Operations and Technology Education Needs for Automated Vehicle Users and Stakeholders

Texas CAV Task Force
Subcommittee on Licensing and Registration

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Disclaimer

The contents of this white paper reflect the views of the Texas CAV Task Force members, who are responsible for the information presented herein. The contents do not necessarily reflect the official views or policies of the State of Texas or any Texas state agencies. The white paper does not constitute a standard, specification, or regulation, nor does it endorse standards, specifications, or regulations. This white paper does not endorse practices, products, or procedures from any private-sector entity and is presented as a consensus broad opinion document for supporting and enhancing the CAV ecosystem within Texas.

Texas CAV Task Force Charter

The Texas CAV Task Force was created at the request of Texas Governor Greg Abbott in January 2019. The task force is responsible for preparing Texas for the safe and efficient rollout of CAVs on all forms of transportation infrastructure.

The primary functions are:

1. Coordinating and providing information on CAV technology use and testing in Texas.
2. Informing the public and leaders on current and future CAV advancements and what they mean in Texas. This process includes reporting on the current status, future concerns, and how these technologies are changing future quality of life and well-being.
3. Making Texas a leader in understanding how to best prepare and wisely integrate CAV technologies in a positive, safe way, as well as promoting positive development and experiences for the state.

The CAV Task Force is composed of a voting group of no more than 25 members and represents the full spectrum of CAV stakeholders.

Terminology Note

The Texas CAV Task Force addresses the full spectrum of connected, automated, and autonomous vehicles. An *automated vehicle* refers to a vehicle that may perform a subset of driving tasks and requires a driver to perform the remainder of the driving tasks and supervise each feature's performance while engaged. The performance capabilities of automated and autonomous vehicles

consist of levels 0–5 with level 0 having no driving automation and level 5 having full automation, with automation increasing at each progressive level. A fully autonomous vehicle can perform all driving tasks on a sustained basis without the need for a driver to intervene.

These definitions are still blurred in common discussions and language. Currently, the industry is developing automated vehicle capability while pursuing fully autonomous vehicles. The white papers generally use the term *autonomous* to refer to vehicles with fully autonomous capabilities and the term *CAV* to refer to the grouping of connected, automated, and autonomous vehicles. Please see the 2021 terminology white paper for a full listing of terms and definitions used in this developing technology ecosystem.

List of Terms and Acronyms

AAA	American Automobile Association
ACC	adaptive cruise control
ADAS	advanced driver assistance system
ASA-Texas	Automotive Service Association of Texas
BSW	blind spot warning
CAV	connected and autonomous vehicle
NHTSA	National Highway Traffic Safety Administration
OEM	original equipment manufacturers
PAVE	Partners for Automated Vehicle Education
POI	program of organized instruction
RSO	right-seat operator
SAE	Society of Automotive Engineers
TDLR	Texas Department of Licensing and Registration
TTI	Texas A&M Transportation Institute
TxDOT	Texas Department of Transportation
UTA	University of Texas at Arlington

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Executive Summary

Vehicles with automated features and autonomous vehicle deployments are rapidly growing in number. However, the public has a general level of confusion regarding what these automated and autonomous features are truly capable of, which can lead to a false sense of security or drivers operating vehicles in a manner in which they were not intended. Education and guidance are critical needs for the public so that they can fully understand vehicle technologies and operate them safely. This white paper details a literature review and stakeholder interviews conducted to gather information on how to best inform the public and automated and autonomous vehicle stakeholders about what is needed to improve and expand the education of owners and operators of automated and autonomous vehicles. The takeaways from this process include:

- Using consistent terminology is important,
- Automated vehicle technology is intended to increase safety by assisting in some of the driving tasks, such as lane-keeping assistance, automatic emergency braking, or adaptive cruise control, which can ultimately reduce the severity of or even prevent crashes.
- Automated vehicles still require a driver in the driver's seat or a safety operator in the case of shuttles and freight.
- Autonomous vehicles are those vehicles where no driver is needed at all. Further compounding the issue, naming conventions for vehicle technology and the description of how technologies can be used lead to greater misperceptions.
- There is a great need to use consistent terminology, accurately describe the intent of vehicle technology, and promote the general understanding of automated and autonomous vehicles.

Due to this continued high level of misunderstanding and misconceptions about CAV technologies and capabilities, several key opportunities exist, including:

- Collaborating with automobile manufacturers and dealers,
- Consider mandating manufacturer-led training for service and collision technicians,
- Using chat rooms or discussion boards for sharing information between service and collision technicians
- Providing educational materials in multiple formats for different audiences (e.g., a printed document versus a video distributed on the internet),
- Embracing autonomous vehicle deployments will enhance public understanding,
- Including the correct stakeholders in discussions,
- Recognizing the potential value of vehicle safety inspections,
- Updating crash reporting to reflect automated vehicles, and
- Planning for the use of data from connected and autonomous vehicles (CAVs) to improve safety and reduce congestion.

