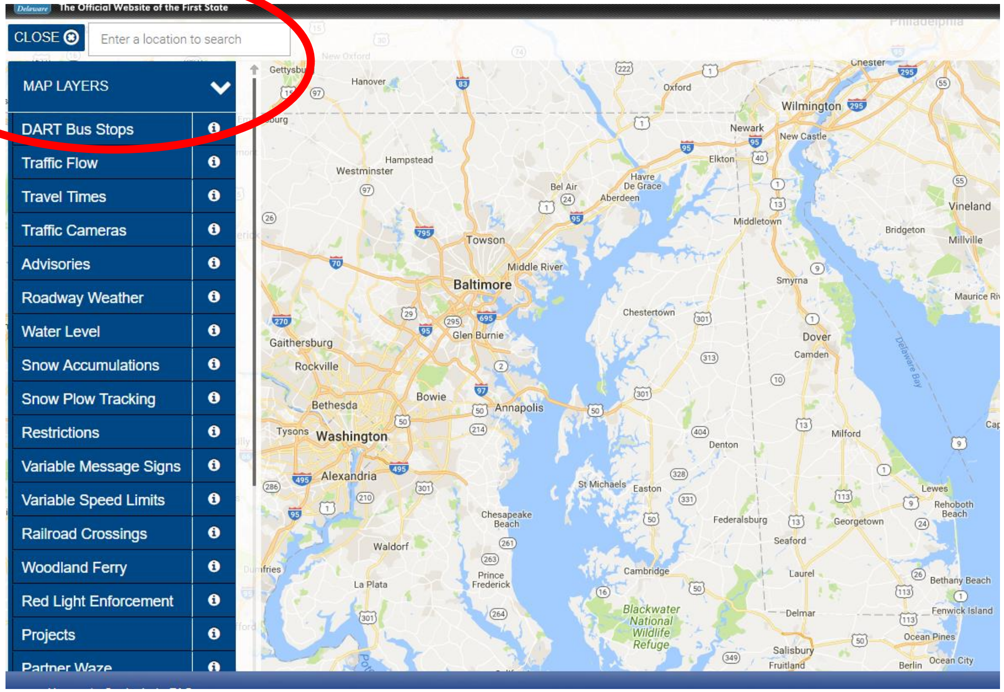
ITMS Interactive Map

www.deldot.gov

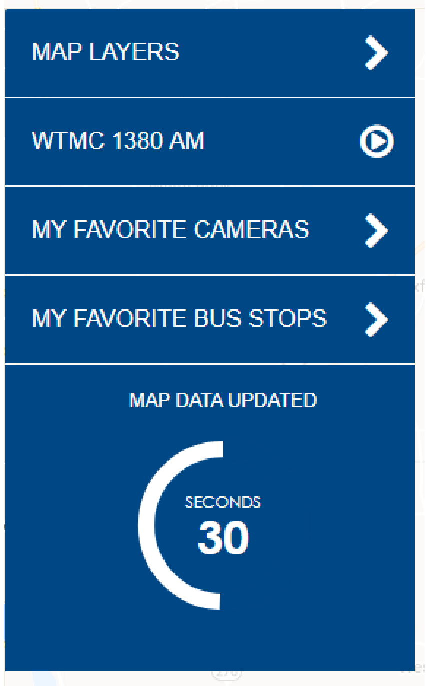


www.deldot.gov/map

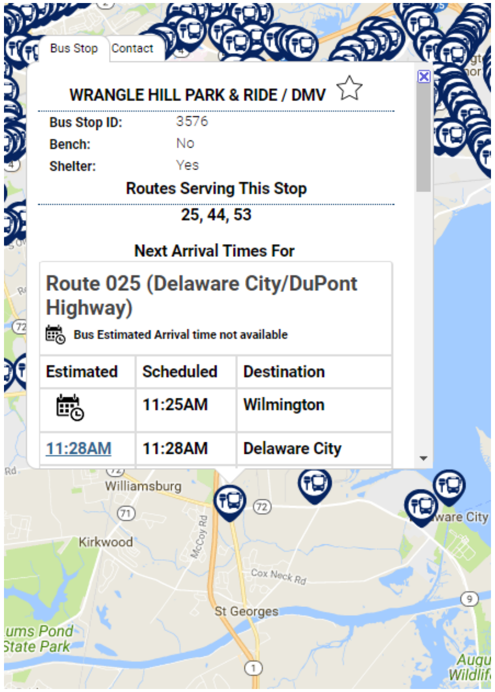
Map Layers


The Official Website of the First State
CLOSE
Enter a location to search
MAP LAYERS
DART Bus Stops
Traffic Flow
Travel Times
Traffic Cameras
Advisories
Roadway Weather
Water Level
Snow Accumulations
Snow Plow Tracking
Restrictions
Variable Message Signs
Variable Speed Limits
Railroad Crossings
Woodland Ferry
Red Light Enforcement
Projects
Baltimore
Washington
Wilmington
Dover
Annapolis

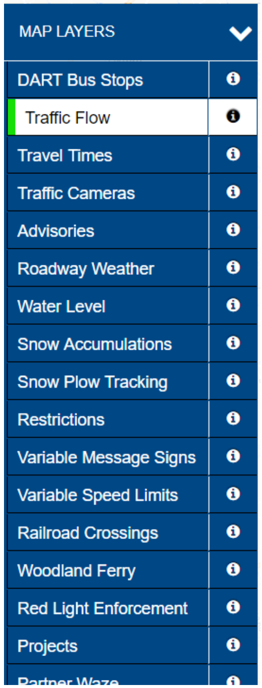
WTMC, Favorites

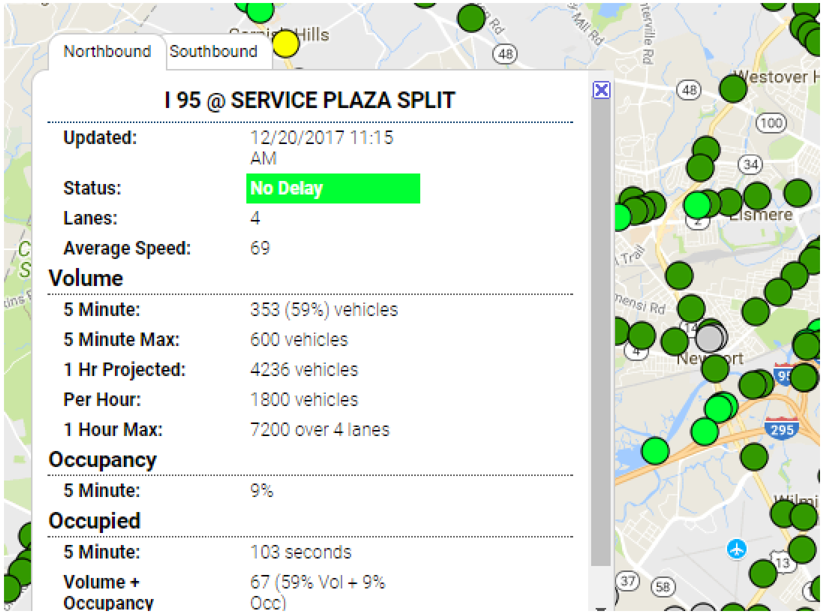


DART Bus Stops

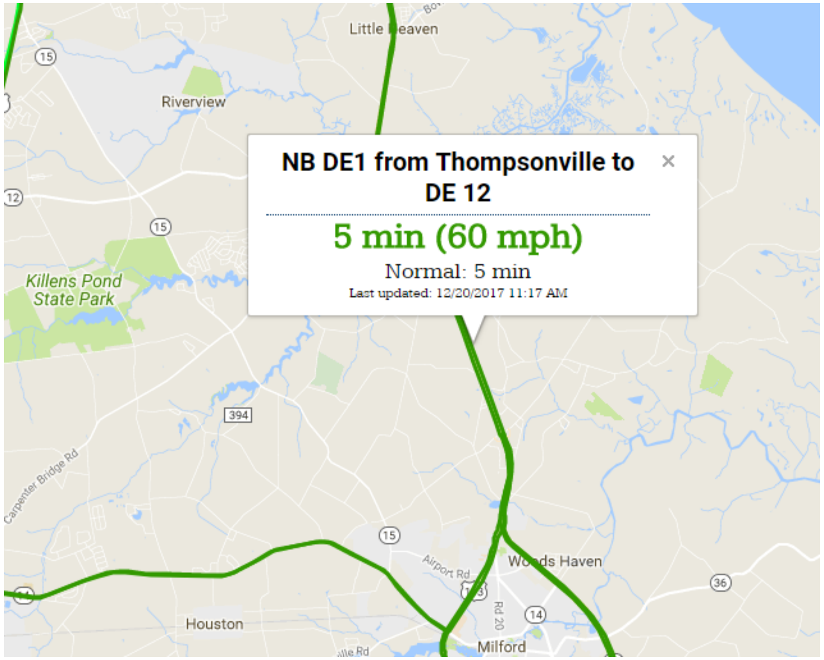


Traffic Flow

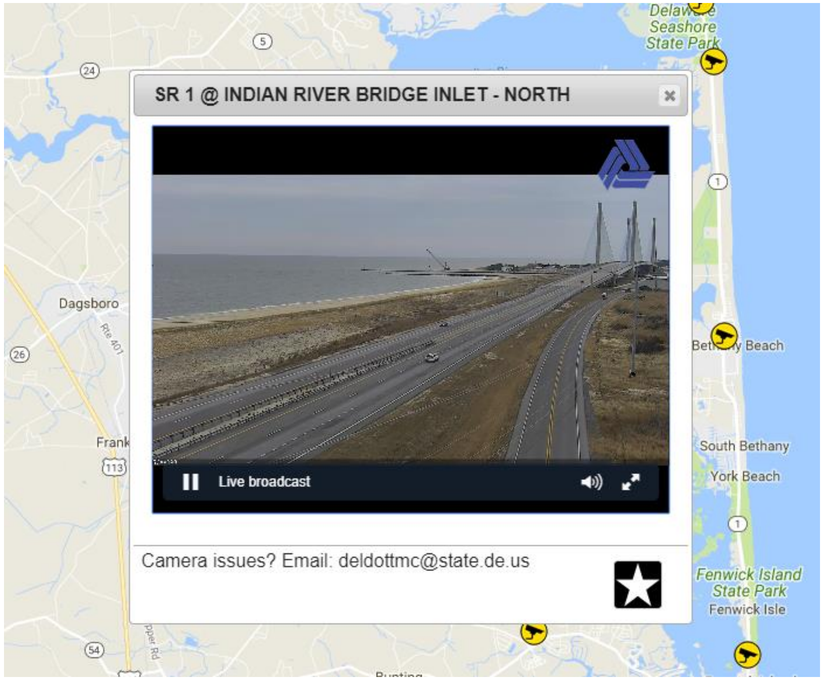




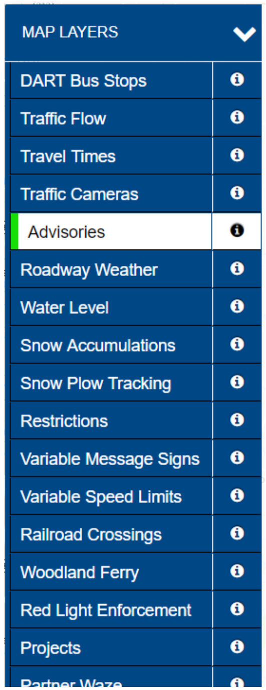
Travel Times

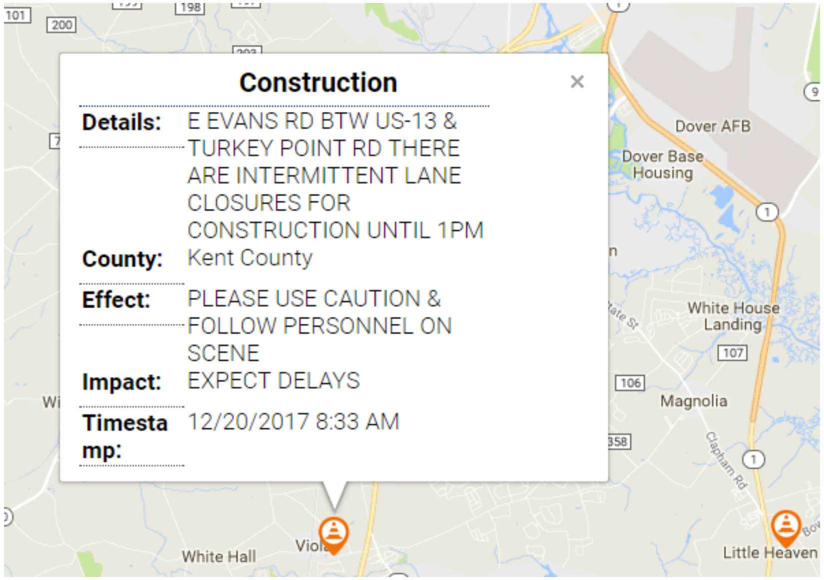


Traffic Cameras

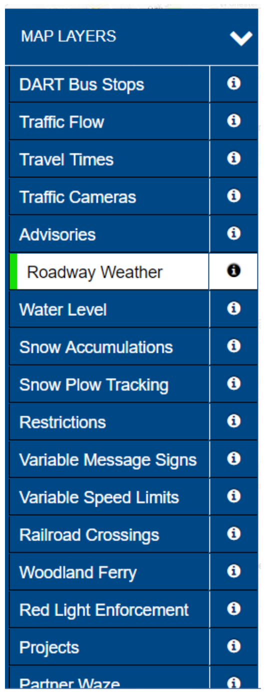


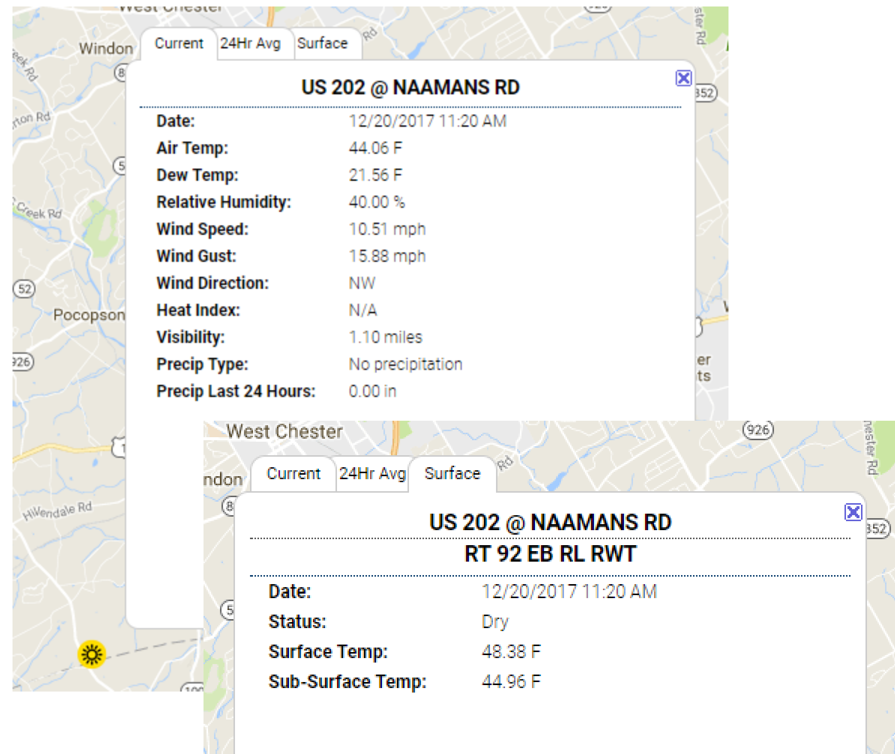
Advisories


MAP LAYERS
DART Bus Stops
Traffic Flow
Travel Times
Traffic Cameras
Advisories
Roadway Weather
Water Level
Snow Accumulations
Snow Plow Tracking
Restrictions
Variable Message Signs
Variable Speed Limits
Railroad Crossings
Woodland Ferry
Red Light Enforcement
Projects
Partner Waze

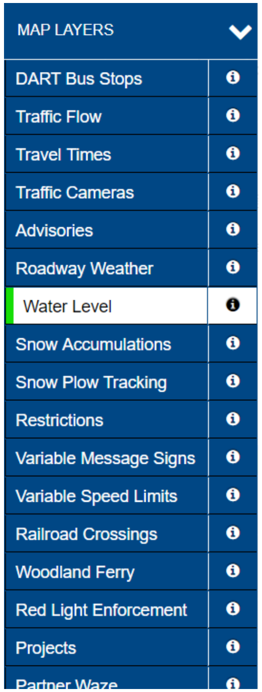

Construction
Details: E EVANS RD BTW US-13 & TURKEY POINT RD THERE ARE INTERMITTENT LANE CLOSURES FOR CONSTRUCTION UNTIL 1PM
County: Kent County
Effect: PLEASE USE CAUTION & FOLLOW PERSONNEL ON SCENE
Impact: EXPECT DELAYS
Timestamp: 12/20/2017 8:33 AM
Dover AFB
Dover Base Housing
White House Landing
Magnolia
White Hall
Little Heaven

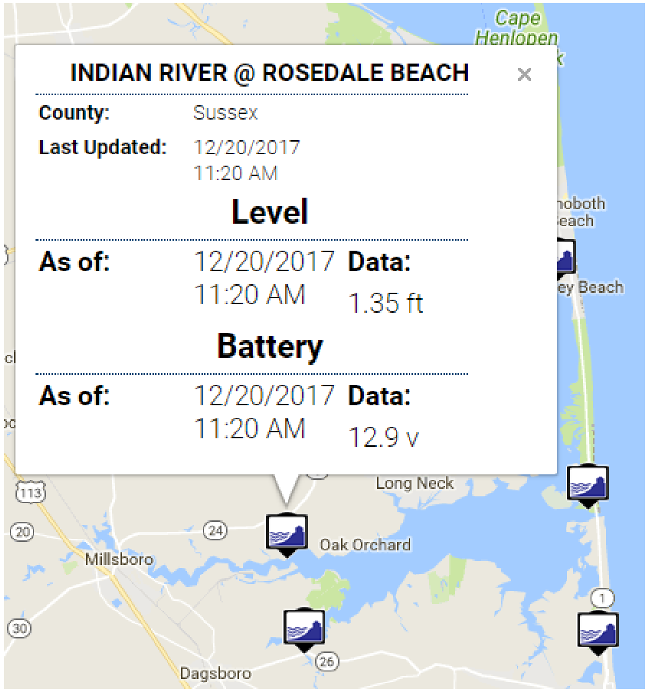
Roadway Weather



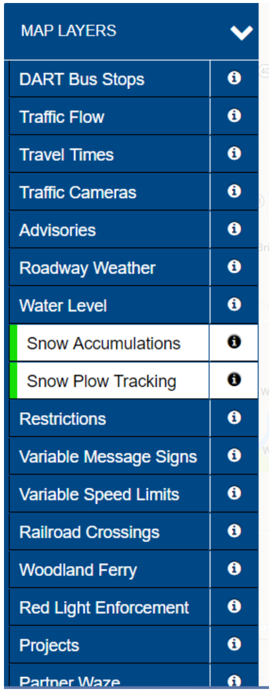


Water Level

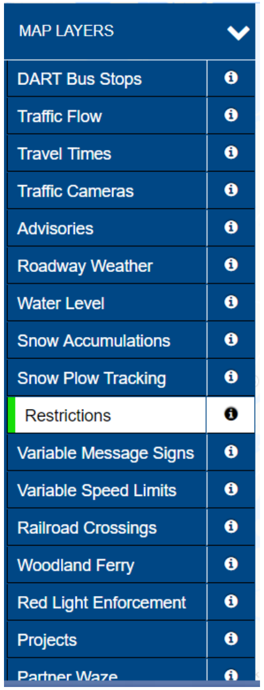

MAP LAYERS
DART Bus Stops
Traffic Flow
Travel Times
Traffic Cameras
Advisories
Roadway Weather
Water Level
Snow Accumulations
Snow Plow Tracking
Restrictions
Variable Message Signs
Variable Speed Limits
Railroad Crossings
Woodland Ferry
Red Light Enforcement
Projects
Partner Waze

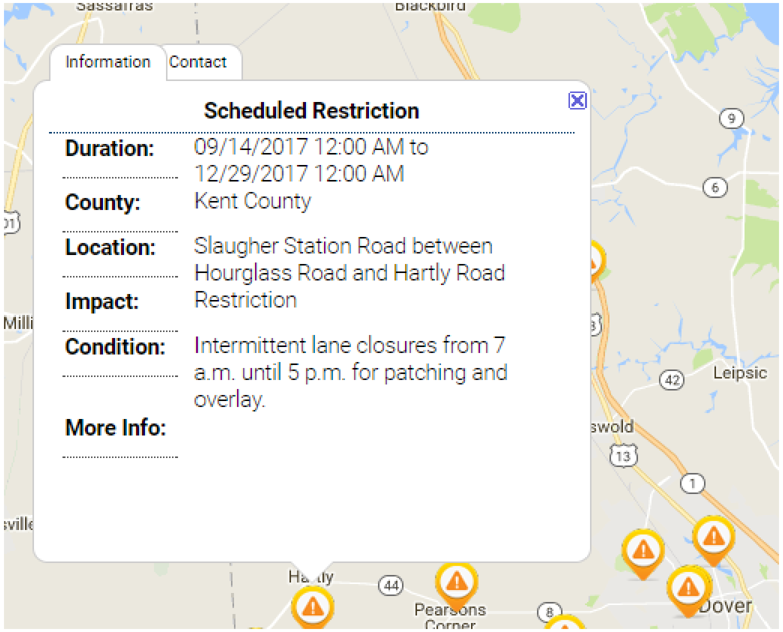

INDIAN RIVER @ ROSEDALE BEACH
County: Sussex
Last Updated: 12/20/2017 11:20 AM
Level
As of: 12/20/2017 11:20 AM
Data: 1.35 ft
Battery
As of: 12/20/2017 11:20 AM
Data: 12.9 v
Cape Henlopen
Long Neck
Oak Orchard
Millsboro
Dagsboro

Snow Accumulation and Snow Plow Tracking

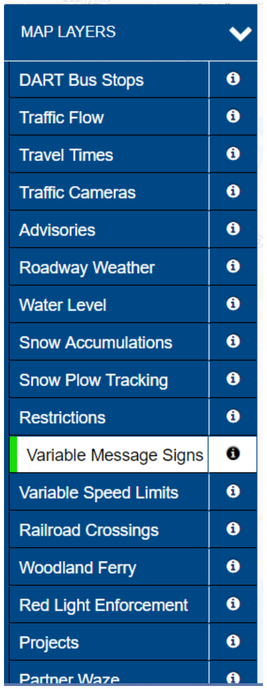


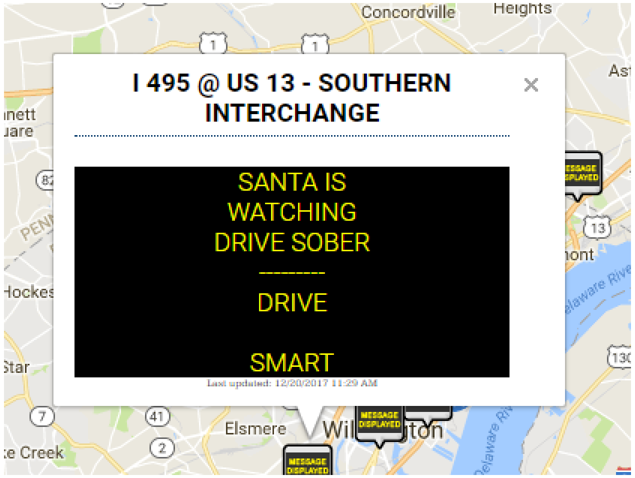
Restrictions



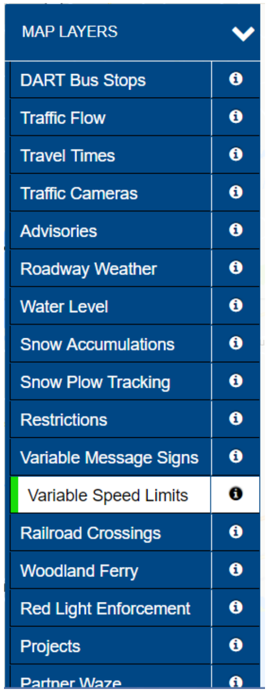


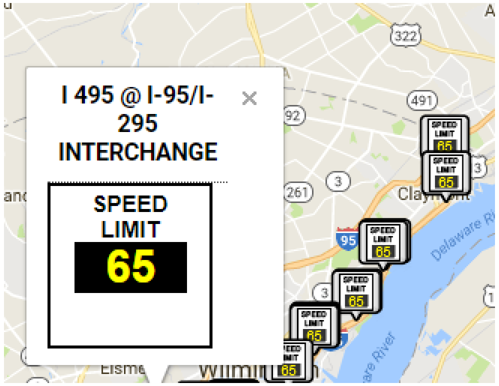
Variable Message Signs



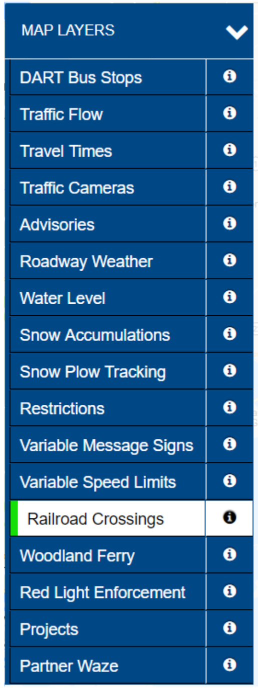


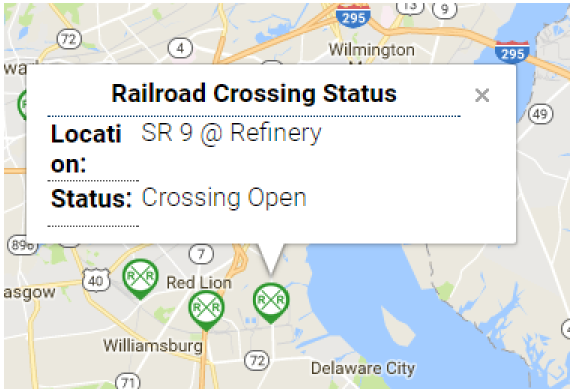
Variable Speed Limits



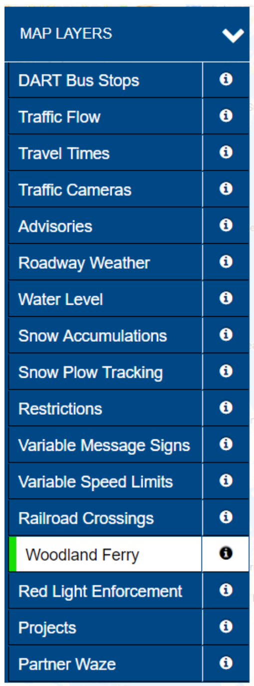


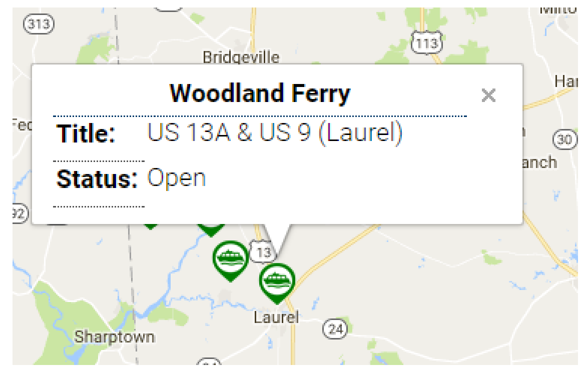
Railroad Crossings



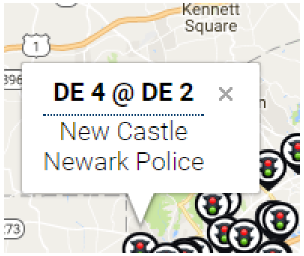


Woodland Ferry





Red Light Enforcement



Projects


MAP LAYERS
DART Bus Stops
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Traffic Cameras
Advisories
Roadway Weather
Water Level
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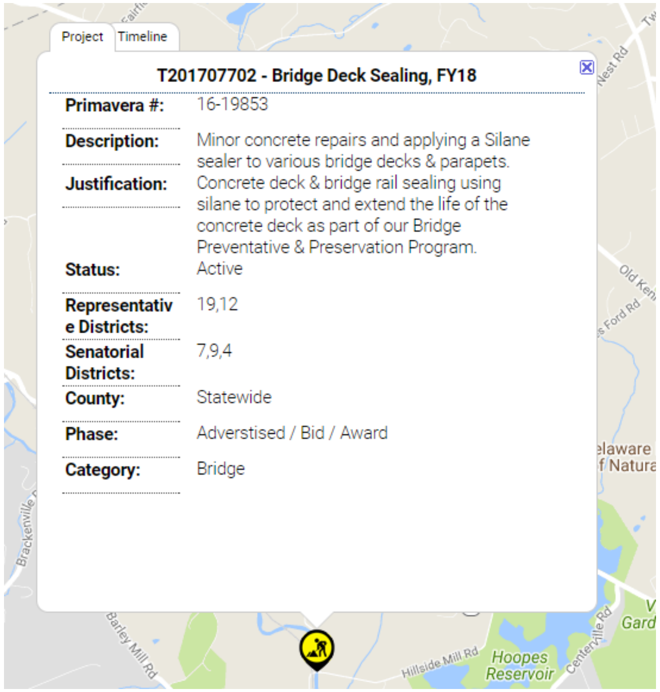
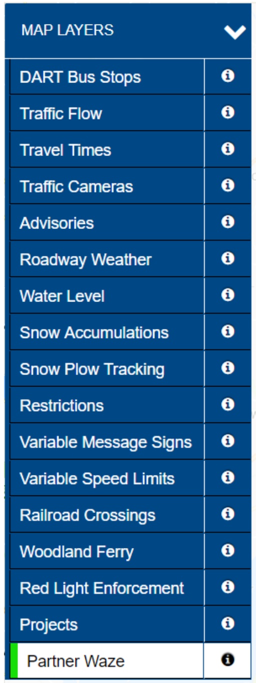
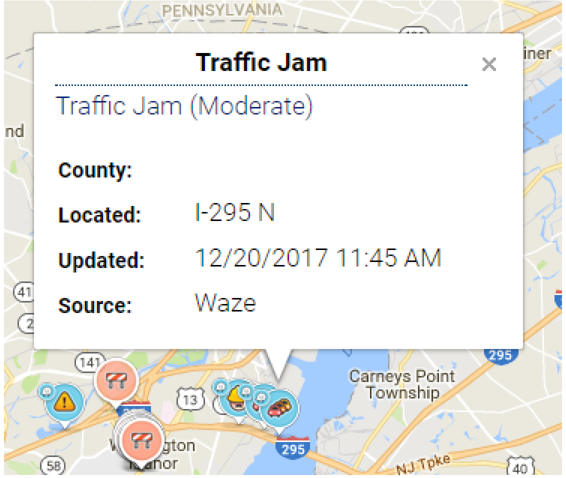

Project
Timeline
T201707702 - Bridge Deck Sealing, FY18
Primavera #: 16-19853
Description: Minor concrete repairs and applying a Silane sealer to various bridge decks & parapets.
Justification: Concrete deck & bridge rail sealing using silane to protect and extend the life of the concrete deck as part of our Bridge Preventative & Preservation Program.
Status: Active
Representative Districts: 19,12
Senatorial Districts: 7,9,4
County: Statewide
Phase: Adverstised / Bid / Award
Category: Bridge
Hoopes Reservoir

Partner Waze





Connected-Automated Vehicle Research at the Univeristy of Delaware

December 21st, 2017

Governor's Advisory Council on Connected and Automous Vehicles

Philip Barnes, Ph.D.
School of Public Policy and Administration
Institute for Public Administration
University of Delaware

Researchers at UD

Andreas Malikopolous – Mechanical Eng., Autonomous Vehicles

Nii Attoh-Okine – Civil Eng., Big Data and Network Optimization

Tom Powers – Philosophy, Autonomous Vehicle Ethics, Decision-Making

Mark Nejad – Civil Eng., Multi-Layer Network Optimization

Troy Mix – Institute for Public Administration, Autonomous Freight

John McNutt – Public Policy & Admin., Civic Technology, E-Government

NSF Research Team

Andreas Malikopolous – Mechanical Engineering

Timothy Vickery – Psychological and Brain Sciences

Benjamin Seibold – Mathematics (Temple University)

Philip Barnes – Institute for Public Administraiton, School of Public Policy

Sunita Chandrasekaran – Computer Science, Big Data Analysis

UD’s “Smart City”

Looking ahead…

Looking ahead…

UD Data Science Institute?

Looking ahead…

"The Biden Institute will be complemented by the addition of new faculty, increased enrollment in the school, and an initiative to expand the school's offerings in the areas of **smart cities**, environment and energy, social justice, and disaster management."

Thank you!

Questions?

I (may) have answers.

Strategies to Advance Automated and Connected Vehicles

DETAILS

30 pages | 8.5 x 11 | PAPERBACK
ISBN 978-0-309-44647-1 | DOI 10.17226/24873

CONTRIBUTORS

Johanna Zmud, Ginger Goodin, Maarit Moran, Nidhi Kalra, and Eric Thorn; National Cooperative Highway Research Program; Transportation Research Board; National Academies of Sciences, Engineering, and Medicine

Strategies to Advance Automated and Connected Vehicles:

Briefing Document

CONTENTS

The National Academies of
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TRB
TRANSPORTATION RESEARCH BOARD

Briefing Document

This briefing document concisely conveys the key findings of *NCHRP Research Report 845: Advancing Automated and Connected Vehicles: Policy and Planning Strategies for State and Local Transportation Agencies*. The research report and briefing document were created, and the research behind the report was conducted, under NCHRP Project 20-102 (01) by Texas A&M Transportation Institute, RAND Coproration, and Southwest Research Institute (please see *NCHRP Research Report 845* for full authorship and publication information).

NCHRP Research Report 845

NCHRP Research Report 845 assesses policy and planning strategies at the state, regional, and local levels that could influence private-sector automated vehicle (AV) and connected vehicle (CV) choices to positively affect societal goals. The researchers identified and described mis-matches between potential societal impacts and factors that influence private-sector decisions on CV and AV technologies. Policy and planning actions that might better align these interests were then identified. Researchers and the project oversight panel identified the promising actions and then conducted in-depth evaluations of the feasibility, applicability, and impacts of 18 strategies. *NCHRP Research Report 845* can be purchased or downloaded from the TRB website (www.trb.org).

Acknowledgment

This work was sponsored by the American Association of State Highway and Transportation Officials (AASHTO), in cooperation with the Federal Highway Administration, and was conduct-ed in the National Cooperative Highway Research Program (NCHRP), which is administered by the Transportation Research Board (TRB) of the National Academies of Sciences, Engineering, and Medicine.

Disclaimer

The opinions and conclusions expressed or implied in this material are those of the researchers who performed the research. They are not necessarily those of the Transportation Research Board, the Academies, or the program sponsors.

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AVS AND CVS ARE COMING. WHY SHOULD I CARE?

Private companies producing automated vehicles (AVs) and connected vehicles (CVs) are investing billions in a race to market. New consumer products promise to fix intractable transportation challenges and make our lives easier. New business models in mobility are introducing market-based services and transforming travel behavior. Vehicles that are increasingly automated and connected have the potential to change personal, freight, and public transportation profoundly. Some impacts of those vehicles can be foreseen, others are uncertain, and all are complex.

This document helps decision makers assess and leverage the policy tools they have and consider how to align traditional public policy interests with rapidly emerging AV and CV technologies, even amid a high level of uncertainty.

The benefits to consumers are tangible and immense, but what about society writ large? Social benefits for safety, congestion, emissions, and mobility seem intuitive. At the same time, it is unclear to what degree these issues will be addressed through new vehicle technologies and to what extent these technologies pose risks to public safety, security, health and social equity. Technology will solve some problems, but could also create new ones.

Disruption is upon us. As a public official, how will I respond?

The transportation industry has moved gradually and deliberately forward since the introduction of the modern highway system. New ideas emerge methodically; standards are fine-tuned and evolve at a measured pace. Transportation projects can take a decade or more to implement. On the other hand, the start-up culture moves nimbly, fails quickly, and learns rapidly. Vehicle technology is advancing at a startling, uncontrolled pace.

The transportation community can choose to wait and react. Or, decision makers can reframe the conventional public policy discussion to responsibly and assertively advance AV and CV technologies in light of social interests, adopting the principles of rapid learning and shared knowledge creation.

This document helps decision makers assess and leverage the policy tools they have and consider how to align traditional public policy interests with rapidly emerging AV and CV technologies, even amid a high level of uncertainty. In spite of that uncertainty, the transformational nature of AV and CV technology argues that public agencies should consider the strategies and possible outcomes to effectively manage public interest concerns.

Overseeing the deployment of AV and CV technologies is a natural extension of the longstanding role of government to:

- Ensure safe and efficient operation of public roadways.
- Foster equity across users of the system.
- Mitigate negative effects of transportation.

The strategies provided in this resource can guide policy development that proactively shapes the deployment of these technologies in ways that advance societal benefits while lessening potentially harmful consequences.

Technology Context

For the purposes of this work, an **automated vehicle** is one that takes full control of all aspects of the dynamic driving task for at least some of the time. Using the Society of Automotive Engineers (SAE) taxonomy, *this research focuses on the role of higher levels of AV in mitigating or exacerbating the societal effects of driving*, or in creating new effects. The higher levels of vehicle automation are designated SAE levels 3, 4, and 5 and are referred to in federal policy guidance as highly automated vehicles (HAVs).

High Levels of Driving Automation (SAE 2014)

Level	Name	Description
Automated driving system monitors the driving environment		
3	Conditional automation	The driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task with the expectation that the human driver will respond appropriately to a request to intervene
4	High automation	The driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene
5	Full automation	The full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver

A **connected vehicle** has internal devices that connect to other vehicles, as in vehicle-to-vehicle (V2V) communication, or a back-end infrastructure system, as in vehicle-to-infrastructure (V2I) communication. V2V applications enable crash prevention, and V2I applications enable telecommunication, safety, mobility, and environmental benefits. Their foundation of data communications enables real-time driver advisories and warnings of imminent threats and roadway hazards.

Dedicated short-range communications standards—the two-way, short-to-medium-range wireless communications capability that permits very high data transmission—are currently the leading medium for:

- V2I safety applications (e.g., red-light violation warnings, curve speed warnings, and work zone warnings).
- V2V safety applications (e.g., forward collision warnings, intersection movement assist, left-turn assist, and do-not-pass warnings).
- V2X or vehicle-to-everything, as in the Internet of Things; for example, a wearable device in a highway worker's safety vest that warns drivers of the person's location.

However, non-safety critical applications (e.g., weather advisories and eco-approach and departure at signalized intersections) could also be achieved using other wireless communications.

At present, the V2I and V2V applications solely provide driver alerts; they do not control the operation of the vehicle.

Regulatory Context

In September 2016, the National Highway Traffic Safety Administration released the official Federal Automated Vehicle Policy, issued as "guidance rather than in a rulemaking capacity in order to speed the delivery of an initial regulatory framework and best practices to guide manufacturers and other entities in the safe design, development, testing, and deployment of Highly Automated Vehicles (HAVs)." The policy reaffirms that states retain their responsibilities for licensing and registering vehicles, defining and enforcing traffic law, and regulating insurance and liability requirements and policies. The framework envisions that each state's AV-related policies and regulations be administered by a single lead agency and associated technology committee. The issues and actionable strategies covered in this document are those that would be relevant to such entities.

How AVs and CVs Could Lead to Positive Societal Outcomes

By what mechanisms might AVs and CVs *create desirable outcomes for society, either by encouraging direct positive effects or reducing negative ones?* Through inferences based on reviews of the literature, the research team identified ways in which CVs and AVs could lead to those desirable outcomes.

Potential Benefits of Connectivity and Automation

Driving Externality	Connectivity (Full V2X)	Autonomy* (L4,5)	Shared Autonomy (L4,5)**	Electrification***
Safety	Strong benefits	Strong benefits	Strong benefits	Weakest benefits/no impact
Congestion	Strong benefits	Uncertain impact	Some expected benefits	Weakest benefits/no impact
Emissions	Some expected benefits	Weakest benefits/no impact	Weakest benefits/no impact	Strong benefits
Land Use	Weakest benefits/no impact	Uncertain impact	Some expected benefits	Weakest benefits/no impact
Mobility	Weakest benefits/no impact	Strong benefits	Strong benefits	Weakest benefits/no impact

Strong benefits — Weakest benefits/no impact — Some expected benefits — Uncertain impact

*Autonomy is defined for this purpose as individually owned vehicle.
**Shared Autonomous Vehicles (SAV) are on-demand self-driving vehicles supporting shared rides as part of a privately or publicly managed fleet.
***While not a focus of this NCHRP research, the team provides assumptions of potential benefits of electrification based on known literature.

Even without CVs, AVs could reduce most driver-related errors, which account for a vast majority of traffic crashes, but AVs also might introduce new types of errors.


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TRAFFIC CRASHES

When individuals drive a vehicle, they not only increase their own risk of a crash and its associated costs, they also increase crash risks and costs for other motorists, pedestrians, cyclists, and society in general. V2V safety applications could mitigate these risks by addressing most vehicle crash types if the V2V applications are demonstrably effective and widely used, the driver-vehicle interface performs well, and there is sufficient market penetration. An increase in benefit could be obtained through V2I safety applications. Even without CVs, AVs could reduce most driver-related errors, which account for a vast majority of traffic crashes, but AVs also might introduce new types of errors. Flawed hardware or software could cause accidents due to errors that humans would not make. AVs and CVs both create cybersecurity risks. Level 3 AVs could also introduce risks posed by inattentive drivers who fail to take safe control of the vehicle when needed. Early research suggests that these technologies have promise, but the safety benefits of AVs and CVs are not guaranteed.

CONGESTION

As the number of vehicles on a road increases past a certain density, vehicle speed and throughput decrease, causing congestion. Each additional driver adds to the congestion but does not bear the full cost of that effect. Ultimately, it is unclear how AVs and CVs will affect congestion; the literature in this area shows mixed results for a variety of different traffic measures under varying conditions. Congestion occurs on a regular basis (i.e., recurring) and on a sporadic basis (i.e., non-recurring). CV applications could mitigate non-recurring congestion by reducing delays caused by safety incidents. CV mobility applications could reduce recurring congestion by increasing system efficiency and enabling CV-facilitated truck platoons. Widespread adoption of V2V capabilities, widespread V2I infrastructure, and interoperability among mobility applications would maximize these impacts. AVs that are safer than human drivers could reduce the frequency of crash-related delays. In addition, more closely-spaced AVs could enhance traffic flow. At the same time, a proliferation of on-demand, shared AVs (SAVs) could put more vehicles on the road and increase congestion. Alternatively, multi-occupancy SAVs could reduce the number of vehicles on the road. Although the travel delay caused by congestion may be redefined if the occupant in an AV can be productive while waiting in traffic, there still might be the need to minimize associated vehicle miles traveled (VMT) growth because it contributes to other negative effects, such as pollution. The net effects of AVs and CVs on congestion have yet to be fully understood or predicted.

Ultimately, it is unclear how AVs and CVs will affect congestion; the literature in this area shows mixed results for a variety of different traffic measures under varying conditions.

POLLUTION

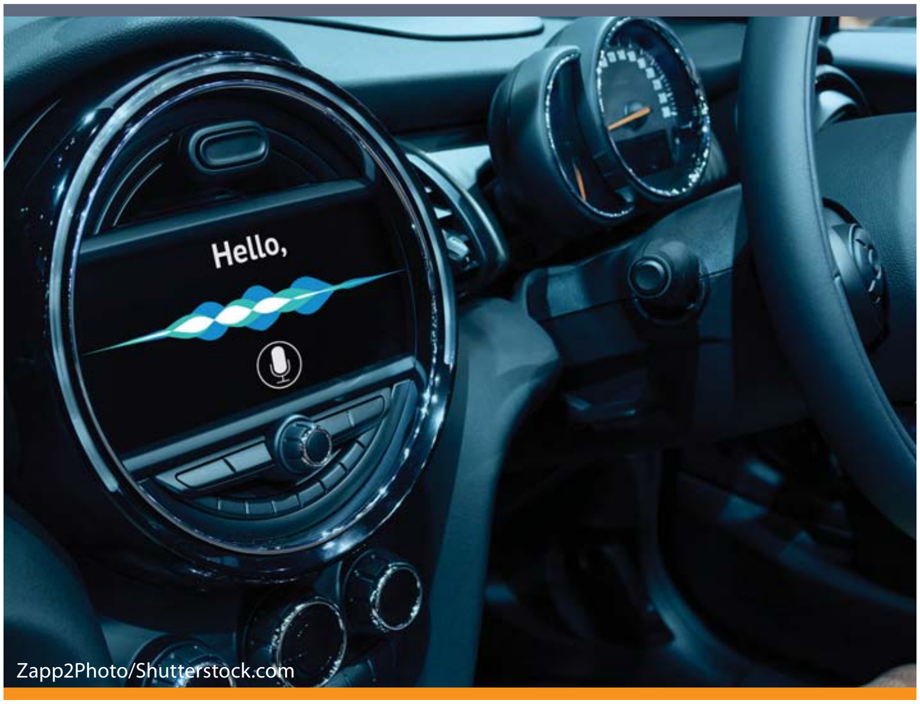
Vehicles emit local air pollutants (e.g., particulate matter, hydrocarbons, nitrogen oxides, and carbon monoxide) and global air pollutants (greenhouse gases). When someone drives a vehicle, he or she reduces the air quality and adds to noise pollution in surrounding areas. That person also imposes the costs of climate change on the global society. AVs could mitigate these effects by leading to reduced vehicle production rates and parking needs, and to increased use of smaller, electric vehicles and eco-driving. On the other hand, by increasing safety and improving the convenience of vehicle travel, AVs and CVs could lower transportation costs, which could increase VMT. While this increase in VMT may facilitate additional economic activity or enhanced quality of life, it may also produce negative environmental impacts that would need to be mitigated.

LAND DEVELOPMENT

Land devoted to automobile infrastructure and dispersed development patterns—while historically increasing mobility and decreasing travel costs—may also impose negative environmental, economic, and public health effects on society. AVs and CVs could increase safety, improve convenience of vehicle travel, and lower transportation costs, but these effects might lead consumers to take more trips and travel more miles in order to access lower priced land and rural locations, exacerbating inefficient land-use patterns. On the other hand, if fully autonomous (SAE Levels 4 or 5) AVs reduced the need for parking adjacent to destinations, land dedicated to parking in urban areas could be assigned to other, more beneficial uses. The largest effects would be in dense urban areas, where land is very expensive, while impacts might be less substantive in most areas of the country.

MOBILITY

Older adults, youths under age 16, and individuals with disabilities have limited access to desired destinations, activities, and services. The existing transportation infrastructure does not completely address the limited mobility of this population. Levels 4 and 5 AVs could mitigate this negative externality by enabling significant improvements in access and mobility for such individuals. This is particularly true for those who live in areas with few alternative modes. Less-than-full automation (Level 3) and CVs would not reduce this negative externality.



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Consumers may be unwilling to pay for expensive technology if much of the benefit goes to others, and consequently, producers may be less willing to develop and market CVs and AVs.

Foundational Research: Social Welfare and Market Economics

The analytical foundation for identifying the potential policy and planning strategies reviewed in this document involved an examination of mechanisms by which AVs and CVs could create desirable outcomes for society. These mechanisms could either encourage positive effects or reduce negative ones. For example, if safe AVs and CVs are developed and marketed by producers and then used widely and responsibly by consumers, the current traffic safety crisis could be mitigated. However in this example, many of the benefits accrue to society rather than to producers or consumers of AV or CV technology. Consumers may be unwilling to pay for expensive technology if much of the benefit goes to others, and consequently, producers may be less willing to develop and market CVs and AVs. This is an example of an *externality*. An externality is an effect produced by either a consumer or producer that affects others, yet is not accounted for in the market price (i.e., occurs external to the market). Externalities have important implications for realizing the benefits of AVs and CVs. AVs and CVs may also result in a range of economic disruptions to groups such as professional drivers, insurance companies, medical facilities, trauma centers, collision repair shops, and other industries. Some of these effects are internal to the market, while others are pecuniary externalities (i.e., operating through market prices) and not real externalities. Because these costs are internal to market decision making, the research excluded pecuniary externalities from the analysis.

