Understanding Perceptions and Opinions about Connected and Automated Vehicle Technology: Advancing the Dialogue

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Texas CAV Task Force White Paper
Subcommittee on Education, Communication, and User Needs

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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 Texas CAV 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 Texas 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 require a driver to perform the remainder of the driving tasks and supervise each feature's performance while engaged. A *fully autonomous vehicle* refers to a vehicle that can perform all driving tasks on a sustained basis. 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 the vehicles with fully autonomous capabilities and the term *CAV* to refer to the grouping of connected, automated, and autonomous vehicles. Please see the “CAV 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
ADAS	advanced driver assistance system
AV	automated vehicle
CAV	connected and autonomous vehicle; also, connected and automated vehicle
CV	connected vehicle
FAQ	frequently asked question
GPS	global positioning system
ITS	intelligent transportation system
NHTSA	National Highway Traffic Safety Administration
PAVE	Partners for Automated Vehicle Education
TTI	Texas A&M Transportation Institute
USDOT	U.S. Department of Transportation
WYDOT	Wyoming Department of Transportation

Executive Summary

The transportation sector has experienced substantial disruption in the last decade. Advances in technology, both in vehicles and infrastructure, have changed how systems are operated, managed, and maintained. The rate of advancement will continue to increase, and transportation agencies will likely adopt some technologies because of the promise of helping them achieve agency goals. Yet, the general public still does not fully understand or care about the transportation network, even though they expect it to always be available.

Billions of dollars are being invested by private companies as well as local, state, and federal public agencies to implement the technologies associated with connected and autonomous vehicles (CAVs). These technologies have the potential to dramatically change personal, freight, and public transportation. Benefits include improved safety and reduced congestion, more efficient land use and reduced emissions, and new or improved personal mobility and socioeconomic opportunities. The benefits to be realized will be proportional to the rate of public acceptance and adoption.

CAV technology holds much promise, but questions remain surrounding its widespread use and adoption. The issues include planning, policy making, regulatory and legal frameworks, institutional issues, operations, funding, and ultimately public trust and acceptance. Addressing these issues and answering these questions will require many agencies to work cooperatively across disciplines in a rapidly changing environment. Some questions are known at this time, while more are likely to arise as implementation progresses. For now, pilots, demonstrations, and first-use cases provide useful data inputs to answering some of the questions and serve to introduce the public to the technologies.

The Texas CAV Task Force's Subcommittee on Education, Communication, and User Needs supports statewide efforts to inform and engage with agencies, stakeholders, industry, and the general public. The majority of outreach and engagement, to date, is associated with pilots and demonstrations although some surveys have assessed the general public's awareness, familiarity, and use of various automated features currently available on vehicles—as well as overall trust in these technologies. The results of the efforts thus far show confusion around the concepts of automated vehicles (AVs), connected vehicles, and autonomous vehicles. This confusion makes it difficult to engage meaningfully with the public about impacts, use, and preference. Additionally, the public may not be fully aware of how these technologies can and will impact their daily lives.

Where pilots and demonstrations have been implemented, research conducted afterward shows that use or experience with CAV technologies suggests a greater likelihood of acceptance. Survey respondents who had experiences with CAV features tended to feel comfortable and safe using them. In the Texas A&M Transportation Institute's survey of the Frisco Drive.ai pilot, 78 percent of respondents who had taken a ride in an AV had positive opinions of AVs, whereas 49 percent of respondents who had not taken a ride in an AV had positive opinions of them (1).

Familiarity and experience have increased favorability in pilots, but trust in the technologies appears more limited, with the majority of survey respondents since 2016 indicating that they would be afraid to ride in a fully automated vehicle. Some of the concern extends beyond the technology itself and references laws surrounding autonomous vehicle safety, systems vulnerability, and operating complexity.

Education and outreach to multiple audiences are necessary to build awareness, generate trust, and thereby increase adoption. Efforts should expand beyond the identification of benefits and should seek to answer questions and address issues across broad categories based on audience. Baseline research should inform these efforts by identifying the positions and interests of each audience. Overarching key messages will be supported by secondary messages that are relevant to each audience. Education and outreach should function in a continuous feedback loop so that as issues are raised, input can be gathered, and solutions can be formulated.

Education and outreach about CAV benefits and opportunities in Texas will benefit from fundamental communication of best practices for effectiveness. These include:

- **Audience identification**—Identifying the audience and their motivations will enable development of messages that empower supporters, convince uncertain individuals, and minimize the impact of opponents.
- **Market research**—Learn about the audience, what they care about, and what messages will best convince them.
- **Message design**—Several principles define the best ways to design a message, including keeping it simple, staying positive, using metaphors, making it personal, and offering a call to action.
- **Message delivery**—Inconsistent delivery will derail even the best messages. Continually and consistently repeat the message so it will not get lost (2).

A stakeholder engagement plan and a complementary public outreach plan can guide development of materials and provide a comprehensive roadmap for education and outreach efforts beyond the key messages. Development of such plans will ensure that messaging is consistent across formats. The plans will also serve to allocate adequate time and resources by identifying specific actions. The plans can prioritize activities.

The Education Subcommittee, with its broad multidisciplinary representation, is the forward-facing entity responsible for executing an engagement plan. The subcommittee's charge and responsibility are to develop tools and resources that allow for meaningful engagement. These are already being developed. The engagement plan lays out what, when, where, and how engagement will occur—the *tactics*. But an engagement strategy also establishes the reason for engagement—the *why*. The subcommittee has the cachet to engage with everyone in the mobility ecosystem to discuss the *why* of engagement.

This white paper is a living document that will evolve as more research and feedback inform education and outreach. This paper is not the engagement plan itself nor does it discuss specific tactics; rather, it lays the foundation for the subsequent work of the Education Subcommittee.

Introduction

"Many transportation departments are concerned that the public is relatively uninformed about such issues as how transportation facilities and services are financed, how they are provided, how well they function, and, in general, the importance of an effective transportation system"; this quote is included in the opening summary of National Cooperative Highway Research Program Report 20-24(93), *Mobile Messages: Moving People to Support Transportation* (3). The report was written in 2015, but the quote was written in 1994 as part of the introduction to the *Public Outreach Handbook for Departments of Transportation* (4). Nearly three decades later, these words still ring true. Agencies today still grapple with how to effectively communicate their mission, their functions, their needs, and their performance.

At the same time, the transportation sector has experienced substantial disruption in the last decade. Advances in technology, both in vehicles and infrastructure, have changed how systems are operated, managed, and maintained. The rate of advancement will continue to increase, and transportation agencies will likely adopt some technologies because of the promise of helping them achieve an agency goal. Yet, the general public still does not fully understand or care about the transportation network, even though they expect it to always be available.