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Introduction

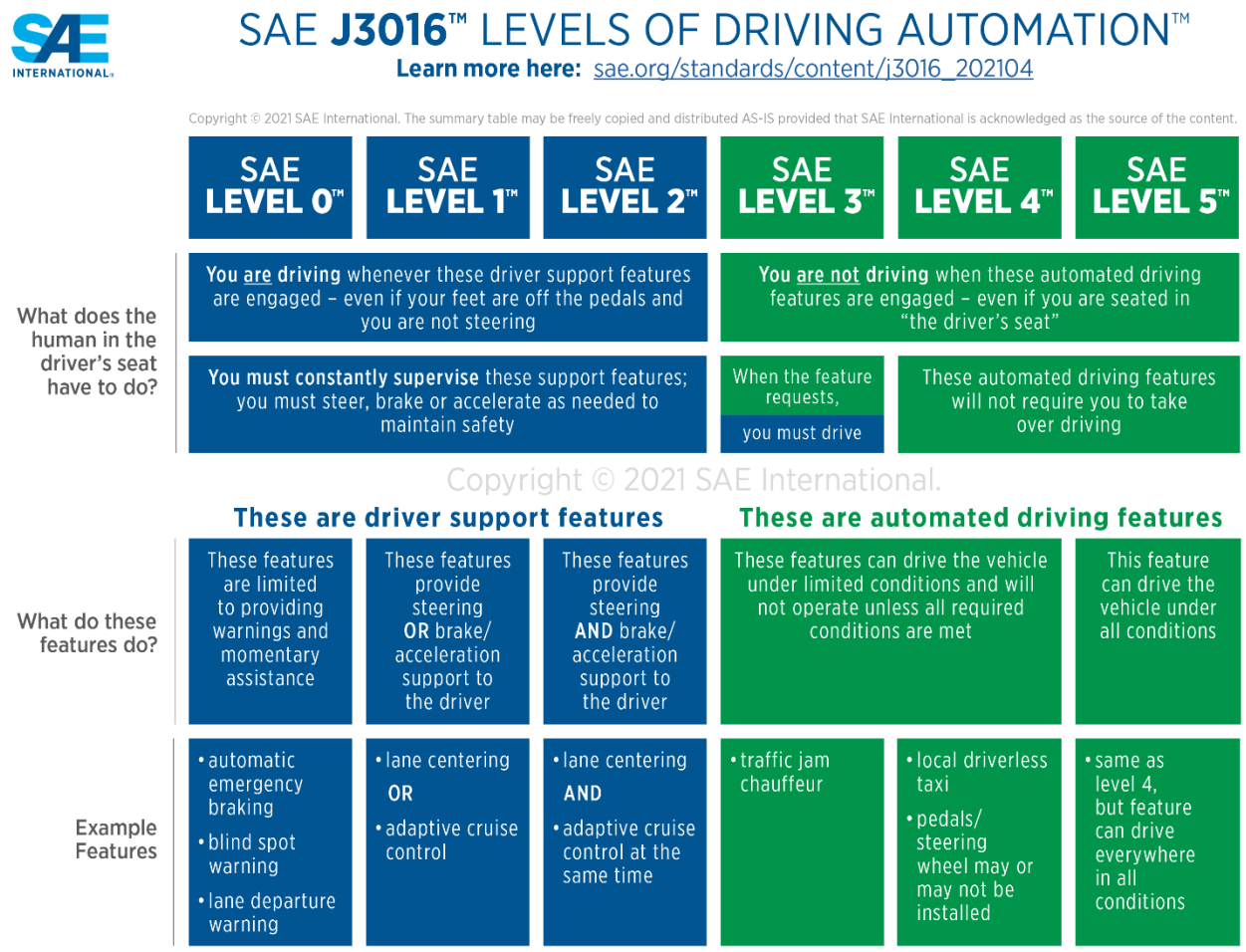
Vehicles with automated features and autonomous vehicle deployments are rapidly growing in number. However, the public has a general level of confusion regarding what these automated and autonomous features are truly capable of, which can lead to a false sense of security or drivers operating vehicles in a manner in which they were not intended. Education and guidance are a critical need for the public so that they can fully understand vehicle technologies and operate them safely.

The purpose of this document is to identify the public perception issues related to automated and autonomous vehicles, as well as document the needs for industry partners as automated and autonomous vehicle technologies continue to advance. Relevant literature was reviewed to form a basis for how the public understands the technology on automated and autonomous vehicles. Stakeholders were interviewed to identify agency and stakeholder needs and concerns.

Background

According to the American Automobile Association (AAA) (*1*), in May 2018, more than 90 percent of new cars in the U.S. market had at least one automated technology feature available. As of February 2021, 58 percent of the respondents in the annual AAA Annual Automated Vehicle Survey wanted an advanced driver assistance system (ADAS) feature on their next vehicle, and nearly 96 percent of 2020 vehicle models had at least one ADAS feature (*2*). As of May 2021, 38 states have active self-driving vehicle deployments (*3*). Automated vehicle technology is expanding, and drivers are becoming more comfortable with the technology. This paper discusses how people understand automated technology and what the different automated vehicle stakeholders want to be included in operations education for users of automated vehicles, including freight, passenger vehicles, and shuttles.

ADASs are automated features, such as automatic emergency braking, lane-keeping assistance, and adaptive cruise control that can help drivers with driving tasks and enhance safety by preventing crashes. Automated technology features help drivers alleviate some driving tasks and increase safety by preventing and mitigating accidents. When automated technology features are engaged, drivers should remain aware and engaged with the driving task and be ready and able to take over control of the vehicle at any point in time. Level 2 automated vehicles include vehicles with ADAS features and are not intended to be self-driving. Figure 1 highlights the Society of Automotive Engineers (SAE)–defined levels of automation and includes feature descriptions, which were created by SAE International (*4*).