Society as a whole could benefit if state, regional, and local governments were to implement policy (e.g., regulations or taxes) or planning strategies (e.g., public education) to internalize these externalities in decision making by consumers or producers. Such instruments or activities could force the market to account for costs that would otherwise not be included.

With social welfare economics as the foundation, researchers identified categories of policy levers. The groups of policy strategies presented below are most common in internalizing externalities within the traditional roles of state, regional and local government:

Economic Instruments: These are policy strategies that provide an explicit price signal by applying a tax, fee, or subsidy to effect a specific outcome.

Examples of Price-Based Economic Policy Instruments

Fuel Taxes	Value Added Taxes	Vehicle Age Taxes
• Carbon taxes • Distance-based taxes (VMT fees) • Fully differentiated VMT fees • Registration fees • Tolls	• Insurance taxes • Circulation taxes • Vehicle sales taxes • Parking fees • Transit subsidies	• Vehicle value taxes • Vehicle size and weight taxes • Vehicle engine size taxes

Regulatory Instruments: With these tools, governing bodies are able to affect behaviors or processes by establishing or changing regulations directly, rather than relying on price signals to encourage socially optimal choices.

Examples of Regulatory Policy Instruments

Require	Establish or Update
• Collision insurance • Pay-as-you-drive insurance • Safety equipment use • Training or certification • Vehicle inspections	• Rules of the road • License requirements

Structure of private rights: Agencies may, if they have the authority, restructure civil and criminal liabilities to shift risk and alter producer and/or consumer behavior.

Service provision: This family of policy instruments generally refers to changes in how a transportation agency provides its current range of transportation services.

Information/education: Transportation agencies may, through any number of mediums and strategies, provide information to consumers to encourage desired behavior.

Financing/contracting/collaboration: In some cases, a private-sector market for a good or service may not exist or cannot exist absent government intervention. In these cases, a transportation agency may need to establish the market itself or work in partnership with the private sector to establish the necessary environment for the market to flourish.

Given the growing public and media interest in AVs and CVs, decision makers can leverage this interest toward prudent support of testing and deployment by aligning policy actions with agency goals—goals that represent societal interests.

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Importance of Strategic Goals

Transportation agencies will want to consider how the effects of AV and CV technologies can contribute to broad agency goals. Given the growing public and media interest in AVs and CVs, decision makers can leverage this interest toward prudent support of testing and deployment by aligning policy actions with agency goals—goals that represent societal interests. This is particularly important where investment of public resources is at stake. Associated strategic planning activities undertaken at a high level may include:

- Identification of transportation and societal goals and objectives that may be achieved through AV and CV technologies.
- Development of performance measures that support specific safety, congestion, mobility, and environmental goals that may be supported by AV and CV systems and can be used to track the results of testing and investment in these systems over time.
- Setting the general parameters under which CV and AV deployment can be facilitated to achieve agency and societal goals.
- Contributions toward building the business case for investing in CVs, generating support for adoption of safety and mobility applications, and promoting incentives for producers to improve applications and technology.

High-Level Summaries of Policy and Planning Strategies

To facilitate the alignment of transportation agency goals with AV and CV technologies, a menu of strategies is provided for policy makers to consider. Each strategy is presented in a one-page overview. The purpose of each overview is to offer a snapshot of a policy or planning strategy and an assessment of its utility, which allows decision makers to match outcomes with high-level strategic goals. An in-depth review of key strategies can follow using the detail provided in the accompanying report, *NCHRP Research Report 845: Advancing Automated and Connected Vehicles: Policy and Planning Strategies for State and Local Transportation Agencies*. Eighteen different policy and planning strategies—organized by desired outcome—are provided for policy makers to consider, beginning on page 12.

OUTCOME: To mitigate safety risks through testing, training, and public education:

- Enact legislation to legalize AV testing
- Enact legislation to stimulate CV or AV testing
- Modify driver training standards and curricula
- Increase public awareness of benefits and risks

OUTCOME: To encourage shared AV use:

- Subsidize shared AV use
- Implement transit benefits for SAVs
- Implement a parking cash-out strategy
- Implement location-efficient mortgages
- Implement land use policies and parking requirements
- Apply road use pricing

OUTCOME: To address liability issues that may impact market development:

- Implement a no-fault insurance approach
- Require motorists to carry more insurance

OUTCOME: To enhance safety, congestion, and air quality benefits by influencing market demand:

- Subsidize CVs
- Invest in CV infrastructure
- Grant AVs and CVs priority access to dedicated lanes
- Grant signal priority to CVs
- Grant parking access to AVs and CVs
- Implement new contractual mechanisms with private-sector providers

Each overview offers a general assessment of strategy viability by a range of criteria:

- **Effectiveness:** If the strategy is economic, how well does it internalize external costs into decision making by producers and consumers? If the strategy is not economic, how likely is it to achieve its desired policy outcome?
- **Efficiency:** If the strategy is economic, how well does it recover the costs from the externality? How likely is the strategy to produce a net-positive social benefit outcome?
- **Political Acceptability:** How likely is the general public to accept this strategy? Are any politically powerful stakeholders likely to oppose the strategy? How likely is the strategy to increase costs, place burdens on low-income or socially disadvantaged groups, or result in social inequity?
- **Operational Feasibility:** How disruptive is implementation to the implementing agency? Are new or complex governing structures required? Is it expensive to implement? Are new workforce skills or infrastructure adaptation required?
- **Geographic Impact:** At what geographic scale does this strategy make the most sense?
- **Who:** What level of government would implement this strategy?
- **Hurdles:** Are there any notable barriers to implementation?

In spite of uncertainties, the transformational nature of AV and CV technologies argues that public agencies should consider the strategies and possible outcomes to manage public interest concerns.

CONCLUSIONS

Public policy making can be challenging within a dynamic and uncertain technological landscape. The private market is highly competitive, and objective information upon which policy can be based is largely unavailable from the developers of this transformational technology. Many OEMs have made bold claims as to their timeframe for making Level 4 AV technology available in new models in the years leading up to 2021*. The timeframe for bringing Level 5 automation technology to market is hard to forecast; however, several studies estimate that Level 5 cars will be available on public roads in the late 2020s**.

At the same time, the federal government has played a significant role in supporting the research, development, and piloting of CV technology. The USDOT Connected Vehicle Pilot Program has examined multiple modes of wireless communication and has continued demonstrations to position Dedicated Short-Range Communications (DSRC)-based CV technology for large-scale deployment. Significant research and standardization has gone into the development of CV technology, specifically related to DSRC. But some companies are developing V2X equipment that uses other forms of wireless communications, including cellular, Wi-Fi, and Bluetooth.

*Korosec, K. 2015. Elon Musk Says Tesla Vehicles Will Drive Themselves in Two Years. Fortune.
**Cellan-Jones, R. 2015. Toyota Promises Driverless Cars on Roads by 2020. BBC News; Volvo. 2016. Autopilot—Travel Calmer, Safer, Cleaner. http://www.volvocars.com/au/about/innovations/intellisafe/autopilot

In spite of uncertainties, the transformational nature of AV and CV technologies argues that public agencies should consider the strategies and possible outcomes to manage public interest concerns. The strategies provided through this research offer considerations for public agency decision makers using the best information available at the time. Technology direction may change, consumers may not adopt certain products, and any number of global economic or environmental drivers could alter the policy course.

For state and local transportation agencies, the impacts of AV or CV technologies on their organizations may be highly disruptive and generate a range of uncertainties unique to public agencies:

Institutional: Institutional impacts affect a transportation agency's focus and organizational structure. This includes how an agency prioritizes its responsibilities and allocates its funding. Proliferation of AVs and CVs could increase transportation agencies' focus on non-safety goals, increase responsibility for data integrity, security, privacy, and analytics, and increase reliance on private-sector relationships where agencies lack funding or expertise.

Operational: These are impacts on how an agency develops, maintains, operates, and manages transportation infrastructure and transportation-related services. Proliferation of AV and CV technologies could cause existing intelligent transportation system investments to become outdated, reduce or shift demand for transit and parking services, and increase maintenance requirements. It is uncertain whether the technologies will mitigate or exacerbate current roadway capacity deficits.

Funding and financing: These are impacts to the funding and financing sources available for transportation infrastructure and related services. AV and CV systems could exacerbate funding deficits through increased costs for maintaining and operating roadways. AVs deployed with alternative fuel technologies, such as electricity, would reduce revenues from fuel-based taxes. A proliferation of shared AVs could reduce the amount of revenue from driver licensing, vehicle sales tax, vehicle registration, moving violations, transit fares, and federal funding associated with ridership levels. Conversely, CV technology could potentially increase revenue from road-user charges by providing a technology platform that supports usage-based revenue measurement and reporting.

Ultimately, public policy making for AVs and CVs will be informed through a cycle of learning and leveraging the activities of early-adopter agencies that support testing, evaluation, research, and continuous knowledge creation. Agencies can create a nimble policy-making framework that espouses these principles and sets in place a continual "look ahead" assessment.

POLICY STRATEGY SUMMARIES

Enact Legislation to Legalize AV Testing

Mitigate Safety Risks | Encourage Shared AV Use | Address Liability Issues | Influence Market Demand

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Effectiveness

Efficiency

Political Acceptability

Operational Feasibility

Geographic Impact

Urban, suburban, rural

Who

Legislature, state and local transportation agencies

Hurdles

Passing enabling legislation, identifying funding sources for rulemaking and administration of testing requirements

Description

This strategy aims to accelerate the development, adoption, and implementation of automated and connected vehicles by enacting legislation to establish the legality of AV testing. States or local governments could implement a version of the model state policy recently released by the USDOT to avoid any concerns about interstate inconsistencies in regulating AVs.

Technologies targeted/ownership model distinctions

A policy built around the USDOT's model state policy would focus on highly automated vehicles, or HAVs (SAE Level 4 or 5), as lower-level AVs are already in production or operating on the roads under current federal, state and local laws, with the driver primarily responsible for the vehicle's safe operation. Current states with AV testing legislation and associated regulations, like California, define automated vehicles in such a way to explicitly exclude lower-level automation, with language exempting systems using advanced driver assistance systems (ADAS) like adaptive cruise control or emergency braking.

How will this help?

Establishing the legality of testing could serve as an advertisement to attract companies to a given state or locality, although the value of this strategy in attracting testing activity is unproven. Conversely, some states have taken the position that AV testing is not necessarily illegal, and have claimed to have a more favorable, less burdensome regulatory environment for testing without it. The safety risk associated with a non-regulatory position has not been quantified.

Implementation issues

The state legislature, along with the agencies it directs to carry out or oversee testing, would bear the responsibility for implementing this strategy. Adopting a regulatory scheme such as the one recommended by USDOT could require significant action by state or local agencies to undertake rulemaking, which would involve assigning resources to accept, review and issue decisions on testing proposals. This would likely require some coordination and collaboration among state and local agencies, as there are often overlapping and shared jurisdictions in transportation management and operations. Some likely challenges to implementation of this strategy are identifying funding sources for implementation, setting up regulatory processes, and training staff. USDOT, through its model state policy, has offered advice for implementation based on the practices of leading states. The guidance is not clear about the role of local governments. NHTSA expects to update its state guidance over time. Achieving consensus on a legislative approach to testing, within the political process, could pose challenges.

Stakeholder benefits/concerns

Stakeholders include vehicle manufacturers and developers, the agencies involved in testing or regulating testing, and the general traveling public. Most consumer surveys indicate a sizable percentage of respondents who are concerned about the safety of AVs, which may be a barrier to adoption.

Optimal timing

This strategy addresses testing AVs, and as such, the optimal timing would be in the near term. AVs are developing rapidly, so policies designed to stimulate testing should occur in the near term, over approximately the next five years.

Legality

There is no legal barrier to enacting legislation.

EXAMPLES

Nevada became the first state to authorize the operation of highly automated vehicles with AV 511 in 2011, and rules were adopted for licensing and operation. Additional legislation was passed in 2013 and the statutes are reviewed every two years to account for advancements in technology.

California AB 1352, enacted in 2016, authorizes the Contra Costa Transportation Authority to conduct a pilot project testing autonomous vehicles not equipped with steering wheels, brake pedals, accelerators, or operators inside, at specified locations and speeds less than 35 miles per hour.

Establishing the legality of testing could serve as an advertisement to attract companies to a given state or locality, although the value of this strategy in attracting testing activity is unproven.

Enact Legislation to Stimulate CV or AV Testing

Mitigate Safety Risks	Encourage Shared AV Use	Address Liability Issues	Influence Market Demand

holbox/Shutterstock.com

Effectiveness

Efficiency

Political Acceptability

Operational Feasibility

Geographic Impact

Urban, suburban, rural

Who

Legislature, state and local transportation agencies

Hurdles

Passing legislation, upgrading or installing new infrastructure, creating new governmental agreements and partnerships

Description

This strategy aims to accelerate the development, adoption, and implementation of automated and connected vehicles by enacting legislation to directly fund testing for CV or AV development.

Technologies targeted/ownership model distinctions

Legislation providing direct funding designed to stimulate testing can target AV or CV technologies, although as the likely implementer of CV systems, state and local governments may wish to prioritize CV spending to gain experience and institutional knowledge with the emerging technology.

How will this help?

Directly funding AV or CV testing could incentivize companies or public agencies to engage in testing AV or CV systems. Funding CV testing would build institutional knowledge and experience with these emerging technologies, which could increase the likelihood of the systems being implemented in the future. Additionally, private companies are already investing large sums to develop and test AVs, but similar investments are not being made in CV systems. As an economic intervention, providing funding for testing would increase testing activities, and as such, would be an effective strategy to advance the societal benefits of the technology. For these reasons, state and local agencies may wish to prioritize their investments in testing CV systems.

Implementation issues

The state legislature, along with the agencies it directs to carry out or oversee testing, would bear the responsibility for implementing the strategy. Some likely challenges to implementation of this strategy include: identifying funding sources for testing activities, training staff, developing new governmental structures or agreements, installing and upgrading communications systems and infrastructure, and integrating data with existing ITS operations. USDOT, through its model state policy and V2I deployment guidance, has offered advice for implementation. State agencies could also independently fund testing, if they have resources available, or if they procure funding for a federal test bed. In these settings, state and local agencies may have the opportunity to learn how to operate and efficiently run these systems.

In addition, the 2015 federal transportation authorization legislation, known as the FAST Act, could provide a potential funding source for pilot activities. The act loosened restrictions on federal funding categories, like Category 2, to provide wider latitude for local agencies to fund ITS with federal dollars through their MPOs. This change is essential for the direct funding option: state and local agencies – under direction from their policy makers – can use their own state and local funding (or federal dollars) for testing if there is a clear value proposition to doing so, given the many other system needs that require financial resources.

Testing a new system will provide useful information to state agencies about how these technologies function and perform: implementation and operational processes and procedures, data on system effectiveness and efficiency, more accurate cost information – and in addition, the agencies will gain valuable institutional knowledge and experience with the new technologies.

Stakeholder benefits/concerns

Stakeholders include vehicle manufacturers and developers, CV system suppliers and contractors, the agencies involved in testing, and the general traveling public. Legislation to support testing would either require new funding or using existing funds for a different purpose, which may prove contentious, especially in a legislative setting. The policy does not harm stakeholders, but the financial concerns alone resulted in a relatively lower score on political acceptability. This strategy could be perceived as directly benefiting private equipment vendors.

Optimal timing

These policies address testing AVs and CVs, and as such, the optimal timing would be in the near term and up to ten years. AVs are developing rapidly, so policies designed to stimulate testing should occur in the near term, over approximately the next five years. CV systems are developing on a longer cycle, so CV testing could begin now but continue throughout the development life cycle, at least now to ten years hence.

Legality

There is no legal barrier to enacting legislation.

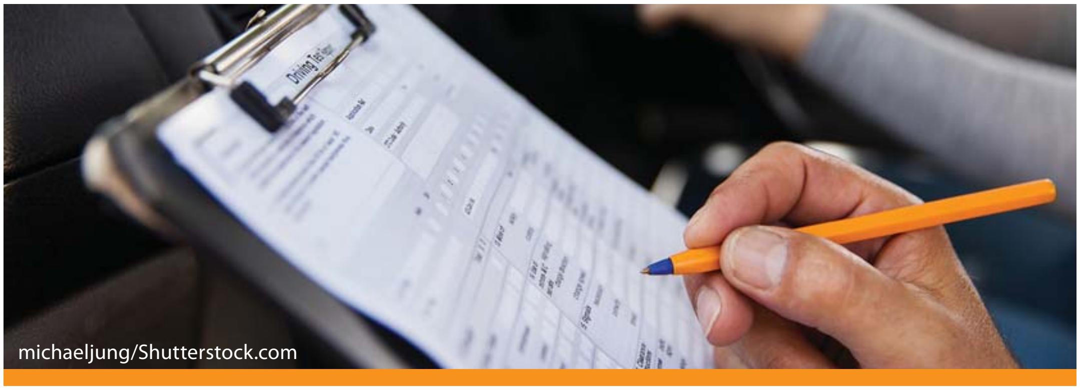
EXAMPLE

Utah HB 373, enacted in 2015, authorizes the department of transportation to conduct a connected vehicle testing program outside of an urbanized area, and requires the state DOT to report the results to a committee of the legislature.

Funding CV testing would build institutional knowledge and experience with these emerging technologies, which could increase the likelihood of the systems being implemented in the future.

Modify Driver Training Standards and Curricula

Mitigate Safety Risks	Encourage Shared AV Use	Address Liability Issues	Influence Market Demand



michaeljung/Shutterstock.com

Description

This strategy addresses the requirements for operating vehicles equipped with CV and AV technologies by establishing, codifying, and enforcing operator/owner/passenger requirements, and modifying driver training standards and curricula to reflect use of CV/AV applications.

Technologies targeted/ownership model distinctions

CV technologies will represent a minimal departure from current driver requirements. Driver training may need to address effective use of the added warnings and roadway information, and testing requirements for driver licenses may be modified to incorporate use of some CV technologies. AVs will have a larger effect on vehicle operator requirements and, therefore, on driver training and licensing. Level 5 AVs may require a complete restructuring of operator licensing, and "licensing" of the vehicles themselves may supplant driver licensing at higher levels of automation.

How will this help?

Reducing the human driver's direct control of the vehicle can result in reduced situational awareness, skills degradation, and overreliance on automation. Driver training, testing, and license requirements need to reflect the altered role and responsibilities of a driver using Level 3-4 automated vehicles.

Implementation issues

State legislatures codify new training and licensing criteria. NHTSA's Federal Automated Vehicles Policy recommends that states evaluate their current vehicle operation laws, to avoid unnecessary impediments to safe AV operation, and to update their references to and standards for human drivers where appropriate. Updates to driver license standards within states should be coordinated via the American Association of State Motor Vehicle Administrators (AAMVA) to ensure continued consistency and reciprocity of driver licensing across states. Commercial-vehicle operator license requirements would be addressed by the Federal Motor Carriers Safety Administration (FMCSA). In some states, licensing is managed by the Department of Motor Vehicles (DMV); in others, it is under the Department of Public Safety or the secretary of state. In many states, DMVs work with state departments of education to implement driver training programs.

Changes could be very disruptive. Changes in licensing will have to accommodate people driving AVs/CVs as well as those driving conventional vehicles for many years to come. Licensing requirements will either have to ensure that a driver can safely drive vehicles at multiple levels of automation, or specify what type(s) of vehicle a driver may operate. Driver training curricula, materials, and standards will need to accommodate new warnings and in-vehicle information channels, or accommodate changing roles and necessary skills for vehicle operators. Many states provide driver training materials in different languages so any changes will have to be incorporated into multiple formats.

New licensing requirements for Level 3-4 AVs will necessitate retraining of driver license examiners, and may require the development of multiple new licensing classes. Level 5 AVs will not require any operational input from vehicle occupants, reducing or eliminating driving instruction and examiners, and potentially eliminating the need for vehicle operator licenses. This could eliminate a significant source of state revenue from licensing, unless other fees are instituted or unless licenses are retained in a different form. Reduced revenues could impact staffing levels at agencies responsible for driver licensing and testing.

Stakeholder benefits/concerns

Driver testing/licensing/training agencies will likely resist changes due to a lack of understanding and acceptance of advanced vehicle technologies. The law enforcement community will be affected by changes to vehicle licensing requirements in different ways. Enforcing traffic laws is likely to become far more complex. Eventually, less traffic law enforcement may be needed. The American Association of Retired Persons may be a potential champion because of the potential that automated vehicles represent for increased mobility.

Optimal timing

Revisions should be established and implemented prior to widespread availability of highly automated vehicles to the general public. Driver license revisions may be less crucial and time sensitive for CVs.

Effectiveness

●●●○○

Efficiency

●●●○○

Political Acceptability

●●●○○

Operational Feasibility

●●○○○

Geographic Impact

State

Who

State legislators, state licensing/training agencies

Hurdles

Operational issues

Legality

State legislatures have the legal authority to determine driver license requirements for non-commercial vehicles and to set requirements for state driver licensing agencies. Any commercial vehicle-related changes to rules and policies would need to conform to FMCSA's regulations.

EXAMPLE

A current example is the use of backup cameras during road tests. The prevailing opinion among driver examiners is that in-vehicle backup cameras aid the driver too much and interfere with testing a driver's skill in safely reversing a vehicle, so use of these cameras is generally forbidden during driver testing, although this technology will soon become standard equipment on all new vehicles. States will need to put significant resources into educating their staff on the benefits of CV and AV technologies and how to test drivers using them.

Driver training, testing, and license requirements need to reflect the altered role and responsibilities of a driver using certain automated vehicles.

Increase Public Awareness of Benefits and Risks

Mitigate Safety Risks	Encourage Shared AV Use	Address Liability Issues	Influence Market Demand


Matej Kastelic/Shutterstock.com

Description

This strategy aims to increase the public's awareness of automated and connected vehicle (AV/CV) technologies through education, training, communication, and outreach to stimulate consumer action and supportive public investment. Outreach and educational campaigns could provide a necessary "push" to spur additional investments in AV and CV technologies by both the public and private sectors.

Technologies targeted/ownership model distinctions

Public awareness could apply to all levels of AV/CV technologies and ownership models. Information and education should focus on how the public will benefit from these advances. It is important to make the public aware of and provide access to pilot tests and demonstration projects. This strategy has the potential to affect technology adoption.

How will this help?

Public outreach can easily target all positive and negative impacts of AV and CV depending on the education message. Public education about the safety, congestion, mobility, privacy safeguards, and environmental implications of AV/CV could affect technology adoption and market acceptance. Information about the proper use of the technologies could promote safer use. These messages could also increase support for investment in infrastructure that produces societal benefits. Consumer awareness could lead to use of shared AVs rather than privately owned vehicles, which could have congestion, mobility, and environmental advantages.

Implementation issues

State and local governments engage in public information efforts routinely. Campaigns to encourage safe driving behavior (e.g., using seat belts, avoiding impaired driving, sharing the road with cyclists) or to educate the public on capital investments are common. AV/CV public education, therefore, would not require new workforce capabilities, only investment in resources to carry out the education activities. Defining the message is the primary challenge. The public has been exposed to commercial messages on AV focused on personal safety benefits and the liberation of the driver to engage in other activities. Given the lack of empirical data on the reliability of the technology, the necessity of connected systems to ensure congestion and environmental benefits, or the value of shared vehicle use in managing demand, what constitutes credible or effective public messaging is still unclear. Joint messages by the private sector and the public sector could enhance credibility and build public trust. The public may see the benefits associated with the public and private sectors working in partnership for greater societal benefits. Field testing and pilots can also be tools to quantify benefits for reliable messaging and increase awareness by giving the public first-hand experience with the technology.

Stakeholder benefits/concerns

Agencies, producers, suppliers, policy makers, and industries in the "crash economy" (insurance, healthcare) all have a stake in the outcome of public education. The messaging must speak to the issues important to a particular audience, and the implementation must be carried out in such a way as to ensure inclusivity and not be perceived as only available to a particular demographic.

Optimal timing

A best practice of public participation is engagement early and often. Testing of these technologies is under way in various cities and states, numerous industry advocates have begun information campaigns, and the USDOT has made CV and AV applications a priority program for outreach. Therefore, it stands to reason that concerted public awareness efforts by state and local agencies should begin now.

Legality

There are no legal or regulatory barriers associated with increasing public awareness. However, the implementing agency should ensure a consistent, fact-based message that instills confidence in their programs to build trust and credibility with the public.

Effectiveness

●●●○○

Efficiency

●●●●○

Political Acceptability

●●●●○

Operational Feasibility

●●●●○

Geographic Impact

Urban, suburban, rural

Who

Any state and local agencies

Hurdles

Developing trusted messages given the uncertainties in technology deployment, benefits, and drawbacks.

EXAMPLE

The safety success associated with near-ubiquitous seat belt use can be attributed to public education and outreach in combination with regulation and enforcement. For CV and AV, the USDOT and state departments of transportation are building outreach programs that showcase the technologies and allow the public to see how these advancements will impact their lives. For example, the Florida Automated Vehicle initiative is creating a "framework for implementation by engaging stakeholders, developing research and pilot projects and creating awareness of the technologies...." Outreach and education are important components of that initiative.

Agencies, producers, suppliers, policy makers and industries in the "crash economy" (insurance, healthcare) all have a stake in the outcome of public education.

Subsidize Shared AV Use

Mitigate Safety Risks	Encourage Shared AV Use	Address Liability Issues	Influence Market Demand

Frederic Legrand - COMEO/Shutterstock.com

Description

This strategy intends to subsidize shared autonomous vehicle (SAV) services to ensure alternatives to individually owned autonomous vehicles (AVs) and to support ridesharing and transit services, including paratransit.

Technologies targeted/ownership model distinctions

SAVs require full automation (SAE Levels 4 and 5) for their operation.

How will this help?

Research is beginning to indicate that individually owned AVs may lead to more frequent and longer trips, and mode shifts away from public transit, all of which could lead to increased pollutant emissions and congestion. SAVs could mitigate added total system vehicle miles traveled because of the likelihood of higher vehicle occupancy, higher marginal per-trip cost, serving first/last-mile connections for line-haul mass transit systems, and shorter trips.

Implementation issues

Current transportation network companies (TNCs), such as Uber, Lyft, or Bridj, are a good analog for SAVs. SAVs are on-demand, driverless TNCs. Growth in the TNC market has been market driven, and market forces have worked well. So, subsidies to incentivize SAV operation in urban areas are simply not needed. However, SAVs are not likely to serve certain market segments because of the need to turn a profit. This strategy could entail re-targeting of the subsidies that currently support public transit for specific SAV use cases: first-mile/last-mile service, paratransit service, transit deserts, and rural areas. Transit agencies are the most likely implementers of a subsidy strategy for specific SAV use cases because of the potential for budget and operating efficiencies. Cities also have a role in policy making to provide a welcoming environment and supportive regulations.

Stakeholder benefits/concerns

If SAV subsidies are re-targeted for specific use cases, SAV operators and users would directly benefit through increased profits and reduced fares. Transit agencies could benefit from budget and operating efficiencies. Conventional taxis, carsharing services, and TNCs would face a disadvantage. Similarly, professional drivers who work for such firms could see their jobs eliminated. The public at large should see benefits in terms of reduced congestion and emissions and increased mobility and transportation equity, though the general public would also be responsible for funding any sales or fuel taxes used as the subsidies.

Optimal timing

Optimal timing for exploration of the SAV subsidies is prior to the initiation of a new SAV service. With current testing in areas such as Pittsburgh, this means exploration in the near term.

Legality

There are no legal or regulatory barriers associated with re-targeting of existing subsidies to transit agencies for specific SAV use cases. However, there is a patchwork of existing regulatory barriers to TNC operations among U.S. cities and counties that may need to be re-visited from a SAV perspective.

Effectiveness

● ○ ○ ○ ○

Efficiency

● ● ● ○ ○

Political Acceptability

● ● ○ ○ ○

Operational Feasibility

● ● ● ○ ○

Geographic Impact

Urban, rural

Who

Public transit agencies, cities

Hurdles

Implementation issues (subsidies needed only for special use cases)

EXAMPLE

Current transit agency examples of re-allocating subsidies to TNCs include: Pinellas Suncoast Transit Authority in Florida for first/last-mile connection; Orange County Transit Authority in California for paratransit services for disabled and elderly people; Denver Regional Transit District for rural, less dense areas; and the city of Gainesville, Florida, for serving low-income neighborhoods.

Transit agencies are the most likely implementers of a subsidy strategy for specific SAV use cases because of the potential for budget and operating efficiencies.

Implement Transit Benefits for SAVs

Mitigate Safety Risks	**Encourage Shared AV Use**	Address Liability Issues	Influence Market Demand

Jim Lyle/Texas A&M Transportation Institute

Effectiveness
●●●○○

Efficiency
●●●○○

Political Acceptability
●●●●○

Operational Feasibility
●●●●○

Geographic Impact
Urban

Who
Public transit agencies, employers

Hurdles
Regulatory: Congressional action needed

Description

The strategy extends transit benefits, a type of existing economic incentive provided to individuals to pay for transit or vanpool fares, to cover fares for shared automated vehicles (SAVs) as well. The economic incentive can be provided either as a direct subsidy or as a pre-tax benefit.

Technologies targeted/ownership model distinctions

As on-demand, driverless vehicles that operate as part of a privately or publicly managed fleet, SAVs require high automation (SAE Levels 4 and 5) for their operation.

How will this help?

This strategy targets congestion, land development, and pollution through providing incentives to use shared vehicles instead of driving for commute trips. The assumption is that a fleet of fully autonomous shared vehicles would constitute an alternative to driving alone (i.e., a new form of transit), and that transit benefits would be expanded to allow employees to pay for SAV trips. Transit benefits by themselves are not particularly successful in increasing transit use, as use depends on service provision and user convenience. Transit benefits could be more effective with SAVs, however, as user convenience should be high.

Implementation issues

Transit benefits are already employed by most transit agencies; in all but a few cities, employer participation is voluntary. Employer challenges are fairly minor: making decisions as to how to implement transit benefits, establishing an enrollment process, setting up and maintaining an account with the transit agency, changing payroll forms if using a pre-tax program, and determining whether to conduct the implementation directly or use a third-party provider. The main impact on employers is the time required to reach decisions.

State and local governments can take several approaches to transit benefits. On the more aggressive side, some states have enacted additional tax advantages for participating employers. However, it is more typical that regional organizations—such as MPOs or transportation management associations, which may be public or private—encourage the use of transit benefits through outreach.

One barrier to more widespread use of transit benefits currently is that individuals cannot choose to participate in a transit agency program; they can participate only if their employer sets up a program. The determining characteristic is whether an employee receives a W-2 form from an employer. Therefore, self-employed persons or contractors cannot set aside pre-tax money to pay for transit fares. One potential change to the law would be to allow individuals to participate directly in transit agency programs on a pre-tax basis, without employer involvement.

Stakeholder benefits/concerns

Since transit benefit programs in their current form have existed for nearly 25 years, there are no particular political concerns about continuing such programs. Several changes could make them slightly controversial. Making them mandatory would probably concern employers, as it could increase the amount they spend on employee benefits. Allowing individuals to participate via pre-tax programs without the intervention of an employer could lead to a small reduction in tax revenues, although this would likely be popular as it would help individuals reduce what they pay in transit fares.

Optimal timing

Changes to transit benefit programs could develop gradually as SAVs spread.

Legality

Federal tax law governs how transit benefits can be implemented. Only Congress can determine which commute modes are eligible for benefits, determine which individuals are eligible to participate, and set the upper limit on the tax-free dollar amount.

EXAMPLE

Washington State allows employers who provide commute trip reduction incentives, including transit benefits, to take a tax credit against other tax liabilities.

This strategy targets congestion, land development, and pollution through providing incentives to use shared vehicles instead of driving for commute trips.

Implement a Parking Cash-out Strategy

Mitigate Safety Risks	**Encourage Shared AV Use**	Address Liability Issues	Influence Market Demand

Singhanart/Shutterstock.com

Effectiveness

●●●○○

Efficiency

●●○○○

Political Acceptability

●●●●●

Operational Feasibility

●●●●○

Geographic Impact

Urban

Who

Employers

Hurdles

Institutional – few direct benefits for employers to implement

Description

The strategy uses parking cash-out benefits, a type of existing economic incentive wherein employers offer employees the choice between retaining a free parking space and taking a cash payment, to encourage SAV use.

Technologies targeted/ownership model distinctions

As on-demand, driverless vehicles that operate as part of a privately or publicly managed fleet, SAVs require high automation (SAE Levels 4 and 5) for their operation. The assumption is that SAVs would constitute an alternative mode to driving alone to work and parking for free.

How will this help?

This strategy targets congestion, land development, and pollution through providing incentives to use SAVs instead of driving for commute trips. While parking cash-out has been fairly successful where adopted, that also depends on the availability of other commute options. But even making the program mandatory would not necessarily encourage SAV use as the employees might opt for the free parking instead. For unintended consequences, the main concern would likely be fraud. Employees could receive the benefit and continue driving to work if, for example, the employer did not adequately enforce parking restrictions. The main consequence would be to employers, not society overall, but unlike illegal sales of transit benefits there would be no incentive to use SAVs.

Implementation issues

Parking cash-out is currently implemented exclusively by employers. No jurisdiction legally prevents an employer from offering the strategy, but it is not particularly popular for two reasons: it is not well-known, and many employers would see no financial benefit from discouraging the use of parking. This is because employers who own the parking outright obtain parking through a lease and cannot unbundle the parking costs, or do not have a parking shortage and would not see a financial benefit to reducing the number of employees who drive alone to work. Otherwise, there is not much reason to pursue parking cash-out unless there is some type of mandate to reduce drive-alone commuting. To be effective, it requires some type of verification of who is using employee parking, or else employees may take the cash and continue to use the parking.

It might be possible to extend this model somehow to discourage other types of parking, such as at shopping malls or entertainment destinations. In such a model, persons who arrive via SAVs could get a small incentive payment (e.g., $5 off a purchase or admission fee). However, this would require reliable information about how travelers arrived at their destination, as self-reported information could be unreliable. Therefore, this strategy would probably remain an employer-based one, as employer-provided parking often requires some type of authorized access and is more reliably verified.

Stakeholder benefits/concerns

Stakeholders for parking cash-out are employers and employees. Many employers would see no financial benefit from discouraging the use of parking. Any mandate for employers to provide parking cash-out would likely be unpopular with employers. It might be popular with employees, depending on their access to SAV fleets and the amount of payment.

Optimal timing

Timing is not particularly important.

Legality

No jurisdiction legally prevents an employer from offering a parking cash-out benefit. Parking cash-out payments are not limited by law, and they are taxable, so employees could use them to pay for rides in an SAV fleet.

EXAMPLE

CALIBRE, in Alexandria, Virginia, provides taxable cash incentives to employees who commute to work via carpools or vanpools that are not eligible for the company's transit subsidy program. Employees who carpool with other employees to one of the company's facilities will each receive $32.50 per month in taxable income and must agree to accept a shared company provided parking benefit in lieu of an individual company provided parking benefit.

(Source: US EPA, Office of Air and Radiation, Parking Cash Out: Implementing Commuter Benefits as One of the Nation's Best Workplaces for Commuters, March 2005.)

This strategy targets congestion, land development, and pollution through providing incentives to use SAVs instead of driving for commute trips.

Implement Location-Efficient Mortgages

Mitigate Safety Risks	**Encourage Shared AV Use**	Address Liability Issues	Influence Market Demand

Natalia Bratslavsky/Shutterstock.com

Effectiveness
●○○○○

Efficiency
●●○○○

Political Acceptability
●●●○○

Operational Feasibility
●●●○○

Geographic Impact
Urban

Who
Lenders

Hurdles
Political

Description

Location-efficient mortgages (LEMs) are mortgages available to homeowners whose properties are located close to transit stations. The goal is to offer homebuyers who are willing to live near transit more advantageous loan terms to encourage the purchase of homes near transit, in the hopes that occupants will drive less and use transit more frequently. This strategy extends LEMs to persons purchasing homes in denser urban areas, where shared autonomous vehicle (SAV) fleets would be more likely to operate first.

Technologies targeted/ownership model distinctions

As on-demand, driverless vehicles that operate as part of a privately or publicly managed fleet, SAVs require high automation (SAE Levels 4 and 5) for their operation. Shared-use fleets would operate most efficiently and profitably in dense urban areas.

How will this help?

This strategy targets congestion, land development, and pollution that result from driving by providing incentives to live in denser urban areas, where alternatives to driving are more prevalent.

Implementation issues

LEMs are not currently available in the United States. Two pilot programs ran from the late 1990s to the mid-2000s. The first program was supported by several non-profit organizations and backed by Fannie Mae, and was available in only four metro areas. The second was a simplified version called the Smart Commute Mortgage, eventually available in several dozen areas. In both cases, the lender used an adjustment factor that increased the amount the prospective buyer was able to borrow. These programs faced several implementation challenges and were eventually withdrawn from the market. Consumer demand was low. Also during the early 2000s, loan underwriting standards were relaxed, making it easier in general for lower-income households to purchase homes.

If a goal of LEMs is to encourage the use of a shared AV fleet to address access to transit stations, the criteria for making an area available to LEM lending could be based on purchasing a home in a denser neighborhood, rather than within a certain radius of a transit station. This is based on the idea that a denser neighborhood would be easier to serve with shared vehicles than a less-dense one.

Stakeholder benefits/concerns

Stakeholders are the lending institutions and prospective homeowners, as well as homeowners with LEMs and other homeowners in the targeted neighborhoods who did not receive LEMs. LEMs to encourage SAV use could have undesirable effects and raise thorny policy questions. First, they could create resentment among existing homeowners in a neighborhood if it becomes known that LEM borrowers were able to secure more-favorable terms. Second, it is possible that LEMs might interact with gentrification in ways that make neighborhoods less affordable. Third, LEMs might generally drive up the price of housing in dense areas. Fourth, they face the challenge of who should be eligible. Fifth, they face the same policy challenge as some affordable housing programs: should the terms be altered when a household's circumstances change? Finally, a related challenge is that it would be difficult to verify how homebuyers are commuting.

Optimal timing

While LEMs could be rolled out as AVs become more available, the timing would be unlikely to matter to AV penetration.

Legality

Federal, state, or local government involvement is not required to implement LEMs.

EXAMPLE

LEMs are not currently available in the United States. Two pilot programs ran from the late 1990s to the mid-2000s. The first program was supported by several non-profit organizations and backed by Fannie Mae, and it was available in four metro areas (i.e., Chicago, Los Angeles, San Francisco and Seattle). The second was a simplified version called the Smart Commute Mortgage, eventually available in several dozen areas. These programs faced several implementation challenges and were eventually withdrawn from the market.

The goal is to offer homebuyers who are willing to live near transit more advantageous loan terms to encourage the purchase of homes near transit.

Implement Land Use Policies and Parking Requirements

Mitigate Safety Risks	Encourage Shared AV Use	Address Liability Issues	Influence Market Demand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Effectiveness
●●●◎◎

Efficiency
●●●◎◎

Political Acceptability
●●●◎◎

Operational Feasibility
●●●●◎

Geographic Impact
Urban

Who
Local government agencies, MPOs

Hurdles
Political, objections by private developers and local residents

Description

The strategy is to implement land use policies and parking requirements to support market penetration of shared autonomous vehicles (SAVs) at transit nodes and other activity centers. The objective is to minimize the potential for private AVs to exacerbate existing land use externalities that are linked to automobile-oriented land development and to promote SAV use rather than private AV use.

Technologies targeted/ownership model distinctions

SAV-supportive transit-oriented development (TOD) and parking strategies apply to Level 4 and 5 AVs that do not require a driver in the vehicle.

How will this help?

SAV-supportive TOD and reduced parking strategies target the land use impacts associated with car-oriented, suburban development, known as “urban sprawl,” which have had some negative social, equity, and environmental consequences. However, urban sprawl has had positive consequences as well, since housing in these developments is more affordable.

Personal AVs may influence urban sprawl by allowing travelers to disengage from the driving task and increase the demand for distant land, thereby exacerbating the excessive consumption of land for development. Land use policies can enable activity centers and transit hubs that support use of SAVs in order to reduce rates of car ownership, decrease VMT growth, and increase travel options. Although the potential for benefits is high, existing TOD efforts have not dramatically altered car-focused land use patterns.

Implementation issues

Land use zoning is under the control of local governments and dictates what plans and projects can be developed, as well as their form and function. Many cities, communities, and even states have already introduced land use policies and regulations that allow for and enable TOD. The biggest barriers to SAV-supportive development are the existing codes and regulations that have encouraged suburban, single-use development. Changes to existing land use and development codes typically require an administrative process and involve city councils, planning boards, and public hearings. Similarly, parking is mandated by local zoning or development departments and changes to those parking requirements will face the same challenges as TOD.

Stakeholder benefits/concerns

Stakeholders include property owners, developers, and local residents. Transit agencies are also common partners in TOD projects. New code or zoning requirements may impose costs or be perceived as a burden, and may be opposed by developers. The public is likely to have mixed acceptance levels, depending on the location and the impact of the strategy on homeowners. Neighbors of TOD may have concerns about increased local congestion and changes to neighborhood character. TOD is gaining support from federal, state, and local planning and transportation programs that may contribute to wider acceptance in the long term. Reduced parking requirements may face similar challenges but could be supported by developers if the strategies reduce construction costs. TOD development can face barriers such as high financial risks, class and racial prejudices, and local concern about gentrification.

Optimal timing

Both strategies have been implemented in cities already, and the impacts of AV technology on existing development is increasingly under consideration by planners. Local and state planners can begin to evaluate how SAVs would fit into existing or planned TOD efforts immediately. TOD and parking strategies can begin before AVs are even on the market, because they could incentivize shared mobility providers and AV manufacturers to develop vehicles for the SAV market. If and when SAVs are introduced, there may be an evolutionary period before a significant shift in travel habits or vehicle ownership would occur.

Legality

Many cities, communities, and even states have already introduced land use policies and regulations that allow for and enable TOD and reduced parking. This may require changes to zoning ordinances or development codes.

EXAMPLE

The City of Evanston, Illinois, a Chicago suburb, maintains a carsharing parking reduction clause in its zoning code for the inclusion of carsharing at development sites. Specifically, the code permits a reduction in the minimum number of required parking spaces for projects that require at least five off-street parking stalls and provide at least one on-site carsharing parking space. Developers are permitted a reduction of one space for projects requiring five to 10 parking spaces. For projects entailing more than 10 off-street parking spaces, a parking reduction of 10 percent is permitted for the inclusion of carsharing. To be eligible, the developer must present a long-term lease with the carsharing operator and a description of carsharing services provided.

The strategy is to implement land use policies and parking requirements to support market penetration of shared autonomous vehicles at transit nodes and other activity centers.

Apply Road Use Pricing

Mitigate Safety Risks	Encourage Shared AV Use	Address Liability Issues	Influence Market Demand

Bjoern Wylezich/Shutterstock.com

Effectiveness

Efficiency

Political Acceptability

Operational Feasibility

Geographic Impact

Urban, suburban, rural

Who

All state and local agencies

Hurdles

Public and political opposition

Description

This strategy would employ direct pricing for the use of roadway infrastructure by automated and connected vehicles (AV/CVs). Pricing would be applied to achieve specific objectives related to the impacts — both positive and negative — of AV and CV systems.

Technologies targeted/ownership model distinctions

Pricing can be applied to any technology or service to align travel behavior or purchase behavior with agency objectives. In the case of encouraging SAVs, pricing could be levied on a per trip or per mile basis, with lower charges for multi-occupancy SAVs and higher charges for other vehicle types. Furthermore, the penetration of both AV and CV technologies within the general vehicle fleet could ease the implementation of pricing, since these vehicles are likely to be equipped with technologies that allow charges to be levied and collected without the need for aftermarket components such as tolling tags or transponders.

How will this help?

The most economically efficient form of pricing, that which truly internalizes the costs of driving, would be marginal cost trip pricing that takes into account any number of societal transportation costs including congestion, pollution, and noise. Pricing could be applied to achieve specific objectives related to impacts of AV/CV systems that minimize the impacts of driving, such as limiting increases in overall travel demand, limiting distance traveled for housing, discouraging parking in urban centers, and promoting shared AV use. As a direct economic instrument, pricing is very efficient at recovering the societal costs of driving. Because pricing can be structured to account for any number of factors (congestion, pollution, etc.) it is more likely to result in a net-positive beneficial outcome as it can achieve numerous transportation policy objectives. Pricing in general represents one of the best policy actions for internalizing the costs associated with transportation by using price signals to modify behavior.

Implementation issues

The implementation of a new pricing system will increase agency responsibility for operating and administering the system. A new system may also result in the generation of new revenues.

Stakeholder benefits/concerns

Agencies, drivers, producers, suppliers, consumers, back-office administrators, policy makers, and local business owners all have a stake in the outcome of pricing applications. Transportation pricing, regardless of the specific mechanism, can generate equity concerns because it imposes new costs on travelers. One of the most common reasons for the failure to implement pricing systems is lack of political support stemming from public opposition.

Road user charges are among the most unpopular of pricing applications in society. In general, drivers do not support paying more for transportation, and road user charges are viewed as being particularly onerous because the public is not accustomed to knowing exactly what it is paying for transportation in the form of fuel taxes.

Optimal timing

There is no optimal timing for this strategy. Road pricing is already being implemented in a number of forms to address public policy concerns outside of those associated with AV/CV deployment, most notably system management and revenue generation.

Legality

Since road pricing is considered a fee or tax, implementation would require legal authority through legislative action.

EXAMPLES

Oregon's OReGO Program began in 2015 and allows for up to 5,000 volunteer drivers to pay a road usage charge of 1.5 cents for each taxable mile driven.

The state of Tennessee, in their 2016 AV testing legislation, included a provision that creates a per-mile tax structure for autonomous vehicles.

Pricing applications are currently implemented in numerous forms throughout the United States. Road pricing can be applied regardless of automated or connected vehicle technology.

Implement a No-fault Insurance Approach

Mitigate Safety Risks	Encourage Shared AV Use	Address Liability Issues	Influence Market Demand

Dmitry Kalinovsky/Shutterstock.com

Description

If automated and connected vehicle (AV/CV) technology reduces the perceived responsibility of the driver, a no-fault approach to assigning financial responsibility for crashes may appear more attractive. A no-fault approach to auto insurance allows crash victims to recover damages from their own auto insurers rather than from another driver.

Technologies targeted/ownership model distinctions

This strategy would apply to all AV/CV technologies and passenger vehicles, but probably not to commercial trucking or transit because they typically use different kinds of insurance and are regulated by different statutes.

How will this help?

Some fear that civil liability will deter the efficient development and adoption of AV/CV technology because of the perception that these technologies are inconsistent with the conventional attribution of fault in automobile crashes and the concern that the liability system inefficiently burdens new technology. However, the conventional fault-based system of crash liability is likely to be able to adjudicate the responsibility for such crashes, with a larger proportion of the responsibility falling on the auto manufacturers. The case for no-fault automobile insurance depends on how important it is to (1) clarify liability and (2) reduce manufacturer liability. At this point, it is not clear whether these goals are worthwhile.

No-fault insurance would likely clarify liability and, depending on the statutory language, reduce or eliminate manufacturer liability. If one believes that the tort system creates externalities, reducing tort liability would reduce externalities. However, no-fault automobile insurance in the United States had the unintended consequence of substantially increasing insurance costs. It is possible that the same would be true for a new no-fault approach, though there may be ways to control this.

For this externality to affect AV/CV adoption, it must uniquely apply to new technologies. If tort judgments are too high across the board, this may result in suboptimal outcomes, but it will not especially slow the adoption of AV/CV technology. If a state passed a no-fault law that prevented suits against manufacturers, this impact, assuming it exists, would be reduced.

