DEPARTMENT OF TRANSPORTATION

Transportation Research Synthesis

Minnesota Department of Transportation
Office of Research & Innovation
651-366-3780
www.mndot.gov/research

TRS 2405

October 2024

PUBLIC EDUCATION ON AUTOMATED DRIVER ASSISTANCE SYSTEMS

Prepared by CTC & Associates LLC

Most new passenger vehicles now include some level of automated driver assistance systems (ADAS) that enhance driver capabilities, and the presence of ADAS in personal vehicles is expected to expand. When used appropriately, ADAS provides drivers with potential safety benefits. But many drivers are unaware of the ADAS features in their vehicles and how to safely operate them.

To address this knowledge gap in public awareness, MnDOT's Connected and Automated Vehicles (CAV) Office is considering launching a public education campaign to inform drivers about ADAS and how these systems are applied in personal vehicles. To assess the need for this campaign, this Transportation Research Synthesis sought information about efforts underway at state transportation and public safety agencies and by other stakeholders to educate the public about these relatively new technologies. Findings from this TRS are expected to inform future actions by MnDOT's CAV Office regarding ADAS education and outreach.

Technical Advisory Panel

Brent Rusco, Project Coordinator
MnDOT Office of Research and Innovation

Scott Meier, Technical Liaison
MnDOT Connected and Automated Vehicles Office

Christine Kline, Principal Investigator
CTC & Associates LLC

Julie Bartkey, Panelist
MnDOT Office of Communications and Public Engagement

Scot Edgeworth, Panelist
MnDOT Metro District

Micaela Kranz, Panelist
MnDOT Office of Research and Innovation

Tara Olds, Panelist
MnDOT Connected and Automated Vehicles Office

Table of Contents

List of Abbreviations and Acronyms

AAA	American Automobile Association
AAMVA	American Association of Motor Vehicle Administration
AASHTO	American Association of State Highway and Transportation Officials
ACC	Adaptive cruise control
ADAS	Automated driver assistance systems *also* advanced driver assistance systems
ADS	Automated driving systems
AEB	Automatic emergency braking
ATMA	Automated truck-mounted attenuator
AV	Automated vehicle
BTSCRP	Behavioral Traffic Safety Cooperative Research Program
CAV	Connected and automated vehicles
CMV	Commercial motor vehicle
CSRC	Collaborative Safety Research Center (Toyota)
CV	Connected vehicle
DOT	Department of transportation
DSF	Driver support features
DSRI	Driving Safety Research Institute
ESV	Enhanced Safety of Vehicles
FAV	Fully automated vehicles
FCW	Forward collision warning
FMCSA	Federal Motor Carrier Safety Administration
IIHS	Insurance Institute of Highway Safety
LKA	Lane keeping assist
LKAS	Lane keep assist system
MnDOT	Minnesota Department of Transportation
OTA	Over-the-air
PAVE	Partners for Automated Vehicle Education
PD	Pedestrian detection
PennDOT	Pennsylvania Department of Transportation
ROI	Return on investment
SAE	Society of Automotive Engineers
TIM	Traffic incident management
TJ	Traffic jam
TRB	Transportation Research Board
TRS	Transportation Research Synthesis
USDOT	U.S. Department of Transportation
V2V	Vehicle-to-vehicle

Executive Summary

Automation began to appear in passenger vehicles in the 1970s with the adoption of the antilock braking system. Efforts to enhance drivers' capabilities continue with the more recent adoption of some level of automated driver assistance systems (ADAS) now included in most new vehicles sold. Partners for Automated Vehicle Education (PAVE), a nonprofit coalition of representatives from industry, nonprofit organizations and academia, provides the following definition of ADAS:

> **Advanced Driver Assistance Systems (ADAS):** A term describing and encompassing all systems that use advanced Active Safety technologies to support human drivers by performing a part of the driving task if engaged. Examples include Adaptive Cruise Control and Automatic Emergency Braking.

With the presence of ADAS in personal vehicles expected to expand, transportation agencies and other stakeholders are seeking to better prepare drivers to properly and safely use these new technologies.