Billions of dollars are being invested by private companies as well as local, state, and federal public agencies to implement the technologies associated with **connected and automated vehicles (CAVs)**. These technologies have the potential to dramatically change personal, freight, and public transportation. Benefits include improved safety and reduced congestion, more efficient land use and reduced emissions, and new or improved personal mobility and socioeconomic opportunities. While growth in technological advances may happen exponentially, benefits may take longer to be realized (5).

The rate at which benefits are realized is proportional to the rate of adoption. CAV adoption will require concerted and sustained efforts to address the myriad issues surrounding implementation including planning, policy making, regulatory and legal frameworks, institutional issues, operations, funding, and ultimately public trust and acceptance. Addressing these issues will require many agencies to work cooperatively across disciplines in a rapidly changing environment.

The State of Texas strongly supports the development of these technologies. One indication of such support is the convening of the Texas CAV Task Force. The Texas CAV Task Force is charged with identifying and exploring many of the identified issues, including public awareness and public education. The Texas CAV Task Force's Subcommittee on Education, Communication, and User Needs strives to inform and engage the general public, elected and appointed officials, industry, and business about the opportunities associated with CAVs. This begins with tools that help to educate and inform discussions. One such tool is a website that includes research and resources for a variety of audiences. This is an important first step. It provides a foundational understanding so that as the technologies advance and unanswered questions arise, the discussions are informed by a common knowledge and understanding. Additional research will inform tactical education efforts that speak to specific issues that are unknown at this time, including impacts on workforce, education, land use, economic development, etc.

This white paper outlines efforts to educate the public through pilots, demonstrations, and first-use operations. The paper also presents the results of consumer acceptability following some CAV pilot programs, identifies tactics that may be effective, and suggests strategies for future educational efforts.

This white paper is a living document that will be revised as necessary to reflect changes in strategic direction, findings from research, and feedback from stakeholders. There are many unknowns at this time. Indeed, it is impossible to even know all of the relevant questions as this disruptive technology evolves. The evolution will be iterative in much the same way that intelligent transportation systems (ITSs) evolved into the smart, integrated systems that are in widespread use today. The advancement and deployment of ITSs in transportation provide a valuable use case to model CAV deployment. The Texas CAV Task Force and the Education Subcommittee are committed to identifying issues, exploring options, and conducting research. Each of these actions supports informed decision making. The subcommittee will engage with stakeholders, elected and appointed officials, industry, and other partners to develop and deliver an effective engagement strategy that supports CAV technology initiatives in Texas. This white paper is not the engagement plan itself nor does it discuss specific tactics; rather, it lays the foundation for the subsequent work of the Education Subcommittee.

Background

The U.S. Department of Transportation (USDOT) reports that more than 80 companies across 36 U.S. states and the District of Columbia are currently testing more than 1,400 self-driving cars, trucks, and other vehicles (4). The private sector is predominately leading these efforts in autonomous vehicles; however, some states such as Texas are aggressively pursuing opportunities with connected vehicle pilots, and a few cities have demonstrated low-speed autonomous shuttles. The federal government is supporting three connected vehicle pilots in Wyoming, New York, and Florida.

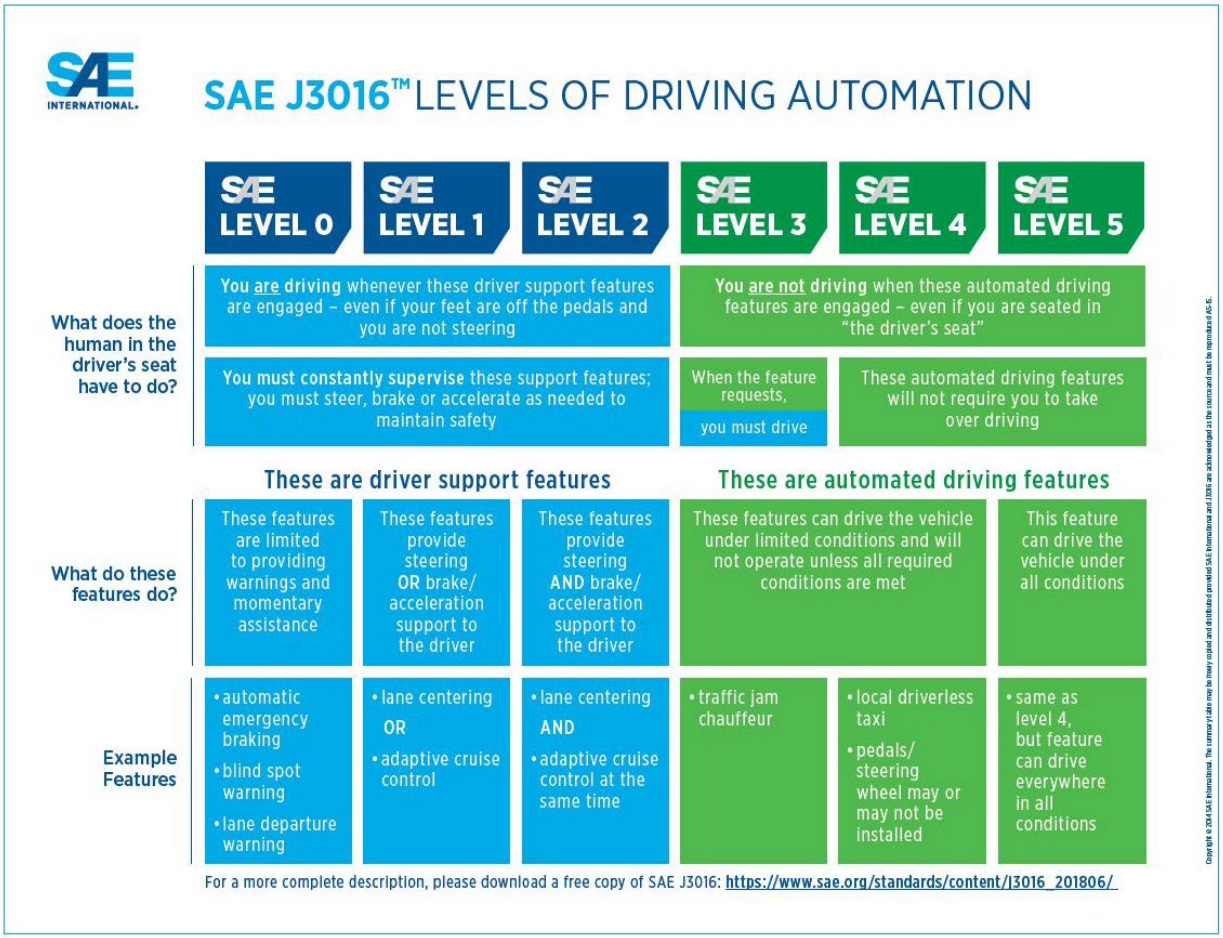
Pilots and demonstrations are imperative to increase public awareness, build trust, and gain acceptance. They also serve to advance technology through operation in specific environments and by identifying challenges and limitations. Likewise, cities and local implementers learn how these technologies can be deployed within their environments and what system changes may be required to accommodate or enhance the deployments. Finally, industry and the private sector benefit by learning, firsthand, how the public reacts to the experimentation. These data indicate the public's acceptance and can serve to guide educational and marketing outreach efforts.