Source: SAE International

Figure 1: SAE-Defined Levels of Automation

Self-driving pilot deployments (e.g., freight, passenger vehicle, and shuttle operations) are occurring across the United States, with safety operators in the driver's seat in many of the deployments. Uncertainty, media scrutiny, and a general lack of understanding can lead the public not to trust automated and autonomous vehicles. If the public lacks trust and confidence in the ADAS features or finds them confusing or intimidating, people may be less likely to use them. Individuals spending more time around automated and autonomous vehicles are more likely to have increased understanding, and their stress related to automated vehicles and the technology is alleviated (*1*, *5*). The first step is getting the public to use the technology so that their general understanding of how the technology works can improve. As market penetration continues and more people begin to use more automated features on their vehicles, their trust that the technology is safe improves. Owners of automated vehicles can share their experiences with others, further generating public acceptance. Autonomous shuttle deployments with safety drivers and other public events where the public can interact with the vehicles can also improve general understanding and acceptance.

The National Highway Traffic Safety Administration (NHTSA) recommends that original equipment manufacturers (OEMs) develop education and training programs to help users safely and adequately use the different ADAS features. Education can reduce the risk of misuse and misunderstanding (*6*). A 2018 survey completed by the Advocates for Highway and Auto Safety discovered that 87 percent

of respondents wanted a website to find information on safety features for automated vehicles (*7*). In 2014, the University of Iowa partnered with the National Safety Council to develop the website MyCarDoesWhat (http://mycardoeswhat.org) to help the public better understand ADAS features and technologies. The website offers information about how the different technologies work, when they should be used, which vehicles have ADAS features, and more. Consumer Reports also has a tool available online for the public to determine which automated technology features are standard, optional, or not available on vehicles (*8*).

Several studies have been completed to determine how drivers learn and understand different ADAS technologies. Forster et al. studied different methods to educate users about ADAS features before driving in a simulator (*9*). The researchers used three different education methods with participants:

- A general overview of the technology,
- A review of the owner's manual, and
- An interactive computer-based tutorial.

The researchers found that reviewing the owner's manual and completing the interactive tutorials increased operation and understanding of the system and features compared to those who only received general guidance *(9)*.

Llaneras et al. completed a study on training and how participants responded to system alerts (*10*). The researchers found that while the training helped, it did not eliminate the misunderstandings the participants had about the ADAS features. The researchers also found that when the participants were penalized (e.g., the ADAS feature was shut off) for ignoring system alerts, they remained more engaged in the driving task and were more mindful of the vehicle warnings while driving *(10)*.

Public Confusion about Terminology

For the public, understanding automated and autonomous vehicles is complicated because OEMs, research organizations, and other automated vehicle stakeholders and agencies use different terminology to describe the same features. Furthermore, misleading feature names can lead drivers and the public to think that some features are capable of performing in ways for which they were not designed. One of the common misconceptions is related to the term *autopilot*, which can lead the public to believe the car can drive itself. However, that is not the current intent of that feature because the driver is still required to be engaged in the driving task.

In 2019, AAA found that adaptive cruise control and lane-keeping assist can each have up to 20 different names (*1*). AAA and Consumer Reports have recommended that OEMs and other agencies normalize the terminology for ADAS features, especially when they perform the same task. Using the same terminology can decrease the misconceptions that drivers and the public face (*1*, *8*). A group of 10 organizations, including AAA, the Insurance Institute for Highway Safety, J.D. Power, the National Safety Council, and several others, have agreed to use these six common terms: forward collision warning, automatic emergency braking, adaptive cruise control, blind spot warning, lane departure warning, and lane-keeping assist (*11*). Table 1 provides these terms, their acronyms, and a feature description.

Table 1: Consumer Reports' List of Acronyms, Terms, and Descriptions

Acronym	Automated Technology Feature	Description
ACC	Adaptive cruise control	Uses lasers, radar, cameras, or a combination of these systems to keep a safe following distance between the ACC-fitted car and the car ahead.
AEB	Automatic emergency braking	Automatically applies brakes to prevent a collision or reduce speed when the system detects an imminent collision with a vehicle directly in front.
BSW	Blind spot warning	Provides visual and/or audible notification of a vehicle in the blind spot. The system may provide an additional warning if the driver uses the turn signal when a car is in another lane next to the BSW-fitted car.
FCW	Forward collision warning	Provides visual and/or audible warning to alert the driver and prevent a collision.
LDW	Lane departure warning	Provides visual, audible, or haptic warning to alert the driver when the vehicle crosses lane markings.
LKA	Lane-keeping assist	Provides automatic corrective steering input or braking when crossing lane markings.

Source: Consumer Reports

The naming conventions and resulting misconceptions are just one reason drivers need to understand the true intent and limitations of the automated technology features. As a result of misconceptions, drivers misuse the technology and subsequently engage in risky behavior while driving. For instance, a 2018 AAA survey found that 13 percent of respondents would feel comfortable performing a separate task outside of driving while an ADAS feature was engaged (*12*). This result could indicate problems with the use of the term *autonomous* and not with the ADAS technology itself.

Current Perspectives and Understanding

Texas A&M Transportation Institute (TTI) staff reviewed relevant literature to understand how people understand automated vehicles and technology. This information can help the Texas Department of Transportation (TxDOT) understand what information needs to be shared with automated and connected vehicle users. The literature review attempts to address the following questions:

- What educational or outreach strategies are others using to inform drivers (e.g., videos, websites, social media campaigns, etc.)?
- Do users understand the technology on the vehicles? How is this comprehension being assessed or measured?
- Are any feature-based educational tools or strategies available through manufacturers, associations, or third parties?
- How are states preparing for crashes or emergencies involving automated vehicles?