The MnDOT Connected and Automated Vehicles (CAV) Office requested this Transportation Research Synthesis (TRS) to inform a possible public education campaign that would advise drivers about ADAS and how to use these technologies safely and effectively when operating their personal vehicles. The CAV Office sought information about the efforts that may be underway at other state departments of transportation (DOTs) and departments of public safety, and the research published or in progress that addresses ADAS education and outreach.

This TRS report presents findings from an extensive review of the literature that is supplemented by limited survey findings. While there appears to be great interest in ADAS education and outreach among researchers and other stakeholders, the survey conducted for this TRS did not identify current efforts by state DOTs or public safety agencies to craft and deliver ADAS-related education and outreach.

Findings from the Literature

Nearly 60 citations that consider ADAS education and outreach are presented in Chapter 2.

Perhaps the most significant of these resources is a set of deliverables still in process. BTSCRP Project BTS-26, *Advanced Driver Assistance Systems (ADAS) Education and Outreach*, is funded through Transportation Research Board's Behavioral Traffic Safety Cooperative Research Program (BTSCRP) and led by a research team from University of Iowa's Driving Safety Research Institute. This project is "documenting and evaluating the state of training and education for ADAS features" and will generate project findings that "inform institutions, agencies and practitioners responsible for driver education and training about tools, strategies and models that can be used to provide consumers and other populations with a better understanding of ADAS technologies." The full complement of research findings from BTSCRP Project BTS-26 is expected to be available in July/August 2025.

The lead investigator for BTSCRP Project BTS-26 shared publications that were evaluated in connection with the scoping literature review conducted for this ongoing project. Many of these publications are cited in this TRS report.

Other publications cited in Chapter 2 address the key topic areas highlighted below:

- *National transportation association and organization resources* include PAVE's website, which offers the PAVE Resource Library, "a database of resources collected from PAVE members, academic institutions, agencies and other experts in the field." Also included are details of the Society of Automotive Engineers (SAE) International's six levels of driving automation, and resources provided by ADAS stakeholders that help consumers identify available safety features about specific vehicles and provide background information about ADAS technologies.
- *State agency education and outreach* includes a sample communication plan and activities for National Autonomous Vehicle Day, and a webinar that provides ideas for identifying target populations, selecting information to convey and then disseminating information about ADAS.
- *Driver training* research examines a range of training practices and reports on the efficacy of those practices to prepare drivers to use ADAS technologies. Highlighted below are selected findings:
    - *National research* assesses training strategies, identifies the elements of driver license testing systems that must be updated and offers recommended topics for agencies developing training protocols.
    - Resources from *state agencies and University Transportation Centers* offer recommendations for a multitiered approach to ADAS education and an assessment of training and learning methods.
    - *ADAS training models* consider ADAS limitations and the application and efficacy of simulators in ADAS education, and compare various training methods to identify those that are most effective.
    - A range of studies consider *demographic differences* in learning preferences and driving habits based on age, gender and other demographic factors. Several studies conclude that ADAS training can be most effective when tailored to specific driver demographics.
- Research examining *driver understanding* evaluates the impacts of demographic factors on trust and understanding, assesses the significance of hands-on and observational experience with ADAS technologies and identifies effective practices for dispelling common ADAS myths through public messaging that uses "simplified, neutral statements."
- *Other road users* are examined in a June 2021 study that sought to better understand the behaviors of pedestrians, bicyclists and other road users in relation to advanced driving features.
- *Commercial and large vehicles* are considered in numerous resources from the Federal Motor Carrier Safety Administration that showcase TechCelerate Now, a program that promotes the adoption of ADAS technologies in commercial vehicles. Also presented are resources that consider a more holistic approach to large vehicle safety that includes ADAS as one of several components in driver training to improve safety.