Terminology and Taxonomy

To understand the issues related to public education and acceptance of CAVs and technology, a brief overview of terminology and a taxonomy of technology are necessary. Indeed, the understanding of a common nomenclature is essential to meaningful public education.

CAV technologies are distinct yet complementary. Often the two systems work together to facilitate improved mobility. **Connected vehicles (CVs)** are equipped with communications devices within the vehicle that transmit data to other devices in the vehicle or to external devices that may be in other vehicles or part of the infrastructure or part of another communication service such as a person's smartphone. Applications include everything from traffic safety and efficiency, infotainment, parking assistance, roadside assistance, remote diagnostics, and telematics to autonomous self-driving vehicles and the global positioning system (GPS) (6). Safety applications are designed to increase situational awareness. Specific features include adaptive cruise control, automated braking, incorporation of GPS and traffic warnings, smartphone connections, alerts about hazards, and blind-spot warning systems. CV communication technology (vehicle to vehicle) could mitigate traffic collisions and improve traffic congestion by exchanging basic safety information such as location, speed, and direction between vehicles within range of each other. The technology can supplement active safety features, such as forward collision warning and blind-spot detection (6).

Automated vehicles (AVs) are equipped with technology that moves some or all of the driving responsibility from a human driver to the machines housing the technology. SAE International has defined levels of automation, and these definitions are now routinely accepted by the industry. Figure 1 illustrates the SAE levels of driving automation. A vehicle is considered autonomous, as opposed to automated, when equipped and operating at Level 4 or 5.



Source: SAE International (7)

Figure 1. SAE Levels of Driving Automation.

The complexity of understanding the levels of automation is compounded by the varied marketing and branding names applied to what are collectively known as **advanced driver assistance systems (ADASs)**. The American Automobile Association (AAA) reported that in 2018 at least one ADAS feature was available on nearly 93 percent of new vehicles available in the United States (8). But the lack of standardized naming conventions for ADASs may confuse motorists in understanding and using these systems. Even regulatory agencies such as the National Highway Traffic Safety Administration (NHTSA) and SAE International have multiple names for some automated systems.

Workshop participants at the Advanced Vehicle Technology Consumer Education and Communications Workshop convened by USDOT in July 2019 reported that in addition to different manufacturers using different terms to describe the same feature, manufacturers also use similar terms to describe functionally different systems (9). Additionally, manufacturers typically package and market multiple ADASs under one single brand name that does not sufficiently describe the functionality. This makes it difficult for consumers to research comparable features when considering purchasing a vehicle with one or more ADASs.

Failure to clearly communicate can lead to misuse that may result in system failures that in turn can lead to crashes. This erodes public trust. AAA has advocated for a standard naming convention of all ADASs (8).

While not directly related to terminology, there are also concerns about how a consumer is educated about using an ADAS in a vehicle. Abraham et al. (10) report that in some cases vehicle dealerships might be expected to provide instruction on ADASs. However, no requirements mandate training or education on the part of dealerships or manufacturers. Many consumers that purchase vehicles with ADASs may be left to figure out the intended purpose of a particular ADAS and how it works by reading the manual associated with the vehicle, conducting their own research on the internet, or even relying on friends and family to explain how the systems work. Clearly, technological advances have increased the complexity of operating a vehicle. New operating systems also require new skills and expertise to service and maintain these systems. These are opportunities. The Education Subcommittee can form and lead partnerships that enable dealers, manufacturers, and consumers to create and disseminate educational resources that inform users about the proper use of CAV technology. Similarly, the Education Subcommittee can work with educators and employers to develop curricula and training programs that will train people to meet the needs of this expanding industry, thereby enhancing economic development and employment opportunities.

If a driver does not have full understanding of an ADAS—its purpose and its functionality—this can lead to frustration and/or disappointment with the system and fatigue for the driver. Ultimately, a driver may disable the systems entirely, thereby negating the safety benefits of the ADAS (10).

The connection between public education and acceptance and common terminology may seem obscure, but a common vocabulary is a necessary step in building meaningful public education and outreach programs. A separate paper within this series includes specific definitions of a multitude of terms.

Connected and Automated Vehicles and Mobility

When considering AVs, it is common to first think of self-driving cars. To be sure, popular media and savvy marketing have focused on a future in which people will travel freely while engaging in other, more enjoyable pursuits such as reading, working, or spending time with friends and family. But it is important to present a clear representation of what connected and automated technology encompasses and the plethora of options for mobility across multiple modes. Each application has ramifications for public acceptance.

At some point in the future, the self-driving car, an **autonomous** vehicle with **automated** features, may easily take a single person from his or her home to the workplace in much the same way as it happens today, but CAV technology is being applied to trucks, shuttles, taxicabs, unmanned aerial systems (e.g., drones), transit vehicles, and even neighborhood delivery vehicles. These applications have far-reaching implications for how transportation infrastructure and services are planned, delivered, operated, maintained, and funded. These applications will undoubtedly improve safety by removing the potential for human error. They may also mitigate congestion by maximizing system efficiencies. Land use will likely change. Acres and acres of land currently allocated for vehicle parking can be redeveloped for its highest and best use because autonomous vehicles can now drop people at their destinations and remove themselves from the dense urban core. Transit vehicles may become more efficient as CAV technologies improve operations. Real-time communication can alert a connecting bus that it should wait. Transit riders may take autonomous neighborhood vehicles from their home to a park-and-ride lot for a CV transit trip to downtown. People may decide they no longer need a private automobile and may opt for shared autonomous vehicles.

Autonomous vehicles will offer new freedom to those individuals that suffer from disabilities that make independent travel impossible. Likewise, older adults and youths can gain and maintain independence afforded by CAV technology. This is especially true in suburban and rural areas that offer few modal alternatives. CAV technologies can also make it safer for people that are walking and biking within the transportation network. Technology can alert drivers to pedestrians and cyclists and vice versa.