No-fault insurance could actually slow adoption of AV/CV technology under a conventional fault-based system rather than accelerate it. If AV/CVs are much less likely to be at fault, then their insurance costs are likely to be comparatively lower under a conventional fault-based system. In that case, instituting a no-fault system may actually reduce incentives to adopt AV/CV technology because purchasers would not recoup the full benefits of crash reduction if most of the avoided crashes are ones in which the operator would have been found at fault.

Implementation issues

The strategy is substantially disruptive to the existing automobile insurance system in states that do not already have a no-fault system. If liability protection was extended to automobile manufacturers, this would be a disruptive change even in states that currently have no-fault systems. States without experience in no-fault systems may encounter challenges as the relevant agencies, policy makers, and courts learn about this approach. Consumers, courts, lawyers, insurers, and claims adjusters would also have to learn about the new approach.

Stakeholder benefits/concerns

Different auto insurers are likely to oppose or support no-fault statutes depending on their perceived comparative advantage in those states. If the statutes included a provision that exempted manufacturers from liability, this would obviously benefit manufacturers. Plaintiff attorneys would almost certainly oppose this strategy because it would reduce access to the courts and prevent some lawsuits against otherwise culpable motorists and manufacturers. Insurance companies are also powerful stakeholders, but their position depends on the specific company. Historically, consumer groups have not been particularly supportive of no-fault statutes.

Optimal timing

The policy is not especially time sensitive.

Effectiveness

●●●○○

Efficiency

●●○○○

Political Acceptability

●●○○○

Operational Feasibility

●●●○○

Geographic Impact

State

Who

State legislatures and state insurance agencies

Hurdles

Political feasibility; powerful stakeholder groups

Legality

A state legislature most likely has legal authority to enact a no-fault statute. However, if the statute precluded lawsuits against manufacturers, plaintiffs may challenge it as violating state constitutional rights regarding access to courts and jurisprudential doctrines on the separation of powers. It is difficult to predict whether those challenges would ultimately succeed, but the litigation would likely delay implementation.

EXAMPLES

Currently, 12 states and Puerto Rico have no-fault insurance laws: Florida, Hawaii, Kansas, Kentucky, Massachusetts, Michigan, Minnesota, New Jersey, New York, North Dakota, Pennsylvania, and Utah. Three of those states—Kentucky, New Jersey and Pennsylvania—give residents the choice of picking no-fault insurance or opting out in favor of "full tort" coverage (no limit on damages). But for insurance customers in the other nine states, opting out of no-fault coverage is not an alternative.

A no-fault approach to auto insurance allows crash victims to recover damages from their own auto insurers rather than from another driver.

Require Motorists to Carry More Insurance

Brian A Jackson/Shutterstock.com

Description

In many states the motorists are only required to carry $30,000 or less in liability insurance. With the value of a statistical life being approximately $9M, this leaves a vast gap between the harms that are regularly inflicted by drivers and the amount available for recovery. This gap discourages the purchase of safer automated and connected vehicles (AV/CVs) because it has the effect of subsidizing vehicles that are more dangerous to others.

Technologies targeted/ownership model distinctions

Raising mandatory insurance minimums would encourage the adoption of technology that results in safer vehicles. To the extent that AVs and CVs are safer than those driven by humans, it will encourage their adoption.

How will this help?

Many motorists are either not insured at all or under-insured, making them essentially judgment proof: they are impossible to sue because they do not have sufficient assets to pay a judgment against them. Other motorists and pedestrians can be harmed without the motorist having to pay for damages, resulting in a de facto subsidy to dangerous vehicles and motoring behavior. One strategy to offset this effect is to require motorists to carry more insurance. Without enforcements, however, the strategy may have unintended consequences — namely increased incidences of consumers not purchasing any insurance. It may also exacerbate existing inequalities because many of the urban poor have very high automobile insurance costs.

Implementation issues

This strategy could be pursued on either a state or federal level, but more likely at the state level. This change would be fairly incremental rather than radical. If it occurred at the state level, it would not fundamentally alter existing laws or relationships. It is possible that federal legislation could also accomplish the same thing. This would have the advantage of accomplishing the goals of reducing this negative externality by passing a single piece of legislation, as well as reduce the patchwork quality of existing laws. States have historically regulated all forms of insurance, so a federal bill would represent a more dramatic change.

Stakeholder benefits/concerns

The web of stakeholders is complex and includes consumer advocates who may be alarmed about mandatory increased purchase requirements. While insurers might support state laws that require the purchase of more insurance, they also may fear additional regulation. Many individual consumers are likely to oppose the increased costs associated with higher mandatory insurance requirements. Trial lawyers are likely to support this change. Victims of car crashes and the lawyers who represent them are likely to benefit from this strategy. The societal benefits that result from increased incentives to adopt safer automobile technology are diffuse. Policy makers may accept this approach based on this outcome.

Urban jurisdictions typically have the most expensive insurance as a function of the claims history (including both likelihood of crash and jury verdicts). This results in very high auto-insurance premiums for many of those least able to pay them. This, in turn, leads to widespread failure to obtain insurance, which can lead to a vicious cycle of increased insurance rates.

Optimal timing

The policy is not especially time sensitive.

Legality

The enforcement of insurance requirements has historically been a problem. Increasing the insurance minimums is likely to exacerbate that problem and lead to more non-compliance. Determining the best method to enforce existing and increased insurance requirements is outside the scope of this paper, but needs to be acknowledged as an important obstacle to this strategy.

Raising mandatory insurance minimums would encourage the adoption of technology that results in safer vehicles.

Effectiveness

Efficiency

Political Acceptability

Operational Feasibility

Geographic Impact

State

Who

State legislatures and state insurance agencies

Hurdles

Popularity with general public; enforcement of insurance minimums

EXAMPLE

In 2013, Ohio elevated its minimum liability coverage for drivers. Both industry and consumer groups opposed the action because premiums were expected to increase by at least 25 percent, prompting some people to drop coverage. Under the prior requirements, drivers in Ohio needed liability coverage that would pay up to $12,500 per person to cover injuries and medical costs, up to $25,000 per accident, and up to $7,500 property damage per accident. Only one state — Florida — had a lower injury liability limit than Ohio. And only four states — Pennsylvania, New Jersey, Massachusetts and California — had lower property damage limits. The new requirements are $25,000 per person or up to $50,000 per accident. The property damage liability coverage must be at least $25,000 to cover damage to other drivers' vehicles or any other property besides one's own.

Subsidize CVs

Mitigate Safety Risks	Encourage Shared AV Use	Address Liability Issues	Influence Market Demand


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Effectiveness
●●●●○

Efficiency
●●●●○

Political Acceptability
●○○○○

Operational Feasibility
●●●○○

Geographic Impact
Urban, suburban, rural

Who
Any state and local agencies

Hurdles
Political feasibility: allocation of funds with unknown return on investment

Description

This strategy seeks to encourage the adoption and penetration of connected vehicle (CV) technology by providing subsidies for CV equipment.

Technologies targeted/ownership model distinctions

This strategy would target both original equipment manufacturers (OEMs) and after-market CV technology, and could apply to all ownership models (privately owned, "shared-vehicle," etc.). Subsidies could be provided for new vehicle purchases with fully integrated CV technology or for CV retrofit "kit" installation, and could potentially originate from a variety of third parties, including insurance agencies.

How will this help?

This strategy will primarily target the impacts related to traffic crashes, congestion, and pollution. Reducing costs of required equipment can encourage producers to develop and sell safe CV equipment that will be integrated into vehicles and roadside infrastructure. It can also encourage consumers to then purchase vehicles and after-market equipment that incorporates V2V/V2I safety, mobility, and environmental applications.

Implementation issues

Federal, state, and local governments are no strangers to offering subsidies to encourage behavior. Electric vehicle (EV) purchases are a recent example, with individuals being able to claim a $7,500 federal income tax credit, as well as additional state and local credits and other incentives (access to carpool lanes and reduced rates for EV charging). Potential challenges to this strategy include a general lack of public knowledge of the benefits of CV technology. With the forthcoming NHTSA rulemaking requiring in-vehicle integration of CV equipment for new light-duty vehicles, subsidization could alleviate price increases associated with the required equipment. However, additional outreach to educate those in the market for new vehicles on why they should take advantage of the subsidies will escalate the overall costs. And as is always a concern with providing economic incentives, reduced revenue can potentially put a strain on funding for other programs.

Stakeholder benefits/concerns

The stakeholders for this strategy include, but are not limited to, federal, state, and local governments and transportation organizations; vehicle OEMs, suppliers, and dealerships; CV equipment manufacturers; and insurance agencies. Benefits to those stakeholders include increased adoption of CV technology that can significantly reduce traffic crashes and associated congestion and pollution, even at low levels of penetration. However, increased expenditures resulting from the economic incentives can have negative effects on funding for other programs.

Optimal timing

NHTSA's forthcoming rulemaking for in-vehicle CV equipment for light-duty vehicles will make the next few years an ideal time to begin an incentive/subsidization program to encourage new CV-equipped vehicle purchases. General Motors has preemptively committed to integrating the technology in select 2017 models, and other OEMs may follow suit. An incentive model similar to that for electric vehicles could be implemented, and could be phased out based on the number of vehicles purchased, to encourage early redemption to increase penetration.

Legality

While there are no explicit legal barriers to providing subsidies for technology adoption, challenges to government decisions are frequent. Incentives will likely require authorization and legislation at their respective level (federal, state, local, etc.).

EXAMPLE

To make environmentally friendly vehicles more appealing to consumers, all-electric and plug-in hybrid cars purchased in or after 2010 may be eligible for a federal income tax credit of up to $7,500. The credit amount will vary based on the capacity of the battery used to power the vehicle. State and/or local incentives may also apply.

Reducing costs of required equipment can encourage producers to develop and sell safe CV equipment that will be integrated into vehicles and roadside infrastructure.

Invest in CV Infrastructure

Mitigate Safety Risks	Encourage Shared AV Use	Address Liability Issues	Influence Market Demand

jamesteohart/Shutterstock.com

Description

This strategy aims to encourage development and adoption of connected vehicle (CV) technologies by supporting deployment of important physical and digital infrastructure that enables an advanced, connected transportation system.

Technologies targeted/ownership model distinctions

CV infrastructure primarily refers to Dedicated Short-Range Communications (DSRC) radio equipment, but can also refer to the supporting infrastructure needed for deployment, such as backhaul communications, CV data analytics, and CV-equipped traffic signal controllers. CV infrastructure investment could apply to all levels of AV/CV technologies and ownership models. Connected vehicles will realize the benefits of infrastructure-based information, whether using original equipment manufacturer (OEM) or after-market devices. Connected AV systems could make use of enhanced situational awareness provided by CV infrastructure.

How will this help?

This strategy will primarily target the impacts of congestion and traffic crashes, with potential impact on pollution. With increased saturation of CV-equipped vehicles, CV infrastructure could allow these vehicles to realize the benefits of V2V and V2I safety applications, which could prevent many common vehicular crashes that could not be prevented due to limited individual AV sensing range. CV infrastructure can facilitate traffic harmonization strategies that reduce congestion, which could affect vehicular emissions and fuel economy. CV infrastructure investment also directly benefits the DOT stakeholders who will be the recipients of the wealth of data created by a CV-enabled transportation system.

Implementation issues

While the federal government is actively funding pilot deployments of CV technology, the investment in CV infrastructure will ultimately fall to state and local entities, whose budgets are already thinly stretched. A strong case can be made to leverage CV and AV technology to increase safety and efficiency of existing roads. Increased levels of CV market penetration can exact significant results; however, the investment in a new digital infrastructure is a significant paradigm shift. The investing organizations will likely be forced to prioritize where CV equipment may be most beneficial. There has been no indication of proposed rulemaking requiring CV infrastructure, and standardization for CV infrastructure information is in its infancy. Installation costs associated with CV infrastructure are also higher than in-vehicle integration, as power and backhaul equipment are also required. USDOT has developed V2I deployment guidance for state and local transportation agencies, which includes information on use of Federal-aid programs to fund deployments that meet eligibility requirements.

Stakeholder benefits/concerns

The benefits to the investing organizations are potentially far-reaching, primarily improving the safety and efficiency of their transportation systems for users, though at a potentially significant cost. As the USDOT CV pilots progress, much information will be gathered to provide recommendations and lessons learned to stakeholders considering CV infrastructure investment benefits.

Optimal timing

With the performance-based initiatives in the MAP-21 legislation, states and MPOs are looking to establish safety targets, and could be open to considering how investment in CV infrastructure may help them meet those goals. The federal government is leading the way in terms of CV research and pilot deployment. Standardization of infrastructure messaging and performance is beginning, and as the CV pilots and AV testing progress, stakeholders will have data to help plan and justify the expenses and deployment. The next few years will be critical to the execution of this strategy. NHTSA's proposed rulemaking related to in-vehicle CV integration is a positive step; however, market penetration may progress slowly, so there is still time for state and local transportation planners to learn about CV technology and its potential benefits to make informed decisions on investing in infrastructure.

Legality

There are no known legal or regulatory barriers to transportation organizations investing in technology to improve their roadways. However, as with all significant investments that are largely funded by their users, the investing agencies will benefit from providing concrete evidence to the benefits that the users will see from the investments.

The benefits to the investing organizations are potentially far-reaching, primarily improving safety and efficiency, though at a potentially significant cost.

Effectiveness

Efficiency

Political Acceptability

Operational Feasibility

Geographic Impact

Urban, suburban, rural

Who

State DOTs, cities, toll agencies, MPOs

Hurdles

Funding availability, understanding benefits, AV compatability

EXAMPLES

Michigan DOT has established a 125-mile test bed for connected vehicle technology in Southeast Michigan, and sees CV infrastructure investment as key to creating an environment supportive of V2I testing. MDOT is supporting equipped vehicles that engage in the system through a combination of partnerships and state vehicle fleets. Through its Data Use Analysis and Processing (DUAP) program, MDOT is pioneering the collection and fusion of CV data with a range of data sources.

Arizona DOT operates a connected vehicle test bed using DSRC in Maricopa County. The test bed was deployed to test and demonstrate signal priority, ramp meter priority, emergency vehicle applications, truck priority for freight movement, and applications for pedestrian and cyclist safety and mobility.

Grant AVs and CVs Priority Access to Dedicated Lanes

Mitigate Safety Risks	Encourage Shared AV Use	Address Liability Issues	Influence Market Demand

oksana.perkins/Shutterstock.com

Effectiveness

●●●○○

Efficiency

●●●●○

Political Acceptability

●●○○○

Operational Feasibility

●●○○○

Geographic Impact

Urban

Who

State and local road operators

Hurdles

Political, operational

Description

This strategy grants priority access to AVs and CVs in dedicated lanes on roadways. Longer trips served by freeways could support the ability of AVs and CVs to travel at close spacing and/or form fast-moving, densely spaced, platoons. For special urban districts, exclusive lanes for SAVs could support reduction of VMT in the district, depending upon the shared ride requirements imposed.

Technologies targeted/ownership model distinctions

Higher level AVs and CVs with V2V capability will have the ability to form platoons that could benefit from exclusive lanes. The strategy works under any ownership model. Urban districts that designate lanes for exclusive AV use would likely do so in support of shared AVs, and may impose ridership requirements to gain public benefits in exchange for the loss of street space for other uses.

How will this help?

The potential for fast and safe travel on dedicated lanes for AVs or CVs would naturally encourage the purchase of AVs and CVs. The improvement in traffic flow and throughput improves social welfare through reduced congestion, reduced travel times, lower emissions, and reduced vehicle operating costs. As long as there are sufficient AVs or CVs to fill the exclusive lane, the benefits would exceed the costs, because a dedicated lane could move many more vehicles much faster, relieving congestion on other lanes. For commercial vehicles, platoons in dedicated lanes could save fuel, reducing emissions. If the intent is to increase market penetration of equipped vehicles, success will depend on road operators' willingness to dedicate lanes to AVs and CVs. If the intent is to reduce VMT in a restricted district or area (like an urban center), success will depend on how well the supply of SAVs matches demand.

Implementation issues

The most common form of dedicated lanes is managed lanes (MLs), which vary in size, allowed uses, and ownership. Allowing closely spaced AVs and CVs would likely require the owners of the lanes to work with the FHWA to ensure minimum standards are met such as 45 mph speed in the lanes for 90% of the peak period. Lane owners would also likely have to work with state legislatures in the case where a lane was dedicated to AVs/CVs only. The best candidates would be those lanes with many travelers using the lanes for long trips. However, one implementation issue would be the different operating responsibilities for CVs and AVs in maintaining platoons. For a CV, the driver is responsible for maintaining vehicle headways, but for a Level 4 or 5 AV, the vehicle would be responsible for this aspect of operation, thus potentially creating alternative regulatory regimes. Financial documents for existing MLs may need to be modified to allow this new user group – especially if the preferential treatment includes a toll discount which would impact the revenue stream. For urban district conversion of lanes exclusively for SAVs or urban freight delivery, implementation challenges arise when restricting use to one travel mode within areas already experiencing high demand. For minimal cost, the potential societal benefits are very large. But deployment will require the right situation. For managed lanes, it will require long distance trip patterns; for urban districts, it will require the right market conditions for SAV. For both cases, displaced users will create a political challenge.

Stakeholder benefits/concerns

Stakeholders include AV and CV manufacturers, the owners, operators, users, and financiers of MLs, and any displaced users of converted lanes. Among the various options for priority lane designation, political acceptability will be lowest for the conversion of a general use lane to a dedicated-use lane.

Optimal timing

To incentivize market adoption, optimal timing would be in the near term. For lane dedication that involves displaced users and local residents, political challenges will likely dictate the timing.

Legality

Allowing platooning of AVs (Levels 3, 4 and 5) or CVs (V2V) on MLs will require enabling legislation. If the lane was dedicated to AVs and CVs only, then it is likely state and local legislative authority would be required. Issues such as following distance requirements will need to be examined and potentially revised.

EXAMPLE

In one example, clean vehicles were granted access to HOV lanes normally restricted to vehicles with two or more occupants. Of the 3,500 plug-in electric vehicle owners surveyed in California, 3,000 were allowed to use HOV lanes. Most indicated that HOV lane access was their primary motivation for buying the car. This is a clear example where travel time savings motivated the purchase of a specific type of vehicle.

The potential for fast and safe travel on dedicated lanes for AVs or CVs would naturally encourage the purchase of AVs and CVs.

Grant Signal Priority to CVs

Mitigate Safety Risks	Encourage Shared AV Use	Address Liability Issues	**Influence Market Demand**


Anna Grigorjeva/Shutterstock.com

Effectiveness
● ◎ ◎ ◎ ◎

Efficiency
● ● ◎ ◎ ◎

Political Acceptability
● ● ◎ ◎ ◎

Operational Feasibility
● ● ● ● ◎

Geographic Impact
Urban, suburban

Who
State and local transportation agencies that operate traffic signals

Hurdles
Political

Description

Traffic signal priority for AVs and CVs involves sophisticated signal timing algorithms that estimate the arrival of platoons of AVs and CVs and coordinate the signal timing to give these platoons green light priority and increase throughput. The goal is to decrease delay at the signal for all vehicles, but particularly AVs and CVs, as a way to stimulate consumer action toward market penetration.

Technologies targeted/ownership model distinctions

All levels of connectivity and automation could benefit from this as long as there was connectivity to the infrastructure. As such, it is considered a CV application. This policy would require a high percentage of connected vehicles in the traffic stream to reduce overall delay. With sufficient numbers of equipped vehicles, the policy could work well in both private- and shared-ownership models.

How will this help?

CV priority would be a more complex version of transit signal priority. The call for CV priority could come from any number of platoons at any time approaching from all directions. Conversely, during periods with very little traffic, the signal may be able to provide green for any approaching CV, saving time, fuel, and operating costs for those vehicles. This strategy will require a large percentage of the fleet to be equipped to obtain benefits that would exceed costs, as the travel time savings will be minimal and can only be used when conditions are right. Given the minimal travel time benefits that would result, it is unlikely that this policy would be a driving force to increase market penetration of CVs.

Implementation issues

Providing CVs priority treatment at signalized intersections would be led by the agency responsible for operating a traffic signal system. Many such agencies currently grant some priority treatment to transit. The overall impact would depend a great deal on the market penetration of CVs. If CVs represent a small portion of the traffic, then granting those individual calls for green might increase overall delay, negatively impacting many non-CV drivers. Additionally, during periods of peak congestion and saturated flows, priority treatment would likely not improve traffic flow; any benefit to the CV owner would be negligible. This strategy could be an extension of the current practice of transit signal priority. The technical and financial challenges are minimal, but the potential positive impact is also minimal. The only operational limitation pertains to the algorithms that prioritize CVs, which have not been developed.

Stakeholder benefits/concerns

Stakeholders include the owners and operators of the traffic signals plus all travelers on the roadway network. All income groups and disadvantaged groups stand to benefit, although higher income groups would likely see more benefit as they are more likely to afford an equipped vehicle. Implementation may require tradeoffs among road users; e.g., the deployment of priority treatment for CVs may increase delay for transit users and non-equipped vehicles. Equity issues could arise in offering privileged service to higher-income owners of CVs to the detriment of captive transit riders, especially where transit priority treatment is currently provided.

Optimal timing

Traffic signal priority requires a traffic signal to be able to receive a signal request message from the platoon and act on it by giving priority to the platoon. Most traffic signal controllers installed in the last 15 to 20 years have this ability. The ability for platoons to send this signal has not been developed, nor have any algorithms that guide when the signal will grant priority.

Legality

There are no expected legal barriers to this strategy, as state and local agencies have authority to operate traffic signals.

EXAMPLE

Transit signal priority (TSP) is an example of an operational strategy that places priority on moving buses or streetcars through traffic-signal controlled intersections. In Portland, Oregon, TSP was implemented on more than 240 intersections (roughly 25% of the city), resulting in a 5% to 12% travel time reduction for transit vehicles. The basic principle of operation: if the vehicle arrives on a green indication, the green is extended 5 to 30 seconds. If the vehicle arrives on red, the phases for the other approaches of the intersection are shortened.

The goal is to decrease delay at the signal for all vehicles, but particularly AVs and CVs, as a way to stimulate consumer action toward market penetration.

Grant Parking Access to AVs and CVs

Mitigate Safety Risks	Encourage Shared AV Use	Address Liability Issues	Influence Market Demand

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Effectiveness
● ◎ ◎ ◎ ◎

Efficiency
● ● ● ◎ ◎

Political Acceptability
● ● ◎ ◎ ◎

Operational Feasibility
● ● ● ● ◎

Geographic Impact
Urban

Who
Local government

Hurdles
Effectiveness

Description

This policy strategy grants priority reserved parking in a desirable location to automated and connected vehicles (AVs and CVs) to accelerate market penetration.

Technologies targeted/ownership model distinctions

Parking priority would give preferential parking spots to AVs (SAE Levels 3, 4, 5) and to CVs (V2V and V2I).

How will this help?

Theoretically, parking priority for AVs and CVs would be an incentive to consumers to purchase personal AVs or use shared AVs, thereby increasing the numbers of AVs and CVs and realizing their safety, congestion, environmental, and mobility benefits. CVs (V2I or V2V) could also alert the vehicle to available parking spots, which might benefit society through reduced VMT from parking searches. The alerts could come from the infrastructure or from other vehicles that sense open spaces. This is similar to some smart phone apps that provide this information to travelers, such as ParkMe (www.ParkMe.com) or SFPark (sfpark.org).

Implementation issues

State and local entities have authority over parking garages and on-street parking. Prototype policies for preferential parking are currently implemented for EVs. Many national, state and city governments have tried to advance the uptake of electric vehicles (EVs) and reduce oil consumption, climate-related emissions, and local air pollution through preferential parking. Most parking that would be impacted by priority parking for AV/CV would lie with private property owners. Some employers now offer preferential parking for low-emission and fuel-efficient vehicles or for vehicles used in carpooling or ridesharing as part of transportation demand management initiatives. These policies work best in a large parking facility with a lot of non-desirable spaces.

AVs are distinct, and may not easily follow the EV or carpool/rideshare model for preferential parking. AVs can be self-parking. Once the traveler leaves the AV, the vehicle can self-park in the least preferred locations such as the top floor of a garage or back areas, reducing the desirability of preferred parking. Further, AVs can use much smaller parking spots and vehicles can be "stacked" since there is no need for the doors to open. Due to these impacts, high value spaces could be reserved for different types of traditional vehicles. Preferred parking spaces may be provided at key transportation hubs to encourage travelers to use public transit. But as noted above, self-parking AVs reduce the value of this incentive. There may be value in shared vehicles having preferential curb access in some instances. There may be a higher utility to the CV-owner or user for preferential parking since the vehicle may not be self-parking. But the capability to receive real-time alerts as to open parking spaces may reduce the incentive.

Many parking facilities are owned and operated by municipalities, airports, and transit stations, and parking fees are a significant revenue source for these organizations. In the event that AV/CV technology reduces the demand for high-cost parking, the revenue streams may be reduced.

Stakeholder benefits/concerns

Stakeholders include travelers and the owners and operators of parking facilities. The impact is likely to be positive (reduced traffic congestion due to reduced parking search times and increased parking spots due to smaller space needs to park an AV). All income groups and disadvantaged groups stand to benefit. With shared AVs, it is likely that these benefits would be more widely dispersed. This strategy could be considered an incremental change since it is simply adjusting who is allowed to park in certain spaces.

Optimal timing

This strategy pertains to a near term scenario where the market penetration of AVs and CVs is relatively small.

Legality

Local jurisdictions that operate parking facilities would have the legal authority to put such a program in place.

EXAMPLE

To facilitate car-sharing (e.g., Zipcar, Car2Go), cities have provided parking spaces for free to car-sharing services. In 2012, Washington, DC offered universal parking passes for 200 car-share vehicles to promote one-way car-sharing in the district. In Austin, Texas, both Car2Go and Zipcar have designated spaces in the downtown area, which are marked by posted signs. Additionally, Car2Go vehicles may park at City of Austin metered spaces for free. Car share vehicles are still subject to most posted signs, and are not allowed to park in no-parking zones, fire zones, commercial zones, etc.

This policy strategy grants priority reserved parking in a desirable location to automated and connected vehicles (AVs and CVs) to accelerate market penetration.

Implement New Contractual Mechanisms with Private-sector Providers

Mitigate Safety Risks	Encourage Shared AV Use	Address Liability Issues	**Influence Market Demand**

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Description

This strategy aims to establish new contractual mechanisms with private-sector providers to incentivize market development for AV and CV technologies, one example of which is a public-private partnership (PPP or P3). PPPs or other arrangements that include/require reinvestment of potential revenue to deploy CV- and AV-enabling technologies could facilitate adoption and penetration. This approach also creates an ecosystem that could lead to innovation.

Technologies targeted/ownership model distinctions

These mechanisms could target all levels of AV/CV technologies and ownership models, especially CV technology and shared AVs. Connected vehicles using either original equipment manufacturer (OEM) or after-market equipment will broadcast immense amounts of data that could be collected anonymously by roadside infrastructure and made available in a data marketplace. This could include vehicle probe data (position, speed, etc.), giving insight into throughput and traffic patterns, and other information such as CV application incidences (forward collision warnings, curve speed warnings, etc.). The CV infrastructure itself could similarly be a data source to the marketplace.

How will this help?

This strategy can potentially target all impacts of driving by encouraging and facilitating the deployment of CV and AV systems and technologies, which can lessen the impacts of traffic crashes, congestion, pollution, land development, and mobility. Producers could be encouraged to further develop CV technology, including V2V and V2I safety and mobility applications, as well as connected AVs. Private, shared vehicle operators and new TNC models could operate shared AVs; and consumer purchases of higher level AVs, including connected AVs, could harmonize traffic flow and reduce incidents.

Implementation issues

P3 arrangements have historically created net-positive benefits for stakeholders and users, often times accelerating the completion of a needed function or facility. However, they are generally perceived as a more expensive mechanism to realize those benefits, including deployment of technology. Identifying a suitable revenue stream to support the marketplace for AV and CV technology could be challenging. With a PPP established for toll or managed roadways, toll revenue could be leveraged for such an investment. Additionally, the data generated by CVs and connected AVs could be a valuable asset for planning and operations, and could be a significant revenue stream.

Stakeholder benefits/concerns

The primary stakeholders for this strategy include the state and local agencies and private organizations that will enter into these agreements. Many examples of PPP arrangements involve design, construction, and maintenance of toll and managed roadways (which can be controversial), and data marketplace models have not been tested. Whenever public assets are monetized, concerns are raised about disproportionate impacts to lower income drivers and transit users. Furthermore, as traditional PPP relationships are typically established for segments of roadways, the perceived benefits are highly localized. As such, P3 relationships that include CV and AV elements may need to occur on a more system-wide level. Data privacy must also be considered, so all entities would need to ensure that any user-generated data would be anonymized.

Optimal timing

Implementation of these new approaches or business models could benefit adoption and deployment of CV and AV technologies in the near-term, since transportation agencies generally have limited budgets for technology development and deployment, and could make use of funding made available from private organizations through these arrangements. Once revenue streams are flowing, the private organizations can recoup their investments and begin to identify new investment opportunities. A new business model may be needed, which could delay the feasibility of this approach.

Legality

Innovative contractual approaches and business models must adhere to relevant, existing legal frameworks for contracts and agreements, which can vary widely among states.

Arrangements that include/require reinvestment of potential revenue to deploy CV- and AV-enabling technologies could facilitate adoption and penetration.

Effectiveness

●●○○○

Efficiency

●●●●○

Political Acceptability

●●○○○

Operational Feasibility

●●○○○

Geographic Impact

Urban

Who

Transportation agencies in urban areas: state DOTs, cities, toll authorities, public transit agencies

Hurdles

Viable business models, legal and governance, political acceptability

EXAMPLE

Utah DOT uses 30-year resource sharing agreements to coordinate fiber-optic broadband network development in the public right of way (ROW) along its state roads. State law was created in 2008 defining shared-use agreements specific to telecom services and longitudinal access to UDOT ROW. UDOT maintains a policy that keeps the ROW open at all times for telecom providers to get easy access to complete continuous build outs, which also ensures that no single company gets exclusive access to the ROW. UDOT installs conduit during all roadway projects anticipating future connection to local communities with fiber optics and broadband. This encourages telecoms to provide access to local communities, and gains access to the telecom's fiber network through a resource sharing agreement.

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AUTOMATED DRIVING SYSTEMS 2.0

A Vision for Safety

U.S. Department of Transportation

NHTSA


SOS
EV

INTRODUCTORY MESSAGE

Secretary Elaine L. Chao
U.S. Department of Transportation

Today, our country is on the verge of one of the most exciting and important innovations in transportation history—the development of Automated Driving Systems (ADSs), commonly referred to as automated or self-driving vehicles.

The future of this new technology is so full of promise. It's a future where vehicles increasingly help drivers avoid crashes. It's a future where the time spent commuting is dramatically reduced, and where millions more—including the elderly and people with disabilities–gain access to the freedom of the open road. And, especially important, it's a future where highway fatalities and injuries are significantly reduced.

Since the Department of Transportation was established in 1966, there have been more than 2.2 million motor-vehicle-related fatalities in the United States. In addition, after decades of decline, motor vehicle fatalities spiked by more than 7.2 percent in 2015, the largest single-year increase since 1966. The major factor in 94 percent of all fatal crashes is human error. So ADSs have the potential to significantly reduce highway fatalities by addressing the root cause of these tragic crashes.

The U.S. Department of Transportation has a role to play in building and shaping this future by developing a regulatory framework that encourages, rather than hampers, the safe development, testing and deployment of automated vehicle technology.

Accordingly, the Department is releasing *A Vision for Safety* to promote improvements in safety, mobility, and efficiency through ADSs.

A Vision for Safety replaces the Federal Automated Vehicle Policy released in 2016. This updated policy framework offers a path forward for the safe deployment of automated vehicles by:

- Encouraging new entrants and ideas that deliver safer vehicles;
- Making Department regulatory processes more nimble to help match the pace of private sector innovation; and
- Supporting industry innovation and encouraging open communication with the public and with stakeholders.

Thanks to a convergence of technological advances, the promise of safer automated driving systems is closer to becoming a reality. From reducing crash-related deaths and injuries, to improving access to transportation, to reducing traffic congestion and vehicle emissions, automated vehicles hold significant potential to increase productivity and improve the quality of life for millions of people. *A Vision for Safety* seeks to facilitate the integration of ADS technology by helping to ensure its safe testing and deployment, as well as encouraging the development of systems that guard against cyber-attacks and protect consumer privacy.

Our goal at the Department of Transportation is to be good stewards of the future by helping to usher in this new era of transportation innovation and safety, and ensuring that our country remains a global leader in autonomous vehicle technology.

EXECUTIVE SUMMARY

The world is facing an unprecedented emergence of automation technologies. In the transportation sector, where 9 out of 10 serious roadway crashes occur due to human behavior, automated vehicle technologies possess the potential to save thousands of lives, as well as reduce congestion, enhance mobility, and improve productivity. The Federal Government wants to ensure it does not impede progress with unnecessary or unintended barriers to innovation. Safety remains the number one priority for the U.S. Department of Transportation (DOT) and is the specific focus of the National Highway Traffic Safety Administration (NHTSA).

NHTSA's mission is to save lives, prevent injuries, and reduce the economic costs of roadway crashes through education, research, safety standards, and enforcement activity. As automated vehicle technologies advance, they have the potential to dramatically reduce the loss of life each day in roadway crashes. To support industry innovators and States in the deployment of this technology, while informing and educating the public, and improving roadway safety through the safe introduction of the technology, NHTSA presents *Automated Driving Systems: A Vision for Safety*. It is an important part of DOT's multimodal efforts to support the safe introduction of automation technologies.

In this document, NHTSA offers a nonregulatory approach to automated vehicle technology safety. *Section 1: Voluntary Guidance for Automated Driving Systems (Voluntary Guidance)* supports the automotive industry and other key stakeholders as they consider and design best practices for the testing and safe deployment of Automated Driving Systems (ADSs - SAE Automation Levels 3 through 5 – Conditional, High, and Full Automation Systems). It contains 12 priority safety design elements for consideration, including vehicle cybersecurity, human machine interface, crashworthiness, consumer education and training, and post-crash ADS behavior.

Given the developing state of the technology, this *Voluntary Guidance* provides a flexible framework for industry to use in choosing how to address a given safety design element. In addition, to help support public trust and confidence, the *Voluntary Guidance* encourages entities engaged in testing and deployment to publicly disclose Voluntary Safety Self-Assessments of their systems in order to demonstrate their varied approaches to achieving safety.

Vehicles operating on public roads are subject to both Federal and State jurisdiction, and States are beginning to draft legislation to safely deploy emerging ADSs. To support the State work, NHTSA offers *Section 2: Technical Assistance to States, Best Practices for Legislatures Regarding Automated Driving Systems (Best Practices)*. The section clarifies and delineates Federal and State roles in the regulation of ADSs. NHTSA remains responsible for regulating the safety design and performance aspects of motor vehicles and motor vehicle equipment; States continue to be responsible for regulating the human driver and vehicle operations.

The section also provides *Best Practices for Legislatures*, which incorporates common safety-related components and significant elements regarding ADSs that States should consider incorporating in legislation. In addition, the section provides *Best Practices for State Highway Safety Officials*, which offers a framework for States to develop procedures and conditions for ADSs' safe operation on public roadways. It includes considerations in such areas as applications and permissions to test, registration and titling, working with public safety officials, and liability and insurance.

Together, the *Voluntary Guidance* and *Best Practices* sections serve to support industry, Government officials, safety advocates, and the public. As our Nation and the world embrace technological advances in motor vehicle transportation through ADSs, safety must remain the top priority.

Over the coming months and years, NHTSA, along with other Federal agencies, where relevant, will continue to take a leadership role in encouraging the safe introduction of automated vehicle technologies into the motor vehicle fleet and on public roadways in the areas of policy, research, safety standards, freight and commercial use, infrastructure, and mass transit.

The **Office of the Under Secretary for Policy (OST-P)** is the office responsible for serving as a principal advisor to the Secretary and provides leadership in the development of policies for the Department, generating proposals and providing advice regarding legislative and regulatory initiatives across all modes of transportation. The Under Secretary coordinates the Department's budget development and policy development functions. The Under Secretary also directs transportation policy development and works to ensure that the Nation's transportation resources function as an integrated national system.
See www.transportation.gov/policy.

The **Office of the Assistant Secretary for Research and Technology (OST-R)** is the lead office responsible for coordinating DOT's research and for sharing advanced technologies with the transportation system. Technical and policy research on these technologies occurs through the Intelligent Transportation Systems (ITS) Research Program, the University Transportation Centers, and the Volpe National Transportation Research Center, which make investments in technology initiatives, exploratory studies, pilot deployment programs and evaluations in intelligent vehicles, infrastructure, and multi-modal systems.
See www.its.dot.gov and www.transportation.gov/research-technology.

The **Federal Motor Carrier Safety Administration (FMCSA)** is the lead Federal Government agency responsible for regulating and providing operational safety oversight (for instance, hours of service regulations, drug and alcohol testing, hazardous materials safety, vehicle inspections) for motor carriers operating commercial motor vehicles (CMVs), such as trucks and buses, and CMV drivers. FMCSA partners with industry, safety advocates, and State and local governments to keep our Nation's roadways safe and improve CMV safety through financial assistance, regulation, education, enforcement, research, and technology.
See www.fmcsa.dot.gov.

The **Federal Highway Administration (FHWA)** supports State and local governments in the design, construction, and maintenance of the Nation's highway system (Federal Aid Highway Program) and various Federal and tribal lands (Federal Lands Highway Program). Through financial and technical assistance to State and local governments, FHWA is responsible for ensuring that America's roads and highways continue to be among the safest and most technologically sound in the world.
See www.fhwa.dot.gov.

The **Federal Transit Administration (FTA)** provides financial and technical assistance to local public transit systems, including buses, subways, light rail, commuter rail, trolleys, and ferries. FTA also oversees safety measures and helps develop next-generation technology research.
See www.transit.dot.gov.

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SECTION 1: VOLUNTARY GUIDANCE

For Automated Driving Systems

OVERVIEW

The U.S. Department of Transportation (DOT) through the National Highway Traffic Safety Administration (NHTSA) is fully committed to reaching an era of crash-free roadways through deployment of innovative lifesaving technologies. Recent negative trends in automotive crashes underscore the urgency to develop and deploy lifesaving technologies that can dramatically decrease the number of fatalities and injuries on our Nation's roadways. NHTSA believes that Automated Driving Systems (ADSs), including those contemplating no driver at all, have the potential to significantly improve roadway safety in the United States.

The purpose of this Voluntary Guidance is to support the automotive industry, the States, and other key stakeholders as they consider and design best practices relative to the testing and deployment of automated vehicle technologies. It updates the Federal Automated Vehicles Policy released in September 2016 and serves as NHTSA's current operating guidance for ADSs.

The Voluntary Guidance contains 12 priority safety design elements.[1] These elements were selected based on research conducted by the Transportation Research Board (TRB), universities, and NHTSA. Each element contains safety goals and approaches that could be used to achieve those safety goals. Entities are encouraged to consider each safety element in the design of their systems and have a self-documented process for assessment, testing, and validation of the various elements. As automated driving technologies evolve at a rapid pace, no single standard exists by which an entity's methods of considering a safety design element can be measured. Each entity is free to be creative and innovative when developing the best method for its system to appropriately mitigate the safety risks associated with their approach.

In addition, to help support public trust and confidence in the safety of ADSs, this Voluntary Guidance encourages entities to disclose Voluntary Safety Self-Assessments demonstrating their varied approaches to achieving safety in the testing and deployment of ADSs.[2]

Entities are encouraged to begin using this Voluntary Guidance on the date of its publication. NHTSA plans to regularly update the Voluntary Guidance to reflect lessons learned, new data, and stakeholder input as technology continues to be developed and refined.

For overall awareness and to ensure consistency in taxonomy usage, NHTSA adopted SAE International's Levels of Automation and other applicable terminology.[3]

NHTSA'S MISSION

Save lives, prevent injuries, and reduce economic costs due to road traffic crashes, through education, research, safety standards, and enforcement activity.

SCOPE AND PURPOSE

Through this Voluntary Guidance, NHTSA is supporting entities that are designing ADSs for use on public roadways in the United States. This includes traditional vehicle manufacturers as well as other entities involved with manufacturing, designing, supplying, testing, selling, operating, or deploying ADSs, including equipment designers and suppliers; entities that outfit any vehicle with automated capabilities or equipment for testing, for commercial sale, and/or for use on public roadways; transit companies; automated fleet operators; "driverless" taxi companies; and any other individual or entity that offers services utilizing ADS technology (referred to collectively as "entities" or "industry").

This Voluntary Guidance applies to the design aspects of motor vehicles and motor vehicle equipment under NHTSA's jurisdiction, including low-speed vehicles, motorcycles, passenger vehicles, medium-duty vehicles, and heavy-duty CMVs such as large trucks and buses. These entities are subject to NHTSA's defect, recall, and enforcement authority.[4] For entities seeking to request regulatory action (e.g., petition for exemption or interpretation) from NHTSA, an informational resource is available on the Agency's website at www.nhtsa.gov/technology-innovation/automated-vehicles, along with other associated references and resources.

Interstate motor carrier operations and CMV drivers fall under the jurisdiction of FMCSA and are not within the scope of this Voluntary Guidance. Currently, per the Federal Motor Carrier Safety Regulations (FMCSRs), a trained commercial driver must be behind the wheel at all times, regardless of any automated driving technologies available on the CMV, unless a petition for a waiver or exemption has been granted. For more information regarding CMV operations and automated driving technologies, including guidance on FMCSA's petition process, see www.fmcsa.dot.gov.

This Voluntary Guidance focuses on vehicles that incorporate SAE Automation Levels 3 through 5 – Automated Driving Systems (ADSs). ADSs may include systems for which there is no human driver or for which the human driver can give control to the ADS and would not be expected to perform any driving-related tasks for a period of time.[5] It is an entity's responsibility to determine its system's automation level in conformity with SAE International's published definitions.

The purpose of this Voluntary Guidance is to help designers of ADSs analyze, identify, and resolve safety considerations prior to deployment using their own, industry, and other best practices. It outlines 12 safety elements, which the Agency believes represent the consensus across the industry, that are generally considered to be the most salient design aspects to consider and address when developing, testing, and deploying ADSs on public roadways. Within each safety design element, entities are encouraged to consider and document their use of industry standards, best practices, company policies, or other methods they have employed to provide for increased system safety in real-world conditions. The 12 safety design elements apply to both ADS original equipment and to replacement equipment or updates (including software updates/upgrades) to ADSs.

This Voluntary Guidance provides recommendations and suggestions for industry's consideration and discussion. This Guidance is entirely voluntary, with no compliance requirement or enforcement mechanism. The sole purpose of this Guidance is to support the industry as it develops best practices in the design, development, testing, and deployment of automated vehicle technologies.

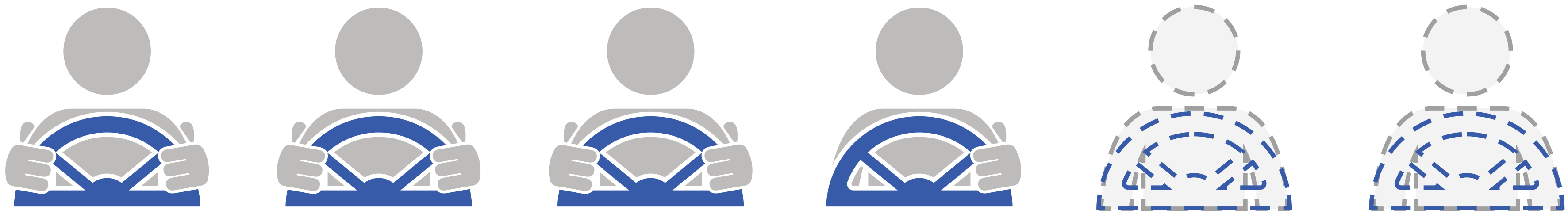
NHTSA'S ENFORCEMENT AUTHORITY

Several States have sought clarification of NHTSA's enforcement authority with respect to ADSs. As DOT is asking States to maintain the delineation of Federal and State regulatory authority, NHTSA understands that States are looking for reassurance that the Federal Government has tools to keep their roadways safe.

NHTSA has broad enforcement authority to address existing and new automotive technologies and equipment. The Agency is commanded by Congress[6] to protect the safety of the driving public against unreasonable risks of harm that may arise because of the design, construction, or performance of a motor vehicle or motor vehicle equipment, and to mitigate risks of harm, including risks that may arise in connection with ADSs. Specifically, NHTSA's enforcement authority concerning safety-related defects in motor vehicles and motor vehicle equipment extends and applies equally to current and emerging ADSs. As NHTSA has always done, when evaluating new automotive technologies, it will be guided by its statutory mission, the laws it is obligated to enforce, and the benefits of the technology.

SAE AUTOMATION LEVELS

Full Automation



0	1	2	3	4	5
No Automation	**Driver Assistance**	**Partial Automation**	**Conditional Automation**	**High Automation**	**Full Automation**
Zero autonomy; the driver performs all driving tasks.	Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design.	Vehicle has combined automated functions, like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment at all times.	Driver is a necessity, but is not required to monitor the environment. The driver must be ready to take control of the vehicle at all times with notice.	The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.	The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.

ADS SAFETY ELEMENTS

1. System Safety

Entities are encouraged to follow a robust design and validation process based on a systems-engineering approach with the goal of designing ADSs free of unreasonable safety risks. The overall process should adopt and follow industry standards, such as the functional safety[7] process standard for road vehicles, and collectively cover the entire operational design domain (i.e., operating parameters and limitations) of the system. Entities are encouraged to adopt voluntary guidance, best practices, design principles, and standards developed by established and accredited standards-developing organizations (as applicable) such as the International Standards Organization (ISO) and SAE International, as well as standards and processes available from other industries such as aviation, space, and the military[8] and other applicable standards or internal company processes as they are relevant and applicable. See NHTSA's June 2016 report, *Assessment of Safety Standards for Automotive Electronic Control Systems*[9], which provides an evaluation of the strengths and limitations of such standards.

The design and validation process should also consider including a hazard analysis and safety risk assessment for ADSs, for the overall vehicle design into which it is being integrated, and when applicable, for the broader transportation ecosystem. Additionally, the process shall describe design redundancies and safety strategies for handling ADS malfunctions. Ideally, the process should place significant emphasis on software development, verification, and validation. The software development process is one that should be well-planned, well-controlled, and well-documented to detect and correct unexpected results from software updates. Thorough and measurable software testing should complement a structured and documented software development and change management process and should be part of each software version release. Industry is encouraged to monitor the evolution, implementation, and safety assessment of artificial intelligence and other relevant software technologies and algorithms to improve the effectiveness and safety of ADSs.

Design decisions should be linked to the assessed risks that could impact safety-critical system functionality. Design safety considerations should include design architecture, sensors, actuators, communication failure, potential software errors, reliability, potential inadequate control, undesirable control actions, potential collisions with environmental objects and other road users, potential collisions that could be caused by actions of an ADS, leaving the roadway, loss of traction or stability, and violation of traffic laws and deviations from normal (expected) driving practices.

All design decisions should be tested, validated, and verified as individual subsystems and as part of the entire vehicle architecture. Entities are encouraged to document the entire process; all actions, changes, design choices, analyses, associated testing, and data should be traceable and transparent.

2. Operational Design Domain

Entities are encouraged to define and document the Operational Design Domain (ODD) for each ADS available on their vehicle(s) as tested or deployed for use on public roadways, as well as document the process and procedure for assessment, testing, and validation of ADS functionality with the prescribed ODD. The ODD should describe the specific conditions under which a given ADS or feature is intended to function. The ODD is the definition of where (such as what roadway types and speeds) and when (under what conditions, such as day/night, weather limits, etc.) an ADS is designed to operate.

The ODD would include the following information at a minimum to define each ADS's capability limits/boundaries:

- Roadway types (interstate, local, etc.) on which the ADS is intended to operate safely;
- Geographic area (city, mountain, desert, etc.);
- Speed range;
- Environmental conditions in which the ADS will operate (weather, daytime/nighttime, etc.); and
- Other domain constraints.