Automated Vehicle Technology and Human Behavior

An area of concern when implementing automated technology relates to human behavior. Recent surveys have shown that there is fear and a lack of trust among the public regarding automated vehicle technology. There is also concern that individuals may intentionally and sometimes even maliciously interact in risky ways with automated vehicles. For example, Banks et al. conducted a study in the United Kingdom that found that drivers were more likely to try to test the ADAS features in risky situations by purposefully trying to make the technology interact in unintended ways (*13*). At times, drivers want to try to break the technology to prove or disprove whether the technology will perform in an intended way. Another example of risky situations where the public tries to test out the technology is when nearby pedestrians run in front of an automated shuttle to see if it will stop, which was often witnessed in the City of Las Vegas automated shuttle deployment. The public may be told the technology is sound, but the public often needs to see it to believe it. As more people participate in automated shuttle and automated vehicle pilot programs, these people can see firsthand that the technology works. Automated vehicles must also learn how to interact with their environments and adapt to different situations. An automated vehicle that works well in one location may not work well in other areas or may take additional time to learn about the new environment.

Oliver et al. found that automated vehicles face challenges in understanding human behavior, but the researchers argued that automated vehicles would improve the more they are used in real-world situations (*14*). After an incident occurs with an automated vehicle, the lessons learned from the incident can be added to the software and updated on all automated vehicles in the area or owned by a manufacturer, thus increasing safety. They conclude that the continued advancement of the technologies will take place when they are in the driving environment and interacting with other vehicles. (*14*).

Public Knowledge and Perceptions of Automated Vehicle Technology

The general confusion about the functionality of automated technology and features and, in some cases, the deliberate misuse of the technology are causes for concern. In January 2014, the University of Iowa received grant funding to see how well drivers understood and to what level they used the different ADAS features available in their vehicles. In 2015, researchers completed the National Consumer Survey of Driving Safety Technologies, highlighting the need for public education because many respondents did not fully understand ADAS features. More than half of respondents (65.2 percent) had at least some confusion regarding ACC, and only 35 percent had any knowledge of or experience with it. Moreover, 40 percent of respondents reported that they experienced the vehicle behaving in a way that they did not expect (*15*).

A 2018 study completed by AAA surveyed owners of vehicles with ADAS features and found that 83 percent of the respondents were first-time owners of ACC. In addition, 52 percent of respondents reported that they did not know how the ADAS feature worked when they purchased the vehicle. Only 45 percent remembered being offered any training on any ADAS features at the dealership. Ninety percent of the respondents revealed that they had since gained knowledge of the features and felt more comfortable the more they used ADAS (*12*).

Since 2016, AAA has also completed annual national vehicle technology surveys using a total of 1,832 interviews among drivers who are 18 years of age or older. The survey completed in January 2017 found that 78 percent of respondents were scared to ride in fully automated vehicles.

However, public acceptance has been shifting in recent years. More people are opening up to the idea of riding in fully automated vehicles, as indicated by the survey completed in December 2017. The survey found that only 63 percent of the respondents were scared to ride in a fully automated vehicle, meaning public acceptance had increased by 15 percent within the year (*16*). As the public spends more time interacting with the technology, the trust and understanding of the technology will likely increase. AAA also contends that "transparent, accurate and frequent information from the industries involved in developing self-driving vehicles will ease consumer concerns" (*2*). Table 2 summarizes the AAA Annual Automated Vehicle Survey results from 2016 through 2019 (*17*, *18*, *1*, *19*).

Table 2: Summary of 2016–2019 AAA Annual Automated Vehicle Survey Results

Survey Information	Phase I	Phase II	Phase III	Phase IIIB	Phase IV
Survey period	January 2016	January 2017	December 2017	April 2018	January 2019
Respondents	1,832	1,012	1,004	1,014	1,008
Percent of respondents afraid to ride in a fully automated vehicle	75%	78%	63%	73%	71%
Percent of women afraid of fully automated vehicle	81%	85%	73%	83%	N/A
Percent of men afraid of fully automated vehicle	67%	69%	52%	63%	N/A
Percent of respondents who want at least one automated technology feature on their next vehicle	61%	59%	51%	55%	N/A

Source: AAA

In 2020, AAA changed the methodology for the Annual Automated Vehicle Survey, so the results are not directly comparable to previous years. The new survey methodology used a probability-based panel that was more characteristic of the U.S. household population, providing sample coverage of roughly 97 percent of the U.S. household population. The survey results indicated that only 12 percent of the respondents would trust a self-driving vehicle, and 28 percent of the respondents were not sure how they would feel about the self-driving technology (*19*). In the 2021 Annual Automated Vehicle Survey, the results were similar to those from the previous year, with only 14 percent of the respondents indicating that they would trust a self-driving vehicle, and 32 percent of the respondents were not sure how they would feel about the self-driving technology (*1*). AAA believes that reliable information will build customer trust for automated and autonomous vehicle technologies (*1*). Table 3 summarizes the AAA Annual Automated Vehicle Survey results from 2020 and 2021 (*19, 2*).