Autonomy and connectivity are also being deployed and tested in the freight arena. Truck platooning uses CV technology to allow several trucks to travel as a single platoon, thereby increasing efficiency. A single driver leads the platoon. Platooning has the potential to improve the operational efficiency of trucking for the movement of goods. Connected freight vehicles and platooning have the potential to address or eliminate current issues such as driver shortages, freight vehicle parking for mandatory rest periods, and overall job satisfaction in the trucking industry. Additionally, connected freight vehicles continuously provide data about road and weather conditions that can alert other drivers and transportation system operators that may need to initiate proactive measures to mitigate dangers.

Finally, unmanned aerial systems are another mode using CAV technology. From just-in-time grocery delivery to personal transport, these systems will also impact the future of transportation and the movement of goods across the globe.

Of course, for each of the benefits touted, unanswered questions remain. Will autonomous vehicles increase vehicle miles traveled and negatively impact the environment? Will the benefits and burdens be evenly or equitably distributed? Will land use changes exacerbate urban sprawl, or will other policies, programs, and technological advances mitigate these effects? Additionally, technological advances will impact the workforce and necessitate changes in educational programs. Perhaps there will no longer be a need for long-haul truck drivers or local delivery drivers, but there will be a need for workers to implement these systems. New integrated traffic management systems will require expertise beyond traditional civil engineering programs. These approaches are multidisciplinary, encompassing communications, computer science, bio-mechanics, robotics, and many types of engineering, to name a few. This will require changes in educational programming to supply a workforce that has the training and education to operate these systems.

In every application of CAV technology, there are positives and negatives and many unanswered questions. USDOT, state and local governments, and certainly the private sector have collectively committed, either formally or informally, to advancing these technologies. What is necessary for adoption and widespread implementation is public acceptance. Public acceptance is achieved through awareness, education, and trust. Trust may be the biggest factor in acceptance. In this case, the public must trust the technology. They must believe that the implementers, be they private or public, are competent and capable of delivering the anticipated benefits. But the public must also trust that the technology has been properly tested and vetted. The public must trust the integrity of a government charged with protecting and safeguarding the public welfare and have confidence in its ability to act in the public's best interest.

Pilots, demonstrations, and initial first-use operations activities are a means to demonstrate technology, instill confidence, and build trust. Evaluations of the public's response to pilots and demonstrations provide insights into areas of concern or features that generate mass appeal. Additionally, messages used for education and communication can be assessed for effectiveness and may inform future outreach efforts.

Gauging Public Perception

In July 2018, Drive.ai pilot-tested a self-driving shuttle service on public roads in Frisco, TX. Following completion of this pilot, the Texas A&M Transportation Institute (TTI) surveyed the community to gauge the acceptance and public perception of the pilot. TTI researchers found that 54 percent of those surveyed out of the general public (which included people that had not ridden in the vehicle) had a favorable view of AVs after the Drive.ai pilot (1).

MILO pilot-tested a continuous autonomous shuttle service in Arlington, TX, in 2017. Surveys found that 97 percent of riders supported AV generally and that 99 percent of riders felt safe on the MILO shuttle (11).

Surveys from a 2018 Drive.ai pilot in Arlington show similar data. The surveys found 98 percent of riders felt safe in the AV over the course of 760 trips (12).

The surveys after these three pilots indicate that experiences with an AV and riding in an AV have significant impacts on the public's perception and acceptance of CAV technologies and services. People who have experienced AV technologies for themselves tend to feel safe in those vehicles.

An important caveat to reported acceptance and/or willingness to use or purchase is the context in which survey respondents are answering. A person that had a firsthand experience on an AV shuttle will likely have different opinions than a respondent who has not experienced an AV. Likewise, the structure of the question is important in interpreting responses. A question that asks the respondents about the favorability of the pilot can be interpreted in many ways if the question is not explicit. A respondent may reply that his or her impression of the pilot was less than favorable, but that response may not have anything to do with the technology. This respondent may have other issues with the pilot such as the hours it was available or the number of stops it made. Likewise, questions about favorability are very different than questions about perceived safety, as are the reasons for the answers. For these reasons, it is important to carefully scrutinize data surrounding surveys about public opinion to understand intent, context, data collection methodology, and any other extenuating factors. How results are communicated and to whom may also need to be considered. Data presented by the company behind the technology may be viewed with more skepticism than data presented by public agencies. Pilots and demonstrations that are evaluated by objective third parties such as academic institutions are likely to be viewed as the most credible.

Knowledge and Awareness

Public knowledge and awareness of CAV technologies and services are skewed. The public has a greater awareness of AV technology than CV technology. This is likely due to the publicity surrounding AV developments such as Tesla's autonomous features and tests and Google's AV testing. Likewise, private companies—including both technology and automotive manufacturers—spend millions of dollars marketing their innovations. Interestingly, 98 percent of the Frisco survey respondents had heard of self-driving vehicles, but many may have been unaware of the automated features that are already in use in their own vehicles (4). This data point underscores the confusion surrounding the naming conventions for various features. This issue is especially prevalent in vehicles with partial automation capabilities. Misunderstanding and/or misuse of automation features leads to risky driving behavior. Disproportionate media attention surrounding crashes involving vehicles using CAV technologies can erode public confidence in the technology.

In 2018, AAA completed a study that asked participants about their personal vehicle and what ADAS features were installed on the vehicle. The study found that 83 percent of respondents who were asked about adaptive cruise control were first-time owners of the technology, and 52 percent reported that they did not know how the feature worked when they purchased the vehicle, but only 45 percent remembered being offered any training on the technology. Moreover, only a slight majority, 58 percent, answered correctly when asked about the basic functionality of the feature. In the study, 90 percent of respondents were first-time owners of vehicles with lane-keeping assist, and 56 percent reported that they did not know how the feature worked when they purchased the vehicle (13).

Similar confusion surrounds responses about ownership versus use. While automotive manufacturers deploy ADASs on new vehicle models, CAV technology may also be used in mobility as a service. In this scenario, individuals experience CAV technology as a shared mobility option through autonomous shuttles or shared neighborhood vehicles, as opposed to purchasing a private vehicle with these capabilities. Each model will have unique effects on adoption and acceptance.