An ADS should be able to operate safely within the ODD for which it is designed. In situations where the ADS is outside of its defined ODD or in which conditions dynamically change to fall outside of the ADS's ODD, the vehicle should transition to a minimal risk condition.[10] For a Level 3 ADS, transitioning to a minimal risk condition could entail transitioning control to a receptive, fallback-ready user.[11] In cases the ADS does not have indications that the user is receptive and fallback-ready, the system should continue to mitigate manageable risks, which may include slowing the vehicle down or bringing the vehicle to a safe stop. To support the safe introduction of ADSs on public roadways and to speed deployment, the ODD concept provides the flexibility for entities to initially limit the complexity of broader driving challenges in a confined ODD.

3. Object and Event Detection and Response

Object and Event Detection and Response (OEDR)[12] refers to the detection by the driver or ADS of any circumstance that is relevant to the immediate driving task, as well as the implementation of the appropriate driver or system response to such circumstance. For the purposes of this Guidance, an ADS is responsible for performing OEDR while it is engaged and operating in its defined ODD.

Entities are encouraged to have a documented process for assessment, testing, and validation of their ADS's OEDR capabilities. When operating within its ODD, an ADS's OEDR functions are expected to be able to detect and respond to other vehicles (in and out of its travel path), pedestrians, bicyclists, animals, and objects that could affect safe operation of the vehicle.

An ADS's OEDR should also include the ability to address a wide variety of foreseeable encounters, including emergency vehicles, temporary work zones, and other unusual conditions (e.g., police manually directing traffic or other first responders or construction workers controlling traffic) that may impact the safe operation of an ADS.

Normal Driving

Entities are encouraged to have a documented process for the assessment, testing, and validation of a variety of behavioral competencies for their ADSs. Behavioral competency refers to the ability of an ADS to operate in the traffic conditions that it will regularly encounter, including keeping the vehicle in a lane, obeying traffic laws, following reasonable road etiquette, and responding to other vehicles or hazards.[13] While research conducted by California PATH[14] provided a set of minimum behavioral competencies for ADSs,[15] the full complement of behavioral competencies a particular ADS would be expected to demonstrate and routinely perform will depend upon the individual ADS, its ODD, and the designated fallback (minimal risk condition) method. Entities are encouraged to consider all known behavioral competencies in the design, test, and validation of their ADSs.

Crash Avoidance Capability – Hazards

Entities are encouraged to have a documented process for assessment, testing, and validation of their crash avoidance capabilities and design choices. Based on the ODD, an ADS should be able to address applicable pre-crash scenarios[16] that relate to control loss; crossing-path crashes; lane change/merge; head-on and opposite-direction travel; and rear-end, road departure, and low-speed situations such as backing and parking maneuvers.[17] Depending on the ODD, an ADS may be expected to handle many of the pre-crash scenarios that NHTSA has identified previously.[18]

The Federal Government wants to ensure it does not impede progress with unnecessary or unintended barriers to innovation. Safety remains the number one priority for U.S. DOT and is the specific focus of NHTSA.

4. Fallback (Minimal Risk Condition)

Entities are encouraged to have a documented process for transitioning to a minimal risk condition when a problem is encountered or the ADS cannot operate safely. ADSs operating on the road should be capable of detecting that the ADS has malfunctioned, is operating in a degraded state, or is operating outside of the ODD. Furthermore, ADSs should be able to notify the human driver of such events in a way that enables the driver to regain proper control of the vehicle or allows the ADS to return to a minimal risk condition independently.

Fallback strategies should take into account that, despite laws and regulations to the contrary, human drivers may be inattentive, under the influence of alcohol or other substances, drowsy, or otherwise impaired.

Fallback actions are encouraged to be administered in a manner that will facilitate safe operation of the vehicle and minimize erratic driving behavior. Such fallback actions should also consider minimizing the effects of errors in human driver recognition and decision-making during and after transition to manual control.

In cases of higher automation in which a human driver may not be available, the ADS must be able to fallback into a minimal risk condition without the need for driver intervention.

A minimal risk condition will vary according to the type and extent of a given failure, but may include automatically bringing the vehicle to a safe stop, preferably outside of an active lane of traffic. Entities are encouraged to have a documented process for assessment, testing, and validation of their fallback approaches.

The purpose of this Voluntary Guidance is to help designers of ADSs analyze, identify, and resolve safety considerations prior to deployment using their own, industry, and other best practices. It outlines 12 safety elements, which the Agency believes represent the consensus across the industry, that are generally considered to be the most salient design aspects to consider and address when developing, testing, and deploying ADSs on public roadways.

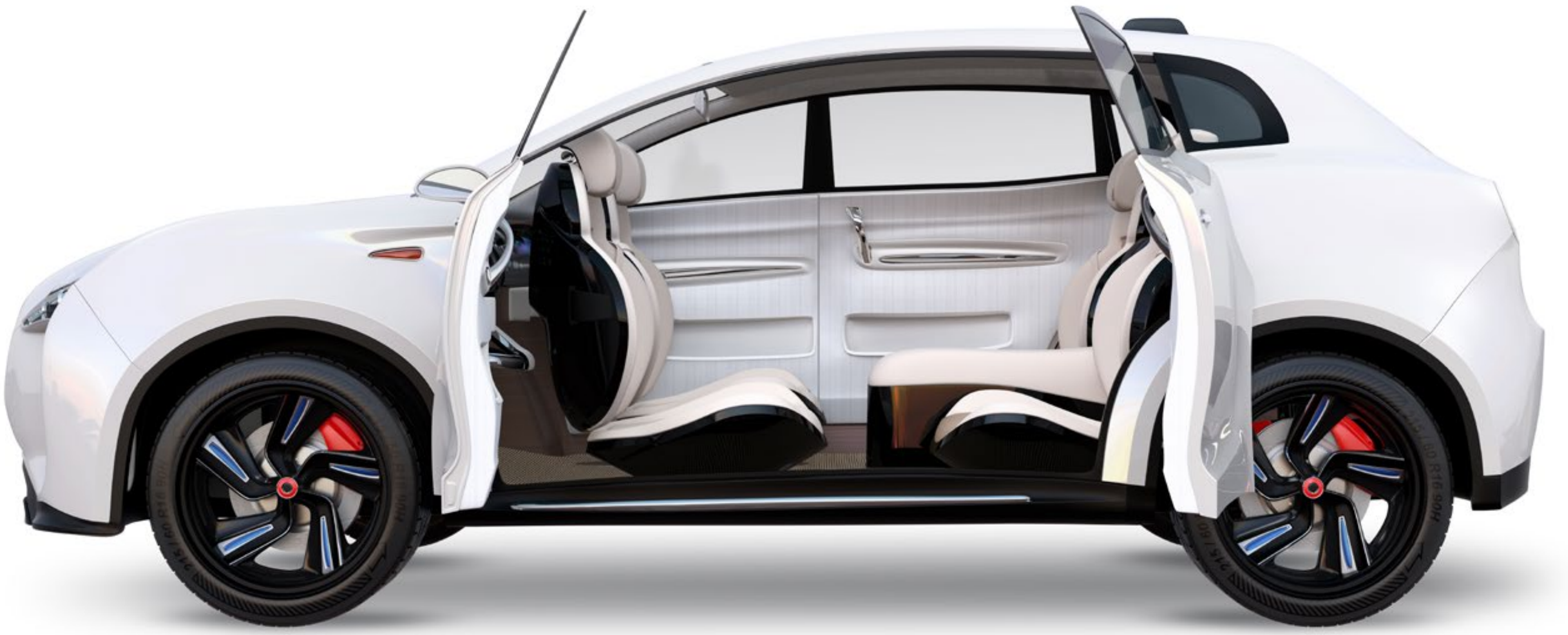
5. Validation Methods

Given that the scope, technology, and capabilities vary widely for different automation functions, entities are encouraged to develop validation methods to appropriately mitigate the safety risks associated with their ADS approach. Tests should demonstrate the behavioral competencies an ADS would be expected to perform during normal operation, the ADS's performance during crash avoidance situations, and the performance of fallback strategies relevant to the ADS's ODD.

To demonstrate the expected performance of an ADS for deployment on public roads, test approaches may include a combination of simulation, test track, and on-road testing.

Prior to on-road testing, entities are encouraged to consider the extent to which simulation and track testing may be necessary. Testing may be performed by the entities themselves, but could also be performed by an independent third party.

Entities should continue working with NHTSA and industry standards organizations (SAE, International Organization for Standards [ISO], etc.) and others to develop and update tests that use innovative methods as well as to develop performance criteria for test facilities that intend to conduct validation tests.



6. Human Machine Interface

Understanding the interaction between the vehicle and the driver, commonly referred to as "human machine interface" (HMI), has always played an important role in the automotive design process. New complexity is introduced to this interaction as ADSs take on driving functions, in part because in some cases the vehicle must be capable of accurately conveying information to the human driver regarding intentions and vehicle performance. This is particularly true for ADSs in which human drivers may be requested to perform any part of the driving task. For example, in a Level 3 vehicle, the driver always must be receptive to a request by the system to take back driving responsibilities. However, a driver's ability to do so is limited by their capacity to stay alert to the driving task and thus capable of quickly taking over control, while at the same time not performing the actual driving task until prompted by the vehicle. Entities are encouraged to consider whether it is reasonable and appropriate to incorporate driver engagement monitoring in cases where drivers could be involved in the driving task so as to assess driver awareness and readiness to perform the full driving task.

Entities are also encouraged to consider and document a process for the assessment, testing, and validation of the vehicle's HMI design. Considerations should be made for the human driver, operator, occupant(s), and external actors with whom the ADS may have interactions, including other vehicles (both traditional and those with ADSs), motorcyclists, bicyclists, and pedestrians. HMI design should also consider the need to communicate information regarding the ADS's state of operation relevant to the various interactions it may encounter and how this information should be communicated.

In vehicles that are anticipated not to have driver controls, entities are encouraged to design their HMI to accommodate people with disabilities (e.g., through visual, auditory, and haptic displays).[19]

In vehicles where an ADS may be intended to operate without a human driver or even any human occupant, the remote dispatcher or central control authority, if such an entity exists, should be able to know the status of the ADS at all times. Examples of these may include unoccupied SAE Automation Level 4 or 5 vehicles, automated delivery vehicles, last-mile special purpose ground drones, and automated maintenance vehicles.

Given the ongoing research and rapidly evolving nature of this field, entities are encouraged to consider and apply voluntary guidance, best practices, and design principles published by SAE International, ISO, NHTSA, the American National Standards Institute (ANSI), the International Commission on Illumination (CIE), and other relevant organizations, based upon the level of automation and expected level of driver engagement.

AT MINIMUM

An ADS should be capable of informing the human operator or occupant through various indicators that the ADS is:

- Functioning properly;
- Currently engaged in ADS mode;
- Currently "unavailable" for use;
- Experiencing a malfunction; and/or
- Requesting control transition from the ADS to the operator.

7. Vehicle Cybersecurity

Entities are encouraged to follow a robust product development process based on a systems engineering approach to minimize risks to safety, including those due to cybersecurity threats and vulnerabilities. This process should include a systematic and ongoing safety risk assessment for each ADS, the overall vehicle design into which it is being integrated, and when applicable, the broader transportation ecosystem.[20]

Entities are encouraged to design their ADSs following established best practices for cyber vehicle physical systems. Entities are encouraged to consider and incorporate voluntary guidance, best practices, and design principles published by National Institute of Standards and Technology (NIST[21]), NHTSA, SAE International, the Alliance of Automobile Manufacturers, the Association of Global Automakers, the Automotive Information Sharing and Analysis Center (Auto-ISAC),[22] and other relevant organizations, as appropriate.

NHTSA encourages entities to document how they incorporated vehicle cybersecurity considerations into ADSs, including all actions, changes, design choices, analyses, and associated testing, and ensure that data is traceable within a robust document version control environment.

Industry sharing of information on vehicle cybersecurity facilitates collaborative learning and helps prevent industry members from experiencing the same cyber vulnerabilities. Entities are encouraged to report to the Auto-ISAC all discovered incidents, exploits, threats and vulnerabilities from internal testing, consumer reporting, or external security research as soon as possible, regardless of membership. Entities are further encouraged to establish robust cyber incident response plans and employ a systems engineering approach that considers vehicle cybersecurity in the design process. Entities involved with ADSs should also consider adopting a coordinated vulnerability reporting/disclosure policy.

8. Crashworthiness

Occupant Protection

Given that a mix of vehicles with ADSs and those without will be operating on public roadways for an extended period of time, entities still need to consider the possible scenario of another vehicle crashing into an ADS-equipped vehicle and how to best protect vehicle occupants in that situation. Regardless of whether the ADS is operating the vehicle or the vehicle is being driven by a human driver, the occupant protection system should maintain its intended performance level in the event of a crash.

Entities should consider incorporating information from the advanced sensing technologies needed for ADS operation into new occupant protection systems that provide enhanced protection to occupants of all ages and sizes. In addition to the seating configurations evaluated in current standards, entities are encouraged to evaluate and consider additional countermeasures that will protect all occupants in any alternative planned seating or interior configurations during use.[23]

Compatibility

Unoccupied vehicles equipped with ADSs should provide geometric and energy absorption crash compatibility with existing vehicles on the road.[24] ADSs intended for product or service delivery or other unoccupied use scenarios should consider appropriate vehicle crash compatibility given the potential for interactions with vulnerable road users and other vehicle types.

Entities are not required to submit a Voluntary Safety Self-Assessment, nor is there any mechanism to compel entities to do so. While these assessments are encouraged prior to testing and deployment, NHTSA does not require that entities provide disclosures nor are they required to delay testing or deployment. Assessments are not subject to Federal approval.

9. Post-Crash ADS Behavior

Entities engaging in testing or deployment should consider methods of returning ADSs to a safe state immediately after being involved in a crash. Depending upon the severity of the crash, actions such as shutting off the fuel pump, removing motive power, moving the vehicle to a safe position off the roadway (or safest place available), disengaging electrical power, and other actions that would assist the ADSs should be considered. If communications with an operations center, collision notification center, or vehicle communications technology exist, relevant data is encouraged to be communicated and shared to help reduce the harm resulting from the crash.

Additionally, entities are encouraged to have documentation available that facilitates the maintenance and repair of ADSs before they can be put back in service. Such documentation would likely identify the equipment and the processes necessary to ensure safe operation of the ADSs after repairs.

10. Data Recording

Learning from crash data is a central component to the safety potential of ADSs. For example, the analysis of a crash involving a single ADS could lead to safety developments and subsequent prevention of that crash scenario in other ADSs. Paramount to this type of learning is proper crash reconstruction. Currently, no standard data elements exist for law enforcement, researchers, and others to use in determining why an ADS-enabled vehicle crashed. Therefore, entities engaging in testing or deployment are encouraged to establish a documented process for testing, validating, and collecting necessary data related to the occurrence of malfunctions, degradations, or failures in a way that can be used to establish the cause of any crash. Data should be collected for on-road testing and use, and entities are encouraged to adopt voluntary guidance, best practices, design principles, and standards issued by accredited standards developing organizations such as SAE International.[25] Likewise, these organizations are encouraged to be actively engaged in the discussion and regularly update standards as necessary and appropriate.

To promote a continual learning environment, entities engaging in testing or deployment should collect data associated with crashes involving: (1) fatal or nonfatal personal injury or (2) damage that requires towing, including damage that prevents a motor vehicle involved from being driven under its own power in its customary manner or damage that prevents a motor vehicle involved from being driven without resulting in further damage or causing a hazard to itself, other traffic elements, or the roadway.

For crash reconstruction purposes (including during testing), it is recommended that ADS data be stored, maintained, and readily available for retrieval as is current practice, including applicable privacy protections, for crash event data recorders.[26] Vehicles should record, at a minimum, all available information relevant to the crash, so that the circumstances of the crash can be reconstructed. These data should also contain the status of the ADS and whether the ADS or the human driver was in control of the vehicle leading up to, during, and immediately following a crash. Entities should have the technical and legal capability to share with government authorities the relevant recorded information as necessary for crash reconstruction purposes. Meanwhile, for consistency and to build public trust and acceptance, NHTSA will continue working with SAE International to begin the work necessary to establish uniform data elements for ADS crash reconstruction.

11. Consumer Education and Training

Education and training is imperative for increased safety during the deployment of ADSs.[27] Therefore, entities are encouraged to develop, document, and maintain employee, dealer, distributor, and consumer education and training programs to address the anticipated differences in the use and operation of ADSs from those of the conventional vehicles that the public owns and operates today.[28] Such programs should consider providing target users the necessary level of understanding to utilize these technologies properly, efficiently, and in the safest manner possible.

Entities, particularly those engaging in testing or deployment, should also ensure that their own staff, including their marketing and sales forces, understand the technology and can educate and train their dealers, distributors, and consumers.[29]

Consumer education programs are encouraged to cover topics such as ADSs' functional intent, operational parameters, system capabilities and limitations, engagement/disengagement methods, HMI, emergency fallback scenarios, operational design domain parameters (i.e., limitations), and mechanisms that could alter ADS behavior while in service. They should also include explicit information on what the ADS is capable and not capable of in an effort to minimize potential risks from user system abuse or misunderstanding.

As part of their education and training programs, ADS dealers and distributors should consider including an on-road or on-track experience demonstrating ADS operations and HMI functions prior to consumer release. Other innovative approaches (e.g., virtual reality or onboard vehicle systems) may also be considered, tested, and employed. These programs should be continually evaluated for their effectiveness and updated on a routine basis, incorporating feedback from dealers, customers, and other sources.

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12. Federal, State, and Local Laws

Entities are also encouraged to document how they intend to account for all applicable Federal, State, and local laws in the design of their vehicles and ADSs. Based on the operational design domain(s), the development of ADSs should account for all governing traffic laws when operating in automated mode for the region of operation.[30] For testing purposes, an entity may rely on an ADS test driver or other mechanism to manage compliance with the applicable laws.

In certain safety-critical situations (such as having to cross double lines on the roadway to travel safely past a broken-down vehicle on the road) human drivers may temporarily violate certain State motor vehicle driving laws. It is expected that ADSs have the capability of handling such foreseeable events safely; entities are encouraged to have a documented process for independent assessment, testing, and validation of such plausible scenarios.

Given that laws and regulations will inevitably change over time, entities should consider developing processes to update and adapt ADSs to address new or revised legal requirements.

NHTSA encourages collaboration and communication between Federal, State, and local governments and the private sector as the technology evolves, and the Agency will continue to coordinate dialogue among all stakeholders. Collaboration is essential as our Nation embraces the many technological developments affecting our public roadways.

VOLUNTARY SAFETY SELF-ASSESSMENT

Entities engaged in ADS testing and deployment may demonstrate how they address – via industry best practices, their own best practices, or other appropriate methods – the safety elements contained in the Voluntary Guidance by publishing a Voluntary Safety Self-Assessment. The Voluntary Safety Self-Assessment is intended to demonstrate to the public (particularly States and consumers) that entities are: (1) considering the safety aspects of ADSs; (2) communicating and collaborating with DOT; (3) encouraging the self-establishment of industry safety norms for ADSs; and (4) building public trust, acceptance, and confidence through transparent testing and deployment of ADSs. It also allows companies an opportunity to showcase their approach to safety, without needing to reveal proprietary intellectual property.

To facilitate this process and as an example of the type of information an entity might provide as part of its Voluntary Safety Self-Assessment, NHTSA has assembled an illustrative template for one of the safety elements within the Voluntary Guidance. This template is available on NHTSA's website. However, the information submitted could vary beyond the template when information is limited or unavailable (e.g., testing activities) or if the entity wishes to provide supplemental information.

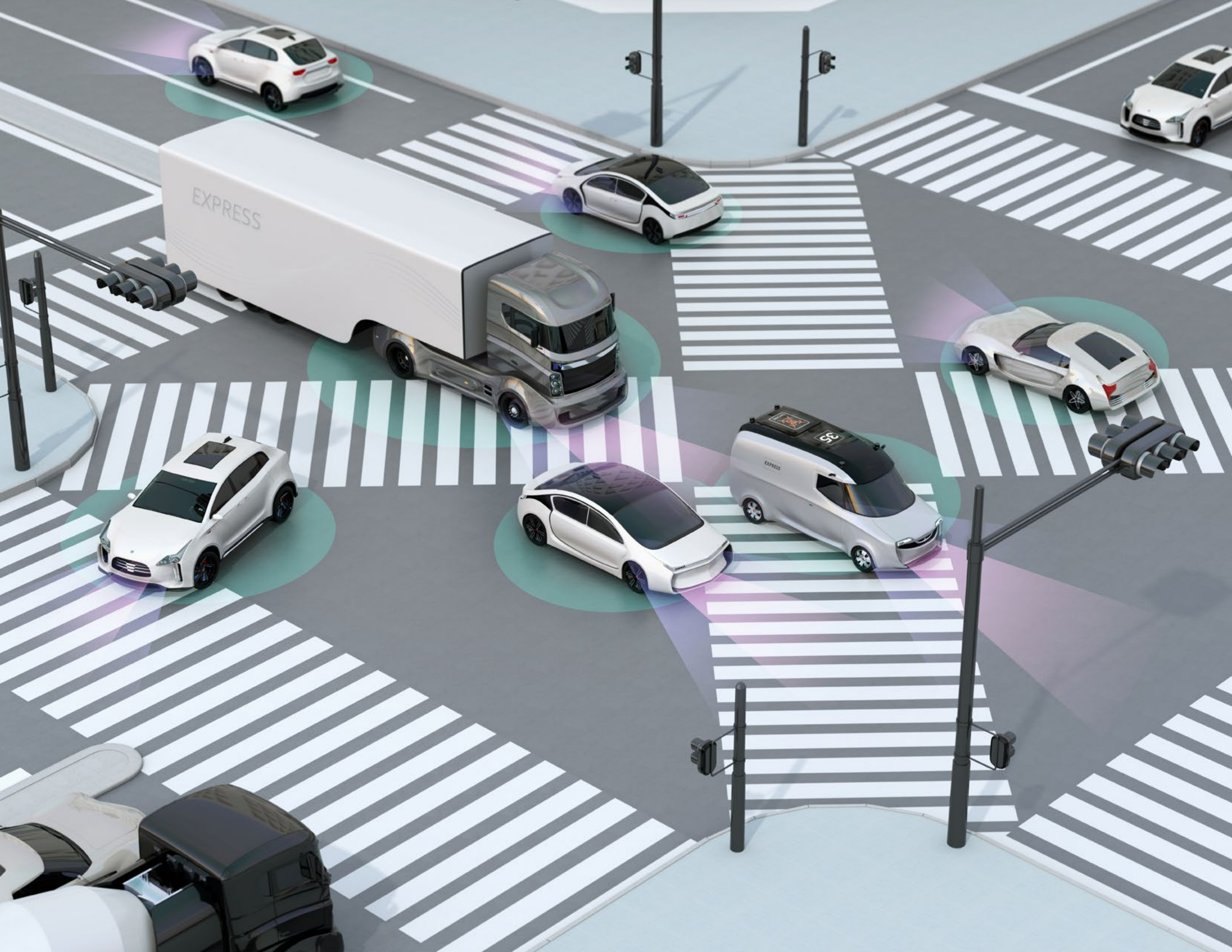
Entities should ensure that Voluntary Safety Self-Assessments do not contain confidential business information (CBI), as it would be information available to the public. Entities will presumably wish to update these documents over time.

For each safety element laid out by the Voluntary Guidance, entities are encouraged to include an acknowledgment within the Voluntary Safety Self-Assessment that indicates one of the following:

- This safety element was considered during product development efforts for the subject feature; or
- This safety element is not applicable to the subject product development effort.

NHTSA envisions that the Voluntary Safety Self-Assessments would contain concise information on how entities are utilizing the Voluntary Guidance and/or their own processes to address applicable safety elements identified in the Voluntary Guidance. The Voluntary Safety Self-Assessment should not serve as an exhaustive recount of every action the entity took to address a particular safety element.

Entities are not required to submit a Voluntary Safety Self-Assessment, nor is there any mechanism to compel entities to do so. While these assessments are encouraged prior to testing and deployment, NHTSA does not require that entities provide submissions nor are they required to delay testing or deployment. Assessments are not subject to Federal approval.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THE FEDERAL AND STATE ROLES

NHTSA strongly encourages States not to codify this Voluntary Guidance (that is, incorporate it into State statutes) as a legal requirement for any phases of development, testing, or deployment of ADSs. Allowing NHTSA alone to regulate the safety design and performance aspects of ADS technology will help avoid conflicting Federal and State laws and regulations that could impede deployment.

SECTION 2: TECHNICAL ASSISTANCE TO STATES

Best Practices for Legislatures Regarding Automated Driving Systems

OVERVIEW

The National Highway Traffic Safety Administration (NHTSA) of the U.S. Department of Transportation (DOT) is prepared to assist with challenges that States face regarding the safe integration of SAE Level 3 and above Automated Driving Systems (ADSs) on public roads. Given that vehicles operating on public roads are subject to both Federal and State jurisdictions and States are beginning to regulate ADSs, NHTSA has developed this section. It is designed to clarify and delineate the Federal and State roles in the regulation of ADSs and lay out a framework that the States can use as they write their laws and regulations surrounding ADSs to ensure a consistent, unified national framework.

NHTSA is working to bring ADSs safely onto the Nation's roadways in a way that encourages ADS entities (manufacturers, suppliers, transit operators, automated fleet operators, or any entity that offers services utilizing ADSs), consumer advocacy organizations, State legislatures, and other interested parties to work together in a shared environment. As the technology grows and the horizon of ADS changes rapidly, it is essential for each of these entities and interested parties to exercise due diligence in staying ahead of activity in a proactive—rather than reactive—manner.

States have begun to propose and pass legislation concerning ADSs. Public comments to NHTSA suggest that these proposals present several disparate approaches for adding and amending State authority over ADSs. Public comments and some State officials have asked NHTSA to provide guidance (and eventually regulations) that would support a more national approach to testing and deploying ADSs.

Further, in a prior collaborative effort between States and the Federal Government, NHTSA entered a 2-year cooperative agreement (beginning in September 2014) with the American Association of Motor Vehicle Administrators (AAMVA) under which the Autonomous Vehicle Best Practices Working Group was created. The working group was chartered to organize and share information related to the development, design, testing, use, and regulation of ADSs and other emerging vehicle technology. Based on the working group's research, a report is currently being developed to assist jurisdictions in enhancing their current ADS regulations or considering developing new legislation.[31] The goal of the report is to promote uniformity amongst jurisdictions and provide a baseline safety approach to possible challenges to the regulation of ADS sand testing the drivers who operate them.

Coinciding with the development of AAMVA's report, NHTSA has continued to work with State stakeholders including the National Conference of State Legislatures (NCSL) and the Governors Highway Safety Association (GHSA) to identify emerging challenges in the integration of ADSs and conventional motor vehicles.

Based on public input and the Agency's ongoing work with partners such as NCSL, GHSA, and AAMVA, NHTSA offers these Best Practices and specific legal components States should consider as we all work toward the shared goal of advancing safe ADS integration. The objective is to assist States in developing ADS laws, if desired, and creating consistency in ADS regulation across the country.

While technology is evolving and new State legislative language is still being drafted and reviewed, States can proactively evaluate current laws and regulations so as not to unintentionally create barriers to ADS operation, such as a requirement that a driver have at least one hand on the steering wheel at all times.

NHTSA encourages States to review others' draft ADS policies and legislation and work toward consistency. The goal of State policies in this realm need not be uniformity or identical laws and regulations across all States. Rather, the aim should be sufficient consistency of laws and policies to promote innovation and the swift, widespread, safe integration of ADSs.

States are encouraged to maintain a good state of infrastructure design, operation, and maintenance that supports ADS deployment and to adhere to the Manual on Uniform Traffic Control Devices (MUTCD), the existing national standard for traffic control devices as required by law. For example, items that may be considered a low priority now because of the presence of a human driver may be considered a higher priority as vehicle systems begin to rely more on machine vision and other techniques to detect where they are in a given lane. In addition, States are urged to continue to work with the Federal Highway Administration (FHWA) and the American Association of State Highway and Transportation Officials (AASHTO)[32] to support uniformity and consensus in infrastructure standards setting. This will support the safe operation of ADSs and ensure the safety of human drivers, who will continue to operate vehicles on the roads for years to come.

FEDERAL AND STATE REGULATORY ROLES

In consideration of State activity regarding ADSs, as well as NHTSA's activity at the Federal level, it is important to delineate Federal and State regulatory responsibility for motor vehicle operation.

These general areas of responsibility should remain largely unchanged for ADSs. NHTSA is responsible for regulating motor vehicles and motor vehicle equipment, and States are responsible for regulating the human driver and most other aspects of motor vehicle operation.

Further DOT involvement includes safety, evaluation, planning, and maintenance of the Nation's infrastructure through FHWA as well as regulation of the safe operation of interstate motor carriers and commercial vehicle drivers, along with registration and insurance requirements through the Federal Motor Carrier Safety Administration (FMCSA).

DOT strongly encourages States to allow DOT alone to regulate the safety design and performance aspects of ADS technology. If a State does pursue ADS performance-related regulations, that State should consult with NHTSA.

NHTSA'S RESPONSIBILITIES	STATES' RESPONSIBILITIES
• Setting Federal Motor Vehicle Safety Standards (FMVSSs) for new motor vehicles and motor vehicle equipment (with which manufacturers must certify compliance before they sell their vehicles)[33] • Enforcing compliance with FMVSSs • Investigating and managing the recall and remedy of noncompliances and safety-related motor vehicle defects nationwide • Communicating with and educating the public about motor vehicle safety issues	• Licensing human drivers and registering motor vehicles in their jurisdictions • Enacting and enforcing traffic laws and regulations • Conducting safety inspections, where States choose to do so • Regulating motor vehicle insurance and liability

BEST PRACTICES FOR LEGISLATURES

As States act to ensure the safety of road users in their jurisdictions, NHTSA continually monitors and reviews language to stay informed on State legislation. In reviewing draft State legislation, the Agency has identified common components and has highlighted significant elements regarding ADSs that States should consider including in legislation. As such, NHTSA recommends the following safety-related best practices when crafting legislation for ADSs:

- **Provide a "technology-neutral" environment.**

  States should not place unnecessary burdens on competition and innovation by limiting ADS testing or deployment to motor vehicle manufacturers only. For example, no data suggests that experience in vehicle manufacturing is an indicator of the ability to safely test or deploy vehicle technology. All entities that meet Federal and State law prerequisites for testing or deployment should have the ability to operate in the State.

- **Provide licensing and registration procedures.**

  States are responsible for driver licensing and vehicle registration procedures. To support these efforts, NHTSA recommends defining "motor vehicle" under ADS laws to include any vehicle operating on the roads and highways of the State; licensing ADS entities and test operators for ADSs; and registering all vehicles equipped with ADSs and establishing proof of financial responsibility requirements in the form of surety bonds or self-insurance. These efforts provide States with the same information as that collected for conventional motor vehicles and improve State recordkeeping for ADS operation.

- **Provide reporting and communications methods for Public Safety Officials.**

  States can take steps to monitor safe ADS operation through reporting and communications mechanisms so that entities can coordinate with public safety agencies. The safety of public safety

  officials, other road users, and ADS passengers will be improved with greater understanding of the technology, capabilities, and functioning environment. States should develop procedures for entities to report crashes and other roadway incidents involving ADSs to law enforcement and first responders.

- **Review traffic laws and regulations that may serve as barriers to operation of ADSs.**

  States should review their vehicle codes, applicable traffic laws, and similar items to determine if there are unnecessary regulatory barriers that would prevent the testing and deployment of ADSs on public roads. For example, some States require a human operator to have one hand on the steering wheel at all times – a law that would pose a barrier to Level 3 through Level 5 ADSs.

BEST PRACTICES FOR STATE HIGHWAY SAFETY OFFICIALS

States have a general responsibility to reduce traffic crashes and the resulting deaths, injuries, and property damage for all road users in their jurisdictions. States use this authority to establish and maintain highway safety programs addressing: driver education and testing; licensing; pedestrian safety; law enforcement; vehicle registration and inspection; traffic control; highway design and maintenance; crash prevention, investigation, and recordkeeping; and emergency services. This includes any legal components States may wish to consider upon drafting legislation on ADSs.

The following sections describe a framework for States looking for assistance in developing procedures and conditions for ADSs' introduction onto public roadways. NHTSA and AAMVA's collaborative partnership on a Model State Policy is the foundation of the following discussion; however, it has been upgraded to incorporate additional concerns of State stakeholders, the clarification of roles, and an emphasis on the States' consideration of the information—rather than a directive for action. NHTSA does not expect that States will necessarily need to create any new processes or requirements in order to support ADS activities. Instead, the references below are intended as guidance for those States that may be looking to incorporate ADSs into existing processes or requirements or States who are considering such processes or requirements.

1. **Administrative:** States may want to consider new oversight activities on an administrative level to support States' roles and activities as they relate to ADSs. NHTSA does not expect that States will need to create any particular new entity in order to support ADS activities, but States may decide to create some of these entities if the State determines that they will be useful. The references below are intended as examples of those that may be appropriate for participation.
   a. Consider identifying a lead agency responsible for deliberation of any ADS testing.
   b. Consider creating a jurisdictional ADS technology committee that is launched by the designated lead agency and includes representatives from the governor's office, the motor vehicle administration, the State department of transportation, the State law enforcement agency, the State Highway Safety Office, State office of information technology, State insurance regulator, the State office(s) representing the aging and disabled communities, toll authorities, trucking and bus authorities, and transit authorities.
   c. To encourage open communication, the designated lead agency may choose to inform the State automated safety technology committee of the requests from entities to test in their State and the status of the designated agency's response to companies.
   d. In an effort to implement a framework for policies and regulations, the designated lead agency could take steps to use or establish statutory authority. This preparation would involve examination of laws and regulations in order to address unnecessary barriers to ADS operation on public roadways.
   e. Consider developing an internal process to include an application for entities to test in their State.
   f. Consider establishing an internal process for issuing test ADS vehicle permits.

2. **Application for Entities to Test ADSs on Public Roadways:** For those States with an existing application process for test vehicles, the following are considerations for applications involving testing of an ADS on public roadways. It is recommended that the application for testing remain at the State level; however, if a State chooses to request applications at a local level, these considerations would carry to those jurisdictions.

a. States could request that an entity submit an application to the designated lead agency in each State in which it plans to test ADSs. A process should be considered for application submission in those situations in which multiple entities are involved in the testing of an ADS.

b. States could request the following information from entities to ensure accurate recordkeeping:

- Name, corporate physical and mailing addresses, in-State physical and mailing addresses (if applicable), and the program administrator/director's name and contact information;
- Identification of each ADS that will be used on public roadways by VIN, vehicle type, or other unique identifiers such as the year, make, and model; and
- Identification of each test operator, the operator's driver license number, and the State or country in which the operator is licensed.

c. Inclusion of the entity's safety and compliance plan for the ADS could provide increased safety assurance to the State.

d. Inclusion of evidence of the entity's ability to satisfy a judgment or judgments for damages for personal injury, death, or property damage caused by an ADS in the form of an instrument of insurance, a surety bond, or proof of self-insurance could provide increased safety assurance to the State.[34]

e. Inclusion of a summary of the training provided to the employees, contractors, or other users designated by the entity as test operators of the ADS could provide increased safety assurance to the State.

3. Permission for Entities to Test ADSs on Public Roadways:
For States that grant permission for testing of vehicles, the following are considerations for granting permission for ADS testing on public roadways. It is recommended that permission to test remain at the State level; however, State and local governments should coordinate. If a State chooses to request applications at a local level, these considerations would carry to those jurisdictions.

a. For greater public safety, it is recommended that a State's lead agency involve law enforcement agencies before responding to the application for testing from the entity.

b. It would be appropriate to suspend permission to test if the entity fails to comply with the State insurance or driver requirements.

   c. It would be appropriate for the lead agency to request additional information or require an entity to modify its application before granting approval.

   d. If a State requires an application, it should consider notification to the entity indicating permission to test that ADS in the State. A State may choose to request that entity's test vehicles carry a copy of proof of permission to test that ADS in those vehicles.

4. **Specific Considerations for ADS Test Drivers and Operations:** Considerations for States providing access for test-ADSs as they are operated under designated circumstances and with entity-based operators.

   a. If a State is concerned about the training of an ADS test driver, the State could request a summary of the training provided to the test driver.

   b. For test vehicles, the test driver should follow all traffic rules and report crashes as appropriate for the State.

   c. States regulate human drivers. Licensed drivers are necessary to perform the driving functions for motor vehicles equipped with automated safety technologies that are less than fully automated (SAE Levels 3 and lower). A licensed driver has responsibility to operate the vehicle, monitor the operation, or be immediately available to perform the driving task when requested or the lower level automated system disengages.

   d. Fully automated vehicles are driven entirely by the vehicle itself and require no licensed human driver (SAE levels 4 and 5), at least in certain environments or under certain conditions.[35] The entire driving operation (under specified conditions) is performed by a motor vehicle automated system from origin to destination.

5. **Considerations for Registration and Titling:** Specific considerations regarding identification and records for ADS deployed for consumer use and operation.

   a. Consider identification of an ADS on the title and registration. This could apply to all ADSs or only those capable of operating without a human driver.

   b. Consider requiring notification of ADS upgrades if the vehicle has been significantly upgraded post-sale. Applicable State forms could be adjusted to reflect the upgrade.

6. **Working With Public Safety Officials:** General considerations as public safety officials begin to understand vehicles and needs.

   a. States could consider training public safety officials in conjunction with ADS deployments in their jurisdictions to improve understanding of ADS operation and potential interactions.

   b. Coordination among States would be beneficial for developing policies on human operator behaviors, as to monitor behavior changes—if any—in the presence of ADSs when the vehicle is in control.

7. **Liability and Insurance:** Initial considerations for State relegation of liability during an incident and insurance of the driver, entity, and/or ADS. These considerations may take time and broad discussion of incident scenarios, understanding of technology, and knowledge of how the ADSs are being used (personal use, rental, ride share, corporate, etc.). Additionally, determination of the operator of an ADS, in a given circumstance, may not necessarily determine liability for crashes involving the ADS.

   a. Begin to consider how to allocate liability among ADS owners, operators, passengers, manufacturers, and other entities when a crash occurs.

   b. For insurance purposes, determine who (owner, operator, passenger, manufacturer, other entity, etc.) must carry motor vehicle insurance.

   c. States could begin to consider rules and laws allocating tort liability.

CONCLUSION

Public trust and confidence in the evolution of ADSs has the potential to advance or inhibit the testing and deployment of ADSs on public roadways. NHTSA is committed to supporting the safety of these emerging and evolutionary technological advancements, which have the potential to significantly improve roadway safety. The Voluntary Guidance, highlighting the 12 priority safety elements, and its associated Voluntary Safety Self-Assessment offer public reassurance that safety remains NHTSA's top priority. The States' Best Practices section reinforces NHTSA's willingness to assist States with the challenges they face regarding ADSs now and in the pivotal years ahead.

This document will be updated periodically to reflect advances in technology, increased presence of ADSs on public roadways, and any regulatory action or statutory changes that could occur at both the Federal and State levels. In the meantime, the information provided herein serves to aid industry as it moves forward with testing and deploying ADSs and States with drafting legislation and developing plans and policies regarding ADSs. NHTSA encourages collaboration and communication between Federal, State, and local governments and the private sector as the technology evolves, and the Agency will continue to coordinate dialogue among all stakeholders. Collaboration is essential as our Nation embraces the many technological developments affecting our public roadways. Together, we can use lessons learned to make any necessary course corrections, to prevent or mitigate unintended consequences or safety risks, and to positively transform American mobility safely and efficiently.

RESOURCES

A central repository of associated references to this and other NHTSA ADS resources will be maintained at www.nhtsa.gov/technology-innovation/automated-vehicles.

This includes an informational resource to support manufacturers and other entities interested in requesting regulatory action from NHTSA.

ENDNOTES

1 NHTSA acknowledges that Privacy and Ethical Considerations are also important elements for entities to deliberate. See www.nhtsa.gov/AVforIndustry for NHTSA's approach on each.

2 NHTSA completed the Paperwork Reduction Act (PRA) process and received clearance from the Office of Management and Budget (OMB) on the Federal Automated Vehicles Policy Voluntary Guidance's information collection through August 31, 2018, 81 FR 65709. However, pursuant to PRA, NHTSA is again seeking public comment on an updated Information Collection Request (ICR) that covers the information included in Automated Driving Systems: A Vision for Safety. The ICR identified in this document will not be effective until the ICR process is completed.

3 SAE International J3016, International Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles (J3016:Sept 2016).

4 See, e.g., 49 U.S.C. §§ 30102(a)(8), 30116, 30120.

5 Parts of this Voluntary Guidance could be applied to any form of ADS.

6 The National Traffic and Motor Vehicle Safety Act, as amended ("Safety Act"), 49 U.S.C. 30101 et seq., provides the basis and framework for NHTSA's enforcement authority over motor vehicle and motor vehicle equipment defects and non-compliances with Federal Motor Vehicle Safety Standards (FMVSS).

7 Under ISO 26262 (Road Vehicles: Functional Safety), functional safety refers to the absence of unreasonable safety risks in cases of electrical and electronic failures.

8 For example, the U.S. Department of Defense standard practice on system safety, MIL-STD-882E. 11 May 2012. Available at www.system-safety.org/Documents/MIL-STD-882E.pdf.

9 See Van Eikema Hommes, Q.D. (2016, June). *Assessment of Safety Standards for Automotive Electronic Control Systems.* (Report No. Dot HS 812 285). Washington, DC: National Highway Traffic Safety Administration. Available at ntl.bts.gov/lib/59000/59300/59359/812285_ElectronicsReliabilityReport.pdf.

10 "Minimal risk condition" means low-risk operating condition that an automated driving system automatically resorts to either when a system fails or when the human driver fails to respond appropriately to a request to take over the dynamic driving task. See SAE International J3016, International Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles (J3016:Sept2016).

11 "Fallback ready user" means the user of a vehicle equipped with an engaged ADS feature who is able to operate the vehicle and is receptive to ADS-issued requests to intervene and to evident dynamic driving task (DDT) performance-relevant system failures in the vehicle compelling him or her to perform the DDT fallback. See SAE International J3016, International Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles (J3016:Sept2016).

12 See Automated Vehicle Research for Enhanced Safety: Final Report. Collision Avoidance Metrics Partnership, Automated Vehicle Research Consortium. June 2016. DTNH22-050H-01277. The report includes detailed functional descriptions for on-road driving automation levels and identifies potential objective test methods that could be used as a framework for evaluating emerging and future driving automation features. Available at www.noticeandcomment.com/Automated-Vehicle-Research-for-Enhanced-Safety-Final-Report-fn-459371.aspx.

13 See Nowakowski, C., et al., *Development of California Regulations to Govern the Testing and Operation of Automated Driving Systems*, California PATH Program, University of California, Berkeley, Nov. 14, 2014, pg. 10. Available at http://docs.trb.org/prp/15-2269.pdf.

14 California Partners for Advanced Transit and Highways (PATH) is a multidisciplinary research and development program of the University of California, Berkeley, with staff, faculty, and students from universities worldwide and cooperative projects with private industry, State and local agencies, and nonprofit institutions. See www.path.berkeley.edu.

15 Id., pgs. 10-11. California PATH's work described minimum behavioral competencies for automated vehicles as "necessary, but by no means sufficient, capabilities for public operation." Id. The document's full peer review is available at www.nspe.org/sites/default/files/resources/pdfs/Peer-Review-Report-IntgratedV2.pdf.

16 See Rau, P., Yanagisawa, M., and Najm, W. G., T*arget Crash Population of Automated Vehicles*, available at www-esv.nhtsa.dot.gov/Proceedings/24/files/Session 21 Written.pdf.

17 See Najm, W. G., Smith, J. D., and Yanagisawa, M., “Pre-Crash Scenario Typology for Crash Avoidance Research,” DOT HS 810 767, April 2007. Available at www.nhtsa.gov/gy-Final_PDF_Version_5-2-07.pdf.

18 Available at http://ntl.bts.gov/lib/55000/55400/55443/AVBenefitFrameworkFinalReport082615_Cover1.pdf.

19 Entities are encouraged to seek technical and engineering advice from members of the disabled community and otherwise engage with that community to develop designs informed by its needs and experiences.

20 Entities should insist that their suppliers build into their equipment robust cybersecurity features. Entities should also address cybersecurity, but they should not wait to receive equipment from a supplier before doing so.

21 www.nist.gov/cyberframework.

22 An Information Sharing and Analysis Center (ISAC) is a trusted, sector specific entity that can provide a 24-hour-per-day 7-day-per-week secure operating capability that establishes the coordination, information sharing, and intelligence requirements for dealing with cybersecurity incidents, threats, and vulnerabilities. See McCarthy, C., Harnett, K., Carter, A., and Hatipoglu, C. (2014, October). *Assessment of the information sharing and analysis center model* (Report No. DOT HS 812 076). Washington, DC: National Highway Traffic Safety Administration.

23 The tools to demonstrate such due care need not be limited to physical testing but also could include virtual tests with vehicle and human body models.

24 In 2003, as part of a voluntary agreement on crash compatibility, the Alliance of Automobile Manufacturers agreed to a geometric compatibility commitment which would provide for alignment of primary energy absorbing structures among vehicles. The European Union recently introduced a new frontal crash test that also requires geometric load distribution similar to the Alliance voluntary agreement.

25 The collection, recording, storage, auditing, and deconstruction of data recorded by an entity must be in strict accordance with the entity’s consumer privacy and security agreements and notices, as well as any applicable legal requirements.

26 See 49 CFR Part 563, Event Data Recorders. Available at www.gpo.gov/fdsys/pkg/CFR-2016-title49-vol6/xml/CFR-2016-title49-vol6-part563.xml.

27 Not applicable to ADS testing.

28 The training and education programs recommended here are intended to complement and augment driver training and education programs run by States that retain the primary responsibility for training, testing, and licensing human drivers.

29 Such training and education programs for employees, dealers, distributors, and consumers may be administered by an entity other than the direct employer, manufacturer, or other applicable entity.

30 Traffic laws vary from State to State (and even city to city); ADSs should be able to follow all laws that apply to the applicable operational design domain. This includes speed limits, traffic control devices, one-way streets, access restrictions (crosswalks, bike lanes), U-turns, right-on-red situations, metering ramps, and other traffic circumstances and situations.