Table 3: Summary of 2020–2021 AAA Annual Automated Vehicle Survey Results

Survey Information	January 2020	January 2021
Respondents	1,301	1,010
Percent of respondents who would trust a self-driving vehicle	12%	14%
Percent of respondents unsure of how they felt about self-driving vehicles	28%	32%

Source: AAA

A 2016 survey sponsored by State Farm found that less than 11 percent of respondents had ridden in some form of automated vehicle, and less than 40 percent were willing to ride in a vehicle with automated capabilities. The survey also found that educated men under the age of 40 were more likely to be comfortable with and use automated vehicles (*20*). A 2016 national survey sponsored by Kelley Blue Book found that 60 percent of respondents knew little to nothing about automated vehicles, with 76 percent of respondents between the ages of 51 and 64 feeling like they knew little to nothing and 19 percent of respondents between the ages of 25 and 34 feeling like they knew a lot. The survey revealed that current owners of vehicles with ADAS features were more open to the idea of using even more automated vehicle technologies (*21*). These survey results may indicate that younger drivers who understand technology may be more open to the idea of automated vehicles.

A 2017 survey completed by the Pew Research Center found that only 6 percent of respondents did not have any knowledge of fully automated vehicles, while 35 percent of respondents thought that they knew a lot about them. The survey also found that 54 percent of the respondents were scared of fully automated vehicles and that educated men were more likely to have heard more about and be more open to fully automated vehicles. In addition, 39 percent of respondents thought that fully automated vehicles would reduce the number of injuries and fatalities in automobile accidents (*22*). The State Farm and Pew Research Center surveys both indicate that educated men are more likely to be open to the idea of automated vehicles. A 2017 survey completed by the Advocates for Highway and Auto Safety found that 64 percent of respondents were worried about having fully automated vehicles on the roadways, and 84 percent believed that there should be a way to guarantee that the driver stays engaged in the driving task (*23*).

Finally, a study by Pradhan et al. found that owners generally felt safer as a result of the automated technology features but were concerned that drivers could become overly dependent on the technology and would lead them to participate in distracted and risky driving behaviors (*24*). The researchers argued that OEMs should take more time to understand human behavior and develop these ADAS features accordingly, ultimately increasing safety in automated vehicles and improving public perception *(24)*.

As the technology continues to advance, it is important to make sure that drivers fully understand the capabilities and limitations of automated vehicles. Without this understanding, public acceptance may be diminished, and society may not fully realize the safety and other societal benefits of automated vehicles.

Stakeholder Interviews

Outreach to several stakeholders was conducted in late 2021 and early 2022 to determine how automated vehicle users understand the technology. TTI staff conducted interviews with several organizations, manufacturers, and operators. Table 4 shows the stakeholder interview information.

Table 4: Stakeholder Interview Information

Type	Stakeholder	Interview Date
Association	Texas Automobile Dealers Association	January 21, 2022
	Automotive Service Association of Texas (ASA-Texas)	January 4, 2022
	Texas Trucking Association	December 13, 2021
Private company	Audi and Partners for Automated Vehicle Education	March 16, 2022
	Wejo	February 25, 2022
	May Mobility	January 26, 2022
	Kodiak Robotics	December 20, 2021
Government	Texas Department of Licensing and Regulation	January 6, 2022
	City of Arlington, Texas	December 20, 2021

The American Automobile Association (AAA) provided information via email. TTI staff contacted the following organizations, but representatives did not respond to TTI's request for an interview:

- American Association of Motor Vehicle Administrators,
- American Car Rental Association,
- Governors Highway Safety Association,
- Motor and Equipment Manufacturers Association,
- Cadillac,
- Tesla,
- Volvo,
- EasyMile,
- TuSimple, and
- Embark.

TTI staff developed an interview guide, but based on the interviews, additional questions were asked, and questions that were not relevant to the stakeholder were eliminated. The following questions guided the interviews:

- How does the technology work with the driver?
- What are the gaps in the technology?
- Is an educational component offered for users to understand vehicle features and services?
- How might different ownership models affect driver use of automated vehicles—rental, mobility as a service, and subscription models?
- Is anything being done to address licensing and registration that needs to be identified?
- Do users understand the technology on the vehicles? How is this measured or assessed?
- Are there any feature-based educational tools or strategies available (i.e., how do dealers educate car owners on features)?

- How are vehicles and associated technologies monitored and maintained?
- What policies exist for when an accident or emergency occurs? What are the unique or special circumstances of the vehicle's technologies that can pose issues for occupants or first responders?

TTI staff conducted the interviews using Microsoft Teams. TTI staff informed each stakeholder that any proprietary information discussed in the interviews would not be included in the paper without permission. TTI staff recorded each interview, except the Texas Automobile Dealers Association interview because it was a phone call only. Each interview lasted approximately 30 minutes.

Texas Automobile Dealers Association

TTI staff interviewed a Texas Automobile Dealers Association representative on January 21, 2022. Many automobile dealers now use product specialists to provide automobile consumers with the necessary information to safely operate their new vehicles with full knowledge. These product specialists review the vehicle's manual and often walk through all the vehicle's features and answer any questions with the owner.

As more automated vehicles enter the market, automobile dealers consider it critical that they have the ability and tools to fix malfunctions associated with the automated features. Manufacturers also need to provide training materials to automobile dealers because every car is different. The key to the successful deployment of automated vehicles will be coordination and collaboration between dealers and manufacturers. If vehicle features are difficult to repair, this could lead to extended periods of time without a driver's ability to use them, which could encourage drivers to use the features less when they do get repaired.