The public seems to have less knowledge about CV technology. CV technology requires at least some interface with other vehicles, other mobility options, or local infrastructure, such as traffic signals. Uses that include infrastructure are typically initiated by state and local governments rather than the private sector although the private sector is usually a partner in this endeavor. Funding these initiatives through the city or state budgeting process faces the same challenges as all budgeting processes—how much to invest and for what benefit. Consequently, few cities or states have the ability to heavily invest in CV technology as a standard practice. CV applications use technology that allows communication between and among vehicles, other mobility options, infrastructure, and wireless devices to improve the operational efficiency of the transportation network. This efficiency provides many benefits, but the public may be less aware that traffic signals are communicating with one another to maximize throughput on a congested route or to other vehicles, bicyclists, and pedestrians about safety risks at an intersection.

USDOT supports the efforts of education and increased awareness through its pilot programs. USDOT also creates and publishes many informational products such as fact sheets and regular website updates. In many cases, these are targeted to audiences such as policy makers and industry rather than the general public. Therefore, the reach to the general public may be limited. As USDOT pilots in Tampa, FL, New York, NY, and Wyoming are completed, communication about the results should be highlighted to a variety of audiences. This will increase public awareness.

Another indicator of public knowledge around CAV technologies and services is the introduction of university courses about the topic. For example, Slippery Rock University in Pennsylvania offered a literature and creative writing seminar course centered around CAV technologies and services. This enabled students, who were not experts on CAV technologies and services, to better understand what these technologies are and explore the impacts of widespread use of CAV technologies and services in society. The professor of the course, Dr. Patrick McGinty, stated during a webinar he gave with Partners for Automated Vehicle Education (PAVE) that students left the course with a belief that CAV technologies and services are safe and will become widespread in coming years (14).

Sentiment

Surveys have gauged public sentiment for CAV technologies and services, usually conducted as part of pilots or demonstrations. Generally, public sentiment is favorable but cautious, with most survey respondents believing that CAV technologies and services have the potential to make roads safer. However, more research needs to be done. More exposure through demonstrations and pilots will foster understanding that will help the public feel comfortable using CAV technologies and services. Use or experience with CAV technologies suggests a greater likelihood of acceptance. Survey respondents who had experiences with CAV features tended to feel comfortable and safe using them. In TTI's survey of the Frisco Drive.ai pilot, 78 percent of respondents who had taken a ride in an AV had positive opinions of AVs, whereas 49 percent of respondents who had not taken a ride in an AV had positive opinions of them (1).

Cost seems to be a concern when determining the rates of adoption and use of CAV technologies and services. Many vehicles equipped with CAV technologies are expensive due to the newness of the technology, making them inaccessible for many people to own. TTI researchers for the Frisco Drive.ai survey found that 60 percent of respondents would own a Level 4 or 5 AV if cost were not a barrier (1). However, the main concern of survey respondents was simply how new the technology is and the belief that there needs to be more testing and pilots of CAV technologies and services before the respondent would feel comfortable owning or using a vehicle equipped with CAV technology. In public-opinion research about the likelihood of owning a Level 4 or 5 vehicle, most people did not think it was worth the expense.

Dr. McGinty, who taught the AV seminar at Slippery Rock University, found that one of the major concerns his students voiced about CAV technologies and services was about how prepared society is, as a whole, to accept and adopt these innovations (14). The course discussed some of the implications relating to job losses due to widespread CAV use and the impacts that those economic changes might have on society.

Overall, the general public tends to agree that CAV technologies and services will likely make roads and travel safer for all. Safety is seen as the predominant benefit. However, most people also believe that more testing is needed, and pilots should be conducted before CAV technologies and services are widely used and adopted.

Cost may be another perceived barrier to the acceptance and adoption of CAV technologies and services. In fact, many ADASs now come standard on new vehicles, so in effect, consumers may already be investing in AV technology. Cost is also a factor for public agencies deploying CV technology. To be most effective, these deployments will require extensive investment and the cooperation and coordination among many governmental entities.

Trust

While the public purports to acknowledge the safety benefits of CAV technology, their trust in those technologies seems more limited. Zmud et al. (13) summarize the results of the annual AAA vehicle technology survey fact sheets from 2016 through 2019 shown in Table 1.

Table 1. AAA Survey Trust in CAV Technology.

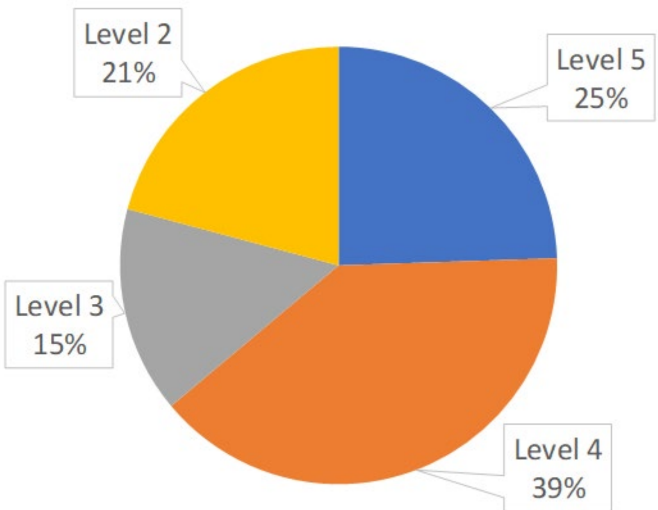
Survey Factor	Phase I	Phase II	Phase III	Phase IIIb	Phase IV
Survey period	Jan. 2016	Jan. 2017	Dec. 2017	April 2018	Jan. 2019
Number of respondents	1,832	1,012	1,004	1,014	1,008
Percent of respondents afraid to ride in a fully automated vehicle	75%	78%	63%	73%	71%
Percent of women afraid to ride in a fully automated vehicle	82%	85%	73%	83%	N/A
Percent of men afraid to ride in a fully automated vehicle	67%	69%	52%	63%	N/A
Percent of respondents who want at least one ADAS feature on their next vehicle	61%	59%	51%	55%	N/A

N/A means not applicable.
Source: Zmud et al. (13)

The annual AAA survey was repeated in January 2020, but a change in methodology means the results year to year are not comparable for 2020. However, of the 1,301 people surveyed in 2020, only 12 percent say they would trust a vehicle to drive itself while they are in it. Roughly about half of respondents want laws to ensure self-driving cars are safe. Respondents are also concerned about the vulnerability to hacking of self-driving vehicles, and 44 percent want easy-to-understand information about how self-driving vehicles will work (15).

Results from the open-ended text responses in the Frisco Drive.ai pilot indicate that not many people prefer or would accept Level 5 vehicles yet because they did not fully trust the technology. However, a small percentage (19 percent) were ready to fully cede control of driving to an AV because they trust the technology (1). Acceptance of Level 4 or 5 technology was highest among young respondents, early adopters of technology, and those that already own vehicles with an ADAS (1).