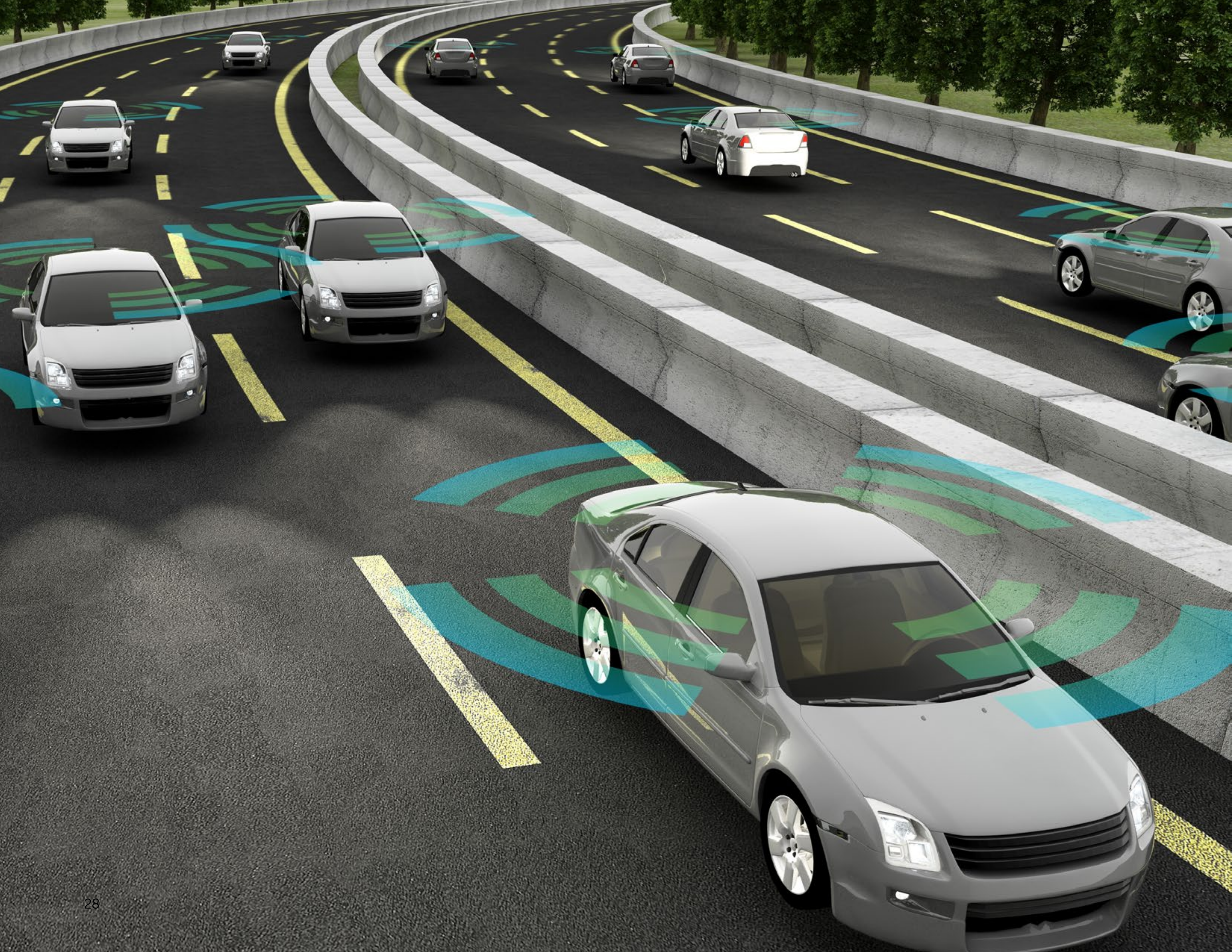
31 Future updates to AAMVA’s guide may integrate commercial vehicle ADS operational aspects brought forth by the Commercial Vehicle Safety Alliance (CVSA).

32 AASHTO is an international leader in setting technical standards for all phases of highway system development. Standards are issued for design, construction of highways and bridges, materials, and many other technical areas. See www.transportation.org/home/organization/.

33 NHTSA does not expressly regulate motor vehicle (or motor vehicle equipment) in-use performance after first sale. However, because the FMVSSs apply to the vehicle or equipment when first manufactured and because taking a vehicle or piece of equipment out of compliance with an applicable standard can be a violation of the Safety Act, the influence of the FMVSSs extends throughout the life of the vehicle even if NHTSA is not directly regulating it. At the same time, States have the authority to regulate a vehicle’s in-use performance (through safety inspection laws), but as the text here states, State regulations cannot conflict with applicable FMVSSs. Additionally, NHTSA continues to have broad enforcement authority to evaluate and address safety risks as they arise.

34 AAMVA experts recommended a minimum insurance requirement of $5 million; however, that is subject to State considerations.

35 Some vehicles may be capable of being entirely “driven” either by the vehicle itself or by a human driver. For such dual-capable vehicles, the States would have jurisdiction to regulate (license, etc.) the human driver.



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U.S. Department of Transportation

NHTSA

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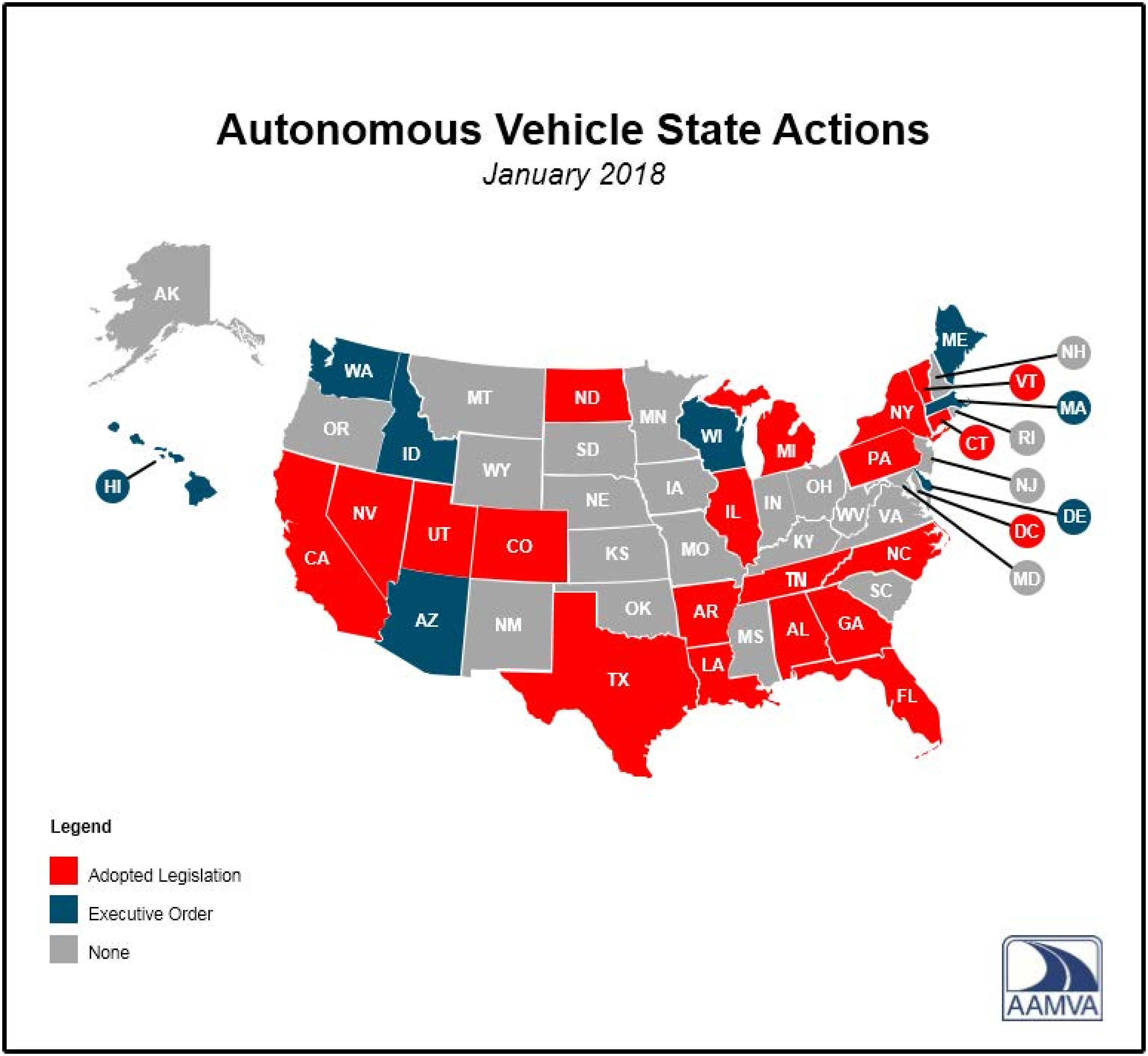

Autonomous Vehicle State Actions
January 2018
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Executive Order
None
AAMVA

Alabama

SJR 81 (2016)

- Established the Joint Legislative Committee to study self-driving vehicles.
- Enacted and chaptered on May 10, 2016.

Arizona

Governor Doug Ducey signed Executive Order 2015-09 in late August 2015 directing various agencies to "undertake any necessary steps to support the testing and operation of self-driving vehicles on public roads within Arizona." He also ordered the enabling of pilot programs at selected universities and developed rules to be followed by the programs. The order established a Self-Driving Vehicle Oversight Committee within the governor's office.

Arkansas

HB 1754 (2017)

- Regulates the testing of vehicles with autonomous technology, relates to vehicles equipped with driver-assistive truck platooning systems.
- Enacted and chaptered on April 1, 2017.

California

SB 1298 (2012)

- Requires the Department of the California Highway Patrol to adopt safety standards and performance requirements to ensure the safe operation and testing of autonomous vehicles, as defined, on the public roads in this state.
- Permits autonomous vehicles to be operated or tested on the public roads in this state pending the adoption of safety standards and performance requirements that would be adopted under this bill.
- Enacted and chaptered on Sept. 25, 2012.

AB 1592 (2016)

- Authorizes the Contra Costa Transportation Authority to conduct a pilot project for the testing of autonomous vehicles that are not equipped with a steering wheel, a brake pedal, an accelerator, or an operator inside the vehicle, if the testing is conducted only at specified locations and the autonomous vehicle operates at specified speeds.
- Enacted and chaptered on Sept. 29, 2016.

AB 669 (2017)

- Extends the sunset date of the law allowing the testing of vehicle platooning with less than 100 feet between each vehicle from January 2018 to January 2020.

- Prohibits someone from participating in the testing unless they hold a valid driver's license for the class of vehicle.
- Effective Jan. 1, 2018.

AB 1444 (2017)

- Authorizes the Livermore Amador Valley Transit Authority to conduct a shared autonomous vehicle demonstration project for the testing of autonomous vehicles that do not have a driver seat in the driver's seat and are not equipped with a steering wheel, a brake pedal, or an accelerator.
- Effective Jan. 1, 2018.

SB 145 (2017)

- Repeals a requirement that the Department of Motor Vehicles notify the Legislature of receipt of an application seeking approval to operate an autonomous vehicle capable of operating without the presence of a driver inside the vehicle on public roads.
- Repeals the requirement that the approval of such an application not be effective any sooner that a specified number of days after the date of the application.
- Effective Oct. 12, 2017.

AB 87 (2018)

- Requires the Department of Motor Vehicles to adopt application requirements for the testing of autonomous vehicles on public roads without the presence of a driver inside.
- Requires that the manufacturer certify that the local authorities within the jurisdiction where the autonomous vehicle will be tested have been provided with a written notification.
- Requires that the manufacturer provide certain law enforcement agencies with a copy of a law enforcement interaction plan.

California Department of Motor Vehicles webpage on AV
https://www.dmv.ca.gov/portal/dmv/detail/vr/autonomous/bkgd

Colorado

SB 213 (2017)

- Defines automated driving system, dynamic driving task and human operator.
- Allows a person to use an automated driving system to drive or control a function of a motor vehicle if the system is capable of complying with every state and federal law that applies to the function that the system is operating.
- Requires approval for vehicle testing if the vehicle cannot comply with every relevant state and federal law. Requires the department of transportation to submit a report on the testing of automated driving systems.
- Effective Aug. 9, 2017.

Connecticut

SB 260 (2017)

- Defines terms including “fully autonomous vehicle,” “automated driving system,” and “operator.”
- Requires the development of a pilot program for up to four municipalities for the testing of fully autonomous vehicles on public roads in those municipalities.
- Specifies the requirements for testing, including having an operator seated in the driver’s seat and providing proof of insurance of at least $5 million.
- Establishes a task force to study fully autonomous vehicles. The study must include an evaluation of NHTSA’s standards regarding state responsibility for regulating AVs, an evaluation of laws, legislation and regulations in other states, recommendations on how Connecticut should legislate and regulate AVs, and an evaluation of the pilot program.
- Enacted and chaptered on June 27, 2017.

Delaware

Governor John Carney signed an executive order in September 2017 establishing the Advisory Council on Connected and Autonomous Vehicles, tasked with developing recommendations for innovative tools and strategies that can be used to prepare Delaware’s transportation network for connected and autonomous vehicles.

Florida

HB 1207 (2012)

- Defines “autonomous vehicle” and “autonomous technology.”
- Declares legislative intent to encourage the safe development, testing and operation of motor vehicles with autonomous technology on public roads of the state and finds that the state does not prohibit or specifically regulate the testing or operation of autonomous technology in motor vehicles on public roads.
- Authorizes a person who possesses a valid driver's license to operate an autonomous vehicle, specifying that the person who causes the vehicle’s autonomous technology to engage is the operator.
- Authorizes the operation of autonomous vehicles by certain persons for testing purposes under certain conditions and requires an instrument of insurance, surety bond or self-insurance prior to the testing of a vehicle.
- Directs the Department of Highway Safety and Motor Vehicles to prepare a report recommending additional legislative or regulatory action that may be required for the safe testing and operation of vehicles equipped with autonomous technology, to be submitted no later than Feb. 12, 2014.
- Enacted and chaptered on April 16, 2012.

HB 599 (2012)

- The relevant portions of this bill are identical to the substitute version of HB 1207.
- Enacted and chaptered on April 29, 2012.

HB 7027 (2016)

- Permits operation of autonomous vehicles on public roads by individuals with a valid driver license.
- This bill eliminates the requirement that the vehicle operation is being done for testing purposes and removes a number of provisions related to vehicle operation for testing purposes.
- Eliminates the requirement that a driver be present in the vehicle. Requires autonomous vehicles meet applicable federal safety standards and regulations.
- Enacted and chaptered on April 4, 2016.

HB 7061 (2016)

- Defines autonomous technology and driver-assistive truck platooning technology.
- Requires a study on the use and safe operation of driver-assistive truck platooning technology and allows for a pilot project upon conclusion of the study.
- Enacted and chaptered on Apr. 14, 2016.

HB 353 (2018)

- Relates to autonomous vehicles; authorizes a person to operate, or engage autonomous technology to operate, an autonomous vehicle
- Provides that autonomous technology is deemed to be the operator of an autonomous vehicle operating in autonomous mode; defines the term human operator.

SB 712 (2018)

- Relates to autonomous vehicles; exempts an autonomous vehicle from a certain prohibition on the operation of a motor vehicle, if such vehicle is actively displaying certain content that is visible from the driver's seat while in motion.

Florida Department of Highway Safety and Motor Vehicles AV Report (February 2014)
http://www.flhsmv.gov/html/HSMVAutonomousVehicleReport2014.pdf

Georgia

HB 472 (2017)

- Specifies that the law prohibiting following too closely does not to apply to the non-leading vehicle in a coordinated platoon.
- Defines coordinated platoon as a group of motor vehicles traveling in the same lane utilizing vehicle-to-vehicle communication technology to automatically coordinate the movement of the vehicles.
- Effective July 1, 2017.

SB 219 (2017)

- Defines automated driving system, dynamic driving task, fully autonomous vehicle, minimal risk condition and operational design domain.
- Exempts a person operating an automated motor vehicle with the automated driving system engaged from the requirement to hold a driver's license.
- Specifies conditions that must be met for a vehicle to operate without a human driver present in the vehicle, including insurance and registration requirements.
- Effective July 1, 2017.

Georgia House AV Technology Study Committee Report (December 2014)
http://www.house.ga.gov/Documents/CommitteeDocuments/2014/Autonomous_Vehicles/Final%20Autonomous%20Vehicle%20Committee%20Report.pdf

Hawaii

Governor David Ige signed an executive order in November 2017 established a connected autonomous vehicles (CAV) contact in the governor's office and requires certain government agencies to work with companies to allow for self-driving vehicle testing in the state.

HB 2253 (2018)

- Authorizes and regulates the testing of autonomous vehicles in the State of Hawaii
- Establishes approval process and annual reporting.
- Defines autonomous vehicles, regulations, and financial liabilities.
- Makes an appropriation.

Idaho

Governor C.L. Otter signed an executive order in January 2018 that established an Autonomous and Connected Vehicle and Deployment Committee.

Illinois

HB 791 (2017)

- Preempts local authorities from enacting or enforcing ordinances that prohibit the use of vehicles equipped with Automated Driving Systems. Defines “automated driving system equipped vehicle.”
- Effective June 1, 2018.

Indiana

HB 1341 (2018)

- Establishes regulation relating to autonomous vehicles.

- Provides that a political subdivision may not prohibit the authorized use of an automated driving system, automated vehicle, or an on demand automated vehicle network.
- Provides criteria for the authorization and operation of automated driving systems and vehicles.
- Provides criteria for the registration of automated vehicles and proof of financial responsibility.
- Provides for required equipment and prerequisites; provides for certain liabilities.

Iowa

Iowa Department of Transportation AV Technologies Project Vision Document (March 2017)
https://www.iowadot.gov/pdf_files/IowaVisionDocument.pdf

Kentucky

Kentucky Transportation Center, Analysis of Autonomous Vehicles Policies
https://uknowledge.uky.edu/ktc_researchreports/1568/

Louisiana

HB 1143 (2016)

- Defines "autonomous technology" for purposes of the Highway Regulatory Act.
- Enacted and chaptered on June 2, 2016.

Louisiana Transportation Research Center, Investigation into Legislative Action Needed To Accommodate the Future Safe Operation of Autonomous Vehicles in the State of Louisiana (October 2016)
http://www.ltrc.lsu.edu/pdf/2016/FR%20571.pdf

Maine

HB 1204 (2017)

- This bill authorizes municipalities to enter into memoranda of agreement with the Secretary of State, the Department of Transportation and the Department of Professional and Financial Regulation, Bureau of Insurance to develop, test and operate pilot programs for the use of autonomous vehicles for public transportation until March 31, 2022.
- It requires any municipality that develops, tests or operates a pilot program to submit a report regarding the pilot program.

Governor Paul R. LePage signed an executive order in January 2018 that establishes the Maine Highly Automated Vehicles Advisory Committee.

Massachusetts

Governor Charlie Baker signed an executive order in October 2016, “To Promote the Testing and Deployment of Highly Automated Driving Technologies.” The order created a working group on AVs and the group is expected to work with experts on vehicle safety and automation, work with members of the legislature on proposed legislation, and support agreements that AV companies will enter with the state DOT, municipalities and state agencies.

Michigan

SB 995 (2016)

- Allows for autonomous vehicles under certain conditions.
- Allows operation without a person in the autonomous vehicle.
- Specifies that the requirement that commercial vehicles maintain a minimum following distance of 500 feet does not apply to vehicles in a platoon.
- Enacted and chaptered on Dec. 9, 2016.

SB 996 (2016)

- Allows for autonomous vehicles under certain conditions.
- Allows operation without a person in the autonomous vehicle.
- Enacted and chaptered on Dec. 9, 2016.

SB 997 (2016)

- Defines automated driving system.
- Allows for the creation of mobility research centers where automated technology can be tested.
- Provides immunity for automated technology manufacturers when modifications are made without the manufacturer's consent.
- Enacted and chaptered on Dec. 9, 2016.

SB 998 (2016)

- Exempts mechanics and repair shops from liability on fixing automated vehicles.
- Enacted and chaptered on Dec. 9, 2016.

SB 169 (2013)

- Defines "automated technology," "automated vehicle," "automated mode," expressly permits testing of automated vehicles by certain parties under certain conditions, defines operator, addresses liability of the original manufacturer of a vehicle on which a third party has installed an automated system, directs state DOT with Secretary of State to submit report by Feb. 1, 2016.
- Enacted and chaptered on Dec. 20, 2013.

SB 663 (2013)

- Limits liability of vehicle manufacturer or upfitter for damages in a product liability suit resulting from modifications made by a third party to an automated vehicle or automated vehicle technology under certain circumstances; relates to automated mode conversions.

- Enacted and chaptered on Dec. 26, 2013.

Missouri

HB 1871 (2018)

- Allows testing of driverless motor vehicles until August 28, 2021.

HB 2271 (2018)

- Contains provisions relating to the operation of automated motor vehicles in the state and establishes the Automated Vehicle Safety Advisory Committee.

Nebraska

LB 989 (2017)

- Authorizes testing of autonomous vehicles by a city of the primary class on its roadways.

LB 1122 (2017)

- Authorizes testing of automated motor vehicles as prescribed.

Nevada

AB 511 (2011)

- Authorizes operation of autonomous vehicles and a driver's license endorsement for operators of autonomous vehicles.
- Defines "autonomous vehicle" and directs state Department of Motor Vehicles (DMV) to adopt rules for license endorsement and for operation, including insurance, safety standards and testing.
- Enacted and chaptered on June 17, 2011.

SB 140 (2011)

- Prohibits the use of cell phones or other handheld wireless communications devices while driving in certain circumstances, and makes it a crime to text or read data on a cellular phone while driving.
- Permits use of such devices for persons in a legally operating autonomous vehicle. These persons are deemed not to be operating a motor vehicle for the purposes of this law.
- Enacted and chaptered on June 17, 2011.

SB 313 (2013)

- Relates to autonomous vehicles. Requires an autonomous vehicle that is being tested on a highway to meet certain conditions relating to a human operator.
- Requires proof of insurance.

- Prohibits an autonomous vehicle from being registered in the state, or tested or operated on a highway within the state, unless it meets certain conditions.
- Provides that the manufacturer of a vehicle that has been converted to be an autonomous vehicle by a third party is immune from liability for certain injuries.
- Enacted and chaptered on June 2, 2013.

AB 69 (2017)

- Defines terms including “driver-assistive platooning technology,” “fully autonomous vehicle” and “automated driving system.”
- Allows the use of driver-assistive platooning technology on highways in the state.
- Preempts local regulation.
- Requires the reporting of any crashes to the department of motor vehicles within 10 days if the crash results in personal injury or property damage greater than $750.
- Allows a fine of up to $2,500 to be imposed for violations of laws and regulations relating to autonomous vehicles.
- Permits the operation of fully autonomous vehicles in the state without a human operator in the vehicle.
- Specifies that the original manufacturer is not liable for damages if a vehicle has been modified by an unauthorized third party.
- Allows the DMV to adopt certain regulations relating to autonomous vehicles.
- Defines “driver,” for purposes of an autonomous vehicle, to be the person who causes the automated driving system to engage.
- Specifies that the following distance requirement does not apply to a vehicle using platooning technology.
- Imposes an excise tax on the connection of a passenger to a fully autonomous vehicle for the purpose of providing transportation services.
- Specifies requirements for autonomous vehicle network companies, including a permitting requirement, prohibitions on discrimination, and addressing accessibility.
- Permits the use of autonomous vehicles by motor carriers and taxi companies if certain requirements are met.
- Enacted and chaptered on June 16, 2017.

New Hampshire

HB 1459 (2017)

- Prohibits operating autonomous vehicles on ways of the state.

HB 314 (2017)

- Relates to autonomous vehicles; establishes licensing requirements for autonomous vehicle operation and testing.

New Jersey

AB 1853 (2018)

- Permits testing and use of autonomous vehicles on state roadways under certain circumstances.

New Mexico

SJM 3 (2018)

- Requests the department of transportation to create a committee that includes relevant state agencies and private entities to review the current and developing state of autonomous vehicle technology and develop a proposal to allow autonomous vehicle use in New Mexico while ensuring public safety.

New York

SB 2005 (2017)

- Allows the commissioner of motor vehicles to approve autonomous vehicle tests and demonstrations.
- Requires supervision from the state police for testing.
- Specifies requirements for operation, including insurance of five million dollars.
- Defines autonomous vehicle technology and dynamic driving task.
- Requires a report on testing and demonstration.
- Enacted and chaptered on April 20, 2017.

North Carolina

HB 469 (2017)

- Establishes regulations for the operation of fully autonomous motor vehicles on public highways of this state.
- Defines terms.
- Specifies that a driver's license is not required for an AV operator.
- Requires an adult be in the vehicle if a person under 12 is in the vehicle.
- Preempts local regulation.
- Establishes the Fully Autonomous Vehicle Committee.
- Effective Dec. 1, 2017.

HB 716 (2017)

- Modifies the follow-too-closely law to allow platooning.
- Effective Aug. 1, 2017.

North Dakota

HB 1065 (2015)

- Provides for a study of autonomous vehicles.
- Includes research into the degree that automated motor vehicles could reduce traffic fatalities and crashes by reducing or eliminating driver error and the degree that automated motor vehicles could reduce congestion and improve fuel economy.
- Enacted and chaptered on March 20, 2015.

HB 1202 (2017)

- Requires the department of transportation to study the use of vehicles equipped with automated driving systems on the highways in this state and the data or information stored or gathered by the use of those vehicles.
- Also requires that the study include a review of current laws dealing with licensing, registration, insurance, data ownership and use, and inspection and how they should apply to vehicles equipped with automated driving systems.
- Effective Aug. 1, 2017.

Pennsylvania

SB 1267 (2016)

- Allows the use of allocated funds, up to $40,000,000, for intelligent transportation system applications, such as autonomous and connected vehicle-related technology, in addition to other specified uses.
- Effective Sept. 19, 2016.

PA Autonomous Vehicle Testing Policy: Final Draft Report of the Autonomous Vehicle Policy Task Force
http://www.penndot.gov/ProjectAndPrograms/ResearchandTesting/Documents/AV%20Testing%20Policy%20DRAFT%20FINAL%20REPORT.pdf

South Carolina

HB 3289 (2017)

- Specifies that minimum following distance laws for vehicles traveling along a highway do not apply to the operator of any non-leading vehicle traveling in a platoon.
- Effective May 19, 2017.

Tennessee

SB 598 (2015)

- Relates to motor vehicles. Prohibits local governments from banning the use of motor vehicles equipped with autonomous technology.
- Enacted and chaptered on April 24, 2015.

SB 2333 (2016)

- Allows a motor vehicle to be operated, or to be equipped with, an integrated electronic display visible to the operator while the motor vehicle's autonomous technology is engaged.
- Enacted and chaptered on March 22, 2016.

SB 1561 (2016)

- Redefines "autonomous technology" for purposes of preemption.
- Defines "driving mode" and "dynamic driving task."
- Enacted and chaptered on April 27, 2016.

SB 676 (2017)

- Permits the operation of a platoon on streets and highways in the state after the person provides notification to the department of transportation and the department of safety.
- Enacted and chaptered on April 24, 2017.

SB 151 (2017)

- Creates the “Automated Vehicles Act.”
- Defines a number of terms.
- Modifies laws related to unattended motor vehicles, child passenger restraint systems, seat belts, and crash reporting in order to address ADS-operated vehicles.
- Specifies that ADS-operated vehicles are exempt from licensing requirements.
- Permits ADS-operated vehicles on streets and highways in the state without a driver in the vehicle if it meets certain conditions.
- Preempts local regulation of ADS-operated vehicles.
- Specifies that the ADS shall be considered a driver for liability purposes when it is fully engaged and operated properly.
- Makes it a class A misdemeanor to operate a motor vehicle on public roads in the states without a human driver in the driver’s seat without meeting the requirements of this Act.
- Specifies that this Act only applies to vehicles in high or full automation mode.
- Enacted and chaptered on June 6, 2017.

Texas

HB 1791 (2017)

- Allows the use of a connected braking system in order to maintain the appropriate distance between vehicles.
- Specifies that "connected braking system" means a system by which the braking of one vehicle is electronically coordinated with the braking system of a following vehicle.
- Enacted and chaptered on May 18, 2017.

SB 2205 (2017)

- Defines a number of terms, including “automated driving system,” “automated motor vehicle,” “entire dynamic driving task” and “human operator.”
- Preempts local regulation of automated motor vehicles and automated driving systems.
- Specifies that the owner of an automated driving system is the operator of the vehicle when the system is engaged and the system is considered licensed to operate the vehicle.
- Allows an automated motor vehicle to operate in the state regardless of whether a human operator is present in the vehicle, as long as certain requirements are met.
- Effective Sept. 1, 2017.

Utah

HB 373 (2015)

- Authorizes the Department of Transportation to conduct a connected vehicle technology testing program.
- Enacted and chaptered on April 22, 2015.

HB 280 (2016)

- Requires a study related to autonomous vehicles, including evaluating NHTSA and AAMVA standards and best practices, evaluating appropriate safety features and regulatory strategies and developing recommendations.
- Enacted and chaptered on March 23, 2016.

Virginia

HB 454 (2016)

- Allows the viewing of a visual display while a vehicle is being operated autonomously.
- Enacted and chaptered on April 6, 2016.

Vermont

HB 494 (2017)

- Requires the department of transportation convene a meeting of stakeholders with expertise on a range of topics related to automated vehicles.
- The secretary of transportation must report to the House and Senate committees on transportation regarding the meetings and any recommendations related automated vehicles, including proposed legislation.
- Enacted and chaptered on May 17, 2017.

Washington

Governor Jay Inslee signed an executive order in June 2017 to address autonomous vehicle testing and establish an autonomous vehicle work group. The order requires that state agencies with pertinent regulator jurisdiction “support the safe testing and operation of autonomous vehicles on Washington’s public roads.” It establishes an interagency work group and enables pilot programs throughout the state. The order specifies certain requirements for vehicles operated with human operators present in the vehicle and for vehicles operated without human operators in the vehicle.

HB 2970 (2017)

- Establishes an autonomous vehicle work group.

HB 2971 (2017)

- Concerns the development of a report by the governor's autonomous vehicle work group concerning the testing of autonomous commercial motor vehicles on public roadways in the state.

HCR 4414 (2017)

- Creates a joint select committee on autonomous vehicle technology policy.

Washington, D.C.

2012 DC B 19-0931

- Defines "autonomous vehicle” as "a vehicle capable of navigating District roadways and interpreting traffic-control devices without a driver actively operating any of the vehicle’s control systems."
- Requires a human driver "prepared to take control of the autonomous vehicle at any moment."
- Restricts conversion to recent vehicles, and addresses liability of the original manufacturer of a converted vehicle.
- Enacted and effective from April 23, 2013.

Wisconsin

Governor Scott Walker signed an executive order in May 2017 creating the Governor's Steering Committee on Autonomous and Connected Vehicle Testing and Deployment. The committee is tasked with advising the governor "on how best to advance the testing and operation of autonomous and connected vehicles in the State of Wisconsin." The order specifies the members of the committee, including six legislators from the state. The duties of the committee include identifying all agencies in the state with jurisdiction over testing and deployment of the vehicles, coordinating with the agencies to address concerns related to issues such as "vehicle registration, licensing, insurance, traffic regulations, equipment standards, and vehicle owner or operator responsibilities and liabilities under current law," and reviewing current state laws and regulations that may impede testing and deployment, along with other tasks. The state department of transportation is required to submit a final report to the governor by June 30, 2018.

Autonomous Vehicles in Delaware: Analyzing the Impact and Readiness for the First State

Written By
Philip Barnes, Associate Policy Scientist
Eli Turkel, Graduate Public Administration Fellow

Published by
Institute for Public Administration
School of Public Policy and Administration
University of Delaware
www.ipa.udel.edu

In collaboration with
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April 2017

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DelDOT

Preface

Autonomous vehicles—long part of the futuristic frontier—are justifiably receiving a great deal of media attention. These vehicles are currently being tested in many cities and states around the country, and the expected timeline for commercial sales is shortening. The transformative potential of this emerging technology is significant.

As the Director of the University of Delaware's Institute for Public Administration (IPA), I am pleased to provide this timely report, Autonomous Vehicles in Delaware: Analyzing the Impact and Readiness for the First State. This report anticipates autonomous vehicle deployment in Delaware and evaluates the possible consequences across a wide range of focus areas—from vehicle ownership projections to local fiscal impacts and transportation equity. The analysis demonstrates that successful integration of autonomous vehicles into the First State's transportation system is not necessarily a technological challenge, but rather an administrative one. Socially beneficial outcomes are possible with the proactive, collaborative involvement of state and local governments, citizens, the business community, research partners, advocacy organizations, and other relevant stakeholder groups.

This report continues IPA's legacy of practical research on Delaware's transportation challenges and opportunities. It leverages our expertise to advance administrative and policy conversations and it responds to emerging trends in transportation systems and urban affairs. It complements our past research for the state on intermodal transportation, paratransit services, and complete communities. Looking forward, this report will form the foundation to advance smart city scholarship and total urban mobility research in Delaware.

IPA is grateful for funding from the Delaware Department of Transportation that supported this research. I would like to thank the lead researchers and authors—IPA's Philip Barnes and Eli Turkel. Additional thanks go to IPA staff members Lisa Moreland for editing support and Sarah Pragg for designing and formatting the document.

Jerome R. Lewis, Ph.D.

Director, Institute for Public Administration

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Acronyms

ACC	Adaptive Cruise Control
AV	Autonomous Vehicle
CACC	Cooperative Adaptive Cruise Control
CAN	Controller Area Network
CV	Connected Vehicle
DelDOT	Delaware Department of Transportation
DMV	Division of Motor Vehicles
DSRC	Dedicated Short Range Communication
FTC	Federal Trade Commission
GPS	Global Positioning System
HAV	Highly Autonomous Vehicle
ITMS	Integrated Transportation Management System
LIDAR	Light Detection and Ranging
NHTSA	National Highway Traffic Safety Administration
RSE	Road Side Equipment
SAE	Society of Automotive Engineers
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
VMT	Vehicle Miles Traveled

01 Executive Summary

The sci-fi reality of self-driving, networked, autonomous vehicles is nearly here. Ford claims it will sell these vehicles within five years, and most analysts expect modest sale numbers by the late 2020s and widespread adoption throughout the 2030s and 2040s. The consequences of the impending autonomous vehicle revolution for Delaware's economy, its residents, and visitors are significant. Public and private stakeholders will need to adapt current practices and processes to accommodate the new advancement in transportation. State regulations that govern vehicles and drivers will need to evolve with the technology. Cybersecurity and privacy limits will be tested. The insurance industry will be required to develop new products and actuarial models. Claims of liability will be argued and settled in the courts.

There will also be impacts, both positive and negative, to important transportation and urban planning areas, especially roadway safety, ownership, parking demand, vehicle miles traveled, roadway congestion and capacity, development patterns, infrastructure design, jobs and the economy, state and local budgets, fuel efficiency and carbon emissions, and transportation equity. The authors of this report attempted to preview the possible impact that autonomous vehicle deployment would have on each area. Major information gaps exist on autonomous vehicles, and there are complex interactions among areas that render such previews extremely challenging and uncertain.

Despite these difficulties, the table summarizes the report's findings. The findings are based on a long-term view and assume full, widespread penetration of autonomous vehicles across all Delaware roadways with a corresponding decline in manually-driven vehicles. A confidence measure was added to articulate the level of certainty/uncertainty for each area. Entries in the table should not be accepted as absolute truths, but rather as starting points for preliminary discussions on policy and administrative options to minimize negative impacts and amplify positive ones.

In terms of readiness to accept autonomous vehicles, the state is well prepared technologically. The Delaware Department of Transportation (DelDOT) possesses an extensive telecommunications network that can be leveraged for autonomous vehicle integration, and DelDOT is proactively upgrading its systems in anticipation of autonomous vehicle deployment. DelDOT plans to install a transportation-specific wireless network in Dover, test signal timing and traffic light priority in Smyrna, and develop software to partially automate decision-making at the state's Transportation Management Center. These are positive steps that will make Delaware attractive for vehicle testing, operation, and deployment. From an administrative standpoint, the state could accelerate the evolution of its governance systems and institutions to align with these technological advances. If action is taken now, Delaware could position itself to be a leader in the autonomous vehicle area.

Possible Impacts of Autonomous Vehicles for Delaware

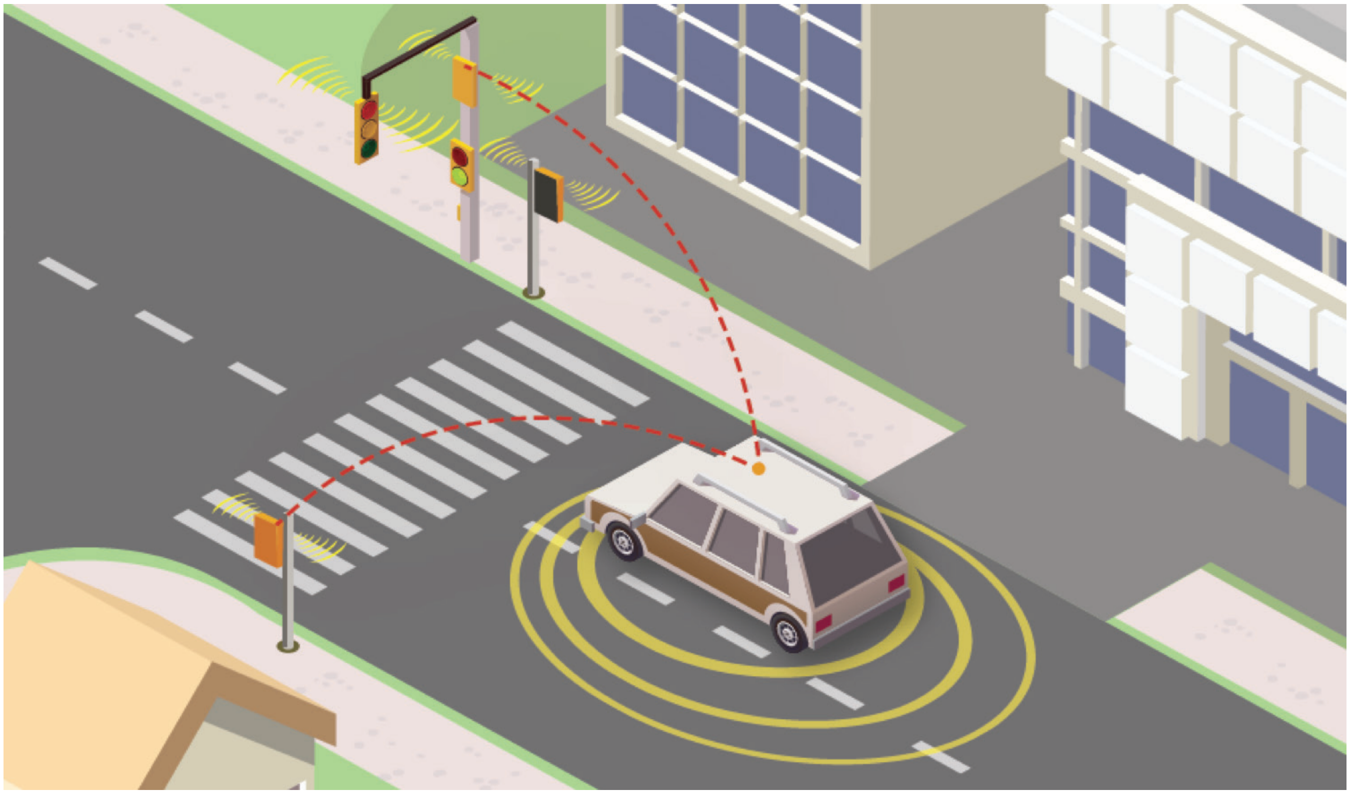
Impact Area	Possible Impact	Confidence
Roadway Safety	Decrease accidents, injuries, fatalities	High
Ownership	Decrease percent of Delawareans owning a vehicle	Medium-High
Parking Demand	Decrease demand for parking	Medium
Vehicle Miles Traveled	Increase state-wide vehicle miles traveled	Medium
Congestion/Capacity	Increase highway capacity and urban core congestion	Low
Development Patterns	Increase sprawl and urban densification	Medium
Infrastructure Design	Decrease lane width, increase roadside technology	Medium-High
Jobs/Economy	Decrease driving-related jobs short-term/long-term increase in overall economic activity	High/Medium-Low
Fiscal Impacts	Decrease revenue for state and local governments	Medium-Low
Modal Shifts	Decrease use of public transportation	Medium
Fuel Economy/Carbon Emissions	Increase fuel efficiency/decrease carbon emissions	High/Low
Equity	Increase transportation inequities	Medium-High

02 Introduction

Self-driving autonomous vehicles (AVs) will transform America. The transportation-related impacts are the most apparent, as AVs will enable safe mobility for those individuals who are currently unable to drive such as children and the visually impaired. These vehicles will converge with ridesharing services (e.g., Uber, Lyft) and upend longstanding traditions of vehicle ownership, particularly in dense, populated areas. They will undoubtedly reshape urban and suburban development, shift demand for parking, and impact roadway congestion and capacity. Significant economic and social consequences of AVs are also expected. As with all disruptive technologies, some job markets will be made redundant, with truck and bus drivers likely bearing the brunt of AV deployment. While the ultimate impact of AVs is uncertain due to many complex variables that will influence the technology's development and deployment, analysts are confident that the transformations to transportation and economic systems will be significant and long lasting.

State departments of transportation such as DelDOT must anticipate and adapt to the many planning and policy implications of AVs. At a recent Delaware Center for Transportation (2013, p. 47) forum, it was recommended that Delaware transportation professionals "engage in the primary stages of [autonomous] vehicle technology in order to guide its development and to position DelDOT for expedited integration." To facilitate that effort—and to provide reliable information to decision-makers at DelDOT as well as policymakers, planners, and state administrators in Delaware—this report presents research results that highlight the relevant issues with AV technology. The intent of the report is to lay the foundation for a future policy and planning framework and ensure the timely integration of autonomous vehicles into the state's transportation network. The information gleaned through the research process will also be useful for budget forecasters and policy analysts who must weigh the merits of various AV policy options.

The report is divided into five major sections. First, it reviews the technology behind AVs and degrees of vehicle autonomy. Predictions on the timing of AV deployment are also reviewed. The second section covers administrative and consumer issues, namely regulation of the new technology, liability, insurance, and cybersecurity/privacy. Third, the report investigates a number of planning and policy areas in Delaware that will be impacted by AVs: roadway safety, ownership, parking demand, vehicle miles traveled, roadway congestion and capacity, development patterns, infrastructure design, jobs and the economy, state and local budgets, fuel efficiency and carbon emissions, and transportation equity. Despite the significant uncertainty involved in prognosticating, an attempt is made to predict the future impacts of AVs in each area. Fourth, the report reviews Delaware's current level of technological and administrative readiness to test and operate AVs on the state's roadways. The report concludes with possible next steps for the state.



Vehicle to Infrastructure (V2I) Interaction
Source: DelDOT

03 Autonomous Vehicle Technology

Also known as driverless or self-driving cars, the vision of developing autonomous vehicles entered the public's imagination at the "Futurama" exhibit for the 1939 World Fair in New York City. A utopian-inspired display sponsored by General Motors and designed by Norman Bel Geddes depicted radio-controlled, electromagnetically propelled vehicles (O'Toole, 2010). More recently in the past decade, the maturation and convergence of the internet and artificial intelligence created technological foundation to transform Geddes's larger vision of driverless transportation into reality. This section quickly reviews the recent history of AV development, the hardware and software systems comprising AV technology, and identifies a spectrum of AV functionality that helps classify varying degrees of vehicle autonomy. It then reviews the current status of the AV industry before reviewing a number of AV deployment scenarios, many of which anticipate commercial availability within the next decade.

History and Technology

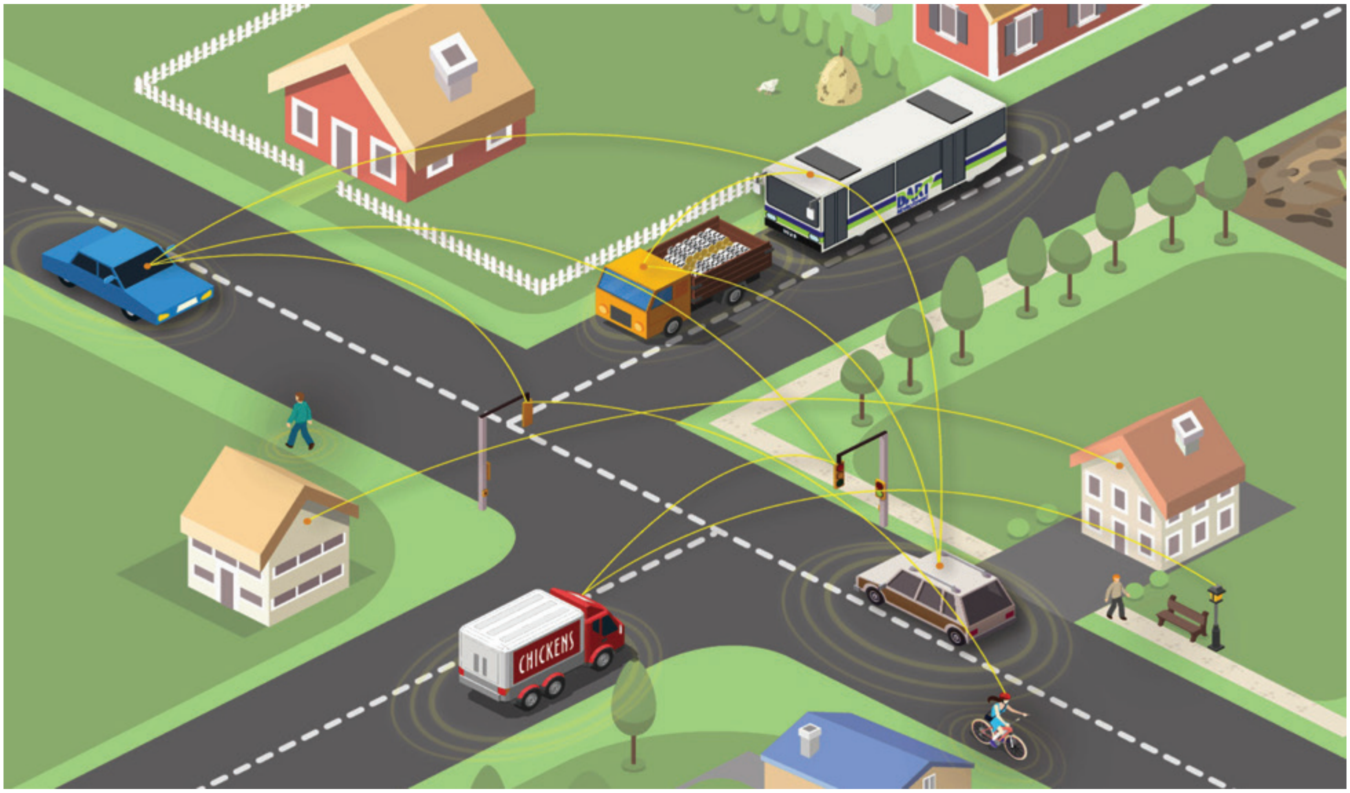
The United States Congress initiated a push to develop military grade AVs between 2003 and 2007 with a series of contests, known as Grand Challenges. With each successive contest, large advances in AV technology were made, and committed private-sector efforts began shortly thereafter. Google leveraged its resources to become a major innovator and accelerated development of fully autonomous vehicles, while the traditional automobile manufacturers began to integrate elements of autonomous technology into their commercial offerings (Anderson et al., 2014).

The technology that provides functionality for AVs is based on three related systems. First, just like a smart phone uses the global positioning system (GPS) to provide driving directions, GPS is necessary for AV technology to allow vehicles to roughly identify their positions relative to the transportation infrastructure and journey starting and ending points. To navigate real-time in an environment that features detours, pedestrians, and other obstacles, a second system of sensors is integrated into the vehicle. Lasers such as Light Detection and Ranging or LIDAR that can "see" in the dark and low-visibility situations, radars, and cameras are common sensors that provide information for vehicle situational awareness. The bulb on the top of Google's AV prototype is a range-finding LIDAR unit that rotates rapidly while sending and receiving signals to detect distances between itself and surrounding environmental features. Cameras and radar units, which are already common on today's vehicles with features such as adaptive cruise control (ACC) or backup parking assistance, are also frequently mounted on AVs. The third system includes the software and algorithms that process the GPS and sensory data to execute movements through space by delivering instructions through the vehicle's Controller Area Network (CAN) bus. The algorithms are designed for machine learning, meaning that while certain rules of the road can be hardwired (e.g., stop at red lights), other non-determined human behaviors such as pedestrian movements are analyzed and continually improved with each successive experience (Madrigal, 2014).

Connected Vehicles

While autonomous vehicles receive most of the media and research attention, connected vehicles (CVs) are an associated automobile technology seen as precursors and prerequisites to full AVs. The major distinguishing characteristic separating AVs and CVs is the presence of an active, involved driver in CVs. CVs enhance and improve driver decision-making, whereas AVs have the potential to replace the driver altogether.

CVs are equipped with communication technologies that relay and receive information among vehicles, near-road infrastructure, and drivers. The exact type of communication technology that will be dominant is still a matter of debate, but two possible versions



Combined V2V and V2I systems
Source: DelDOT

exist: dedicated short-range communication (DSRC) and wireless technology similar to that used in smart phones (e.g., 5G technology under development). DSRC is WiFi-like and enables CVs to rapidly transmit and receive signals to specialized roadside infrastructure up to 1,600 feet away, allowing constant monitoring of surrounding environmental conditions. The 5G version may not be as fast as DSRC, but it could utilize the existing infrastructure currently used by mobile devices (Bradbury, 2016). In either case, a vehicle equipped with CV technology can analyze internal and external data to alert drivers about potential hazards and risks that are hidden from their direct view (Arseneau, Roy, Salazar, & Yang, 2015). The anticipated impacts of CVs are mostly similar to AVs, with a key difference related to the importance of state spending to create the "smart" infrastructure that is required for CV operability (see subsection titled "Infrastructure Design and Upgrades"). CV technologies and systems are generally classified according to the type of connectivity. If they connect vehicles to each other, they are referred to as vehicle to vehicle (V2V) technologies. If they connect to public infrastructure, the systems are referred to as vehicle to infrastructure (V2I) technologies.