Findings from the Survey

An online survey distributed to members of the American Association of State Highway and Transportation Officials (AASHTO) State CAV Community of Practice sought feedback from a national pool of potential respondents. The distribution list also included the Eastern Transportation Coalition, a regional collaboration of

Eastern states that conducted recent work on ADAS public education and outreach. To supplement responses from this respondent group, the survey was also distributed through a mailing list of state public safety agency contacts.

Of the survey's 11 responses, nine responding agencies are state or district transportation agencies, one respondent is a regional consortium, and one is affiliated with a state highway safety program:

- Arizona DOT
- District of Columbia DOT
- Eastern Transportation Coalition
- Missouri DOT
- Nebraska DOT
- Nevada DOT
- North Carolina DOT
- North Dakota DOT
- Oklahoma DOT
- Pennsylvania DOT (PennDOT)
- West Virginia Governor's Highway Safety Program

Only one agency—PennDOT—reported experience with developing educational materials on ADAS.

Agency Experience with ADAS Education and Outreach

The PennDOT survey respondent noted that the agency's educational effort has produced conference presentations, a multipage brochure and social media posts. However, the respondent was unable to provide links to these publications, and a search of the agency's Automated Vehicles website did not identify them.

Staff from PennDOT's Automated Vehicles unit and agency leadership worked together to identify needs when developing a plan for ADAS education and outreach. Materials were produced through a collaboration of the agency's Office of Transformational Technology and staff from two private consulting firms. The respondent described this collaboration, which was established through existing open-end agreements, as "very effective" and noted that the consultants were the most valuable resource in the ADAS outreach effort.

The most challenging aspect of ADAS public outreach has been connecting with a wider and more diverse population. Other agencies seeking to develop and implement ADAS educational materials are advised to "try to be as all-inclusive as possible," take time to craft your message and seek out a wide audience to receive the ADAS outreach.

Agencies Considering ADAS Education and Outreach

Of the four agencies considering developing ADAS educational materials, only one—the District of Columbia DOT—indicated that an ADAS educational effort, if undertaken, could begin within the next six months. Development of ADAS educational materials would likely be addressed by the agency's Highway Safety Office/Vision Zero team, which is responsible for behavioral safety practices and most public training for these issues. Nebraska DOT may develop a customizable brochure for statewide use in another possible effort that could be initiated in 12 months.

Agencies Not Considering ADAS Education and Outreach

Six responding agencies are not considering developing ADAS educational materials:

- Arizona DOT
- Eastern Transportation Coalition
- Nevada DOT
- North Carolina DOT
- North Dakota DOT
- West Virginia Governor's Highway Safety Program

Two respondents offered additional comments:

- *Eastern Transportation Coalition*. Formerly the I-95 Corridor Coalition, the Eastern Transportation Coalition is a partnership of 19 states and the District of Columbia "focused on connecting public agencies across modes of travel to increase safety and efficiency." The survey respondent noted that interest has "migrated toward CV [connected vehicle] awareness and away from AV [automated vehicle] awareness." An example of the coalition's previous focus on AV awareness is the September 2022 webinar, *All Things ADAS (Advanced Driver Assist Systems): State Projects, Outreach and the State of the Industry*. This webinar addressed the need for consumer education on ADAS features and offered ideas for ADAS education.
- *North Dakota DOT*. The survey respondent commented that interest in ADAS education and outreach may intensify when the majority of vehicles are equipped with ADAS features.

Chapter 1 Introduction

Background

Today, most new vehicles sold include some level of automated driver assistance systems (ADAS) to enhance drivers' capabilities, and the presence of ADAS in personal vehicles is expected to expand.

Partners for Automated Vehicle Education (PAVE), a nonprofit coalition of representatives from industry, nonprofit organizations and academia, is among the many stakeholders with an interest in ADAS education and outreach. Organized to "bring the conversation about automated vehicles (AVs) to the public so everyone can play a role in shaping our transportation future," PAVE provides the following definition of ADAS:

> **Advanced Driver Assistance Systems (ADAS):** A term describing and encompassing all systems that use advanced Active Safety technologies to support human drivers by performing a part of the driving task if engaged. Examples include Adaptive Cruise Control and Automatic Emergency Braking.