The Frisco Drive.ai pilot also asked respondents what level of technology they trusted most to reduce the likelihood of being in a crash. Figure 2 provides these results.



Source: Zmud and Sener (1)

Figure 2. Percentage of Respondents Indicating Level of Autonomy Most Trusted.

The authors note some insightful open-ended text responses from queries about the rationale for their choice:

- "People who reported most trusting Level 5 thought the technology would be fully tested to be safe, would best address human driving errors and distractions, and would represent the most advanced safety features.
- "People who most trusted Level 4 did not believe in the readiness of the Level 5 technology and felt Level 4 is the next best thing in terms of advanced safety features.
- "People who most trusted Level 2 and Level 3 also did not believe in the technology readiness of higher levels of automation, and they were not psychologically ready for self-driving cars" (1).

These responses are telling in that there seems to be a willingness to accept the technology to improve safety, yet when asked to personally subscribe, there is not yet enough trust in the technology. This study and the others that have been conducted that ask similar questions all point to increased acceptability due to increased awareness and knowledge. Pilots and demonstrations provide that opportunity to engage the public with the technology and allow them to experience it firsthand. This can and does increase acceptance.

This is not to say that all issues of trust in the technology can be overcome with pilots and demonstrations. Indeed, results of the 2020 AAA survey indicate the public has other concerns that are somewhat outside the technology itself, including a reliance on the government to ensure their safety by enactment of laws.

Education and Outreach

The largest efforts to educate and reach the public have been in areas implementing pilot programs. Outreach efforts generally preceded the launch of the pilot, and marketing continued throughout the pilot. Following the pilots, research has been conducted to assess the user's experiences, but very little research has been conducted to evaluate the messaging associated with the pilots. CAV technologies necessitate high-level key messages, primarily related to the expected benefits of the technologies, with safety being the biggest benefit lauded by the public and the private sector. Other implementations will benefit from a more concerted effort to research what has been effective and with which specific audiences.

Strategies for Success

Development of outreach strategies should be informed by baseline research. Efforts should be made to understand what the public knows and understands about CAV technologies. This foundational research can identify misperceptions and address them in message development. Issues that are important to specific audiences can be identified so that message platforms can speak directly to them. Additionally, how and by whom messages are communicated are important. In areas where there is a low level of trust or confidence in government, a public agency may be well served to enlist a spokesperson that is respected in the community to speak on its behalf.

These are important considerations in the development of any education and/or outreach program. But education and outreach are also needed within the public agencies that are instrumental in the deployments and within the state and local governments that make the deployments possible. It is imperative that leadership identifies and communicates a strategic direction for a CAV technology program. Indeed, each agency should consider how CAV technologies can contribute to achieving broader agency goals. This must be communicated within and beyond the agency so that everyone supports the common objective. Specific performance measures should be developed so that progress can be reported to the public. Advancement toward achieving goals and objectives will demonstrate commitment to the program(s) and ensure resources are available to continue.

Education and outreach will need to extend beyond the identification of benefits. Other questions loom that are important to the public and other agencies. Currently, questions surround the legal and regulatory nature of CAV technology. These public policy issues are the responsibility of elected officials, but the public will require answers in order to become supportive. Education and outreach should address the following broad categories:

- Agency implications.
- Freight implications.
- Economic implications.
- Environmental implications.
- Societal implications.

Each category has numerous known questions as well as questions that are unknown at this time. There are currently answers to some but not all questions. The Education Subcommittee will continue to compile and research issues that arise and will disseminate resources that serve to foster continuous education. Education and outreach will function in a continuous feedback loop (Figure 3) where issues are identified, solutions proposed, input gathered, and more questions identified.

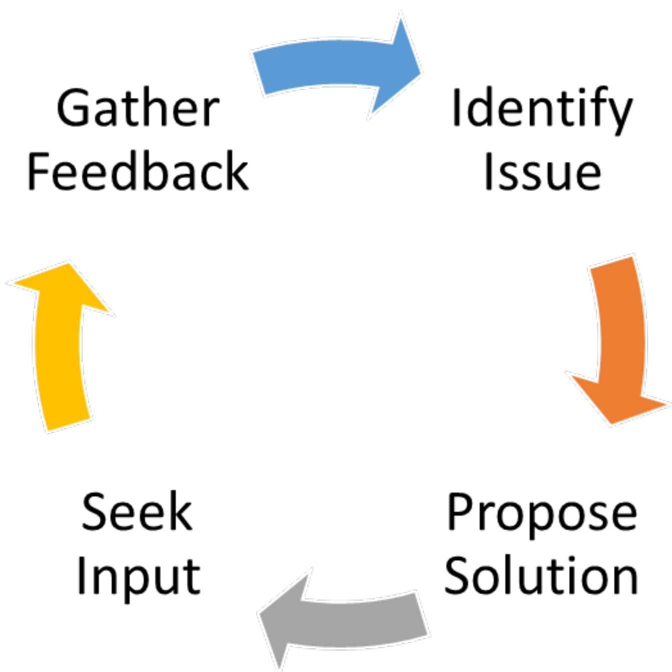


Figure 3. Continuous Feedback Loop.

This list is certainly not exhaustive. Some questions can be answered fully or partially now. The Education Subcommittee intends to serve as a purveyor of information. As research is completed and resources are developed, the subcommittee will convey findings and tools to relevant agencies, partners, and the public.

Pilot Outreach

Outreach and messaging strategies for CAV pilot programs have varied from program to program. Some common outreach techniques across pilot programs were to create webpages for pilots as well as social media profiles and hashtags to promote the pilots online. Also providing opportunities for local media outlets to report on the pilots, such as hosting press conferences or drafting news releases, was a common method of outreach. Both the Tampa, FL, and Wyoming USDOT pilots coordinated with local press and media outlets to promote the pilot programs to their communities.

Holding demonstrations of CAV technology was another way that agencies promoted their pilot programs to the public. The Drive.ai pilot program hosted training on its technology specifically to first responders, which was a unique and targeted outreach strategy to reach key stakeholders and community members. The USDOT pilot programs in Wyoming and Tampa, FL, also hosted public demonstrations at local showcases and public events as a means of conducting public outreach. Table 2 shows the messaging the Wyoming Department of Transportation (WYDOT) used when promoting the pilot program to different audiences, from stakeholders to the media and general public. WYDOT tailored messages to each audience, based on their common goals and interests. The primary messages focus on the pilot's ability to improve safety for drivers and road users, while the secondary messages target each audience's interests and/or pain points (16).

Table 2. WYDOT Messages and Audiences.