Automotive Service Association of Texas

TTI staff interviewed representatives from ASA-Texas on January 4, 2022. ASA-Texas has been actively engaged in the automated vehicle space for several years. One of its primary concerns related to automated vehicles is vehicle safety inspections. ASA-Texas believes that vehicle safety inspections for automated vehicles will be critically important because the ownership model may change from individuals to a fleet-owned or shared-ownership model. In either case, clear responsibility for the inspections must be identified. In the future, autonomous vehicles could be owned by individuals or groups and used by multiple different people, so the user may not know or trust the owner, which could lead to increased fear about the safety of the vehicle from the user's perspective. ASA Texas suggested ensuring that automated and autonomous vehicle features undergo vehicle safety inspections can help inform passengers that the vehicle is safe to operate on roads.

While service technicians are working on vehicles with ADAS features and there have not been any major problems, service provider training is another area of concern for ASA-Texas because there is a need for direct training from the car manufacturer. ASA-Texas would prefer that the manufacturer-led training be mandated at the state or federal level. Otherwise, the training would be too slow. Training is needed now, especially for collision repair technicians. For the many automated vehicles that are still under warranty, the owner can go directly to the automobile dealer for service. For those vehicles not under a manufacturer's warranty or those involved in a collision, non-dealer service and collision repair technicians need training now.

Service technicians have been continually active in chat rooms to discuss any questions about the innovative technologies in vehicles today. The chat rooms are extremely popular and serve as an excellent resource for service technicians. A threat in the industry is that if the training and specialized equipment, which are often expensive, are not provided, it will be harder to prepare and retain qualified technicians.

Texas Trucking Association

TTI staff interviewed representatives from the Texas Trucking Association on December 13, 2021. Many companies are actively pursuing automated trucking and are working with carriers and cargo owners. There are concerns about how law enforcement agencies are prepared for the inevitable crashes or incidents with automated trucks. For example, how will accident investigations be conducted, and how will information be captured in crash-reporting forms? How should state law be adjusted to ensure public agencies have access to the necessary information to investigate crashes and collect applicable details?

Audi and Partners for Automated Vehicle Education

TTI staff interviewed representatives from Audi and the Partners for Automated Vehicle Education (PAVE) on March 16, 2022. PAVE is a coalition of industry nonprofits and academics that supports and promotes the education of automated vehicles to the general public to raise awareness about the benefits of driverless technology (*25*).

Audi currently has level 2 automated vehicles on the market, which means that the driver is still engaged in the driving task. The level 2 systems are becoming increasingly sophisticated, and Audi hopes to get to the point where these systems can monitor the driver's attention to the driving task. This action could lead Audi to develop technology that can limit the number of distractions that take away from the driving task and relieve the driver's cognitive overload.

New-owner training occurs at the dealership, and the sales personnel receive abundant training to train the new owner on the technologies in the automated vehicle. Sales personnel attend classes and have on-demand video training that they can complete. The owner's manual is another resource for new owners regarding the technologies in their automated vehicle. Audi is looking to develop short pamphlets that can be used for owner education. When educating owners on the innovative technologies, it is essential to remember people learn in diverse ways (e.g., auditory, kinesthetic, or visual), so different training methods will be necessary.

Wejo

TTI staff interviewed representatives from Wejo on February 25, 2022. Wejo is a company that collects data from autonomous and connected vehicles to improve vehicle safety by providing indirect benefits to users. Wejo primarily works with OEMs and research organizations to analyze and evaluate connected and autonomous vehicle data. The data collected from vehicles can be analyzed to identify the location of potholes in the roadways or if the windshield wipers are being used (i.e., to indicate that there is a weather event occurring and, as a result, traffic management and congestion may be impacted). Another goal for the company is to elevate the driving experience so eventually a person can enter a fast-food order, and it will be ready when the car arrives because the connected

data can coordinate and streamline the experience in real time. States could also use the data to help navigate traffic during evacuations, mitigate safety concerns, and address congestion.

Based on results from collecting the connected and autonomous data in Paris, France, the data have been used to help reduce vehicle congestion. While the data result in positive experiences across the board, the company still needs to work on increasing education on how connected and autonomous vehicle data can improve safety and reduce congestion. Wejo is currently only collecting connected and autonomous data on passenger vehicles, not autonomous trucks, but the company is beginning to investigate how truck data can be collected.

May Mobility

TTI staff interviewed a representative from May Mobility on January 26, 2022. May Mobility currently has two pilot deployments for automated passenger vehicles in Arlington, Texas, and Fishers, Indiana. The vehicles must abide by local regulations, including inspections, licensing, and registration. The Arlington, Texas, vehicles are registered in Tarrant County. One aspect that May Mobility would like to see improved in the licensing and registration process is requiring documentation of technology in use in the vehicles being registered and sold and expanding crash reporting documentation to indicate which (if any) automated technologies were engaged at the time of an incident. Correctly and consistently reporting information about the types of automated technology included in vehicle-involved crashes is vital. Different manufacturers have different technologies, which cannot always be lumped together in the same category. May Mobility suggests the benefit of a license endorsement or certification for automated vehicle safety operators. However, not all companies and groups agree that endorsements are necessary.