To further define and describe ADAS-related technologies, many look to the six levels of driving automation identified by the Society of Automotive Engineers (SAE) International. SAE's Level 0 through Level 5 are part of a taxonomy described in Revised Standard J3016_202104, Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles. The six levels range from no driving automation (Level 0) to full driving automation (Level 5):

- *Level 0: No driving automation.* Includes automatic emergency braking and blind spot and lane departure warnings.
- *Level 1: Driver assistance.* Includes lane centering OR adaptive cruise control to provide steering or brake/acceleration support.
- *Level 2: Partial driving automation*. Includes lane centering AND adaptive cruise control at the same time.
- *Level 3: Conditional driving automation*. Requires advanced sensor packages. Includes traffic jam chauffeur, which drives the vehicle under limited conditions when all conditions are met. When the feature requests, the driver must drive.
- *Level 4: High driving automation*. Includes local driverless taxi (pedals and steering wheel may or may not be installed). As with SAE Level 3, these features can drive the vehicle under limited conditions when all conditions are met. When the feature requests, the driver must drive.
- *Level 5: Full driving automation*. Can drive the vehicle under all conditions. The driver is not driving when the automated features are engaged even when seated in the driver's seat.

See pages 7 and 8 for details of a current research project by the Transportation Research Board's (TRB's) Behavioral Traffic Safety Cooperative Research Program (BTSCRP) that defines ADAS as including SAE's Level 1 and Level 2 driving automation features.

Project Objective

When used appropriately, ADAS provides drivers with potential safety benefits. But many drivers are unaware of the available ADAS features in their vehicles and how to safely operate them. Some automobile dealerships provide training to drivers who purchase a new vehicle, but the practice of training and the information provided appear to be inconsistent.

To address this knowledge gap in public awareness, the MnDOT Connected and Automated Vehicles (CAV) Office is considering launching a public education campaign to educate drivers about ADAS and how to use it safely and effectively when operating their personal vehicles. To inform the development of such a campaign, the CAV Office requested this Transportation Research Synthesis (TRS) to learn about efforts underway at other state departments of transportation (DOTs) and departments of public safety, as well as the outreach conducted on behalf of other CAV stakeholders to educate the public about this relatively new technology.

Project Methodology

Three information-gathering efforts supported the development of this TRS report:

- **Literature search**. An in-depth search of recent domestic publications and in-progress research gathered resources designed to educate the public about the ADAS technologies present in personal vehicles.
- **Stakeholder outreach**. Outreach to a small group of stakeholders highlighted relevant publications associated with ADAS education and outreach.
- **Survey of practice**. An online survey of state transportation and public safety agencies sought to better understand the current state of the practice for public agencies that may be engaging in ADAS education and outreach.

MnDOT's CAV Office may use the results of these information-gathering efforts to evaluate current practices and consider the development of new materials and activities to educate the public about ADAS.

Report Organization

Chapter 2 presents the results of a literature search of domestic publications and resources related to the topic, which include the resources provided or recommended through stakeholder outreach. Findings from a survey seeking information from representatives of state transportation and public safety agencies are presented in Chapter 3. The full text of the questions included in the survey appears in Appendix A.

Chapter 2 Literature Search

Introduction

Findings from a literature search of recent domestic, publicly available publications and resources are presented in this chapter in the following categories:

- National agency resources
- National transportation association and organization resources
- State agency education and outreach
- Driver training
- Driver understanding
- Other road users
- Commercial and large vehicles

The findings below also include publications identified through outreach to selected contacts in the following stakeholder categories:

- Government agencies
- Nonprofit agencies and associations
- Transportation associations
- Universities and University Transportation Centers

National Agency Resources

This section presents a TRB Cooperative Research Program research project in progress that will assess existing ADAS materials and methods and recommend practices for delivering education information to target populations. Also included is a National Highway Traffic Safety Administration website that offers a comprehensive description of ADAS features.