Message	**Audience**						
	Federal/State/Local Government	**Stakeholders**	**Trucking Industry**	**Media**	**General Public**	**Other CV Pilots & International Partners, Academia, Researchers**	**Vendors**
Primary Message theme							
The Wyoming CV pilot uses state of the art technology to make our highways safer and reduce accidents.	X	X	X	X	X	X	X
The Wyoming CV pilot saves lives and improves traffic flow at the same time.		X	X	X	X		
Wyoming's CV pilot technology is easy and safe to use, and protects drivers' privacy.		X	X	X			
Secondary Message themes							
The Wyoming CV pilot improves efficiency, helps business continuity and productivity, and reduces traffic congestion by minimizing weather-related accidents.	X	X	X	X			
The Wyoming CV pilot is an innovative and worthwhile usage of taxpayer resources for the public good.	X			X	X		
The Wyoming CV pilot is a model for how to use innovative technology to improve quality of life for drivers, businesses, and residents.	X	X				X	

Source: Garcia et al. (16)

Research from pilots about user experience indicates that younger audiences, people that identify as early adopters, and those familiar with ADASs are the most accepting of CAV technology. Some audience segmentation has occurred and seems consistent across pilots. Additional efforts can build on these findings.

Moving Forward in Texas

The Education Subcommittee should necessarily focus initial efforts on outreach and education. *Outreach* establishes initial contact with constituents and stakeholders, providing awareness and information. This lets the audience determine their level of interest, position, and any actions they might wish to take. *Education* provides context to the audience. Education explains why the audience should be interested. It gives stakeholders the tools to be better informed but also provides knowledge that can be used to inform others. Education is not about persuasion but merely providing information.

At this stage, a few key messages should be developed. With input from the entire Texas CAV Task Force, key messages about CAV opportunities in Texas should be developed and propagated. What are the four or five key things that the state wants to convey about CAV development in Texas? The subcommittee will continue to develop tools to inform and educate by providing materials, resources, and outcomes of pilots and demonstrations. In addition to providing information, the subcommittee should help the audiences understand why this should be important to them and their role in advancing CAV technologies in Texas. Developing key messages, providing context, and defining roles are crucial first steps. The key messages provide consistency. Secondary messages can speak to specific audience interests, but the key messages should remain the same regardless of the messenger or the medium. This preserves the integrity of the message and reduces any confusion. Market research can assess the impacts of these efforts.

Education and outreach about CAV benefits and opportunities in Texas will benefit from fundamental communication best practices for effectiveness, including:

- Audience identification—Identifying the audience and their motivations will enable development of messages that empower supporters, convince uncertain individuals, and minimize the impact of opponents.
- Market research—Learn about the audience, what they care about, and what messages will best convince them.
- Message design—Several principles define the best ways to design a message, including keeping it simple, staying positive, using metaphors, making it personal, and offering a call to action.
- Message delivery—Inconsistent delivery will derail even the best messages. Continually and consistently repeat the message so it will not get lost (2).

A stakeholder engagement plan and a complementary public outreach plan can guide development of materials and provide a comprehensive roadmap for education and outreach efforts beyond the key messages. Development of such plans will ensure that messaging is consistent across formats. The plans will also serve to allocate adequate time and resources by identifying specific actions. The plans can prioritize activities. Subplans should be developed for different audiences. For example, a plan specific to the legislature should focus on why investment in these activities is important and how legislation can support that; a plan aimed at local government should include development of information that addresses local issues and why these activities are important.

As outreach occurs, it is imperative that its effectiveness be measured. This evaluation will reveal what messaging is resonating and what methods are most effective. Evaluation can identify gaps in knowledge that can be addressed. Evaluations can also uncover misperceptions that can be addressed before they become set in the public's opinion. Systematic and consistent evaluation will reveal trends over time that will aid in understanding outreach effectiveness. Polls and surveys are useful methods of evaluation, but qualitative research through structured interviews and focus groups allows for a deeper understanding of why a person feels a certain way about something. These rich data will inform subsequent outreach efforts. To be clear, this evaluation should focus not only on the public's perception of CAV technology but also on the effectiveness of the educational information that is being provided. Not assessing the effectiveness of outreach and educational campaigns is a misstep that results in wasted time and resources.

In addition to tailoring messages for specific audiences, information should be provided in a manner that is appropriate to the audience. In all instances, the information should clearly communicate the key messages. It should be comprehensible to the intended audience without the need for additional research. Messages should be available in the media of choice for the receiver and should be accessible and available as requested by the receiver. Fact sheets, frequently asked questions (FAQs), myths, and truths are products that provide information in an easy-to-manage and -digest format. Moreover, this information can be provided in many forms such as printed materials, a website, videos, and social media.

An outreach and education program should focus on the success of pilots and actual business operations deployments. At the same time, the program should not neglect challenges encountered and the lessons learned from those challenges. Research has shown that acceptance is greater with exposure. Pilots and demonstrations are important to give all audiences a firsthand experience.

The Education Subcommittee, with its broad multidisciplinary representation, is the forward-facing entity responsible for executing an engagement plan. The subcommittee's charge and responsibility are to develop tools and resources that allow for meaningful engagement. The engagement plan lays out what, when, where, and how engagement will occur—the *tactics*. But an engagement strategy establishes the reason for engagement—the *why*. The subcommittee has the cachet to engage with everyone in the mobility ecosystem to discuss the *why* of engagement. For example, this could include representatives of the education sector, advocates for the disabled community, and first responders as communities that may not immediately see the relevance to their missions.

Resources

This section lists resources with more information about CAVs, pilot programs, public opinion, and outreach.

Fact Sheets

Intelligent Transportation Systems Joint Program Office. *New York City, New York: Connected Vehicle Pilot Deployment Program*. U.S. Department of Transportation.
https://www.its.dot.gov/factsheets/pdf/NYCCVPliot_Factsheet.pdf.
This fact sheet provides an overview of the USDOT New York City CV pilot program, including the types of CV technology being tested and the locations in the city where the pilot is being run.

U.S. Department of Transportation. ***What Public Officials Need to Know about Connected Vehicles.***
https://its.dot.gov/factsheets/pdf/JPO_PublicOfficials_v6.pdf.
This USDOT fact sheet provides some key information specifically for public officials regarding CVs, including how they operate, the benefits of CVs, and how to prepare for their deployment.

Intelligent Transportation Systems Joint Program Office. ***Wyoming Connected Vehicle Pilot Deployment Program.*** **U.S. Department of Transportation.**
https://www.its.dot.gov/factsheets/pdf/WyomingCVPilot_Factsheet.pdf.
This fact sheet provides an overview of the USDOT WYDOT CV pilot program, including where it is being implemented and what technology is being used.