V2V Technology

V2V technology consists of components integrated into automobiles that effectively allow them to communicate with other V2V-equipped vehicles. The main application of V2V technology involves vehicles wirelessly interacting with each other to monitor conditions and send alert signals to drivers when risks and hazards arise. For example, a vehicle equipped with V2V technology can receive and analyze data from nearby V2V-equipped vehicles to detect rapidly decelerating traffic in the road ahead, giving the driver advanced warning to slow down. Another example of a V2V application involves left-turning assistance that alerts the driver not to execute a left turn because an oncoming vehicle poses an immediate collision risk. Thus, a major benefit of V2V technology is improved on-road safety and traffic flow. The National Highway Traffic Safety Administration (NHTSA) estimates that nearly 600,000 crashes could be avoided with intersection turn assistance (Harding et al., 2014).

V2I Technology

Like V2V systems, V2I technology is also predicted to improve safety and reduce on-road risks, yet unlike V2V where signals are sent between vehicles, the communication in V2I CVs occurs between the vehicle and the surrounding fixed infrastructure. In a V2I network, roadside equipment (RSE) will transmit communication signals to vehicles that then analyze the information and relay warnings to drivers. One of the many applications of V2I systems involves RSE connected to traffic signals that would alert drivers if they are about to run a red light. Other applications include speed-limit advice along highways to optimize traffic flow and ease congestion. V2I systems also could be integrated to traffic control and planning centers that would monitor and analyze the incoming information and make adjustments to existing intelligent transportation system assets such as message signs and intersection signals. In other applications of V2I technology, it is also possible to envision traffic signal priority for particular vehicles such as buses, police, and emergency responders (Government Accountability Office, 2015).

Taxonomy of Autonomous Vehicles

Determined to bring a sense of order to the rapidly advancing field, NHTSA (2013) created an initial AV classification system defined by five levels of autonomy, from zero to four, with each successive level exhibiting greater vehicle self-control. With the release of the 2016 policy guidance, NHTSA adopted the Society of Automotive Engineers (SAE) International Standard J3016 that defines vehicles on a 0-to-5 scale. The taxonomy standard is reproduced in the table (right). While there are gray areas between each level, the SAE classification system is useful for understanding and analyzing the implications of a spectrum of AV technology.

An important distinction in the SAE taxonomy involves the difference between Level 2 and Level 3 vehicles. At Level 2 or below, the human driver is required to be fully engaged and continuously monitoring conditions, whereas at Level 3 and above the vehicle is expected to perform monitoring functions and the driver can be disengaged. Safety risks increase significantly at Levels 3 and above, and are characterized as Highly Autonomous Vehicles (HAVs).

Current Availability

Level 1 automation is currently available and offers assistance to drivers under certain road conditions. For instance, ACC controls a vehicle's speed in response to changes in the traffic environment (Youngs, 2012). Electronic stability control will apply brakes if the vehicle is taking a turn too fast to help prevent roll-overs (Barth, 2015). Emergency dynamic brake support will apply more pressure to the brake if the driver is not braking hard enough in an emergency situation (Ecarma, 2015). Traffic jam assist technology, which adjusts vehicle direction and speed for lane centering while maintaining constant distances between vehicles ahead and behind, is capable of operating in low-speed, high-traffic situations. BMW, Mercedes, Volkswagen, and Volvo all offer models with traffic jam assist.

Vehicles that combine ACC with lane centering to control all steering, braking, and throttle in high-speed situations also satisfy Level 2 criteria. Tesla's Model S with the added Autopilot feature is an example of high-speed Level 2 autonomy. Autopilot is available as a software download on the Model S and the semi-autonomous feature allows hands- and pedal-free driving in conditions where the road is clearly marked and the weather is good. After downloading Autopilot, the vehicle will change lanes and self-operate on winding roads, yet Tesla advises the driver to stay engaged by keeping one hand on the wheel at all times. If the Autopilot system detects an unmanageable situation, it signals to the driver with a blue message on the dashboard, audible alerts, and self-braking (Kessler, 2015).

The General Motors SuperCruise system is under development and will be available on certain Cadillac models in 2017. Like Tesla's Autopilot, SuperCruise-equipped vehicles will be combine lane centering and ACC and will be capable of driving on highways without the driver holding the steering wheel or putting their foot on the pedal (Naughton, 2015).

SAE (2014) and NHTSA (2016) taxonomy of autonomous vehicles

Autonomy Level	Description
Level 0: No Automation	The human driver does everything
Level 1: Driver Assistance	An automated system on the vehicle can sometimes assist the human driver conduct some parts of the driving task
Level 2: Partial Automation	An automated system on the vehicle can conduct some parts of the driving task, while the human continues to monitor the driving environment and performs the rest of the driving task
Level 3: Conditional Automation	An automated system can conduct some parts of the driving task and monitor the driving environment in some instances, but the human driver must be ready to take back control when the automated system requests
Level 4: High Automation	An automated system can conduct the driving task and monitor the driving environment, and the human need not take back control, but the automated system can operate only in certain environments and under certain conditions
Level 5: Full Automation	The automated system can perform all driving tasks under all conditions that a human driver could perform them

There are no Level 3 or 4 AVs available on the commercial market, although prototypes from Audi and Delphi have completed lengthy trips with minimal manual driver control (Davies, 2015a, 2015b). In Level 3 autonomy, situations arise where vehicle control must be quickly transferred between the automated system and an inattentive or distracted driver (Markoff, 2016). This amplifies risk, as the driver must immediately control the vehicle while simultaneously gaining situational awareness, a process that could take considerable time and lead to an accident. Consequently, some manufacturers are opting instead to leapfrog directly to full AV functionality to avoid "mode confusion" between the vehicle and driver (Davies, 2015; Golson, 2016; Marinik et al., 2014).

Several manufacturers have developed and are testing Level 5 prototypes. Google's bubble-like driverless car, named the "Koala," is undergoing on-road testing in California and receives a great deal of media attention (Bergen, 2015). The vehicle, which has no steering wheel or pedals, is equipped with cameras, sensors, and a roof-mounted LIDAR system. Volvo plans on testing their Drive Me Level 5 system in 2017 with 100 prototypes on the streets of Gothenburg, Sweden (Ziegler, 2015). Unlike Tesla, which is taking incremental steps through the autonomy spectrum, Volvo and Google are intent on bypassing intermediate levels of autonomy and are aiming to leapfrog directly to fully autonomous Level 5 technology (Golson, 2016; Markoff, 2016).

Deployment Scenarios and Timeline

Major questions concerning AVs center around the expected timeline for vehicle sales and the extent of market penetration. While it is difficult to accurately predict the deployment of advanced technologies, particularly those with uncertainty around public acceptance and regulatory development, a number of analysts have tried to anticipate when Level 5 AVs would be available for purchase. While analysts differ on the exact timing, they consistently anticipate AVs will follow a standard technology diffusion curve in which a small number of early adopters make initial purchases followed by period of rapid growth before leveling off near a saturation point. These predictions are summarized here to arrive at a range of possible deployment scenarios.

Todd Litman (2015) predicts an optimistic scenario in which AV sales begin in the next ten years, reach 50 percent of all vehicles sold in the 2040s, and achieve nearly 100 percent market penetration by 2060. A report by McKinsey & Co. (2016) offers a similarly optimistic adoption curve, with 15 percent of all vehicle sales by 2030, a quick rise to 50 percent in 2035, and a topping out at 90 percent by 2040. In terms of aggregate number of vehicles sold, a paper delivered at the 2016 Transportation Research Board Annual Conference predicts 1.3 million AVs sold in the United States by 2030, 36 million in 2040, and 84 million in 2050 (Lavasani, Jin, & Du, 2016). Similarly, the consulting firm IHS (2016) recently updated their AV deployment predictions with faster rollout scenarios based on increased research and development commitments by manufacturers, forthcoming regulatory harmonization, and new mobility developments such as ridesharing systems. IHS now anticipates around 300,000 AVs sold in the United States by 2025 and 1.6 million by 2030. Initial rollout could come even sooner, as Ford recently announced they would release an AV for the ridesharing market in 2021 (Boudette, 2016). These analyses indicate that AVs will be commercially available within ten years and will comprise half of all vehicle sales within 20 to 30 years.

Costs

Cost estimates are available for the price premium that AVs will command due to the advanced computing and sensing technologies that are required for functionality. One estimate places an initial $10,000 premium on AVs, falling to around $3,000 several decades later after the technology improves and becomes ubiquitous (Fagnant & Kockelman, 2015). Another study predicts similar figures, with a $7,000 to $10,000 price premium initially and dropping to $3,000 ten years later (IHS Automotive, 2014). The average cost of a new car in 2015 was $33,000, so a $10,000 AV option would increase the price by approximately 30 percent, which would place the product out of range for many consumers. It is therefore likely that AVs will debut with luxury makers that already enjoy an affluent customer base who can afford the added cost (Kelley Blue Book, 2015; Tannert, 2014).

Google's Koala Car

Image credit: Marc van der Chijs under Creative Commons license

04 Administrative and Citizen Issues

The design, testing, and deployment of autonomous vehicles will introduce a number of wrinkles to traditional forms of vehicle administration and governance, such as the regulatory boundaries between federal and state governments. Answers to questions about accident liability will be contentious, and the insurance industry will need to create new products for citizens and manufacturers alike. Also, related to citizens, AVs will generate enormous amounts of geolocated data that could be used to track passengers, thus raising concerns about corporate/government surveillance and privacy. These challenging administrative and citizen-related issues are discussed in the following sections.

Regulations and Vehicle Testing

NHSTA's 2016 policy document contains a section that defines the division of AV regulatory authority between federal and state governments with the goal of ensuring the "establishment of a consistent national framework rather than a patchwork of incompatible laws" (National Highway Traffic Safety Administration, 2016, p. 7). The stated objective of NHSTA's guidance is to provide regulatory clarity to the industry and thus accelerate the development, testing, and deployment of AV technology. Division of regulatory authority for AVs closely mimics the current framework for traditional vehicles. The federal government still retains its ability to establish and enforce vehicles safety standards, regulate vehicle equipment (including computer hardware and software), issue product recalls, and communicate safety-related information to the public. States are still responsible for vehicle licensing, registration, setting and enforcing traffic laws, and establishing insurance and liability standards. New authorities that NHTSA is exploring to ensure AVs safety benefits include new tools to regulate vehicle software updates as well as data collection and storage.

States are encouraged to develop regulations to authorize AV testing and NHTSA offers guidance on the barriers that will need to be overcome. Delaware should appoint a lead agency to handle AV administration and all applications to test AVs within the state's jurisdiction should be submitted to that agency. The agency would review applications, in consultation with state law enforcement, to either grant or refuse authorization to test in Delaware. If authorization is granted, the Delaware Division of Motor Vehicles (DMV) would issue a permit to the applicant for each testing vehicle. Each vehicle should be properly licensed according to Delaware state law. NHTSA recommends that only drivers designated and properly trained by the manufacturer should be allowed to operate AVs during testing trials. These operators should hold a Delaware license and be subject to all state rules of the road. They should also bear responsibility for any traffic offenses that occur during testing (National Highway Traffic Safety Administration, 2016, pp. 40–43).

Liability

A critical, unresolved legal question hangs over fully autonomous vehicles: who is liable for an incident, the user or the manufacturer? Answers to this question depend on many variables and, at this point, are purely speculative because the courts have not been forced to rule. In certain instances, it is likely to assume that users will be liable for an accident if they are negligent under a standard of reasonableness, for instance if a user knows he needs new brakes, fails to obtain them, and the faulty brakes directly lead to an incident (Anderson et al., 2014). On the other hand, if a user is disengaged from the road in a full Level 5 vehicle that experiences internal software or system failure and is involved in an accident, it could be reasonably argued that the manufacturer should be held liable for damages (Silberg & Wallace, 2012). There is an even stronger case for manufacturer liability when an AV is empty, for

> ***...some manufacturers are announcing that they will simply accept responsibility if there are incidents involving their autonomously operated vehicles...***

example if an accident occurs while the AV is picking up a rideshare. Questions may arise over who was in control of safety critical functions at the time of an incident—human driver or vehicle software—but this situation could be mitigated if manufacturers create "black boxes" that store real-time diagnostic data (Bose, 2015).

To avoid some uncertainty and clarify the liability landscape that will evolve in U.S. courts, some manufacturers are announcing that they will simply accept responsibility if there are incidents involving their autonomously operated vehicles. Volvo, for example, committed to accept liability in an effort to avoid lengthy regulatory and legal battles that could delay the development and eventual release of AVs (Korosec, 2015). Google and Mercedes have made similar pronouncements (Whitaker, 2015). This position helps explain why these manufacturers are also avoiding semi-autonomous technology and leapfrogging direct to Level 5 full autonomy.

While clarification of liability will take time to sort out, NHTSA's guidance document offers a first-step recommendation. They argue that states should explicitly define what is meant by "drivers" of AV for the purpose of traffic laws and enforcement. NHTSA recommends that when the AV systems are monitoring the roadway, the surrounding environment, and executing driving tasks (autonomy Levels 3 through 5), the vehicle itself should be classified as the driver, with licensed humans operators classified as drivers for Levels 1 and 2 functionality (National Highway Traffic Safety Administration, 2016, p. 39). If adopted across all states, the classification would set an initial standard of liability that will undoubtedly be refined in the future through successive legal challenges.

Insurance

The automobile insurance marketplace will need to adapt with the deployment of AVs. The anticipated reduction in the number of accidents (see section titled "Roadway Safety" above) will lower expected losses for insurers, and those savings will likely be passed on to consumers in the form of lower premiums (Albright, Bell, Schneider, & Nyce, 2015; Buhayar & Robison, 2015). Yet while the number of claims are expected to decline, the cost per claim is anticipated to increase due to the expensive hi-tech components integrated into AVs. Furthermore, if AV manufacturers are deemed liable in incidents caused by product malfunction, insurance claims will likely need to originate from the manufacturer rather than the owner/operator of the vehicle. While some insurance claims such as theft and hail damage will still be required, it is clear that AVs—and particularly ride-sharing AVs—will force a dramatic transformation of today's automobile insurance industry. Insurers will need to anticipate these changes and develop new products and actuarial models.

One possible innovation for insurers is to use speed and location data collected from the vehicle (see next section) to generate a usage-based, driving mode-based, or trip-based insurance product (PricewaterhouseCoopers, 2015). This new product could be targeted at an urban or casual driving demographic that rarely uses their vehicles. Several insurers, such as the San Francisco-based Metromile, offer a usage-based insurance option for low-mileage drivers through a USB-like dongle that plugs into the vehicle and tracks movements. Another innovation would involve creating new commercial and product liability lines for manufacturers if they are required to (or voluntarily) accept liability for accidents (Albright et al., 2015).

Cybersecurity and Privacy

Autonomous vehicles will introduce a new layer of complexity into growing concerns over cybersecurity. To function properly, AVs must be connected to various digital networks such as GPS systems and possibly wireless and cellular networks. Each digital connection creates a potential gateway and vulnerability for remotely generated malicious intent (Anderson et al., 2014). The magnitude of cybersecurity risk is amplified with autonomous vehicles because the internal vehicle software, which in normal vehicles is already notorious for being "buggy" and requiring recalls, will be designed to adjust safety-critical functions (Gelles, Tabuchi, & Dolan, 2015). A hacker could access an AV's software system and remotely control steering, breaking, and acceleration, as recently demonstrated on a Tesla Model S operating in Autopilot mode (Clark, 2016). The possibility of a system-wide attack also exists. If roadside communication units and ultra-connected V2I and V2V networks become embedded in the U.S. transportation system, a coordinated large-scale cyberattack could exploit that vulnerability and potentially cripple vehicular transportation in the country. Traffic Management Centers also need to exercise caution against being spoofed by malicious and invalid AV traffic data being relayed through their connected networks. Responding to these hacking concerns, U.S. Senators Richard Blumenthal (D-CT) and Edward J. Markey (D-MA) introduced the Security and Privacy in Your Car Act (SPY Act) in 2015 that would instruct NHTSA and the Federal Trade Commission (FTC) to develop security standards for vehicle software and networked controls. The bill is currently in committee but unlikely to proceed further. In August 2016, the Transportation Research Board (2016) initiated a research effort to understand these threats and create a cybersecurity primer for state DOTs. These efforts are warranted as surveys show that potential users are reluctant to adopt AVs because of hacking concerns (Kyriakidis, Happee, & de Winter, 2015).

Citizen privacy is another issue amplified by AVs. As with smartphones, AVs will generate tremendous amount of tracking data that will prove valuable for advertising and marketing purposes. A study conducted by Senator Markey's staff found that even at today's level of vehicle connectivity and partial autonomy, half of the automobile manufacturers generate, transmit, and store on-board data on vehicle movements and diagnostics (Markey, 2015). These data are frequently stored in third-party data centers, sometimes indefinitely, and citizens remain unaware that their movements are being monitored. The aforementioned SPY Act also instructs NHTSA and FTC to develop privacy standards that would force manufacturers to be more transparent in how vehicle data are collected, stored, and used. It would also prohibit data collection by default and would require users to opt in without compromising critical AV capabilities such as self-navigation. NHTSA's (2016) AV policy guidance reiterates many of these recommendations to vehicle manufacturers. For instance, it asks manufacturers to allow AV owners to opt in to data collection rather than having them collected by default. The policy guidance also suggests that citizens need clear, plain language for what data will be collected, how the data will be stored, for how long, and how the data will be protected.

"Does your car have any idea why my car pulled it over?"

Paul Noth, The New Yorker © Condé Nast

05 Planning and Policy Impacts

Delaware's transportation planners, urban planners, and policymakers will need to adjust their models and analyses to account for the tremendous impacts that AVs portend. Decision-makers must consider the changes that AVs will cause to variables such as passenger safety, ownership, parking demand, vehicle miles traveled, roadway congestion, development patterns, infrastructure design, employment, state and local budgets, fuel economy, carbon emissions, and transportation equity. In this section, the variables listed above are investigated, and an attempt is made to predict an increase or decrease for each one. Delaware-specific predictions are made for each variable by using data, when available, and logic based on assumptions about the state's transportation and development environment.

This effort is complicated by the inherent uncertainty surrounding the development, uptake, and deployment of an advanced technology such as AVs. There are countervailing social, economic, political, environmental, and technological forces that impact each variable discussed in this section, and untangling their magnitudes to arrive at a final result is an incredibly complex procedure. So, just as early developers of the internet in the 1980s could only speculate as to the network it would become and how it would transform society four decades later, prognostications surrounding AVs are, at this point, educated best guesses. With that caveat, some variables (safety impacts) benefit from greater certainty than others (carbon emissions).

Roadway Safety

Every year in the United States there are approximately 5.5 million reported vehicle crashes and 33,000 fatalities, with annual economic loses of $300 billion (Cambridge Systematics, 2011). More than 90 percent of these traffic accidents are caused by human driver error, and analysts predict that many of these incidences will be eliminated with driverless vehicles (Fagnant & Kockelman, 2015; Silberg & Wallace, 2012). Indeed, a decrease in fatalities and injuries is one of the most often-cited benefits of the technology. Analyses of accident data indicate that even semi-autonomous crash avoidance technology—such as forward collision warning systems and automatic breaking—featured in current vehicles decreases the frequency of incidents (Highway Loss Data Institute, 2015). However, it is not certain that AVs will deliver totally accident-free transport, especially during the transitional period when AVs and manually-driven vehicles share the road (Sivak & Schoettle, 2015). Assuming full AV saturation, a conservative estimate of a 50 percent reduction in accidents would still yield an overall decrease of approximately 12,000 crashes in Delaware annually, based on 2015 crash data (Hyland, 2016). This would avoid $320 million (in 2015 dollars) in economic loses for the state.

A more realistic state-level estimate for improvement in safety can be found by examining crashes in which humans were impaired and distracted, such as accidents that involved alcohol and texting. In Delaware from 2005 to 2015, there was an average of 106 fatal crashes per year. Drivers under the influence of drugs and alcohol were responsible for 20 percent of those fatal crashes, while distracted drivers accounted for 8 percent (Hyland, 2016). The figures are similar for total crashes (which averaged 20,700 annually): 5 percent are due to impaired driving and 23 percent to distracted driving. Therefore, a 28 percent decrease in fatal accidents and overall accidents in Delaware is an extremely conservative estimate for the expected traffic safety benefits of AVs.

Ownership

A confluence of factors are prompting analysts to question the historical trajectory of ever-increasing vehicle ownership, with some suggesting that the

United States has reached "peak car" (Rosenthal, 2013; Sivak, 2013, 2015). One factor is rural-to-urban migration, which decreases demand for vehicles because urban areas are generally better equipped with alternative transit options and offer greater access to essential services. From 2000 to 2010, the portion of Americans living in urban areas increased by 2 percent while there was an equivalent 2 percent decline in the portion of Americans living in rural areas (Lambert, 2012). A second major factor is a partial rejection of American car culture by the younger Millennial generation. With increasing student loan burdens, stagnant wages, and rising rents in urban areas, Millennials do not have as much disposable income to participate in car ownership (Badger, 2014; Davis, Dutzik, & Baxandall, 2012). There is also evidence that younger Americans value minimizing the environmental impacts of their transportation choices and hence avoid high-polluting options like cars (Sakaria & Stehfest, 2013). The third and, perhaps, most important factor depressing vehicle ownership is the rapid ascension of transport/mobility service providers within the "sharing economy." Uber, Lyft, and Zipcar are the well-known companies operating in this space, and Uber is currently testing AV rideshares in Pittsburgh (Chafkin, 2016). For many urban residents, it is cheaper and more convenient to hail on-demand transport than struggle with driving, parking, vehicle maintenance, insurance, and other costs associated with owning and operating a vehicle (Hampshire & Gaites, 2011; Shaheen & Cohen, 2013). These costs are already significant for Delaware, which ranks in the top third of most expensive states to own a vehicle (Kirkham, 2016).

The fusion of AVs with ridesharing services is an explicitly stated goal of Uber and Lyft. Not only do these companies anticipate replacing their presently commissioned drivers with AVs, they are seeking to upend the traditional model of vehicle ownership and replace it with on-demand, autonomous transportation (Gilbert, 2015). Uber CEO Travis Kalanick said that his company wants to "make car ownership a thing of the past" (Rulsi, 2014). In the future, those who own an AV can ride to work, then release it to Uber or Lyft during working hours. They will receive compensation as the vehicle shuttles customers around until the owner calls back the vehicle to return home. The impact on vehicle ownership and parking (see next section) could be significant, with one study predicting that each shared AV can effectively replace 12 privately owned vehicles (Fagnant & Kockelman, 2014).

The common thread that ties together the downward pressures on vehicle ownership is population density. Urban migration, changing cultural values, and ridesharing all require population density. Delaware, therefore, may experience more rapidly declining vehicle ownership in New Castle County where urban density amplifies these factors, while the sprawling development patterns of Kent and Sussex Counties could limit the impact of AVs on private-vehicle ownership. Nevertheless, aggregated across Delaware, it is reasonable to expect a "peak car" scenario after Level 5 AVs diffuse.

Parking Demand

Deployment of Level 5 AVs will likely reduce the need for parking spaces in urban areas for two main reasons. First, because AVs have the ability to function without a human present in the vehicle, AV owners can be dropped off at their destinations and send their vehicles to free parking spaces outside of the city (Anderson et al., 2014). Second and perhaps more significantly, shared-use AVs that engage in Uber-like services may never need to park. Instead of an owner getting dropped off and sending the vehicle outside the city to park, the owner may choose to lend it to Uber and receive compensation for each fare. This scenario has been modeled and the results predict a 50- to 90-percent reduction in urban space dedicated to parking (Fagnant & Kockelman, 2014; Skinner & Bidwell, 2016). For Delaware, the impacts on parking may not be noticeable in rural areas, but in denser urban areas and locations where parking is constantly at a premium, significant space can be freed up for alternative uses.

Vehicle Miles Traveled

There is a consensus among researchers that AVs will increase vehicle miles traveled (VMT) due to a rebound effect, whereby riders choose to travel more because of reduced travel costs (Anderson et al., 2014; Fagnant & Kockelman, 2015; Litman, 2015). AVs have the potential to reduce the time-related costs of transportation due to the enabled ability to work, sleep, or play while riding. In addition, with reduced congestion (see next section), the cost of transportation declines further. AVs also offer individuals who were previously unable to drive—elderly, children, disabled—greater mobility, with one industry estimate predicting that AVs will increase the number of vehicle operators by 32 million nationwide (Winterhoff, Mishoulam, Shirokinskiy, Chivukula, & Freitas, 2015). The newfound ability of populations who were previously unable to drive could therefore result in increased VMT. There is also the distinct possibility that owners could send their AVs on nonessential trips and errands. For example, a family flying to Vermont for a ski trip could conceivably load their AV with all their gear and program the vehicle to drive itself to their final destination. Analysts therefore estimate that AV deployment could increase nationwide VMT by 9 percent or more, with similar expectations for Delaware (Fagnant & Kockelman, 2015).

Roadway Congestion and Capacity

Evidence suggests that AVs, especially those equipped with V2V technology, could reduce congestion by decreasing traffic accidents and increasing vehicle capacity on highways by smoothing traffic patterns. For instance, it is estimated that 25 percent of congestion is attributable to traffic incidents, around half of which are crashes (Cambridge Systematics, 2004). With the full deployment of AVs, crashes related to certain factors such as operating under the influence are expected to decline and therefore reduce congestion by significant margins. V2V technology, in the form of Cooperative Adaptive Cruise Control (CACC), could reduce congestion even further. CACC technology is similar to standard ACC but with the added function in which vehicles can communicate with each other and adjust their speeds in unison. It is predicted that with widespread deployment of CACC, time gaps between platooning vehicles can be shrunk safely, which would increase traffic density. In addition, highway traffic flows, lane merges, and intersections will be coordinated and smoothed, with more laminar queues and less stop-and-go (Lee & Park, 2012; Tachet et al., 2016). One analysis suggests that when all vehicles become equipped with CACC technology, it is possible to effectively double lane capacity (Shladover, Su, & Lu, 2012). Even at moderate levels of V2V technology deployment, lane capacity is expected to increase (Tientrakool, Ho, & Maxemchuk, 2011).

As with the other impacts of AVs, however, there are countervailing user preferences that could force a trend in direction of increased congestion (Barnard, 2016). For instance, if a perception of enhanced safety exists, operators may program their vehicles to take greater risks, which could possibly lead to more traffic accidents. There also are fears about induced traffic and increased VMT, which will neutralize some of the congestion benefits highlighted above (Fagnant & Kockelman, 2015; Litman, 2015). Increased congestion, particularly in denser urban areas, might also occur if owners get dropped off at their destination and then order their vehicle to circulate until they are ready to be picked up. Owners could also send their AVs on delivery or pick-up errands without the inconvenience of having to actually sit in the vehicle.

Even physiological factors become relevant, as one recent study finds that vehicle passengers tend to be more sensitive to acceleration than drivers. So when occupants use travel time to work or rest, it is plausible that, for comfort's sake, users will program their vehicles for lower acceleration/deceleration characteristics, leading to reductions in total urban roadway capacity (Le Vine, Zolfaghari, & Polak, 2015).

After accounting for both sets of congestion and capacity dynamics, it is difficult to anticipate if the induced risk-taking and travel demand will overwhelm the safety and traffic smoothing benefits of AVs, and what impact that would have on congestion and Delaware's roadway capacity. Some overall benefits might be realized on high speed thoroughfares such as highways, while denser urban areas could become more clogged and congested with empty AVs.

(Sub)Urban Development Patterns

As with many of the potential impacts of AVs, the consequences for (sub)urban development and density is influenced by countervailing forces and analysts disagree on the ultimate outcome. On the one hand, as noted in the previous section, AVs will likely decrease parking requirements in cities, which will free up land for high-density residential or mixed-use development. One study anticipates a 15 percent to 20 percent increase in urban land that will be made available through this process (Skinner & Bidwell, 2016). As a result of this land-use change, a number of analysts argue that urban densification is a likely outcome of AV deployment (Skinner & Bidwell, 2016; The Economist, 2015). On the other hand, there is a real possibility that AVs could catalyze another round of sprawl beyond the fringes of today's suburban communities. This is due to the fact that AVs reduce the opportunity cost of transportation because the operator is now free to engage in other activities such as work, entertainment, or even sleep. Longer commutes become more tolerable. In addition, as noted above, congestion will likely decrease. In this way, a vehicle will be able to cover a greater distance for any give length of time. For these reasons, many analysts anticipate that AVs will increase residential demand beyond the current fringes and generate more suburban sprawl (Fox, 2016; Gill, Kirk, Godsmark, & Flemming, 2015; Glancy, 2015; Litman, 2015; McDonald, 2016).

The end result may likely be a mix of the two processes: densification in urban centers coupled with sprawl beyond the urban fringes. With the natural increase in overall population and the rural-to-urban migration mentioned earlier, people will need to find somewhere to live in urban environments. AVs could offer residents a choice to live in urban centers and not have to own a vehicle and, by the same token, they could make it desirable to live outside those cores. For Delaware, which is experiencing sprawling development patterns as well as densification of urban areas like Newark and Wilmington, these dual trends could continue with AVs.

Infrastructure Design and Upgrades

AVs could generate changes into the way that engineers design and operate transportation infrastructure. To start, it is possible that AV operation will be so precise, traffic lanes could become narrower (Blumenauer, 2016). Richard Biter, the assistant secretary of Florida's DOT suggested that 12-foot lanes could be reduced, and it may be possible to "get by with 9 ½- or 10-foot lanes. We could turn that four-lane express highway into a six-lane express highway with literally the same right-of-way footprint" (McFarland, 2105). Traffic lights could also become redundant by designing a "slot-based intersection" where rights-of-way are optimized by a connected vehicle platooning model that coordinates groups of vehicles to pass through intersections at variable rates while still enhancing overall efficiency (Tachet et al., 2016). Pedestrians and cyclists introduce a degree of uncertainty and complexity into the slot-based intersection strategy, so it also may be necessary to design grade-separated intersections that place vehicles on one level and pedestrians and cyclists on another, thus optimizing AV traffic flow while preserving non-motorized access to city spaces (Alpert, 2012).

In terms of Delaware needing to install RSE statewide to enable V2I functionality, it is still uncertain what will be required. RSE could relay information between vehicles and the Transportation Management Center where it would be analyzed to monitor and optimize traffic flows. But RSE will need to compete with other forms of communication that AVs utilize. Low-latency DSRC channels between vehicles and RSE operate within the 5.9 GHz spectrum regulated by the Federal Communications Commission, but it is not certain that such short-range networks and the associated hardware will be necessary. Some new vehicles already come equipped with 4G LTE capacity that could replace aspects of DSRC, effectively transmitting and receiving information over the existing mobile network rather than through dedicated on-board and roadside infrastructure (Glancy, 2015). Looking ahead, the 5G systems currently under research development will likely compete with the low-latency DSRC option for V2I communication (Bradbury, 2016). AV manufactures also use their own closed private wireless networks to send and receive vehicle information to monitor vehicle diagnostics, update vehicle software, and perform other real-time functions. While the networks and information are proprietary, they too could be used as channels to replace DSRC and enable V2I functionality.

Jobs and the Economy

The consequences of AVs for the country's and Delaware's labor markets will be profound (Solon, 2016). There are nearly 10,000 Delawareans employed as heavy and light truck drivers, bus drivers, taxi drivers, and chauffeurs, and many of these workers could be made redundant as vehicle automation reduces demand for traditional behind-the-wheel employment (Bureau of Labor Statistics, 2015). At the same time, there is some evidence that over long-enough timeframes, labor-displacing technologies stimulate economic growth in unintended and unanticipated ways, such that jobs lost in certain sectors are partially compensated for with new employment opportunities in others (Pianta & Vivarelli, 2003). Uncertainty surrounds the extent to which AVs will stimulate new markets, grow companies, and increase overall labor productivity. What is clear is that there will be initial job losses, particularly the behind-the-wheel type, as AVs become commercially available. What is less clear is whether or not those displaced workers are able to translate their skills into employment elsewhere.

Ridesharing services are seeking to upend the traditional model of vehicle ownership and replace it with on-demand, autonomous transportation.

State and Local Fiscal Impacts

Approximately one quarter of the Delaware Transportation Trust Fund revenue comes from motor vehicle fuel tax (Delaware Department of Transportation, 2013; Transportation Trust Fund Task Force, 2011). A number of factors will impact the ability of the state to continue to produce this amount of revenue through this vital source. First, in 2012 the federal DOT and the EPA finalized a fuel efficiency standard of 54.5 miles per gallon for cars and light-duty trucks by 2025, which is predicted to reduce nationwide oil consumption by two million barrels per day in 2025 (National Highway Traffic Safety Administration, 2012). Vehicles are also becoming electrified, running on grid-charged batteries instead of liquid fuels. The United States is already the largest market for electric vehicles, and by 2040 they are predicted to comprise 25 percent of all vehicles on the road, further displacing 13 million barrels of oil per day globally (Bloomberg New Energy Finance, 2016).

AVs could put further downward pressure on fuel consumption and consequently gas tax revenue for Delaware. For instance, AVs will reduce accidents and related congestion. Vehicles can platoon and smooth traffic flows through heavy volume. They can also utilize GPS and traffic-sensing technology to navigate along optimally efficient routes (Litman, 2015). AVs are also predicted to be lighter (and hence more fuel efficient) than a standard vehicle due to the reduced collision risk they will provide to passengers. The ultimate impact that AVs will have on fuel consumption and gas tax revenue is uncertain, however, due to countervailing factors such as a possible increase in VMT (see section "Vehicle Miles Traveled" above). Nonetheless, it is important to consider that AVs could depress critical sources of transportation-related revenue for Delaware at a time when those sources are predicted to decline due to vehicle electrification and federally mandated improvements to fuel economy.

For Delaware's local governments, AVs could also have a significant impact on revenue generation. For example, from FY13 to FY15, Wilmington generated $5 million in net revenue from red light traffic cameras alone (City of Wilmington, 2014, 2015). In Dover and Newark, net revenue from red light cameras was $3.5 million and $2.4 million between 2010 and 2015 (Cohan, 2016). Because AVs will be programmed to avoid these types of traffic violations, this source of revenue will almost certainly decrease as the technology diffuses. Citations for other common driving-related offenses—speeding, failure to stop, cell phone usage, driving under the influence—will also decline. Additionally, municipal parking revenue generated through meters and fines will decline if the demand for parking decreases in urbanized areas (see section "Parking Demand" above) (Desouza et al., 2015).

Modal Shifts

Public transportation advocates are concerned that AV deployment will be used to rationalize policy choices to defund (or fail to invest in) more communal transit options. The International Transport Forum (2015, p. 6) argues that in "small- and medium-sized cities it is conceivable that a shared fleet of self-driving vehicles could completely obviate the need for traditional public transporter [because]….self-driving car fleets will compete with public transportation services, as currently organised." There is some evidence that this is already occurring. In Pinellas County, Florida, the impending mobility afforded by AV was used as an excuse by opponents to lobby against and eventually defeat a plan to build light rail in the area (Morris, 2014). Light rail has also been placed on the backburner in Columbus, Ohio, after the city won a major $40 million federal Smart City Challenge grant to enhance the municipality's intelligent transportation system (Knox, 2016). However, some analysts predict that AVs could help solve the first- and last-mile problem of public transit, effectively making it more

> ***Affluent drivers who can afford AVs would receive the full benefit of enhanced speed and safety in dedicated lanes, while the less affluent are resigned to slower, more dangerous conditions.***

convenient to take transit and therefore boosting demand (Freemark, 2015). Municipalities are exploring hybrid models of public-AV transit services, like Beverly Hills, California, where the city council recently accepted a funding request to study the possibility of having publicly owned AVs close first- and last-mile gaps for residents (Mirisch, 2015; Vincent, 2016). This model would preserve the long-standing idea that public transportation services are funded and delivered by local and regional governing bodies.

If the cost of shared-use AV services becomes affordable for all Delaware residents, short-distance DART routes could face competition for riders. State-sponsored paratransit services could also experience decreased demand because AVs could easily be modified to comply with Americans with Disabilities Act requirements to enhance mobility for physically and mentally impaired users.

Fuel Economy and Carbon Emissions

It is widely expected that AVs will have positive impacts on average vehicle fuel efficiency. There are several reasons for optimism. First, as noted earlier, the reduction in crashes and congestion that AVs will likely offer will smooth traffic flows and decrease inefficient idling and stop-and-go traffic (Anderson et al., 2014; Tientrakool et al., 2011). Second, further fuel efficiency gains can be achieved through platooning in which a series of vehicles follow in the draft of a lead vehicle. The reduced wind resistance for all vehicles in the series can increase fuel efficiency by up to 10 percent (Brown, Gonder, & Repac, 2014). Third, analysts predict that AVs will be lighter—and hence more fuel efficient—than current vehicles because of the enhanced safety and crash-avoidance benefits they will offer users (Anderson et al., 2014; Mattow et al., 2014).

The impact of AVs on carbon gas emissions is less certain. Despite the high confidence that overall vehicle fuel efficiencies will increase, the possible increase in overall VMT (see section above) could offset the reduction in fuel consumed per mile and lead to an increase in annual per-vehicle carbon emissions (Wadud, MacKenzie, & Leiby, 2016). However, the potential fusion of AV technology with ridesharing services could reduce the number of vehicles on the road, thus catalyzing a net decrease in carbon emissions (Greenblatt & Shaheen, 2015). Several studies analyzed the potential for shared-use AVs to impact carbon emissions and they concluded that life-cycle reductions are possible in urban areas despite the expected increase in VMT (Fagnant & Kockelman, 2014; Greenblatt & Saxena, 2015). If overall decrease in emissions is realized, this would be encouraging news for Delaware, which has seen aggregate transportation-sector emissions decrease only slightly in the past twenty-five years (personal communication, February 7, 2016).

Transportation Equity

The anticipated safety and speed benefits of AVs will increase as more and more AVs appear on the road, displacing manually operated vehicles that add uncertainty and risk into the optimally efficient transportation network. Some commentators and analysts suggest that AV- and manually-operated conflicts can be avoided by creating dedicated infrastructure that is only accessible with automated technology (Kurczewski, 2014; Litman, 2015). For instance, it would be possible to set aside existing lanes—or build new lanes solely dedicated for AV use—a situation similar to the current system of high-occupancy/carpool lanes.

Dedicated AV lanes could generate significant transportation equity concerns. From a socio-economic standpoint, AVs are predicted to attract a price premium of $10,000 and will be financially unfeasible for low-income individuals (Mosquet et al., 2015). Consequently, affluent drivers who can afford to purchase AVs would receive the full benefit of enhanced speed and safety in dedicated lanes, while the less affluent are resigned to slower, more dangerous conditions. The result would be speed and safety disparities among socio-economic levels and raise serious questions of transportation equity. Even without dedicated AV lanes, early adopters who can afford the technology would still experience enhanced safety and speed benefits.

There are additional scenarios whereby low-income communities do not receive the full benefits of AVs. For instance, AV access could be limited for low-income individuals who do not have smart phones or methods of electronic payment that are necessary to use ridesharing services. The infrastructure upgrades, RSE installations, and system maintenance to enable AVs could be concentrated in wealthier communities, effectively creating an unequal geography of AV functionality.

Other equity concerns are possible when looking at transportation funding. Fuel efficient AVs will pay a smaller share of gas tax revenue even though they are likely to travel greater miles compared to conventional vehicles. If the current pay-at-the-pump transportation funding system continues, non-AV vehicles will effectively be subsidizing AV users. Again, because AV ownership will be partially separated along a socio-economic spectrum, the current transportation funding model would become a regressive policy structure (Blumenauer, 2016).

Finally, depending on policy and regulatory frameworks that develop around AVs, urban mobility could decline for low-income urban residents. Because AVs, particularly shared-use AVs, will compete with public transportation alternatives, the potential for bus route closures would have negative mobility impacts on low-income commuters if they are unable to afford to ride in shared-use AVs (Arieff, 2013; Litman, 2015). It was noted above that public transportation proposals in Pinellas County, Florida, and Columbus, Ohio, were defeated because of the prospect of stiff competition from AVs (Knox, 2016; Morris, 2014). Again, transportation equity concerns are raised due to negative AV outcomes falling on socio-economic groups that already experience limited and unequal access to mobility options.

For certain populations, AVs will enhance transportation access. The blind, elderly, minors, and those unable to obtain a conventional driver's license will all experienced greater access to mobility options.

06 Delaware's Readiness

The pace of AV innovation within the private sector is remarkable, and the public sector needs to accelerate its efforts in order to successfully integrate AVs on the roads in ways that amplify the positive benefits of the technology while minimizing the costly outcomes. Two areas are particularly noteworthy for Delaware's public institutions, the current capacity of the state's transportation system technology and the state's ability and capacity to govern AVs successfully.

Technological Readiness

Delaware is well positioned, technologically speaking, to expedite the integration of AVs. For several decades, DelDOT has been building communications capabilities such as high-speed fiber optic broadband and Wavetronix hardware into the state transportation infrastructure and is already capable of managing traffic in real-time. The Integrated Transportation Management System (ITMS), which comprises these communication technologies and the human resources that manage them, is an integral part of the department, from planning and design to operations, maintenance, and services. ITMS is built into planning, capital project development, and design so that every program and project, when appropriate, incorporates the necessary technology and telecommunications. Currently there are 300 miles of fiber optic cable in the state, with another 300 miles planned. The system is designed to be resilient to damage because it employs a redundant signal routing process, meaning that if a fiber cable gets cut in one area the network can still transmit information from point to point. The result is a state-owned telecommunications system—a backbone for AV functionality and success—that is highly advanced with regard to existing and planned coverage, bandwidth and performance. For instance, DelDOT's computerized traffic signal system is a useful tool for daily transportation management, and it integrates with other data systems such as traffic monitoring, incident management, and transit operations. Furthermore, with its ITMS, DelDOT already collects several types of data (signal timings, delays, travel times, volumes) that connected and autonomous vehicles will need for full functionality. Data collection is processed through an open-architecture, state-owned database that can be readily amended and adapted to incorporate emerging data.

In anticipation of connected and autonomous vehicle deployment, DelDOT is taking additional proactive steps to facilitate integration of these advanced transportation technologies by extending the reach and capacity of the state's ITMS. Three projects that are scheduled for 2017 are particularly noteworthy. First, DelDOT will enhance ITMS in Dover by installing a state-owned 4.9 GHz wireless system that will eliminate the need to lease circuits from mobile carriers. A second project designed to test signal timing will see an upgrade to signal controllers at 11 intersections along U.S. 13 in Smyrna, installation of networked roadside equipment on the same corridor, and installation of on-board units in select DelDOT vehicles. The third project involves DelDOT partnering with the Federal Highway Administration to develop an artificial intelligence system for northern Delaware that will analyze real-time data gathered through remote traffic detectors and semi-automate decision-making and operations in the area.

Administrative Readiness

From a technological feasibility standpoint, the preceding section demonstrates that Delaware is proactively preparing the state for testing, operation, and deployment of connected and autonomous vehicles. This advancement in transportation infrastructure and technology must parallel a similar effort to augment the state's administrative and policy structures so that timely testing, deployment, and the associated AV impacts are appropriately managed. DelDOT is already engaged in several AV-related regional and national partnerships. For instance, the state participates in the I-95 Corridor Coalition's Connected and Autonomous Vehicles Leadership Team and the American Association of State Highway and Transportation Officials's AV Working Group. DelDOT should continue to leverage these partnerships as they will prove fruitful for information sharing, policy development, and the creation of standardized frameworks as well as standardized infrastructure designs across state lines (e.g., pavement markings, traffic signs, signals, lights).

NHTSA's (2016, sec. II) guidance document offers a number of recommendations to states for creating decision-making bodies that will oversee and advise on AV issues. They suggest that a lead agency be appointed to oversee AV administration, especially early testing. The lead agency would identify possible gaps or legal issues in current state regulations, such as the definition of "driver" within state statutes, and propose necessary changes to permit AV testing and operation. The agency would also examine state laws for barriers in the areas of licensing and registration, driver education and training, insurance and liability, traffic law enforcement, and vehicle inspection. For testing AVs on public roads, procedures and protocols would be developed for accepting and reviewing applications from manufacturers. This may include designation of prohibited areas (near schools, construction zones, etc.) and the submission of applications for testing to a review by state law enforcement representatives.

Two important pieces are in place to advance and accelerate AV governance in Delaware. First, DelDOT owns 90 percent of the roads and most of the traffic signals, and it operates the transit system. Second, the state's small size generates a level of familiarity among stakeholders, legislators, and administrators, meaning that action can occur quickly. The combination of these two factors could create a fertile environment for public and private investment in a flexible transportation system that is well positioned to accommodate AV testing, operation, and deployment.

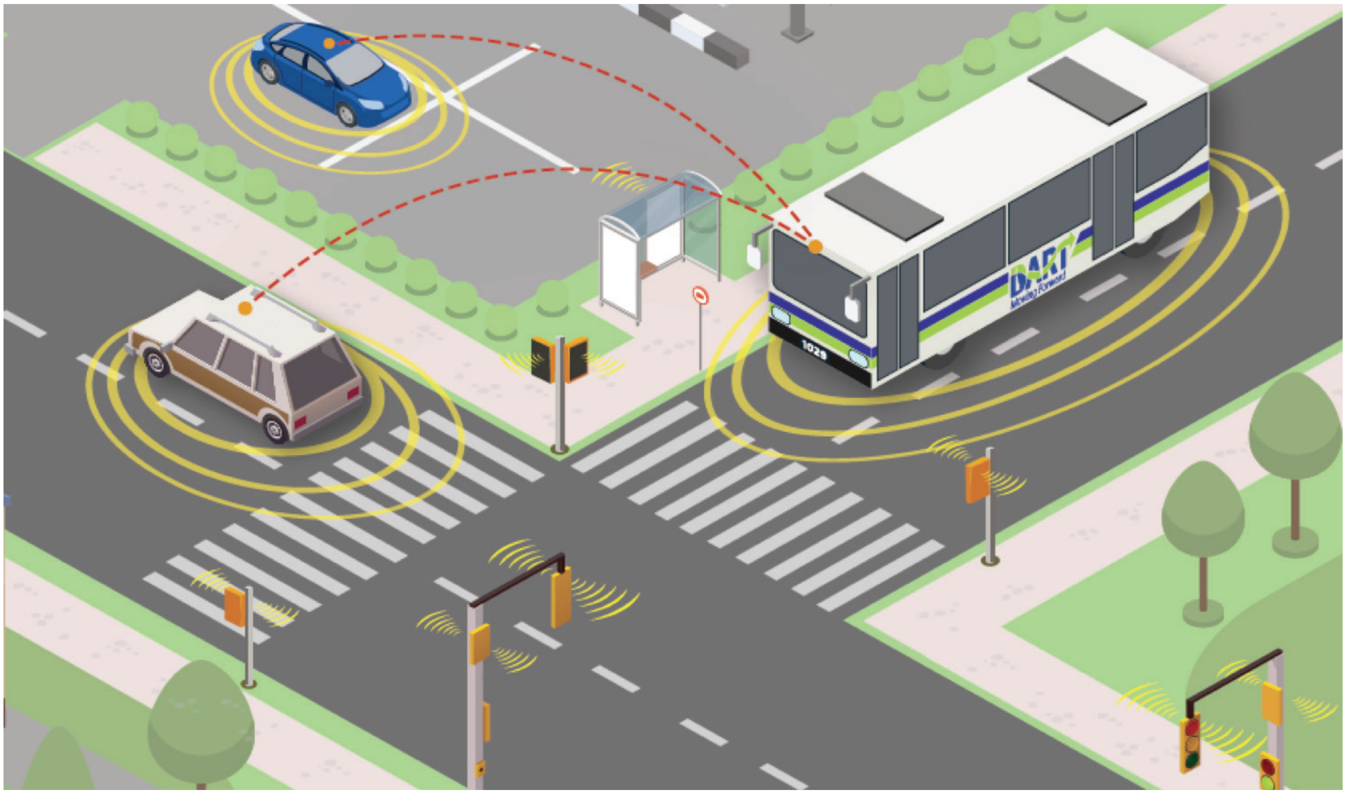
Delaware is well positioned, technologically speaking, to expedite the integration of AVs.