Automated vehicle safety operators at May Mobility undergo extensive training before operating the automated vehicles. The safety operator training lasts four to six weeks and includes two written exams and an evaluation. Safety operators must also complete in-vehicle shadowing, training behind the wheel, and two evaluations with a supervisor; and must successfully pass a screening and background check. Safety operators have several check-ins and quality assessments with supervisors and team huddles daily. Safety operators receive weekly newsletters containing important information, including information about updates to the software. May Mobility also conducted several training courses with local first responders, with overwhelming attendance. The training was successful, and first responders learned about vehicle technology and what to do in case of an incident.

May Mobility found that many riders would use the service for the first time primarily to test the technology and see how the vehicles worked. Before the pilot deployment in Fishers, Indiana, another six-month deployment took place at the Indiana University–Purdue University Indianapolis campus. Initial survey results indicated that 60 percent of riders used the service to test out the technology. Within two months, 57 percent of riders used the service for needed trips. The riders seemed comfortable with the technology and often asked when the vehicle was in autonomous mode, indicating that they could not tell the difference between when the vehicle was operating in autonomous mode and when it was not.

Kodiak Robotics

TTI staff interviewed a representative from Kodiak Robotics on December 20, 2021. Kodiak automated trucks operating in Texas are registered as regular trucks. No special licensing requirements currently exist for drivers of automated trucks. Several automated truck interest groups have discussed using an endorsement, which is an approval on a license to operate in a special capacity. The interest in a special endorsement is relatively limited. However, if an endorsement become necessary, it would likely be developed as an in-house concept in addition to the rigorous internal training for safety operators.

Kodiak provides an intense amount of in-house education to truck safety operators. The driver-screening and -hiring process is a major event, and drivers undergo intense scrutiny. They must have a spotless driving record with a great deal of experience. Kodiak also focuses on hiring drivers interested in the technology that want to be employed there. Safety operators must complete a variety of training activities prior to getting on the road, including classroom training, mentoring, and on-the-job training, which includes several weeks of driving with an experienced safety operator. Kodiak also spends a great deal of time ensuring that the safety operators understand the software updates and test the new features before going out on the road.

Kodiak also ensures that its safety operators follow the rules while in the truck, including remaining in the driver's seat at all times and staying off of cell phones. The safety operator in the driver's seat is responsible for monitoring the roadway but does not deal with the vehicle's operation. A right-seat operator (RSO) is in the cab and is responsible for communication with the operations base. At the point when only one safety operator is needed, the RSO will operate out of the remote operations center, where the RSO will continually monitor the truck's operation.

Kodiak has not had any incidents involving any of its automated trucks. Still, there is a policy in place for the safety operator to work with law enforcement in the event of an incident or law enforcement response. Kodiak has engaged with the Texas Department of Public Safety because there is a significant difference between cars and trucks: automated trucks will primarily operate on interstates for the near future. In contrast, automated passenger vehicles would be more engaged with local jurisdictions and city police, so it is important to remember to engage with the correct audience.

Kodiak understands the need for and importance of public awareness education so that all highway users are comfortable with the technology operating on the roadways. Safety cannot be understated in the realm of automated trucks, but when people see the vehicles and interact with them, they begin to understand that the vehicles are very safe. Kodiak also takes feedback from the safety operator very seriously. If the vehicle is operating in a way that the operator does not like, the safety operator needs to recognize the problem and take corrective action.

Texas Department of Licensing and Regulation

TTI staff interviewed representatives from the Texas Department of Licensing and Registration (TDLR) on January 6, 2022. Driver education is mainly conducted by private businesses and in parent-taught online curricula; public schools are a tiny part of driver education. Commercial driver's license training is managed/regulated by the Texas Workforce Commission. The state specifies a program of organized instruction (POI), which is a relatively flexible set of content requirements. The POI has lots of content on driver distraction and driving while intoxicated/driving under the influence

but only a short section on vehicle technology. The Texas Legislature could consider amending the Education Code driver education content (the statement of assurance) to require more technology training. TDLR could also be engaged to work on technology training for State of Texas employees who travel on state business in their personal vehicles or rental cars.

City of Arlington, Texas

TTI staff interviewed a representative from the City of Arlington, Texas, on December 20, 2021. The City of Arlington has been involved in three autonomous vehicle pilot deployments:

- The first deployment was a collaboration between EasyMile and First Transit with an off-street shuttle deployment. Because the shuttles were operated off-street, there were no licensing, registration, or NHTSA interactions. Some challenges involved acquiring the necessary insurance. The city attorney wanted EasyMile to carry insurance it had not had in other deployments because this was one of EasyMile's first U.S. deployments.
- The second deployment was with DriveAI, which no longer exists. DriveAI retrofitted a Nissan Envy 200 van with the hardware and software to make it automated in this deployment. The vehicle met NHTSA safety standards, so DriveAI did not need to obtain any waivers for the operation. The vehicle had all the standard license plates, registration, and insurance that a normal vehicle had.
- The third deployment was with May Mobility in collaboration with Via, a ride share service. This deployment used automated Lexus sport utility vehicles licensed and registered in Texas.

The City of Arlington offered educational components about the May Mobility deployment in several ways, such as on a website (https://www.arlingtontx.gov/city_hall/departments/transportation/rapid) and social media. The City of Arlington also focused on student education at the University of Texas at Arlington (UTA), where the deployment routinely operated. Citizen education was one of the primary goals, and the website hosts a robust frequently asked questions section. Based on survey results for the deployment, respondents have been incredibly positive about the automated experience. The deployment has many repeat riders, indicating that the passengers are pleased with the service. UTA students also ride for free.