Intelligent Transportation Systems Joint Program Office. ***Tampa, Florida, Connected Vehicle Pilot Deployment Program.*** **U.S. Department of Transportation.**
https://www.its.dot.gov/factsheets/pdf/TampaCVPIlot_Factsheet.pdf.
This fact sheet provides an overview of the USDOT Tampa, FL, CV pilot program, including what types of technology are being used and where the pilot program is being run.

Reports

Perkins, L., N. Dupuis, and B. Rainwater. ***Autonomous Vehicle Pilots across America: Municipal Action Guide.*** **National League of Cities, 2018.**
https://www.nlc.org/sites/default/files/2018-10/AV%20MAG%20Web.pdf.
This report summarizes a variety of AV pilot programs being run across the United States. The report identifies specific programs and provides a brief overview of each one.

Websites/Webpages

Partners for Automated Vehicle Education. Homepage.
https://pavecampaign.org/.
The PAVE website describes the organization's goal to increase public knowledge and understanding of AV technology. The site hosts a variety of resources including news articles and webinars relating to AV technology.

National Highway Traffic Safety Administration. AV TEST Initiative.
https://www.nhtsa.gov/automated-vehicles-safety/av-test-initiative-tracking-tool.
This NHTSA webpage shows the AV pilot programs currently running across the United States. The map shows the location of the pilots and provides links to further information about each pilot program.

U.S. Department of Transportation. ***Preparing for the Future of Transportation: Automated Vehicles 3.0.*** **October 4, 2018.**
https://www.transportation.gov/av/3.
This webpage provides an overview of the USDOT AV 3.0 program. The page includes a presentation outlining the goals of the program, the different levels of automation, and the next steps in moving toward accepting and implementing AV technologies across the country.

National Operations Center of Excellence. Vehicle to Infrastructure Deployment Coalition.
https://transportationops.org/V2I/V2I-overview.
This webpage provides an overview of the Vehicle to Infrastructure Deployment Coalition, a group designed to encourage discussion and collaboration among stakeholders about issues surrounding vehicle-to-infrastructure program deployments.

Intelligent Transportation Systems Joint Program Office. Public Availability of Connected Vehicle Documents. U.S. Department of Transportation.
https://www.its.dot.gov/pilots/cv_docs.htm.
This USDOT webpage provides information about documents from USDOT CV pilot programs that are publicly available and where to find them.

Wyoming Department of Transportation. Wyoming DOT Connected Vehicle Pilot.
https://wydotcvp.wyoroad.info/.
This website for the WYDOT pilot project includes many resources and how to get involved.

Webinars

Partners for Automated Vehicle Education. *PAVE's Virtual Panel: The View from the Rider's Seat: Insights from Early AV Customer Experience.* June 17, 2020.
https://www.youtube.com/watch?v=P5DwbiopdWw&feature=youtu.be.
This PAVE webinar provides information on how users and drivers are responding to AV technology developments. Speakers include a PAVE representative/moderator, an executive from Lyft, an executive from the APTIV AV developer, and a representative from a data company called Dataspeed.

Partners for Automated Vehicle Education. *PAVE's Virtual Panel: Engaging Stakeholders, Building Trust.* May 27, 2020.
https://www.youtube.com/watch?v=eUim4ErXIR8&feature=youtu.be.
This PAVE webinar provides information and discussion on how to better engage stakeholders and gain public trust with regard to AV technology. Speakers include representatives from Mothers Against Drunk Driving, a non-profit called SF New Deal, the National Federation of the Blind, and a representative from an AV developer called Cruise.

Podcasts

Davis, K. *Mobility: Decoding the Secret Sauce*. Anchor, 2020.
https://anchor.fm/katelyn-davis7/episodes/Trailer-efv5df.
This podcast discusses the issues surrounding marketing and communications with regard to mobility issues, including CAV technologies and pilots.

Videos

City of Frisco, Texas. *Progress in Motion—Drive.ai Town Hall Meetings.* July 20, 2018.
https://www.youtube.com/watch?v=LD6Ag1CGLMo.
This video shows the Drive.ai pilot in Frisco, TX.

City of Frisco, Texas. ***Driverless Car Company Drive.ai Rolls Out in Frisco*****. August 1, 2018.**
https://www.youtube.com/watch?v=9darOAbdbKY.
This video gives testimonials about the Drive.ai pilot in Frisco, TX.

New York City Department of Transportation. ***NYC DOT Connected Vehicle Pilot—Part 1*****. July 17, 2017.**
https://www.youtube.com/watch?v=Bxu29Qbs-zI&t=81s.
This video describes a New York City Department of Transportation pilot.

New York City Department of Transportation. ***NYC DOT Connected Vehicle Pilot—Part 3.*** **July 17, 2017.**
https://www.youtube.com/watch?v=TWPn-Tyd3sw.
This video describes the applications being tested in a New York City Department of Transportation pilot.

Wyoming Department of Transportation. ***WYDOT Connected Vehicle Pilot Program Deployment.*** **July 21, 2017.**
https://www.youtube.com/watch?v=9TPluh2dm20.
This video describes the Wyoming I-80 pilot project.

Brochures

Metropolitan Transit Authority of Harris County. ***Ride into the Future*****.**
https://www.ridemetro.org/MetroPDFs/GettingAround/Autonomous-Shuttle-Brochure.pdf.
This brochure includes FAQs, safety tips, and shuttle stops.

Special Events

City of Arlington. Drive.ai On-Street Autonomous Shuttle Program. May 2019.
http://events.r20.constantcontact.com/register/event?oeidk=a07egaqd92md68bbb26&llr=8fn9w5iab.
The City of Arlington, TX, hosted a special event to debut the Drive.ai self-driving, ride-hailing service in the entertainment district.

Press Releases

City of Austin. ***Austin to Pilot INRIX Platform for Autonomous Vehicle Deployment*****. July 17, 2018.**
https://www.kxan.com/news/local/austin/austin-joins-pilot-program-to-help-manage-self-driving-vehicles. This press release provides information about the INRIX Road Rules program.

City of Austin. ***Austin-Bergstrom Begins Autonomous Vehicle Testing.*** **August 2, 2019.**
https://austintexas.gov/news/austin-bergstrom-begins-autonomous-vehicle-testing.
This press release provides information about the Easy Mile EZ10 pilot at the Austin-Bergstrom International Airport.

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8. American Automobile Association. *Advanced Driver Assistance Technology Names.* January 2019. https://www.aaa.com/AAA/common/AAR/files/ADAS-Technology-Names-Research-Report.pdf.

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