07 Conclusion

AV technology is rapidly advancing, and when these vehicles become commercially available, they will disrupt traditional forms of transportation behavior and associated socio-economic outcomes—both positively and negatively. The impacts will be long lasting as urban development and policy structures become embedded on Delaware's landscape. If, because of the pace of AV technology advancement, the new form of transportation is accepted passively without an effort to manage and direct its consequences, then the likelihood of Delaware experiencing greater negative impacts increases significantly.

The negative and costly consequences that Delaware could experience if AVs are not managed properly include cybersecurity and hacking threats, erosion of citizen privacy, increased VMT, continued sprawling development beyond the already-extensive urban fringe, costly upgrades to state's transportation infrastructure, job losses for Delaware drivers and vehicle operators, loss of revenue for state and local governments, declining public transportation ridership, increased carbon emissions, and inequitable access to safe and efficient mobility. On the other hand, there are substantial benefits that could be accentuated through effective governance and management of AVs including a reduction in the number of traffic accidents, injuries, and fatalities on Delaware roads, less roadway congestion, greater roadway capacity, and a decrease in land used specifically for parking.

It is therefore imperative that the state's transportation planners and decision-makers engage in AV development if they are to accentuate the beneficial outcomes while minimizing the costly ones. Fortunately, DelDOT has already anticipated the needed upgrades to its ITMS and is taking a proactive approach to preparing the state technologically. As a parallel effort, Delaware should develop an administrative and governance framework to enable AV integration into the state's transportation network, thus ensuring that AVs serve the needs of Delawareans, the state economy, and visitors alike. The state should begin that process without delay since the AV-dominated future will arrive shortly.



Vehicle to Vehicle (V2V) Communication
Source: DelDOT

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APPENDIX E: MEETING AGENDAS & MINUTES

STATE OF DELAWARE
DEPARTMENT OF TRANSPORTATION
800 BAY ROAD
P.O. BOX 778
DOVER, DELAWARE 19903

JENNIFER COHAN
SECRETARY

Advisory Council on Connected and Autonomous Vehicles Meeting
(Executive Order 14)

Thursday, November 16, 2017
2:00pm – 3:30pm
DelDOT Administration Building, 800 Bay Road, Dover, DE
Farmington/Felton Conference Room

AGENDA

- Welcome and Introductions
- Review the Goals of Executive Order 14 and Participant Expectations
- Current Assessment of the Transportation Network and Connected and Autonomous Vehicles
- National/Regional Perspective
- Future Meetings and Topics for Discussion
- Public Comment

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JENNIFER COHAN
SECRETARY

Advisory Council on Connected and Autonomous Vehicles Meeting
(Executive Order 14)

Thursday, November 16, 2017
2:00pm – 3:30pm
DelDOT Administration Building, 800 Bay Road, Dover, DE
Farmington/Felton Conference Room

MINUTES

1. Welcome and Introductions

a. The meeting commenced at 2:02 PM. Secretary Cohan directed Advisory Council members and attendees to introduce themselves.

Present Advisory Council Members

Jennifer Cohan	Delaware Department of Transportation (DelDOT)
Patty Cannon	Division of Small Business, Development and Tourism
Glenn Dixon	Delaware Safety and Homeland Security (DSP)
Elayne Starkey	DTI
Scott Vien	Division of Motor Vehicles (DMV)
Ed Osienski	House of Representatives
Jen Parrish	State Senate (Proxy for Senator Hansen)
Brian Pettyjohn	State Senate
Terri Megee	Delaware Automobile and Truck Dealers' Association
Cathy Rossi	AAA Mid-Atlantic
Renee Gibson	Alliance of Automobile Manufacturers
Lee Derrickson	Delaware Motor Transport Association
Phillip Barnes	University of Delaware (UD) Institute of Public Administration
Jerome Lewis	UD Institute of Public Administration
John Sisson	WILMAPCO
Reed Macmillan	Dover/Kent Metropolitan Planning Organization
William Pfaff	Sussex County
Shari Shapiro	Uber

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Also Present

Brian DePan	Jacobs
Megan Rosica	Jacobs
Ian Grossman	American Assoc. of Motor Vehicle Administrators (AAMVA)
Josh Froler	Global Automakers
Verity Watson	Ruggerio Willson
Lisa Goodman	Hamilton Goodman Partners, LLC
John Sisson	Delaware Transit Corporation
Debbie Pfeil	KCI Technologies
Peter Bourne	KCI Technologies
Matt Buckley	WRA
Peter Korolyk	Delaware OMB-Government Support Services
Gene Donaldson	DelDOT
Mark Luszcz	DelDOT
Anne Brown	DelDOT
Rob McCleary	DelDOT
Nicole Majeski	DelDOT
Annie Cordo	DelDOT
Mir Wahed	JMT
Barry Benton	GPI
Jim Lardear	AAA Mid-Atlantic

Absent Advisory Council Members

Danielle Brennan	Attorney General's Office
Ruth Briggs King	House of Representatives
Leslie Ledogar	Insurance Commissioner's Office

2. Review the Goals of Executive Order 14 and Participation Expectations

a. Secretary Cohan reviewed Governor Carney's Executive Order 14 which established this council; referencing Item 5 of the order, the Secretary announced there will be at least four subcommittees under this council to focus on the following subject areas:

   i. *Promoting economic development*
   ii. *Technology, security, and privacy*
   iii. *Transportation network infrastructure*
   iv. *Impacts on public and highway safety*

3. **Current Assessment of the Transportation Network and Connected and Autonomous Vehicles**

   a. Secretary Cohan indicated DelDOT's unique ability to implement such innovative technologies as CAV by noting DelDOT's ownership of 90% of roads and most of the traffic signals in the state. The agency operates the transit system and tolls making it truly multimodal. Innovations in Intelligent Transportation Systems (ITS) are well underway.

   b. Gene Donaldson reported on DelDOT's current transportation network and Connected and Automated Vehicle (CAV) installments.

      i. Integrated Transportation Management System (ITMS)
         1. Intelligent Transportation Technology
         2. Incident and Event Management
         3. 24-Hour Transportation Management Center (TMC)
         4. Transportation Homeland Security
      ii. Three Critical Functions of ITMS: monitoring, control, information
         1. Almost all signals in DE are integrated into the central software system, which increases the agency's ability to implement CAV technologies in accordance with traffic signals.
      iii. Integration of operations and planning
      iv. DelDOT ITMS Strategic Plan
         1. In the process of being updated; will be available shortly.
      v. Next phase of ITMS
         1. Smart Delaware; DelDOT has built a state-wide telecommunications system to promote connections.
         2. Machine learning is at the core of advanced technology: Artificial Intelligence and Automated Vehicles.
      vi. Ongoing Projects
         1. Connected Vehicle Enabled Weather Responsive Traffic Management (CV-WRTM)
         2. US 13 Technology Proving Ground
         3. Signal Phasing and Timing (SPaT) Challenge
         4. Machine Learning/Artificial Intelligence—Automating TMC Operations
         5. Dilemma Zone

4. **National/Regional Perspective**

a. Scott Vien reviewed the DMV's role in the development of CAV in Delaware.
    i. Currently the DMV is reviewing regulations and laws in order to make changes where necessary in accordance with developing technologies.
    ii. Throughout the process it will be important to focus on drivers amidst frequent vehicle-centric discussions.
    iii. There will be a major transition period before a commonplace is reached regarding CAV operation, interaction, education and training; safety benefits will become prevalent when this commonplace is reached.
    iv. The DMV is staying engaged at a national level in preparation for when testing can occur; the goal is to have a set of regulatory processes in place in advance of any testing.

b. S. Vien introduced Ian Grossman who reported on the perspective of the American Association of Motor Vehicle Administrators (AAMVA).

    i. AAMVA is finalizing a report that will include considerations and recommendations regarding CAV from driver, vehicle, and law enforcement perspectives; the report should be completed by February/March 2018.
        1. Administrative Considerations: recommends establishing a group focused on the development of CAV technologies (Advisory Council will serve as this group for Delaware).
        2. Vehicle Considerations: addresses the application and permit processes; discusses license plates for automated vehicles (i.e. identified separately vs. standard for CAV and traditional vehicles).
        3. Driver Licensing Considerations: discusses the testing process and how this will change with future developments; addresses endorsements or restrictions for drivers; considers how the skill set will change for a driver in an automated vehicle vs. a traditional vehicle.
            a. Secretary Cohan reiterated the benefit of increased mobility in an automated vehicle for users who are unable to drive traditional vehicles.
        4. Enforcement Considerations: considers response and determination of liability if an incident occurs.
    ii. National Highway Traffic Safety Administration (NHTSA's) Automated Driving Systems voluntary guidance document
        1. AAMVA recommends NHTSA create a central reference point for research being developed under voluntary guidance.

2. The guidance document is voluntary; however AAMVA strongly recommends manufacturers/industry users follow its policies when developing technologies.
3. Vehicle vs. Driver domain: federal vs. state authority

iii. Federal legislation
1. House Bill: SELF DRIVE Act
2. Senate Bill: AV START Act

iv. Common themes in CAV development throughout various states
1. Granting permission vs. limited restrictions (prescriptive vs. silent)
2. Insurance requirements
3. Program oversight is varying (DOT Level, DMV)
4. Regulations varied (statute, agency, executive order)
5. Incident reporting
6. Human driver presence

v. I. Grossman concluded his presentation by emphasizing the need for a balance between promoting consistency and encouraging innovation as progress is made.

5. Advisory Council Discussion

a. A question about Delaware's progress in autonomous vehicles was asked: How far along is Delaware?

i. Secretary Cohan noted that Delaware is at the very beginning stages of implementing CAVs. Different organizations throughout the country are responding differently regarding a timeline for when these technological developments will come in to play. There will be a major transition period before connected and automated vehicles become a common part of the vehicle fleet in Delaware. The purpose of having a council such as this is to be as prepared as possible for development and implementation.

b. P. Barnes asked about data sharing and availability. Will the State know how a vehicle is operating or where it is traveling?

i. I. Grossman responded that data requirements will vary: some regulations will require reporting data on a more regular basis.

ii. AAMVA and NHTSA is recommending following Society of Automotive Engineers (SAE) classification terms and definitions for shared vocabulary moving forward- there is a need to standardize Title 21using SAE vocabulary.

iii. Secretary Cohan mentioned from a public policy standpoint, data sharing is a huge concern, as it becomes a privacy issue. These concerns will be further investigated as a part of the *Technology, Security, and Privacy* subcommittee.
iv. Data will be a critical part of CAV technology development as a learning platform.

c. P. Cannon mentioned that the permitting process for tractor trailers blends federal and state authorization; attention was then directed toward the trucking industry and the use of automation/platooning.

i. Platooning was compared to pilot operation of an airplane by I. Grossman: plane operation is automated for most of the flight, with exception during takeoff and landing.
ii. The first automated delivery was completed in Colorado (route had been mapped many times; once the truck reached the interstate the system went into automation).

d. R. Gibson asked I. Grossman to further explain his statement about balancing standardization and innovation.

i. I. Grossman indicated that uniformity is important but developing standards too soon may take certain options off the table that have the potential to be helpful.
ii. Definitions may change, overall vehicle design will not.
iii. Representative Ed Osienski: there will be difficulty during the major transition period, because there is no common standard yet, especially in regard to vehicle design; dashboard messages, make, model, symbols will all be different, perhaps some federal standards should be in place when vehicles are manufactured.

e. Representative Ed Osienski: When does the focus move to vehicle-to-vehicle communication from infrastructure concerns?

i. Secretary Cohan noted that there will be more progress more quickly on vehicle-to-vehicle developments-infrastructure projects simply take longer.
ii. S. Shapiro responded by noting the importance of understanding the difference between connected and autonomous vehicles.
iii. Secretary Cohan made the point that with these vehicle/infrastructure changes, land use will also change: vehicle density is expected to change with the

development of autonomous vehicles so coordinating with land use agencies will be imperative throughout the process of developing CAV in Delaware.

f. P. Cannon asked G. Donaldson if the technology regarding Dilemma Zone detection and warning will link to in-vehicle technologies such as OnStar.

   i. G. Donaldson responded by indicating that if a vehicle/device has connection capability, the TMC will be able to communicate.
   ii. Technology development is based on the willingness of users to share data and personal information: the more information available, the more helpful the system can become and the more accurately it will respond to incidents.
   iii. Senator Cohan related this discussion to DelDOT's partnership with Waze.

6. Future Meetings and Topics for Discussion

a. Secretary Cohan indicated the need to form subcommittees based on the subject areas specified in Executive Order 14. The following subcommittee chairs/members were established:

   i. *Subcommittee on Promoting Economic Development*:
      1. Chair: Patty Cannon (Division of Small Business, Development and Tourism)
      2. Members: Sussex County (William Pfaff), Representative Ed Osienski, DMV (Scott Vien)
   ii. *Subcommittee on Technology, Security, and Privacy*:
      1. Chair: Elayne Starkey (DTI)
      2. Members: DOJ (Annie Cordo), Uber (Shari Shapiro), Insurance Commissioner's Office, Senator Brian Pettyjohn, Alliance of Automobile Manufacturers (Renee Gibson), UD IPA (Phillip Barnes), DMV (Scott Vien)
   iii. *Subcommittee on Transportation Network Infrastructure*:
      1. Chair: Secretary Jennifer Cohan
      2. Members: DelDOT (Gene Donaldson), DelDOT's traffic group, Representative Ed Osienski, Senator Brian Pettyjohn, Senator Stephanie Hansen, Representative Ruth Briggs King, Dover/Kent MPO (Reed Macmillan), DMV (Scott Vien)
   iv. *Subcommittee on Impacts on Public and Highway Safety*:
      1. Chair: Glenn Dixon (Delaware Safety and Homeland Security)

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2. Members: Senator Brian Pettyjohn, Delaware Office of Highway Safety, Delaware Motor Transport Association (Lee Derrickson), AAA Mid Atlantic (Cathy Rossi), DMV (Scott Vien)

b. Future Meetings:

i. Future discussions will include standardizing Title 21using SAE vocabulary to ensure uniformity moving forward

ii. Advisory Council will meet monthly
   1. Meetings will occur on the third Thursday of every month from 11:00AM-12:30PM.
   2. Subcommittee chairs will report back to the Advisory Council.
   3. It is expected that initial meetings will involve frequent expert presentations in order to better establish where agencies stand with CAV developments (entire council will learn what is going on to better establish what the next steps are).
   4. A. Cordo (DOJ) will follow up with administrative information regarding FOIA and meeting details.

7. Public Comment

a. There were no additional comments from the public.

8. Secretary Cohan called the meeting to adjourn at 3:21 PM.

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(Executive Order 14)

Thursday, December 21, 2017
11:00am – 12:30pm
DelDOT Administration Building, 800 Bay Road, Dover, DE
Farmington/Felton Conference Room

AGENDA

- Welcome and Introduction
- Approval of the Previous Meeting Minutes
    - November 16, 2017
- Updates on Subcommittees
    - Promoting Economic Development
    - Technology, Security and Privacy
    - Transportation Network Infrastructure
    - Impacts on Public and Highway Safety
- Presentation on DelDOT's Integrated Transportation Management System
- Presentation by the University of Delaware
- Public Comment

If you have any questions please contact Lesley Devine at (302) 760-2197.

DelDOT

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MINUTES

1. Welcome and Introductions

a. The meeting commenced at 11:02 AM. Secretary Cohan directed Advisory Council members and attendees to introduce themselves.

Present Voting Council Members

Jennifer Cohan	Delaware Department of Transportation (DelDOT)
Patty Cannon	Division of Small Business, Development and Tourism
Elayne Starkey	Delaware Department of Technology and Information (DTI)
Scott Vien	Division of Motor Vehicles (DMV)
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Reed Macmillan	Dover/Kent Metropolitan Planning Organization
William Pfaff	Sussex County
Shari Shapiro	Uber
Barzilai Axelrod	Attorney General's Office
Ruth Briggs King	House of Representatives
Leslie Ledogar	Insurance Commissioner's Office

Members Present by Proxy

Verity Watson	Alliance of Automobile Manufacturers (Proxy for Renee Gibson)
Jenn Parrish	State Senate (Proxy for Senator Hansen)

Patrick Wenk	Delaware Department of Safety and Homeland Security (DSP) (Proxy for Glenn Dixon)

Also Present

Philip Barnes	University of Delaware (UD) Institute of Public Administration
Barry Benton	GPI
Steven Chillas	Delaware OMB – Contracting (representing Peter Korolyk)
Shante Hastings	DelDOT
Lisa Goodman	Hamilton Goodman Partners, LLC – Uber
Deb Hamilton	Hamilton Goodman Partners, LLC
Scott Clapper	DMV
Li Wen Lin	DelDOT—Technology and Innovation
Nicole Majeski	DelDOT
Anne Brown	DelDOT
Rob McCleary	DelDOT
Gene Donaldson	DelDOT
Jen Duval	Jacobs
Erin Coombs	Jacobs
Megan Rosica	Jacobs
Debbie Pfeil	KCI Technologies
Peter Bourne	KCI Technologies
Brad Eaby	Deputy Attorney General-DelDOT
Matt Buckley	WRA
Jason Walsh	Price Auto Group
Dan Corey	AECOM
Ken Grant	AAA Mid-Atlantic
Lloyd Schmitz	State Council for Persons with Disabilities

Absent Voting Council Members

Terri Megee	Delaware Automobile and Truck Dealers' Association

2. **Approval of the Previous Meeting Minutes**
   a. J. Cohan made a motion to accept the minutes from the previous meeting held on November 16, 2017. Motion was seconded by S. Vien. Motion passed and minutes were approved.

3. **Updates on Subcommittees**
   a. Promoting Economic Development

i. First subcommittee meeting anticipated to be held in January.
ii. The committee anticipates a major challenge to be defining the type of autonomous devices to target and addressing more general autonomous devices, not just vehicles on the roadway, i.e. autonomous drones.
iii. More members to be added, including Rep. R. B. King and S. Chillas

b. Technology, Security and Privacy
   i. First subcommittee meeting was held December 21, 2017 9:30 AM.
   ii. Additional members were added to total thirteen voting members.
   iii. Discussion included: open meeting requirements by DOJ; meeting frequency, scope and topics for future meetings.
   iv. J. Cohan and the Council agreed that a commitment to coordinate communication between council members and subcommittees is important to ensure things stay on track and continue to develop.
c. Transportation Network Infrastructure
   i. First subcommittee meeting anticipated to be held in January.
   ii. More members to be added, including R. McCleary.
   iii. Various planning aspects were identified as an important discussion topic.
d. Impacts on Public and Highway Safety
   i. First subcommittee meeting to be held on January 8, 2018 1:00 PM.
   ii. More members to be added, including B. Axelrod.
e. Department of Insurance
   i. Main concern: consumer advocacy
   ii. Researching risks, holding separate meetings to analyze risks and how to insure them in order to have the best products available for Delaware consumers.

4. Presentation on DelDOT's Integrated Transportation Management System (ITMS)

a. G. Donaldson presented the Council with information regarding DelDOT's recently updated Integrated Transportation Management System (ITMS) Strategic Plan.
   i. Updates include discussion of CAV in Delaware.
   ii. DelDOT is collecting large amounts of data to facilitate in the design, planning, management, and operation of its ITMS.
   iii. A predictive and adaptive transportation management system is the ultimate goal, using Artificial Intelligence (machine learning).
   iv. Goals of Smart Delaware include: safety improvements, less congestion, less energy consumption, and enhanced mobility.
b. G. Donaldson gave an overview of the interactive map that can be found on DelDOT's website. The map displays real-time data that is monitored by the Transportation Management Center (TMC) to show users real-time data like traffic flow, travel times,

traffic cameras, snow accumulation and weather reports, projects on the roadway, and red light enforcement. http://www.deldot.gov/map/

   i. L. Ledogar asked if the interactive map is interfaced with Google Maps. G. Donaldson explained that DelDOT is currently engaging in further conversations with Google.

c. J. Cohan pointed out that the ITMS Strategic Plan and DelDOT's interactive map form the foundation for the next steps toward CAV development in Delaware.

5. Presentation by the University of Delaware

a. P. Barnes presented the Council with an update on the University's role in the development of CAV, specifically in research, planning and policy, and public education.

b. P. Barnes showed a public education video that summarizes Barnes's report on Autonomous Vehicles in Delaware completed in April 2017; P. Barnes indicated the importance of gaining public acceptance in regards to CAV development—goal is to mitigate uncertainty, fear, and misconception.

c. The status of CAV research at UD was presented including an update on the UD Smart City: a CAV model with intersections that display seamless acceleration and deceleration of connected and autonomous vehicles.

d. Future developments:

   i. Domenico Grasso (former provost) has identified the need for a focus on smart cities and is supporting research in this area.

   ii. UD Data Science Institute is being developed as big data research hub on Newark's campus.

   iii. President of the University, Dr. Dennis Assanis, has indicated a high expectation for UD as far as CAV, and supports the demonstration of an autonomous shuttle on campus (in the coming months) as well as the UD Smart City development and model

   iv. The Biden Institute will serve as a foundation for research into smart cities, public policy, and engineering for CAV.

e. S. Shapiro asked about the timeline for NSF research being developed by P. Barnes:

   i. P. Barnes answered that the proposal is due February 28, 2018 and the four year project will begin in the fall of 2018.

f. R. B. King asked if Barnes was looking at any available research prototypes and considering coordinating with other development projects going on in the U.S.:

   i. P. Barnes answered that he is coordinating with other states.

   ii. J. Cohan indicated that DelDOT is also paying close attention to the development of CAV in other states and that the focus should be more on Vehicle-to-Vehicle communication, since this aspect of CAV is moving forward fast (e.g. freight platooning).

iii. J. Lewis noted that as a part of the research process, a literature review is completed to keep updated on CAV development and progress in the US and foreign countries.

iv. S. Shapiro recommended posting other CAV task force scopes/topics from other states as a guideline for this council's scope development. N. Majeski indicated that information being gathered can be sent to her to be distributed to the rest of the council.

g. J. Cohan asked council members to put ideas and questions together in order to develop a scope for each subcommittee and the council as a whole.

i. Review of Title 21 and CAV in legislation needs to be included in future discussions.

ii. Next meeting will include a discussion about the scope of the Council's report and committee actions to be taken moving forward.

6. Public Comment

a. There were no additional comments from the public.

7. Senator B. Pettyjohn made the motion to close the meeting and was seconded by S. Shapiro. The motion passed and meeting adjourned at 12:11 PM.

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Thursday, January 18, 2018
11:00am – 12:30pm
DelDOT Administration Building, 800 Bay Road, Dover, DE
Farmington/Felton Conference Room

AGENDA

1. Welcome and Introduction
2. Approval of the Previous Meeting Minutes
   - December 21, 2017
3. Updates from Subcommittees
   - Promoting Economic Development
   - Technology, Security and Privacy
   - Transportation Network Infrastructure
   - Impacts on Public and Highway Safety
4. Presentation by UBER
5. Public Comment

If you have any questions please contact Lesley Devine at (302) 760-2197.

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Advisory Council on Connected and Autonomous Vehicles Meeting
(Executive Order 14)

Thursday, January 18, 2018
11:00am – 12:30pm
DelDOT Administration Building, 800 Bay Road, Dover, DE
Farmington/Felton Conference Room

MINUTES

1. Welcome and Introductions

a. The meeting commenced at 11:04 AM. N. Majeski introduced herself and indicated she would be representing Secretary Cohan at this meeting. She then directed Advisory Council members and attendees to introduce themselves.

Present Voting Council Members

Barzilai Axelrod	Attorney General's Office
Ruth Briggs King	House of Representatives
Patty Cannon	Division of Small Business, Development and Tourism (DOS)
Glenn Dixon	Delaware Department of Safety and Homeland Security (DSP)
Jerome Lewis	University of Delaware (UD) Institute of Public Administration
Stephanie Hansen	State Senate
Leslie Ledogar	Insurance Commissioner's Office
Reed Macmillan	Dover/Kent Metropolitan Planning Organization
Terry Megee	Delaware Automobile and Truck Dealers' Association
Ed Osienski	House of Representatives
William Pfaff	Sussex County
Cathy Rossi	AAA Mid-Atlantic
Shari Shapiro	Uber
Elayne Starkey	Delaware Department of Technology and Information (DTI)
Scott Vien	Division of Motor Vehicles (DMV)

Members Present by Proxy

Nicole Majeski	DelDOT (Proxy for Secretary Cohan)
Keri Rapa	State Senate (Proxy for Senator Pettyjohn)

Tigist Zegeye	WILMAPCO (Proxy for John Sisson)
Tarik Zerrad	Alliance of Automobile Manufacturers (Proxy for Renee Gibson)

Also Present

Patrick Wenk	Delaware Department of Safety and Homeland Security (DSP)
Philip Barnes	University of Delaware (UD) Institute of Public Administration
Chris Kelly	University of Delaware (UD) Institute of Public Administration
Barry Benton	GPI
Steven Chillas	Delaware OMB – Contracting
Barbara McCleary	Delaware OMB—Department of Human Resources
Wendy Carpenter	Davis, Bowen, & Friedel, Inc. (DBF)
Joe Zilcosky	DOS
Leah Gallagher	DOS
Lisna Utami	DOS
Lisa Goodman	Hamilton Goodman Partners, LLC – Uber
Scott Clapper	DMV
Li Wen Lin	DelDOT—Technology and Innovation
Shante Hastings	DelDOT
Mark Luszcz	DelDOT
Gene Donaldson	DelDOT
Pat Kennedy	FHWA
Jen Duval	Jacobs
Erin Coombs	Jacobs
Megan Rosica	Jacobs
Peter Bourne	KCI Technologies
Matt Buckley	WRA
Jason Walsh	Price Auto Group
Adam Weiser	AECOM
Ken Grant	AAA Mid-Atlantic

Absent Voting Council Members

Jennifer Cohan	Delaware Department of Transportation (DelDOT)
Lee Derrickson	Delaware Motor Transport Association (DMTA)

2. Approval of the Previous Meeting Minutes

a. E. Starkey made a motion to accept the minutes from the previous meeting held on December 21, 2017. Motion was seconded by S. Vien. Motion passed and minutes were approved.

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3. Updates on Subcommittees

a. N. Majeski notified attendees that a website has been created for the Advisory Council and that information regarding meetings and materials is available on the site. The website can be accessed using the following link: https://www.deldot.gov/Programs/autonomous-vehicles/

b. Promoting Economic Development
   i. First meeting was held January 18, 2018 at 9:30 AM.
   ii. Discussion was focused around the following topics:
      1. Policy and code changes that may be needed to promote economic development in regards to CAV in Delaware.
      2. Potential incentives for using CAV and opportunities for the creation of jobs.
      3. Making Delaware a testing ground for CAV in order to gain recognition.
      4. Being aware of impacts CAV may have moving forward and being prepared for the future.

c. Technology, Security, and Privacy
   i. Meeting held January 18, 2018 at 8:30 AM.
   ii. Discussion facilitated by B. McCleary included the following:
      1. Issues and unknowns surrounding CAV technology, security, and privacy.
      2. Focusing on a more detailed scope and mission for the subcommittee.
      3. A draft charter for the subcommittee, including key deliverables and target outcomes, will be ready for submission to the Secretary by the February monthly meeting.
      4. A representative from the DOJ was added to the committee, as well as a representative from the private sector of cybersecurity.

d. Transportation Network Infrastructure
   i. First meeting to be held February 1, 2018.

e. Impacts on Public and Highway Safety
   i. First meeting was held January 8, 2018 at 1:00 PM.
   ii. Discussion included the following topics:
      1. A presentation by M. Luszcz on DelDOT’s Strategic Highway Safety plan and the impacts CAV will have on Delaware’s safety-related issues.
      2. Future discussion to include topics such as policies, infrastructure design, legal aspects, enforcement, crash investigations, public acceptance, insurance benefits, pedestrian safety, and driver education.

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3. It was decided that the committee's discussion and reports will follow a structure based on the Society of Automotive Engineers (SAE) Levels of Driving Automation.
4. A representative from Delaware Criminal Justice Information System (DELJIS) was added to the subcommittee.

f. P. Cannon asked a question regarding the communication between subcommittees as implementation of CAV technology develops moving forward, specifically having to do with the recommendation of a pilot program.
   i. N. Majeski responded that as these technologies develop there will need to be increased communication between subcommittees, given that topics in CAV will often overlap.
   ii. A discussion occurred surrounding these topics:
      1. Many factors would need to be considered before a pilot could be implemented, such as the location (controlled environment vs. populated roadway), insurance, code/regulations, etc.
      2. Current testing is occurring in other states (e.g. Waymo /UBER passenger vehicles, AAA shuttle bus in Las Vegas).
      3. Public education will be crucial to gain acceptance and mitigate fear.
   iii. N. Majeski assigned an action item to Jacobs to compile information on surrounding state legislation relevant to CAV testing and implementation and share with the Advisory Council.

4. Presentation by UBER

a. S. Shapiro gave an overview of UBER's status in the development of autonomous vehicles (AV).
   i. UBER is already testing self-driving vehicles with passengers on public roads. The company has testing locations in San Francisco, Pittsburgh, Toronto, and Phoenix.
   ii. A number of economic development opportunities are associated with AV implementation; for example there are 750 engineers and vehicle operators working in Pittsburgh.
   iii. UBER focuses on the following areas of development as they implement AV testing: safety, scalability, mapping, hardware, vehicle programs, and operations.
   iv. AV Testing involves three steps: offline testing of the software, closed-course testing, and on-road testing. S. Shapiro shared a video of a self-driving UBER which can be accessed at the following link: https://www.youtube.com/watch?v=YKQ-6YnrKNc

v. S. Shapiro noted the need to consider opportunities in AV technologies, other than in passenger vehicles; for example self-driving trucks for transporting goods.

vi. Benefits of self-driving fleets were reviewed and include improved safety, increased efficiency, decreased congestion, beneficial environmental impacts, urban development opportunity and increased accessibility.

vii. Policies to improve AV utilization may include road/congestion pricing, urban HOV lanes, smart pricing for off-street and curbside parking, parking maximums instead of minimums as part of building code policy, in-lieu parking fees and parking cash outs.

b. J. Lewis asked about the possibility of a self-driving vehicle demonstration in Delaware.

   i. N. Majeski responded that DelDOT anticipates having a demo later this year for the council.

c. S. Vien asked about testing being done by UBER in Delaware.

   i. S. Shapiro responded that UBER has not mapped Delaware yet and therefore a demo by the UBER self-driving vehicle is not yet possible.

d. T. Megee raised a concern about glitches in electronic systems, like satellite radio, when a vehicle travels in areas with weak network connection.

   i. S. Shapiro responded that mapping mitigates this issue and the autonomous vehicle will be able to operate under all circumstances and will not depend on the existing infrastructure. Even if there is limited connection, it is intended that the vehicle will be able to navigate.

5. Topics of discussion for the next meeting:

a. NHTSA *Automated Driving Systems 2.0 A Vision for Safety* Report

b. Opportunities for Delaware to implement AV technologies

6. Public Comment

a. There were no additional comments from the public.

7. P. Cannon made the motion to adjourn the meeting and was seconded by S. Vien. The motion passed and meeting adjourned at 12:11 PM.

Action Item Summary

1. Jacobs to compile information on surrounding state legislation relevant to CAV testing and implementation and share with the Advisory Council.

STATE OF DELAWARE
DEPARTMENT OF TRANSPORTATION
800 BAY ROAD
P.O. BOX 778
DOVER, DELAWARE 19903

JENNIFER COHAN
SECRETARY

Advisory Council on Connected and Autonomous Vehicles Meeting (Executive Order 14)

Thursday, February 15, 2018
11:00am – 12:30pm
DelDOT Administration Building, 800 Bay Road, Dover, DE
Farmington/Felton Conference Room

MINUTES

1. **Welcome and Introductions**
   a. The meeting commenced at 11:01 AM. Secretary J. Cohan introduced herself and proceeded to direct the Advisory Council members and attendees to introduce themselves.

Present Voting Council Members

Barzilai Axelrod	Attorney General's Office
Patty Cannon	Division of Small Business, Development and Tourism (DOS)
Jennifer Cohan	Delaware Department of Transportation (DelDOT)
Lee Derrickson	Delaware Motor Transport Association (DMTA)
Renee Gibson	Alliance of Automobile Manufacturers
Jerome Lewis	University of Delaware (UD) Institute of Public Administration
Leslie Ledogar	Insurance Commissioner's Office
Reed Macmillan	Dover/Kent Metropolitan Planning Organization
Ed Osienski	House of Representatives
William Pfaff	Sussex County
Cathy Rossi	AAA Mid-Atlantic
John Sisson	WILMAPCO
Elayne Starkey	Delaware Department of Technology and Information (DTI)
Scott Vien	Division of Motor Vehicles (DMV)

Members Present by Proxy

Jenn Parrish	State Senate (Proxy for Senator Hansen)
Keri Rapa	State Senate (Proxy for Senator Pettyjohn)

Also Present

Bruce Demeter	DTC
CR Marshall	DelDOT
Dan Corey	AECOM
Debbie Pfeil	KCI Technologies
Don Weber	DelDOT
Erin Coombs	Jacobs
Frank DeSanis	OPC
Gene Donaldson	DelDOT
Jaime Vargas	Wallace Montgomery
Jason Walsh	Price Auto Group
Jen Duval	Jacobs
Jim Garrity	Diamond Tech
Jim Lorden	AAA Mid-Atlantic
Ken Grant	AAA Mid-Atlantic
Li Wen Lin	DelDOT—Technology and Innovation
Lisa Goodman	Hamilton Goodman Partners, LLC – Uber
Mark Luszcz	DelDOT
Matt Buckley	WRA
Megan Rosica	Jacobs
Pat Kennedy	FHWA
Peter Bourne	KCI Technologies
Rob McCleary	DelDOT
Scott Clapper	DMV
Shante Hastings	DelDOT
Steven Chillas	Delaware OMB – Contracting
Tarik Zerrad	Alliance of Automobile Manufacturers

Absent Voting Council Members

Ruth Briggs King	House of Representatives
Glenn Dixon	Delaware Department of Safety and Homeland Security (DSP)
Shari Shapiro	Uber

2. Approval of the Previous Meeting Minutes

a. B. Axelrod made a motion to accept the minutes from the previous meeting held on January 18, 2018. Motion was seconded by B. Pfaff. Motion passed and minutes were approved.

3. Updates on Subcommittees

STATE OF DELAWARE
DEPARTMENT OF TRANSPORTATION
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Advisory Council on Connected and Autonomous Vehicles Meeting
(Executive Order 14)

Thursday, February 15, 2018
11:00am – 12:30pm
DelDOT Administration Building, 800 Bay Road, Dover, DE
Farmington/Felton Conference Room

AGENDA

- Welcome and Introduction
- Approval of the Previous Meeting Minutes
  - January 18, 2018
- Updates from Subcommittees
  - Promoting Economic Development
  - Technology, Security and Privacy
  - Transportation Network Infrastructure
  - Impacts on Public and Highway Safety
- Presentation by AAA Mid-Atlantic
- Launch of Autonomous Shuttle
- Legislation on Connected and Autonomous Vehicles by Other States *
- Public Comment

If you have any questions please contact Lesley Devine at (302) 760-2197.

* 2/13/18 - Revised agenda to add additional item.

DelDOT

a. Secretary Cohan updated the council that the subcommittee drafts will be due in July for the final report to be completed by September. Templates for reports will be sent out to subcommittee chairs. Attendees were reminded that a website has been created for the Advisory Council and that information regarding meetings and materials is available on the site. The website can be accessed using the following link: https://www.deldot.gov/Programs/autonomous-vehicles/
b. Promoting Economic Development
    i. P. Cannon reported that they had their second meeting on February 15. The committee has shifted focus from "economic development" to "promoting economic development" with more emphasis on how to create a market for attracting businesses to Delaware.
    ii. Discussion was focused around the following topics:
        1. Promoting policies to make Delaware an attractive place for both CAV and robotics technologies.
        2. Creating marketing tools with a clear, defined message about CAV in Delaware.
    iii. P. Cannon shared that she had been in contact with Amazon about Delaware's HQ2 proposal, and Delaware was stated as a strong contender. That should be leveraged in attracting future opportunities.
    iv. E. Osienski plans to invite DelDOT Communications and the State Representative's Communication team to future meetings to discuss how messaging can be released to the public. There was general discussion amongst the council regarding public outreach and the importance of developing a campaign that does not overwhelm the public.
c. Technology, Security, and Privacy
    i. E. Starkey provided committee update. Third meeting hosted February 15. Charter has been finalized and is expected to be submitted next week.
    ii. Subcommittee has split into three groups, each investigating the top challenges and opportunities of technology, security, and privacy.
    iii. Added two new members, Aleine Cohen from DOJ, and Jim Garrity of Diamond Technologies, a private sector technology firm. Committee membership is now complete.
d. Transportation Network Infrastructure
    i. R. McCleary provided subcommittee update. First meeting was held on February 1. Subcommittee discussed purpose and scope and plans to engage with other subcommittees.
    ii. Identified key stakeholders and is creating a questionnaire to be sent out to stakeholders to gauge current CAV initiatives, interest, and input.

iii. The subcommittee intends to meet the first Thursday of the month.

e. Impacts on Public and Highway Safety
   i. M. Luszcz provided the subcommittee report on behalf of G. Dixon. The committee met for the second time on February 2.
   ii. Focused on levels of autonomy and will be creating recommendations based on levels of vehicle automation.
   iii. Discussed existing Delaware Code and potential amendments to code.
   iv. Subcommittee has expressed concerns about driver safety during the transition period of a mixed fleet on roadways.
   v. There was general discussion amongst the council about OEMs moving beyond the testing phase.

4. Presentation by AAA Mid-Atlantic

a. K. Grant presented "Connected and Autonomous Vehicle Insights from CES" PowerPoint
   i. Additional videos from the 2018 Consumer Electronics Show (CES) can be found online at www.aaa.com/ces
   ii. The presentation focused on the January 2018 CES held in Las Vegas, NV
   iii. The key takeaways from the event were that CAVs are anticipated to be on the street sooner than expected and public acceptance is increased with more information.
      1. AAA did a survey finding 63% of people are afraid to ride in autonomous vehicles, down from 77% at the 2017 CES.
   iv. Information Sharing and Analysis Center
      1. AUTO-ISAC created in 2015 to share information with auto manufacturers.
         a. 99% of vehicles on the road toady are manufactured by members of AUTO-ISAC
   v. Video of people on board a level 4, self-driving vehicle with operator.
      1. Vehicle was traveling 20 mph.
      2. Shuttle is receiving ratings of 4.8 out of 5
      3. Crash that occurred on day of launch was not caused by automated shuttle but by a delivery driver making illegal turn. Shuttle stopped as it was supposed to do but the delivery driver continued moving hitting the shuttle.
      4. Running on a V2I system, dependent on traffic signals and LiDAR.
   vi. There was also an autonomous taxi run by another company and CAVs run by Lyft at 2018 CES. This contributed to decreased fear amongst the public.

5. Launch of Autonomous Shuttle

a. J. Cohan stated that the best way to attract and test is to do. She has met with the President of University of Delaware and will be launching two autonomous shuttles at the Science, Technology and Advanced Research (STAR) Campus. Decision to use two shuttles was so that they can interact with each other as well as infrastructure. This also serves as a public relations opportunity.

b. J. Lewis discussed that this opportunity allows for collaboration between DelDOT, UD Institute of Public Administration and the Mechanical Engineering Department, and WILMAPCO.

c. J. Sisson stated that putting the shuttles in a controlled environment allows the public to safely experience and accept the technology.

d. Questions

    i. P. Cannon asked about the timeline of the launch.

        1. J. Cohan—working on the MOU now with UD. Will release RFP and plan to have the council as engaged as possible. Shuttle launch will remain a running agenda item.

    ii. E. Osienski asked about the size of the intended shuttle loop.

        1. J. Sisson—has not yet been defined but plans to start small and expand with the intent to expand beyond campus.

e. J. Lewis stated that UD is looking at other shuttle demonstrations around the country to learn from their experiences.

6. Insurance Commissioner Update

a. L. Ledogar provided an update about the Insurance Commissioner's roundtable meeting. The discussion was a broad ranging discussion about how to insure the risks of CAV technology. She will be creating a summary to share with the Secretary and will outline the next steps. It was decided that the insurance implications associated with CAV will be included as a separate chapter in the final council report.

b. J. Cohan requested that Insurance Commissioner progress be included on the subcommittee report outs during future meetings.

7. Possible Legislation

a. J. Cohan discussed the map and activities summary of other states CAV legislation. There was general discussion amongst the council to keep legislation as a running agenda item.

b. Alliance of Automobile Manufacturers—has model language available for legislation and can provide to the council. The Alliance is also able to put the council in touch with members of AUTO-ISAC for more information.

8. Public Comment

a. M. Topal from the Office of Highway Safety requested that the committee develop a series of talking points for public interfacing on CAV.

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i. J. Cohan requested that CR Marshall (DelDOT) look into creating a one-page document for committee on talking points.

9. Adjourn

a. S. Vien made the motion to adjourn the meeting and was seconded by P. Cannon. The motion passed and meeting adjourned at 12:10 PM.

Action Item Summary

1. CR Marshall to develop talking points one-pager.
2. Add Insurance Commissioner to subcommittee updates and legislation for future agenda items.

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Advisory Council on Connected and Autonomous Vehicles Meeting
(Executive Order 14)

Thursday, March 15, 2018
11:00am – 12:30pm
DelDOT Administration Building, 800 Bay Road, Dover, DE
Farmington/Felton Conference Room

REVISED AGENDA

- Welcome and Introduction
- Approval of the Previous Meeting Minutes
  - February 15, 2018
- Updates from Subcommittees
  - Promoting Economic Development
  - Technology, Security and Privacy
  - Transportation Network Infrastructure
  - Impacts on Public and Highway Safety
- Update from the Delaware Department of Insurance
- Presentation by Ed Bradley from Toyota
- Public Comment

If you have any questions please contact Lesley Devine at (302) 760-2197.

* Revised Agenda 3/14/18 - Rescheduling the presentation by the Alliance of Automobile Manufacturers

DelDOT

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Advisory Council on Connected and Autonomous Vehicles Meeting
(Executive Order 14)

Thursday, March 15, 2018
11:00am – 12:30pm
DelDOT Administration Building, 800 Bay Road, Dover, DE
Farmington/Felton Conference Room

MINUTES

1. Welcome and Introductions

a. The meeting commenced at 11:05 AM. N. Majeski introduced herself and indicated she would be representing Secretary Cohan until she arrived. She then directed Advisory Council members and attendees to introduce themselves.

Present Voting Council Members

Barzilai Axelrod	Attorney General's Office
Brian Pettyjohn	State Senate
Cathy Rossi	AAA Mid-Atlantic
Elayne Starkey	Delaware Department of Technology and Information (DTI)
Glenn Dixon	Delaware Department of Safety and Homeland Security (DSP)
Jennifer Cohan	Delaware Department of Transportation (DelDOT)
Jerome Lewis	University of Delaware (UD) Institute of Public Administration
John Sisson	WILMAPCO
Lee Derrickson	Delaware Motor Transport Association (DMTA)
Patty Cannon	Division of Small Business, Development and Tourism (DOS)
Reed Macmillan	Dover/Kent Metropolitan Planning Organization
Ruth Briggs King	House of Representatives
Shari Shapiro	Uber
Terry Megee	DE Automobile and Truck Dealers Association
William Pfaff	Sussex County

Members Present by Proxy

Jenn Parrish	State Senate (Proxy for Senator Hansen)
Frank Pyle	Insurance Commissioner's Office (Proxy for Leslie Ledogar)

Rhett Ruggerio	Alliance of Automobile Manufacturers (Proxy for Renee Gibson)

Also Present

Al McGowan	TrafficCast
Brett Swan	UD IPA
Brett Taylor	Diamond Tech
Bruce Demeter	DTC
Chris Kelly	UD IPA
Debbie Pfeil	KCI Technologies
Ed Bradley	Toyota
Erin Coombs	Jacobs
Gene Donaldson	DelDOT
George Spadafino	GPI
Jim Lardear	AAA Mid-Atlantic
John Walsh	Price Auto Group
Jonathan Derryberry	Davis, Bowen, & Friedel, Inc
Ken Feaster	DOJ/DelDOT
Ken Grant	AAA Mid-Atlantic
Li Wen Lin	DelDOT—Technology and Innovation
Lisa Goodman	Hamilton Goodman Partners, LLC
Lizzie Lewis	Hamilton Goodman Partners, LLC
Mark Eichman	WHYY
Mark Luszcz	DelDOT
Mark Thompson	WhyFly
Megan Rosica	Jacobs
Nicole Majeski	DelDOT
Pat Kennedy	FHWA
Rob McCleary	DelDOT
Shante Hastings	DelDOT
Steven Chillas	Delaware OMB – Contracting

2. Approval of the Previous Meeting Minutes

a. B. Axelrod made a motion to accept the minutes from the previous meeting held on February 15, 2018. J. Sisson noted his name misspelling and. made a motion to approve with changes. P. Cannon seconded the motion and motion passed and minutes were approved.

b. Sec. J. Cohan announced there was an amendment to the posted agenda and that there would be only one presentation from Toyota.

3. Updates on Subcommittees

a. Promoting Economic Development
   i. P. Cannon reported that there was no quorum for 3/15 meeting.
   ii. Al McGowan, TrafficCast International, Inc., and Mark Thompson, WhyFly, were invited to the 3/15 meeting to discuss their businesses. P. Cannon asked them to explain their companies and why they were invited to present to the subcommittee:
      1. Al Gowan CEO of TrafficCast International—company provides real-time traffic data to 49 states. Recently moved to Wilmington because of critical mass in Delaware and the ease of doing business/accessibility to Delaware legislatures. Sees Delaware as a prime state for opportunity. Believes that the Delaware's Open Data attracts technology/businesses.
      2. Mark Thompson ofWhyFly—Working in Wilmington/Philadelphia/Baltimore to provide residential Wi-Fi and Smart City retrofitting with sensors.

b. Technology, Security, and Privacy
   i. E. Starkey provided committee update. The fourth meeting was held on 3/15.
   ii. Productive discussion and the committee has moved past administrative set-up and has begun to develop the research and content for report.
   iii. Subcommittee has split into three groups, each investigating the top challenges and opportunities of technology, security, and privacy. All three subgroups spent time during meeting fleshing out issues—data ownership is going to be an important focus of council—who owns/what kinds of data.
   iv. Sec. J. Cohan asked if there are any hurdles or foreseeable issues arising. E. Starkey responded that there are no major hurdles but it is important to note that while it is tempting to enact state standards/guidelines the recommendation is to let the federal government regulate.
   v. S. Shapiro thanked E. Starkey for her diligence and focus in keeping the committee moving.

c. Transportation Network Infrastructure
   i. R. McCleary provided subcommittee update. Second meeting was held on 3/1.
   ii. Subcommittee discussed the charter, identifying stakeholders, mission, and role of subcommittee in relation to the larger report.
   iii. Identified key stakeholders and have developed a questionnaire that has been sent out to gauge current CAV initiatives, interest, and input—looking forward to responses.
   iv. Have scheduled stakeholder attendance at future meetings
      1. Small cell companies

2. 3M
3. Military organizations—Defense Advanced Research Project Administration referred us to the ARMY for more information. Trying to figure out the logistics.

v. The subcommittee intends to meet the first Thursday of the month, next meeting April 5th at 10AM, all who are interested are invited.

d. Impacts on Public and Highway Safety

i. G. Dixon provided the subcommittee report.
ii. Discussed how police agencies will have to change and the changes to DE Code based on level 5 automation.
iii. Members providing input to matrix looking at recommendations, actions, impacts to various topics based on automation level.
iv. M. Luscsz and G. Dixon working on the final proposal for report.
v. P. Cannon asked L. Derrickson to explain about truck platooning.