The safety operators for the deployments complete a rigorous onboarding program, and the interview process is designed to pick candidates with a good aptitude for the technology. To be a safety operator, a person needs to be able to pay close attention to the vehicle's operations while not actually being in control of the vehicle—a trait that can be challenging to find. The safety operators also complete classroom training and training in the vehicle, first with a few days of ride-along training and then several more with a training supervisor in the passenger seat. Safety operators undergo frequent retraining and receive information on any software or hardware updates.

May Mobility has an incident-reporting form in case of any issues, which can range from a disgruntled passenger (e.g., refusing to wear a mask) to a vehicle not operating appropriately or at the ideal level (e.g., wheels rubbing the curb) or an actual crash, which they have not had. While the issues May Mobility has reported are not NHTSA safety violations, the company still reports the issues for maintenance and historical documentation. May Mobility and the City of Arlington invited local first responders to attend safety training for deployments, which allowed the first responders to

become familiar with the vehicles to know how to respond in case of an incident. The first responders learned how the vehicles work, how to shut off the vehicle, where the battery is located, and where all other electronics are located.

American Automobile Association

TTI staff contacted AAA via email, and AAA provided educational information in response. The results from AAA's Annual Automated Vehicle Survey between 2016 and 2021, which highlight the public's perceptions of automated vehicles, are discussed in previous sections of this report. According to the email communication received from AAA, AAA produces the following educational information on ADAS features:

- The AAA Foundation for Traffic Safety has produced the following reports:
  - *The Impact of Information on Consumer Understanding of a Partially Automated Driving System*,
  - *Understanding the Impact of Technology: Do ADA and Semi-automated Vehicle Systems Lead to Improper Driving Behavior*, and
  - *An Examination of Longer-Term Exposure and User Experiences Affect Drivers' Mental Models of ADAS Technology*.
- The National AAA Advocacy team has testified in Congress about the standardization of automated system terms so that consumers can more easily understand what the various degrees of automated systems provide to the consumer.
- AAA has included occasional articles in the AAA member publication, which has been newly minted as *AAA Explorer* (previously *AAA Journey Magazine*).

Conclusion

Automated vehicle features and autonomous vehicle deployments are rapidly expanding across the country. However, there is still a high level of misunderstanding and misconceptions about these vehicle technologies and capabilities. Automated vehicles are intended to increase safety by assisting in some of the driving tasks, such as lane-keeping assistance, automatic emergency braking, or ACC, which can ultimately reduce the severity of or even prevent crashes. Automated vehicles still require a driver or safety operator in the driver's seat. Autonomous vehicles, on the other hand, are those vehicles in which no driver is needed at all. Further compounding the issue, differing naming conventions for vehicle technology and the varied description of how technologies can be used lead to greater misperceptions. There is a great need to use consistent terminology, accurately describe the intent of vehicle technology, and promote general education about automated and autonomous vehicles.

Opportunities

This section provides strategies for TxDOT and other organizations to help educate the users of automated and connected vehicles. This information will help Texas state agencies and other stakeholders understand how to best move forward and prepare their citizens for automated vehicle technologies. Based on the literature review and stakeholder interviews, the following key takeaways allow decision makers to prepare for and educate the users of automated and autonomous vehicles, including freight, passenger vehicles, and shuttles:

- It is critical that all automated vehicle stakeholders use consistent terminology that accurately reflects the capabilities of the technology.
- Collaboration between automobile manufacturers and dealers is important to guarantee successful educational efforts for the consumer regarding the automated features of new vehicles.
- States may consider mandating manufacturer-led training efforts for service and collision technicians that can ensure the prompt transfer of knowledge regarding automated vehicles.
- Chat rooms can be another tool to provide educational elements of automated vehicles, which can apply to automobile dealers, service centers, and collision technicians.
- It is critical to remember that individuals may have different learning styles, so redundant forms of educational tools in assorted styles (e.g., written, video, chat rooms, etc.) will be extremely beneficial for all individuals who interact with automated vehicles.
- States may want to embrace autonomous vehicle deployments because survey results from other deployments have indicated that users have positive experiences. However, the public needs to become familiar and comfortable with the technology before they are willing to use the services on a more frequent basis.
- It is critical that states include the correct stakeholders in the conversations. For example, the state police will be a critical stakeholder concerning automated trucks because these trucks will primarily operate on interstates. Passenger vehicles and shuttles will require interaction with local police because passenger vehicles and shuttles will primarily operate in local jurisdictions.
- Because the ownership model may change with automated and autonomous vehicles, states may want to recognize the value that vehicle safety inspections could play in ensuring that automated and autonomous vehicles are safe for transportation purposes. Vehicle safety inspections in Texas do not currently, by law, require the evaluation of ADAS or autonomous features. This factor could become important when another individual or group owns the vehicle after its initial purchase from a licensed dealer because there will likely be multiple users of the vehicle during its useful life. This is similar in concept to fleet vehicles or car rentals that have multiple users.
- States may want to plan how crash reporting can be updated to reflect automated vehicles. As more data are recorded, states can accurately reflect the safety of autonomous vehicles, but if the data are not recorded, there is no way to tell consumers honestly and transparently about the safety of automated vehicles.
- States may want to plan on how data from connected and autonomous vehicles can and should be used to improve safety and reduce congestion.

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