1. Germany and Florida are currently running truck platooning pilot projects
   a. German project spent extensive time on driver training.
2. Kentucky—requiring trucks to be demarcated that they are participating in platooning.
3. Platooning can occur at level 1—drivers have control of all functions except following distance. Shifting from standard of 300ft to 50-60ft. Lead truck controls the breaking, minimal lag between vehicles reacting together.
4. Virginia Tech has two projects beginning with vehicle cut ins and developing driver reaction models when platooning fails.
5. Auburn is developing cooperative adaptive cruise control and engagement.
6. California PATH projects

vi. R. McCleary—TARDEC is a platooning technology and the committee wants to explore if any road technology is needed to expand the data that they are collecting. Hoping to have them on the April agenda, if not May.
vii. P. Cannon—committee discussed at last meeting that education is needed to understand what platooning is, how to recognize on the roadway and how to respond.
viii. S. Shapiro—this is important to the comprehensive nature of the CAV technology and the different types of vehicles interpretation

4. Update from Delaware Department of Insurance

a. F. Pyle provided the update on behalf of L. Ledogar.

b. He explained that L. Ledogar met with Insurance Commissioner and developed a draft mission statement for the research to be conducted for report:
    i. The mission of the Insurance Subcommittee of the Advisory Council on Connected and Autonomous Vehicles is to identify ways for the Department to ensure that, as insurance products evolve in response to the invention and deployment of connected and autonomous vehicles, those products provide consumers with appropriate and adequate insurance coverage.
c. Preliminary areas of focus
    i. Track and report on the National Association of Insurance Commissioners
    ii. Include the federal and state legislation as it impacts insurance products
    iii. Understand the budgetary impact to department of insurance if there are any shifts to the premium tax
    iv. Assess insurance products that are designed to deal with the phase in period—from level 1-level 5
    v. Assess the development of new insurance products and liability
    vi. Report on existing legal constraints to the insurance market and their potential evolution
d. Meeting with other insurance regulatory bodies to garner understanding of what they are working on

5. Presentation by Toyota

a. Ed Bradley—Program Manager Toyota Motor North America
    i. Provide high level overview from Toyota perspective
b. Why do connected and automated vehicles matter
    i. Improved safety
    ii. Enhanced mobility
    iii. Reduced environmental impact
c. Toyota approach
    i. Collision avoidance
    ii. Risk mitigation
    iii. Risk avoidance
    iv. DSRC enables expansion of the safety horizon
    v. Tested in Japan
        1. Sold over 100K vehicles with optional DSRC connectivity
            a. Toyota Prius, Lexus RS and Toyota Crown vehicles
        2. V2I technology—left hand turn detection
        3. "Intersection Turn Assist App"
        4. "Red Light Caution App"—Audio alerts/messages on display

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5. "Signal Timing App"—Icons on instrument panel with vehicle approaches DSRC intersection
6. "Eco Approach App"—Supports economical driving and driver notified of signal timing (not V2I technology)
7. V2V
    a. Cooperative Adaptive Cruise Control—icon illuminated to alert that vehicle ahead has V2V technology
    b. Emergency Vehicle Notification—notifies driver of the location/direction of emergency vehicle
8. Toyota supports V2V federal regulation
    a. DSRC
    b. Future regulations for apps
    c. SAE& IEEE standards
    d. 5.9GHz spectrum
    e. Support aftermarket devices as long as they meet same standards

vi. Mobility Teammate Concept
1. Driving Intelligence
2. Connected Intelligence

vii. Toyota sensors
1. Camera
2. Millimeter-wave radar
    a. Vehicle pre collision system
    b. Cruise control
    c. Lane assist
3. Cooperative automated vehicle technology for greatest benefits
4. GPS, laser, cameras, radar, orientation via sensors, odometer, computing power

viii. Precision Mapping
1. 3D maps—expect the expected and reason what is different
2. Access to 3D maps make traffic signal detection highly reliable

ix. Challenges (via J. Leonard MIT)
1. Adoption/technical
2. Left turn across traffic
3. Changes to surface markings
4. All weather driving
5. Traffic cops, crossing guards, police, fire

x. NTSB Investigation of Tesla Model S Crash
1. 13 factors contributing to crash of level 2 vehicle

2. Safety recommendation to limit minimum performance standards for CAV
3. Once developed—require these standards on all vehicles

d. Current state
  i. AASHTO SPaT challenge
    1. 20 intersections in 50 states by 2020

e. Current technology not ready for CAVs

f. Many factors play a critical role in how the technology is brought to market

g. Questions
  i. C. Rossi—can you share with us what Toyota has in terms of planned vehicles and levels of automation
    1. Toyota does not disclose future product plans. Important to question in regards to preparing for new technology but Toyota has level 2 technology in the US market in the Lexus LS sedan and can expect to see that in other Lexus models and eventually throughout all Toyota models. Doing tremendous amount of work, research and development in levels 3-5. Made the announcement that Toyota will introduce high levels of automation in 2020—will have a demonstration in Tokyo at 2020 Olympics will transport athletes/spectators in Toyota owned vehicles.
  ii. C. Rossi—Toyota has been very forward facing in educating the public. What features are in the LS sedan and what is the price point?
    1. Not standard features but included in the technology packages—adaptive cruise control and lane centering. Other models have lane keep assist to keep drivers from driving—lane centering keeps driver in the center of the lane.
  iii. A. McGowan—as you see other technologies like 5G where do you see that in comparison to DSRC
    1. There are questions about DSRC vs 5G. 5G is not ready yet for device deployment and not quite ready as an LTE cellular technology. For consideration for device-to-device it needs to advance—not able to compare with DSRC at this point, similar to VHS to DVD. DSRC allows for development now. 5G is many years away from a Toyota vehicle. Must be fully developed, confident of interoperability and then testing on vehicles to be able to roll out for consumers.
    2. J. Cohan—Delaware wants to be 5G capable sooner than way out.
    3. McGowan—TrafficCast is now deploying in 9 states after pairing with Denso.

4. E. Bradley—see connectivity to be through two mechanisms, V2V and cellular.

iv. R. McCleary—we put data out through the TMC, a central hub for companies to make available to the vehicles. Has Toyota thought about that as an alternative via satellite instead of requiring separate device deployment.
   1. Yes, fits with dual method of connectivity via cellular. Critical collision mitigation/emergency situations are envisioned as being communicated through DSRC.

h. SPaT challenge (M. Luszcz/G. Donaldson)
   i. Delaware is participating
   ii. Starting in Smyrna—11 signals on US 13
   iii. 2 locations have cellular based first step, deployed in the field—currently in beta testing, data not available
   iv. First DSRC test is at the signal shop
      1. Expect first signal to be released in the coming weeks
   v. Largest issue is acquiring the equipment—in conversations with Turner-Fairbanks

6. Public Comment

a. None

7. Adjourn

a. B. Axelrod made the motion to adjourn the meeting and was seconded by J. Cohan. The motion passed and meeting adjourned at 12:05 PM.

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Advisory Council on Connected and Autonomous Vehicles Meeting
(Executive Order 14)

Thursday, April 19, 2018
11:00am – 12:30pm
DelDOT Administration Building, 800 Bay Road, Dover, DE
Farmington/Felton Conference Room

AGENDA

- Welcome and Introduction
- Approval of the Previous Meeting Minutes
  - March 15, 2018
- Updates from Subcommittees
  - Promoting Economic Development
  - Technology, Security and Privacy
  - Transportation Network Infrastructure
  - Impacts on Public and Highway Safety
- Update from the Delaware Department of Insurance
- Presentation by the Alliance of Automobile Manufacturers
- Public Comment

If you have any questions please contact Lesley Devine at (302) 760-2197.

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Advisory Council on Connected and Autonomous Vehicles Meeting (Executive Order 14)

Thursday, April 19, 2018
11:00am – 12:30pm
DelDOT Administration Building, 800 Bay Road, Dover, DE
Farmington/Felton Conference Room

MINUTES

1. Welcome and Introductions

a. The meeting commenced at 11:05 AM. Secretary Cohan introduced herself and directed Advisory Council members and attendees to introduce themselves.

Present Voting Council Members

Barzilai Axelrod	Attorney General's Office
Patty Cannon	Division of Small Business, Development and Tourism (DOS)
Jennifer Cohan	Delaware Department of Transportation (DelDOT)
Milton Lee Derrickson	Delaware Motor Transport Association (DMTA)
Renee Gibson	Alliance of Automobile Manufacturers
Leslie Ledogar	Department of Insurance (DOI)
Jerome Lewis	University of Delaware (UD) Institute of Public Administration
Reed Macmillan	Dover/Kent Metropolitan Planning Organization
Terry Megee	DE Automobile and Truck Dealers Association
Rep. Ed Osienski	State Representatives
William Pfaff	Sussex County
Shari Shapiro	Uber
Elayne Starkey	Delaware Department of Technology and Information (DTI)
Patrick Wenk	Delaware State Police (DSP)

Members Present by Proxy

Jim Lardear	AAA Mid-Atlantic (Proxy for Cathy Rossi)
Tigist Zegeye	WILMAPCO (Proxy for John Sisson)

Absent Council Members

Rep. Ruth Briggs King	State Representatives
Sen. Stephanie Hansen	State Senate

Sen. Brian Pettyjohn	State Senate
Scott Vien	DMV

Also Present

Christie Bonniwell	DelDOT
Steven Chillas	Delaware OMB – Contracting
Aleine Cohen	DOJ
Erin Coombs	Jacobs
Gene Donaldson	DelDOT
Jen Duval	Jacobs
Ken Feaster	DOJ/DelDOT
Lisa Goodman	Hamilton Goodman Partners, LLC
Ken Grant	AAA Mid-Atlantic
Dawn Hopkins	Economic Development
Chris Kelly	UD IPA
Pat Kennedy	FHWA
Anne Marie Lewis	Alliance of Automobile Manufacturers
Lizzie Lewis	Hamilton Goodman Partners, LLC
Li Wen Lin	DelDOT—Technology and Innovation
Mark Luszcz	DelDOT
Nicole Majeski	DelDOT
Rob McCleary	DelDOT
Colton Phillips	DelDOT
Megan Rosica	Jacobs
Peggy Shultz	League of Women's Voters
Mark Thompson	WhyFly
Jason Walsh	Price Auto Group
James Wilson	BikeDE
Joe Zilcosky	DOS

2. Approval of the Previous Meeting Minutes

a. There was a correction to the 3/15 meeting minutes—section 4.b from the Insurance Commissioner's office:
We agreed on a draft mission statement for the Insurance subcommittee which is: "The mission of the Insurance Subcommittee of the Advisory Council on Connected and Autonomous Vehicles is to identify ways for the Department to ensure that, as insurance

products evolve in response to the invention and deployment of connected and autonomous vehicles, those products provide consumers with appropriate and adequate insurance coverage."

b. P. Cannon made a motion to accept the updated meeting minutes from the previous meeting held on March 15, 2018. B. Axelrod seconded the motion and motion passed and minutes were approved.

3. Updates on Subcommittees

a. Promoting Economic Development
   i. P. Cannon reported that there was no quorum for 4/19 meeting. During the allotted meeting time, there was a review of the ITMS Strategic Plan handout (drafts provided to committee).
   ii. L. Derrickson provided an update on the Commercial Trucking industry and the upcoming state Truck Driving Championship for CDL drivers.

b. Technology, Security, and Privacy
   i. E. Starkey provided committee update. The fifth meeting was held on 4/19.
   ii. Productive discussion focusing on privacy and insurance.
   iii. Subcommittee has split into three groups, each working through the template provided to the committee. The working groups spent time looking at privacy issues from different angles—driver, passenger, and manufacturer. The goal is to identify the broad issues, pitfalls, and concerns.
   iv. Sec. Cohan reinforced that the goals for the subcommittees and council is not to solve all issues but to identify the issues and steer the direction moving forward.

c. Transportation Network Infrastructure
   i. R. McCleary provided subcommittee update. There was no quorum for the committee's third meeting on 4/5.
   ii. The committee hosted a Q&A session with TARDEC gaining more information about their Leader/Follower technology for trucks and fleet vehicles. TARDEC provided more information on roadside infrastructure and DSRC technology deployment.
   iii. 3M provided the subcommittee with a presentation on pavement markings and visibility enhancements.
      1. Sec. Cohan asked R. McCleary if 3M provided insight on any new developments. R. McCleary explained that they discussed magnetic tape being reintroduced for vehicles to identify in snow conditions and the introduction of signage with invisible QR codes tied to a database that can be read by an on-board camera.
   iv. The next committee meeting is scheduled for 5/8/18

d. Impacts on Public and Highway Safety

i. M. Luszcz provided the committee report for G. Dixon. Last meeting was held on 4/13 and the next meeting is scheduled for 5/11.
ii. The subcommittee is working to organize the matrix for safety related issues at each level of automation. K. Grant has shared the matrix at the national level of AAA and the subcommittee is in alignment with what they are also researching.
iii. The first draft of the subcommittee report will be sent out to the members in the coming week.
iv. Key topics that the subcommittee is discussing:
1. Licensed driver in vehicle
2. Level of automation listed on vehicle for inspection
3. Testing on DE roadways

4. Update from Delaware Department of Insurance

a. L. Ledogar provided update on recent attendance to the National Association of Insurance Commissioner's (NAIC) quarterly meeting in Wisconsin.
i. NAIC establishes Model Acts for states to use for reference on legislation.
ii. NAIC has a committee dedicated to the insurance related issues of autonomous vehicles.
iii. There is an Innovation and Technology Task Force and Cyber Security Working Group
1. Discuss regulatory issues for AV and the state regulatory framework
2. Released model rule, Insurance Data Security Model Law in October 2017, that was adopted during National Cyber Security Awareness Month. This model law requires companies to notify the public in the event of a data breach. Delaware is looking at this model and will consider the implications.
iv. Big Data Working Group
1. Reviewing regulatory framework and making modifications to model laws as they relate to data needs.

b. Delaware Insurance Commissioner's Office is looking at what the NAIC is doing and basing the state direction on their efforts.

c. Sec. Cohan inquired about the insurance implications of current DE Code not explicitly requiring a driver in the vehicle.
i. L. Ledogar did not have a definite answer.

d. L. Ledogar is currently investigating data collection devices that plug into the vehicle allowing for the insurance company to collect data on personal driving habits. This data is useful in determining insurance rates and driving trends.

5. Presentation by Alliance of Automobile Manufacturers

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a. "Automated Driving Systems (ADS) Equipped Vehicles" presented by Anne Marie Lewis, Ph.D
    i. Automated Driving Systems (ADS)
        1. ADS is a natural evolution—anti-lock brakes to lane keeping assistance
        2. ADS utilizes machine learning
    ii. SAE Levels of Automation
        1. Levels 3-5 "Highly Automated"
            a. Conditional Level 3
            b. High Level 4
            c. Full Level 5
        2. Personal vehicles at Level 3
    iii. ADS-equipped vehicles—must meet FMCSA safety standards
        1. GM Cruise AV
            a. No steering wheel/no pedals
            b. Posted safety self-assessment outline 12 safety areas that are required by manufacturers
                i. System safety
                ii. Operational design domain
                iii. Object and event detection and response
                iv. Fallback (minimal risk condition)
                v. Validation methods
                vi. Human machine interface
                vii. Vehicle cybersecurity
                viii. Crashworthiness
                ix. Post-crash behavior
                x. Data recording
                xi. Consumer education and training
                xii. Federal, state, and local laws
        2. Smart Vision EQ 2030
            a. Concept vehicle
            b. V2X communications
        3. Toyota e-Palette Concept Vehicle
            a. Electric vehicle
            b. Designed in modular fashion—partnered with Amazon
                i. No seating requirements
                ii. Can be retrofitted for any concept/use
    iv. When does this happen

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1. First Level 3 should be available for purchase in 2018 for stop and go highway traffic only (37 mph or less)
2. 2020 available
3. 2030 common
4. 2035 standard
5. 2045 majority
6. 2055 ubiquitous (full fleet conversion)

v. Four dynamics influencing the modern auto industry
1. 4 trends happening in parallel
   a. Automation
      i. Innovation in traditional manufacturing companies, start-ups, mergers
   b. Connectivity
      i. Enhance safety capabilities of Automated vehicles. Benefits of 5G/DSRC
      ii. Signal phase and timing (SPaT), reducing congestion
   c. Ridesharing
      i. First applications of advanced automated vehicles will be geo-fenced areas
   d. Electrification
      i. Concepts that have been announced are in electric or hybrid electric platforms—not a requirement but the trend is simultaneous to be more sustainable
2. Trends are not reliant on each other

vi. Infrastructure considerations
1. Comments submitted to FHWA Docket No FHWA 2017-0049
2. AV needs benefit non-AVs and cost effective for safety benefit
3. Consistency with MUTCD
   a. Lane markings top priority
   b. Traffic signals and signs –consistency
   c. Construction zones
4. Digital infrastructure
   a. Can provide benefits of communication, sharing information, notifications to drivers'/emergency vehicles, V2I, SPaT

vii. Update on Federal Activity regarding ADS-equipped vehicles
1. NHTSA request for Comments on potential FMVSS barriers for ADS equipped vehicles
2. NHTSA public meeting (3/6/18)

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3. NHTSA stakeholder meeting (4/3-4/4/18)
4. FHWA request for comments on potential FMVSS barriers for ADS-equipped vehicles (3/5/18)
5. FTA request for comments (3/2/18)
6. FHWA meetings between ADS industry
7. Stakeholders and infrastructure owners and operators (TBD)

viii. Non-traditional seating configurations require additional efforts

ix. Alliance has reviewed and provided input on 30 FMVSS
   1. It is important to keep in mind that any potential new FMVSS for ADS or non-ADS equipped vehicles

x. Event Data Recorder SAE J1698 (black box) is being updated to account for parameters uniquely related to ADS

xi. Auto Alliance Model Bill created based on SAE J3016. Technology neutral and all-inclusive as technologies are being developed
   1. Insurance
   2. Ride-sharing networks
   3. Reporting

xii. Instead of having a permitting process—utilize NHTSA

b. Questions

i. J. Lardear—curious about Level 3 automation and the distraction of the driver / emergency situations
   1. A. Lewis—some manufacturers are looking at Level 3 technology. Important to stress response/reactions/focus on driving. GM Super Cruise has camera that monitors driver eye movement. There will be redundancies and further research over time.

ii. L. Derrickson—do you envision training for drivers before operating Level 3? In Europe they require about 20 hours of training.
   1. A. Lewis—not 100% sure of any plans but it is reasonable to expect some level of training. Consumer must be educated on what vehicle can/cannot do

iii. R. McCleary—can we get a copy of model legislation? Do you have recommendations for roadside signage?
   1. A. Lewis—clean signage and consistency. Outlined further in comments to NHTSA report. No hard recommendations on DSRC/5G requirements.

iv. L. Ledogar—what are your thoughts on data recorder?
   1. A. Lewis—the current "black box" standards are being updated.

v. L. Ledogar—what happens to the data of used cars?

1. A. Lewis—data is recorded when there is a trigger threshold met (indicative of a crash). No personal data is stored and data is recorded in the process of crash reconstruction.

vi. B. Axelrod—there was a discussion about training drivers at various levels of automation. Do you envision auto manufacturers embedding training in vehicles so that the end-user is forced to learn?
   1. A. Lewis—unaware of any manufacturers working on this.

vii. B. Axelrod—how does the Auto Alliance envision having a measure of how many automated vehicles are on the roadway?
   1. A. Lewis—it is understood that that type of information would be tracked through the Department of Motor Vehicles.

viii. S. Chillas—what are the recommendations to the state to teach levels of autonomy in the school curriculum?
   1. A. Lewis—state level education not discussed at Auto Alliance and would be up to the individual school districts or states.

ix. E. Osienski—are manufacturers looking at standardizing dashboard symbols?
   1. A. Lewis—currently manufacturers are engaged in conversations on this but the competitive market has not always been receptive to the standardizing of features and symbols.

x. M. Luscsz—what is the timeline for introduction?
   1. A. Lewis—Level 3 vehicles will be on the roadways likely by the end of 2018. Manufacturers have announced plans to release Level 4 by 2020. Level 5 is still unknown.

6. Public Comment

a. P. Shultz on behalf of the League of Women's Voters requested that the council research land use implications of CAVs and sustainable energy.
   i. Land use—with the increase of vehicles what are the potential implications on the land and development. Is it possible to add someone to the council from the planning field to address land use?
      1. Sec. Cohan informed that WILMAPCO is on the council.
   ii. Sustainable Energy—what are the potential impacts of expending carbon dioxide emissions?

7. Adjourn

a. Sec. Cohan informed council and attendees that there will be no May meeting and the next meeting is scheduled for June 21st.

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b. P. Cannon made the motion to adjourn the meeting and was seconded by B. Axelrod. The motion passed and meeting adjourned at 12:20 PM.

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Advisory Council on Connected and Autonomous Vehicles Meeting
(Executive Order 14)

Thursday, June 21, 2018
11:00am – 12:30pm
DelDOT Administration Building, 800 Bay Road, Dover, DE
Farmington/Felton Conference Room

AGENDA

- Welcome and Introduction
- Approval of the Previous Meeting Minutes
  - April 19, 2018
- Updates from Subcommittees
  - Promoting Economic Development
  - Technology, Security and Privacy
  - Transportation Network Infrastructure
  - Impacts on Public and Highway Safety
- Update from the Delaware Department of Insurance
- Presentation by the Council of State Governments
- Presentation by the National Automobile Dealers Association
- Public Comment

If you have any questions please contact Lesley Devine at (302) 760-2197.

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Advisory Council on Connected and Autonomous Vehicles Meeting (Executive Order 14)

Thursday, June 21, 2018
11:00am – 12:30pm
DelDOT Administration Building, 800 Bay Road, Dover, DE
Farmington/Felton Conference Room

MINUTES

1. Welcome and Introductions

a. The meeting commenced at 11:04 AM. Secretary Cohan introduced herself and directed Advisory Council members and attendees to introduce themselves.

Present Voting Council Members

Barzilai Axelrod	Attorney General's Office
Rep. Ruth Briggs King	State Representatives
Patty Cannon	Division of Small Business, Development and Tourism (DOS)
Jennifer Cohan	Delaware Department of Transportation (DelDOT)
Milton Lee Derrickson	Delaware Motor Transport Association (DMTA)
Renee Gibson	Alliance of Automobile Manufacturers
Reed Macmillan	Dover/Kent Metropolitan Planning Organization
Jason Walsh	DE Automobile and Truck Dealers Association
Rep. Ed Osienski	State Representatives
Sen. Brian Pettyjohn	State Senate
William Pfaff	Sussex County
Shari Shapiro	Uber
Elayne Starkey	Delaware Department of Technology and Information (DTI)
Scott Vien	DMV
Patrick Wenk	Delaware State Police (DSP)

Members Present by Proxy

Philip Barnes	University of Delaware (UD) Institute of Public Administration
Jim Lardear	AAA Mid-Atlantic (Proxy for Cathy Rossi)
Tigist Zegeye	WILMAPCO (Proxy for John Sisson)

Absent Council Members

Sen. Stephanie Hansen	State Senate

Also Present

Erin Coombs	Jacobs
Megan Rosica	Jacobs
Jim Ponte	Ponte's Autocare
Colton Phillips	DelDOT
Greg Buckley	Buckley's Auto Care
Norm Jones	Kirkwood Auto Center
Dawn Hopkins	DOS
Don Hannon	ERC
Scott O'Connor	Delaware Department of Technology and Information (DTI)

2. Approval of the Previous Meeting Minutes

a. J. Lardear made a motion to accept the updated meeting minutes from the previous meeting held on April 19, 2018. E. Osienski seconded the motion and motion passed and minutes were approved.

3. Updates on Subcommittees

a. Promoting Economic Development
   i. Industry as drive
   ii. Osienski reached out to automotive professionals, curious about their needs, workforce, training
   iii. Seeing current training (comes from manufacturers) but need for training centers, encourage manufacturers to consider Delaware as a regional training hub in this technology
   iv. Ford purchased transit center in Detroit, turning into training center
   v. Gulftainer port deal – goal is to have same sort of operation building workforce from within, bringing talent into marketplace
   vi. Manufacturers and independents need to coexist better than they have been – need to share, both need to learn
   vii. Report should mentioned displaced workers, aware and connect them to training
   viii. Comment from J. Walsh, dealers: technicians often trained on the fly, currently not a lot of teams going to training center, building blocks coming from mechanical understanding, not just aspect of self-driving but vehicle in general, auto body, collision repair, etc.
      1. S. Shapiro: Uber has done research—training AV techs is not needed now, layer on automotive tech programs, computer related skills and precision measurement skills; work with community college and tech

schools for incorporation here; RBK need for skilled labor, agreed; need connection between education and jobs and meaningful employment.
2. Discussion about the importance of attracting youth, getting youth involved early

b. Technology, Security, and Privacy
   i. Polishing final report, consolidated research
   ii. Shared preliminary recommendations
      1. Data collection/ownership: unanswered questions, recommend collect least amount of data to have CAV functionality, minimalist approach; keep data shortest time possible, anonymize, encrypt all PII, separate two data's (all in recs)
      2. Resistance to adoption of this from consumers – joint DelDOT CPU large scale education campaign to inform Delawareans about issues
      3. Potential state legislation recommendations – automakers to provide plain language consent in forms to owners, unknown data collection, want consent forms and plain language; concern with used vehicles, wipe clean data (secretary brought up rental vehicles, current issues, don't want conflicting legislation)
      4. E. Starkey retiring, S. O'Connor taking over chair position.

c. Transportation Network Infrastructure
   i. R. McCleary—last meeting there was presentation from George Zhao (IAI) – technology experimenting with in Delaware and around, branches of DOD, other companies
      1. Testing RSU/OBU system, advance warning, Dilemma zone project – advanced warning to drivers when to slow down.
      2. Difficulty getting data from vendors – locked down for liability issues, will probably be a barrier.
   ii. Drafted recommendations report, generated comments, addressing comments in July – will reach consensus to get out July 31.

d. Impacts on Public and Highway Safety
   i. P. Wenk on behalf of Dixon.
   ii. Final report, approved 4 sections
   iii. 6 total recommendations with subcategories
   iv. 3/6 approved
   v. Meeting Monday, anticipating having final draft complete at the end of meeting.

4. Update from Delaware Department of Insurance

a. No update provided.

b. Sec. Cohan—stated that there should be a separate section on insurance recommendations.

5. Presentation by the Council of State Governments – Don Hannon

a. Regional, governmental perspective – northeastern states
b. CSG/ERC (Council of State Governments Eastern Regional Conference)
c. CV technology is already present—there are existing regulations across the nation
d. Federal/state roles
    i. Federal rules the vehicle – safety standards, recalls
    ii. State controls the driver – manage vehicle operations, licensing, regulating behavior, speed limits, etc.
    iii. AV combines car and driver
    iv. Existing patchwork of state regulations makes it impossible to sell vehicle nationwide; infrastructure is not consistent – can vary widely, makes it difficult to ensure traffic jam pilot would work everywhere
e. States
    i. 2010 – Google announces testing in CA – no regulation
    ii. 2011 – Nevada, Florida
    iii. 2012 – California, requires driver, wheel, av permit
    iv. 2015 – Arizona signs executive order
    v. 2016 – Florida and Michigan jump, no driver needed
    vi. 2018 – CA let AVs operate without person, but have remote operations
        1. Companies were testing elsewhere to avoid regulation
    vii. 41 states legislation, 29 issued laws, 7 executive orders
f. Federal Government
    i. 2010-16: seeking federal legislation to avoid patchwork of state laws
    ii. January 2016: voluntary AV guidelines
    iii. September 2017: updated version of voluntary AV Guidelines
    iv. September 2018: Anticipate release of AV Guidelines 3.0 –develop "common sense" regulations that don't hamper innovation while encouraging safety
g. Congress
    i. House: Self-Drive Act
    ii. Senate: AV START Act
h. CA, AZ, FL, MI – states with significant activity
i. Idaho, established something similar to advisory council – let others solve issues
j. Northeast states: 11 states, 4 no legislation or executive order, 2 have existing order, 1 with both, 4 with enacted legislation
    i. NJ

1. Two bills in senate committee – insurance requirements and permitting testing; avoiding authorizing on public roads

ii. NH
  1. Bill last year would have prohibited AVs on roads – failed and ended in session
  2. This year again, lots of provisions
  3. Senate picked it up, created commission
  4. Av license testing, $500

iii. RI
  1. Nothing now, DOT looking at P3 pilot program, see how AVs change transportation, economy, social structure

iv. MD
  1. Limited engagement; first testing permits to tech firm in DOT parking lots testing; established UMD transportation institute with annual funding

v. MA
  1. First one with executive order
  2. Working towards proposed legislation
  3. Public outreach: holding 5 public listening sessions exploring transportation issues including AVs

vi. ME
  1. Executive order
  2. Bill

vii. VT
  1. Introduced legislation, identify policy areas
     a. Avoid patchwork regulations
     b. Safe deployment
     c. Avoid delaying deployment if lifesaving technology
     d. Don't fall behind, take advantage of technologies

viii. CT
  1. Legislation: allows cities and towns to enter agreements with testers; concern in towns because of Tempe
  2. Realization: safety #1

ix. NY
  1. Legislation allows testing
  2. Need approval and police escort

x. PA
  1. Testing in Pittsburgh, active program on public street

a. Issue: mayor doesn't want to see uber testing unless meeting restrictions
b. State pull power to regulate on this, not city
2. Av testing policy task force, recommendations
3. Actively engaged with federal and state agencies, etc.
4. Allow use of allocated funds for ITS applications (including CAV)
5. Increased safety oversight
6. AV summit
7. Seeking voluntary compliance legislative authority to oversee AV testing

k. Common issues
   i. Physically present operator
   ii. Special rules to ensure safe testing and operations
   iii. Special training/certifications for AV operators
   iv. Handheld devices
   v. Av corridors
l. Important and what will differentiate
   i. Electric vehicles and AVs go hand in hand
   ii. Utilize university research capability
   iii. Don't lose sight of "connectivity"
   iv. Balance safety with everything
   v. Define goals, what will attract AV industry to DE
   vi. Host ongoing AV car programs
   vii. Transparent reporting
m. Questions
   i. Secretary: Delaware is currently silent laws, is it better to not have?
      1. Better idea to wait until after upcoming election – if bills pass it may preempt anything you do. Find out what will make Delaware attractive moving forward, best for citizens.

6. Presentation by the National Automobile Dealers Association

a. Missing from research: what do consumers think/wants? – measure predictions residing with consumers
b. Surveyed focus groups, 1200 consumers – key findings
   i. Presented data, safety, convenience, money savings (still wanted to own)
   ii. 20% exclusively rideshare, 93% cars provide freedom vs. 7% car is hassle
c. Research in silicon valley focus on VMT – don't look at how people use their cars (e.g. person driving 10 mi each way, 20 per day, or person taking 10 2 mi trips)
d. Average US household – 10 trips in car per day
e. Number of trips, time waiting – another cost

i. Wanted to drill down how people value time
ii. People giving up cars to save $9.44 per hour – 88.5% said they'd have to save 15% to rideshare only; 50%, $50 or more
iii. Time more valuable than money – third finding

f. Traffic could increase with shared autonomy
g. Generally people have favorable idea of AVs – 56% would purchase, this will change over time
h. Safety benefit
i. Owning and rideshare
j. Questions and Discussion:
   i. J. Lardear: how quantitative data? 2 focus groups, LA and Boston; survey with 1200 consumers, oversample 400 millennials.
   ii. Economic and convenience factor
   iii. Senior citizen survey? – yes, haven't used rideshare
   iv. Improve efficiency, less congestion, merging, etc.
   v. Aesthetic – patty; not considered
   vi. Uber – 25% pool trips
   vii. B. Axelrod: is it the responsibility of automakers to educate the consumer?
      1. J. Walsh: Dealers are expected to educate on features of vehicle however after the lengthy purchasing process most consumers are ready to just drive off. It is important to do things that are intuitively user friendly; try to pair phones, getting them fully vested is difficult (under 10% come back to learn)

7. Public Comment

a. D. Hannon: PA has no enacted legislation, but set aside 40,000 dollars for research.
b. Sec. Cohan: MOU is complete, NDA developed (UD Shuttle) – delivery by end of year.

8. Adjourn

a. P. Cannon made the motion to adjourn the meeting and was seconded by B. Axelrod. The motion passed and meeting adjourned at 12:28 PM.

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(Executive Order 14)

Thursday, July 19, 2018
11:00am – 12:30pm
DelDOT Administration Building, 800 Bay Road, Dover, DE
Farmington/Felton Conference Room

AGENDA

- Welcome and Introduction
- Approval of the Previous Meeting Minutes
    - June 21, 2018
- Updates from Subcommittees
    - Promoting Economic Development
    - Technology, Security and Privacy
    - Transportation Network Infrastructure
    - Impacts on Public and Highway Safety
- Update from the Delaware Department of Insurance
- Discuss Final Report
- Public Comment

If you have any questions please contact Lesley Devine at (302) 760-2197.

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Advisory Council on Connected and Autonomous Vehicles (Executive Order 14)

Thursday, July 19, 2018
11:00 AM – 12:30 PM
DelDOT Administration Building, 800 Bay Road, Dover, DE
Farmington/Felton Conference Room

MINUTES

1. Welcome & Introductions

a. The meeting commenced at 11:03 AM. S. Vien filling in for Sec. Cohan, introduced himself and opened the meeting with a round of introductions.

Present Voting Committee Members

Barzilai Axelrod	Attorney General's Office
Phillip Barnes	University of Delaware (UD) Institute of Public Administration
Rep. Ruth Briggs King	State Representatives
Patty Cannon	Division of Small Business, Development and Tourism (DOS)
Scott O'Connor	Delaware Department of Technology and Information (DTI)
Jim Lardear	AAA
Leslie Ledogar	Department of Insurance (DOI)
Jason Walsh	DE Automobile and Truck Dealers Association
Rep. Ed Osienski	State Representatives
William Pfaff	Sussex County
Shari Shapiro	Uber
Scott Vien	DMV
Patrick Wenk	Delaware State Police (DSP)

Absent Committee Members

Jennifer Cohan	Delaware Department of Transportation (DelDOT)
Milton Lee Derrickson	Delaware Motor Transport Association (DMTA)
Renee Gibson	Alliance of Automobile Manufacturers
Reed Macmillian	Dover/Kent Metropolitan Planning Organization
Sen. Brian Pettyjohn	State Representatives
John Sission	WILMAPCO

Also Present

Steve Chillas	OMB
Erin Coombs	Jacobs
Gene Donaldson	DelDOT
Jennifer Duval	Jacobs
Ken Feaster	DOJ
Ken Grant	AAA
Norman Jones	Kirkwood Auto/DASP
Pat Kennedy	FHWA
Rob McCleary	DelDOT
Al McGowan	TrafficCast
CR McLeod	DelDOT
Lloyd Schmitz	Public
Mark Thompson	WhyFly

2. **Approval of Previous Meeting Minutes**
   a. There were two requested amendments to the June 21, 2018 minutes—L. Ledogar was not present at the meeting as listed and S. O'Connor needs to be listed at present.
   b. E. Osienski made a motion to approve the minutes with the requested amendments. Motion was seconded by S. Shapiro. Motion carried and the amended minutes were approved.
3. **Updates from Subcommittees**
   a. Promoting Economic Development
      i. P. Cannon reported that the subcommittee is on task to have the draft report finished before the July 31st deadline.
   b. Technology, Security, and Privacy
      i. S. O'Connor provided update—the subcommittee finalized report content during the 7/19 meeting and plan to submit next week.
   c. Transportation Network Infrastructure
      i. R. McCleary provided subcommittee update.
      ii. Last meeting held on 7/5 and the report submitted to Secretary Cohan.
      iii. R. McCleary thanked committee members for efforts.
   d. Impacts on Public and Highway Safety
      i. M. Luszcz provided update on behalf of G. Dixon
      ii. Subcommittee met 3 times over the summer. The report was approved during the June 25th meeting and submitted to Sec. Cohan.

   iii. M. Luszcz thanked committee members for efforts and work to complete the report.

e. S. Vien thanked everyone for participation and expects to see the overlap of committee discussions in final report

4. Update from Delaware Dept. of Insurance

a. L. Ledogar reported that the draft chapter is finished and she has submitted to the Insurance Commissioner for review before submitting to Sec. Cohan.
   i. In order to develop the chapter, L. Ledogar attended several conferences surrounding CAV/insurance issues
   ii. Typically, she was one of the only members of the insurance sector to be participating in the conversation/no one discussing risks
   iii. It is important to stay ahead of innovation so that when CAV technology is released the department is ready and innovators are encouraged to engage with insurance agencies.

b. B. Pfaff questioned if the insurance ramifications will put barriers on development.
   i. L. Ledogar explained that it is important to educate developers on the purpose of insurance and its design. Insurance can potentially encourage innovation.

c. P. Cannon questioned if the report will address liability shifts.
   i. L. Ledogar responded that report addresses liability shifts at length. The shift from personal liability to vehicle manufacturers (product liability). The idea of pedestrian insurance has also been introduced.

d. S. Vien asked if there has been any discussion between insurance industry and original equipment manufacturers (OEMs) about liability shifts.
   i. L. Ledogar responded that those discussions have not been happening yet but it is important to discuss. The National Association of Insurance Companies has developed task forces for outreach to OEMs.
   ii. There is the issue of who is providing insurance and who provides the vehicle. New providers of mobility allow for a broader picture of liability.

5. Discuss Final Report

a. Subcommittee reports are due 7/31 to Sec. Cohan. Draft of final report anticipated at the August 16th meeting.

6. Public Comment

a. L. Schmitz concerned about multi-lane roadways and the consideration for CAVs to be placed in the left lane to account for people with disabilities.

b. L. Schmitz mentioned the impact to state revenue since the DMV will potentially lose relevancy and the impacts to municipalities.
   i. P. Barnes discussed how the UD Institute of Public Administration is researching state and local fiscal impacts—policy brief will be available on IPA website.

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7. Next Meeting

a. The next subcommittee meeting is scheduled for August 16th, 2018 from 11:00 AM – 12:30 PM. R. Briggs King made a motion to adjourn the meeting. E. Osienski seconded and the motion was approved. The meeting adjourned at 11:40 AM.

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(Executive Order 14)

Thursday, August 16, 2018
11:00am – 12:30pm
DelDOT Administration Building, 800 Bay Road, Dover, DE
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AGENDA

- Welcome and Introduction
- Approval of the Previous Meeting Minutes
  - July 19, 2018
- Updates from Subcommittees on Final Reports
  - Promoting Economic Development
  - Technology, Security and Privacy
  - Transportation Network Infrastructure
  - Impacts on Public and Highway Safety
- Update from the Delaware Department of Insurance
- Discussion on Final Report and Recommendations
- Presentation by University of Delaware and Nuvve Corporation
- Public Comment

If you have any questions please contact Lesley Devine at (302) 760-2197.

DelDOT

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DEPARTMENT OF TRANSPORTATION
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JENNIFER COHAN
SECRETARY

Advisory Council on Connected and Autonomous Vehicles (Executive Order 14)

Thursday, August 16, 2018
11:00 AM – 12:30 PM
DelDOT Administration Building, 800 Bay Road, Dover, DE
Farmington/Felton Conference Room

MINUTES

1. Welcome & Introductions

a. The meeting commenced at 11:04 AM. Sec. Cohan introduced herself and indicated the purpose of the meeting was to approve subcommittee recommendations for the final Advisory Council report to the Governor due September 5, 2018. Sec. Cohan opened the meeting with a round of introductions.

Present Voting Committee Members

Philip Barnes	University of Delaware (UD) Institute of Public Administration
Rep. Ruth Briggs King	State Representatives
Patty Cannon	Division of Small Business, Development and Tourism (DOS)
Jennifer Cohan	Delaware Department of Transportation (DelDOT)
Milton Lee Derrickson	Delaware Motor Transport Association (DMTA)
Leslie Ledogar	Department of Insurance (DOI)
Reed Macmillan	Dover/Kent Metropolitan Planning Organization
Scott O'Connor	Delaware Department of Technology and Information (DTI)
Rep. Ed Osienski	State Representatives
William Pfaff	Sussex County
Cathy Rossi	AAA Mid-Atlantic
John Sisson	WILMAPCO

Absent Committee Members

Barzilai Axelrod	Attorney General's Office
Patrick Wenk	Delaware State Police (DSP)
Renee Gibson	Alliance of Automobile Manufacturers
Brian Pettyjohn	State Senate
Terry Megee	DE Automobile and Truck Dealers Association

Shari Shapiro	Uber

Also Present

Steve Chillas	Delaware OMB – Contracting
Erin Coombs	Jacobs
Annie Cordo	DOJ
Gene Donaldson	DelDOT
Ken Grant	AAA Mid-Atlantic
Shante Hastings	DelDOT
Willett Kempton	UD
Pat Kennedy	FHWA
Jim Lardear	AAA Mid-Atlantic
Lizzie Lewis	Hamilton Goodman Partners, LLC
Mark Luszcz	DelDOT
Rob McCleary	DelDOT
Colton Phillips	DelDOT – Planning
Todd Reavis	DelDOT – Technology and Innovation
Megan Rosica	Jacobs
Ted Smith	Nuvve Corporation
David Weir	UD

2. **Approval of Previous Meeting Minutes**
   a. There were two requested amendments to the July 19, 2018 minutes—R. MacMillan should be listed as present, and Philip Barnes is spelled with one 'l' rather than two.
   b. L. Ledogar made a motion to approve the minutes with the requested amendments. Motion was seconded by E. Osienski. Motion carried and the amended minutes were approved.
3. **Presentation by University of Delaware and Nuvve Corporation**
   a. D. Weir reviewed UD's partnership with the Nuvve Corporation related to Grid Integrated Vehicles (GIV) with Vehicle-to-Grid (V2G) initiatives and introduced W. Kempton who provided a detailed presentation about UD's research and development.
      i. Concept of electric vehicles (EVs) as grid storage capability and aggregating EVs for power storage
      ii. EV, V2G and AV
         1. Highly compatible, V2G produces value and can produce revenue when an EV is parked
         2. AV/EV could go to nearby plug/build/substation when not in use.
      iii. UD created V2G – licensing started 2011

1. Patents for: aggregator, vehicle smart link (VSL), smart charging station

iv. W. Kempton reviewed Nuvve initiatives happening worldwide – including locations in Denmark, United Kingdom, and California

v. Delaware Activities
1. Demonstration of grid services along with bill reduction at STAR campus
   a. EVs with GIV and V2G capability
   b. Stationary batteries dispatched for grid services along with EVs
2. Technology demonstrated with PJM Interconnection registration and revenue
3. Proposed project with Delmarva Power to manage EV charging (reduce need to power system upgrades) – decision pending.

b. Potential acceleration
   i. State fleets good for GIV/V2G in Delaware
   ii. Could incentivize transit use
   iii. DNREC tax credits for work place charging stations and EVs
   iv. Adjust credits to add for GIV/V2G

c. Questions & Discussion
   i. R. Briggs King – car batteries can ignite and are difficult to extinguish – is battery storage a consideration as far as safety purposes?
      1. UD is not developing battery packs as part of this research and development; they are managing battery packs made by auto manufacturers.
      2. Fewer battery fires than gasoline fires – still hazard that needs to be managed and auto manufacturers are aware.
      3. OEM have override power if UD is heating batteries too much
   ii. P. Cannon – is there a system in place to protect the decline in technology functionality?
      1. OEMs perform a lot of testing so things don't go wrong
      2. There is a diagnostic system in place for problems
   iii. P. Barnes – are there policy changes regarding electricity usage being considered to incentivize more rollout in DE?
      1. To make this possible: there has to be allowance for storage behind meter – adding refinement for SAE J372; there are rules required to operate (in place in other countries, NJ, NY).
      2. To incentivize: EV purchase, workplace charging stations in place; add incentive to make more common, perhaps retrofitting initially, maybe for school buses which are building in AC directional systems.

iv. E. Osienski – Instead of going to grid can power go to household use, for example?
   1. Yes – fewer transactions, higher efficiency.
   2. Operating based on local company (i.e. Delmarva) and grid operator.

v. R. McCleary – Does an EV owner know whether their vehicle is being used to charge grid? Is there any policy that prohibits that today?
   1. If using an employee lot or home charging station users do not know; can look on app to see that charging is happening –legally need permission from owner, but what power is going toward is not obvious, it will just say “charging.”
   2. Have to deliberately say what kind of charge the vehicle needs –tell app how much charge the car needs, or tell app that the car needs to be charged as fast as possible.

4. Discussion Final Report and Recommendations

a. Promoting Economic Development
   i. The Council decided that the subcommittee should include a recommendation to develop financial incentives in order to attract new CAV technology-related companies, especially those focusing in robotics, sensors, and software development, to encourage and attract businesses to locate in Delaware.
   ii. P. Cannon emphasized the need for legislation that supports economic development (existing and future) to include the need for robotics, sensors, and software development.
   iii. L. Ledogar made a motion to approve the subcommittee’s recommendations as amended. S. Chillas seconded and the motion passed.

b. Technology, Security, and Privacy
   i. Sec. Cohan asked for clarification of who is responsible for encrypting and anonymizing CAV data, as stated in the recommendations. S. O’Connor responded that there is ongoing discussion about whether the State or OEMs are responsible, and since this has not yet been determined the language was kept general. Sec. Cohan agreed it is best to keep this language broad in the recommendations.
   ii. Sec. Cohan asked for clarification on the term “living communications plan” in reference to the subcommittee’s recommendation to continue to keep citizens informed on data collection, use, and storage. S. O’Connor responded the term “living” is meant to indicate the communications plan will be regularly updated.
   iii. The subcommittee’s first recommendation for Potential State Legislation was amended to be geared towards federal legislation for automakers to provide plain language consent forms to owners.

iv. The subcommittee's third recommendation for Potential State Legislation was amended to be specifically for state legislation and to add rental car providers to those who should be required to wipe vehicle data clean before resale.

v. W. Pfaff made a motion to approve the subcommittee's recommendations as amended. S. Chillas seconded and the motion passed.

c. Transportation Network Infrastructure

i. Sec. Cohan suggested amending the recommendation to establish CAV testing grounds to include deployment in addition to testing.

ii. Sec. Cohan indicated that the subcommittee's recommendation for Potential State Legislation regarding Delaware code encourage all companies manufacturing and/or operating CAV on Delaware's roadway to collect and share data specific to roadway and traffic conditions is applicable on a federal level.

iii. Sec. Cohan indicated that the final report from the Advisory Council should include considerations of impact to the State fleet after deployment.

iv. J. Sisson made a motion to approve the subcommittee's recommendations as amended. S. Chillas seconded and the motion passed.

d. Impacts on Public and Highway Safety

i. P. Barnes requested more information about the $2.8 billion figure for the cost to society of highway crashes indicated in the discussion section of the subcommittee's final report. After a separate discussion, M. Luszcz and P. Barnes agreed the $2.8 billion figure was defensible.

ii. P. Cannon made a motion to approve the subcommittee's recommendations. W. Pfaff seconded and the motion passed.

e. Delaware Dept. of Insurance

i. P. Cannon suggested adding a note to the potential state legislation recommendation regarding the need for evidence of a testing entity's ability to satisfy a judgment for damages for personal injury, death, or property damage caused by a CAV to include that innovation and creativity will not be stifled by the need for coverage. The Council agreed the language can be softened as to not scare away potential companies.

ii. S. O'Connor made a motion to approve the subcommittee's recommendations as amended. P. Barnes seconded and the motion passed.

5. Public Comment

a. There was no additional comment from the public.

6. Next Meeting

a. All subcommittee chairs were directed to send their recommendation/report edits to the Jacobs team to make adjustments as the final report is completed. The final report is anticipated to be completed and sent to the Council for final review before the end of the week of August 27th.
b. The Council agreed that a formal submittal of the final report to the Governor should occur as an opportunity for public outreach. A specific date was not decided upon during this meeting.
c. W. Pfaff made a motion to adjourn the meeting. J. Sisson seconded and the motion was approved. The meeting adjourned at 12:46 PM.

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