Research in Progress: Advanced Driver Assistance Systems (ADAS) Education and Outreach, BTSCRP Project BTS-26, Behavioral Traffic Safety Cooperative Research Program; start date: July 2023; expected completion date: July 2025.
Project description at https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=5391
From the project description:

> **BACKGROUND**
> Proper use of advanced driver assistance systems (ADAS)—which are rapidly being introduced into the U.S. vehicle fleet—offers the promise of reducing motor vehicle crashes and fatalities. ADAS features, however, can be confusing to drivers, include a wide variance of terminology, and have many differences in design and functionality. ADAS technology differs from previous vehicle safety enhancements for which a simple message or warning conveys direction to drivers. ADAS requires new models for messaging to help drivers understand and effectively use these complex new technologies.
>
> ….

For the purpose of this request for proposals, ADAS is defined as the Society of Automotive Engineers (SAE) Level 1 and Level 2 advanced driver assist systems that are readily available to U.S. consumers in passenger vehicles and commercial trucks, and through the aftermarket.

TRB's Cooperative Research Program Developing ADAS Guidance for Practitioners

A research team at University of Iowa's Driving Safety Research Institute (DSRI) is developing a practitioners guide and webinar that will present effective methods for preparing and delivering ADAS training and educational materials. The excerpt below from the research team's project description for BTSCRP Project BTS-26 provides further details of the project in process:

> **Advanced Driver Assistance Systems (ADAS) Education and Outreach**
> As part of the Behavioral Traffic Safety Cooperative Research Program (BTSCRP) administered by the National Academies, DSRI researchers are documenting and evaluating the state of training and education for ADAS features. Ultimately, the team's findings will inform institutions, agencies and practitioners responsible for driver education and training about tools, strategies and models that can be used to provide consumers and other populations with a better understanding of ADAS technologies.
>
> Phase 1 of the project involves collecting information about existing ADAS training or educational materials and then evaluating the material content and effectiveness. Specifically, the team will identify (1) gaps and errors in those materials, (2) the methods of delivery, and (3) populations in need of ADAS education and training.
>
> Phase 2, which is slated to begin in 2024, will include synthesizing the information identified in Phase 1, identifying the characteristics of effective methods of delivering ADAS training and educational materials to target populations, and creating deliverables that include a practitioners guide and webinar for practitioners, such as Department of Motor Vehicle staff.

Dr. Justin Mason, the project's principal investigator, noted that research findings will be publicly available only after the project is complete and has received approval from the National Academies of Science, which Mason anticipates will be July/August 2025. The earliest certain findings can be discussed publicly is May 2025, when Mason and his team hope to workshop a practitioners guide at the March 2025 Lifesavers Conference on Roadway Safety. Information about these workshops will be posted in early winter 2025 on the Lifesavers Conference, Inc. website.

While project findings are not yet available, Mason shared publications addressing ADAS education or training that were evaluated in connection with the scoping literature review conducted for the ongoing BTSCRP project. Many of the domestic publications evaluated by the DSRI research team are cited in this chapter.

> *Contact*: Dr. Justin Mason, Assistant Research Scientist, Driving Safety Research Institute, University of Iowa, 319-467-1614, justin-mason@uiowa.edu.

Driver Assistance Technologies, National Highway Traffic Safety Administration, U.S. Department of Transportation, undated.
https://www.nhtsa.gov/vehicle-safety/driver-assistance-technologies
This in-depth website describes a range of ADAS features, including systems for collision warning, collision intervention and driving control assistance.

National Transportation Association and Organization Resources

In the citations below, national transportation-related associations and organizations offer resources for consumers to identify available safety features about specific vehicles and provide background information about ADAS technologies, including SAE International's six levels of driving automation.

Partners for Automated Vehicle Education (PAVE), undated.
https://pavecampaign.org/
From the website:

> PAVE is a coalition of partners dedicated to educating the public and policymakers about automated vehicles and the increased safety, mobility and sustainability they can bring.

PAVE's "About" webpage describes the coalition's mission:

> **A Coalition of Public and Private Sector Partners With One Goal:**
> To bring the conversation about automated vehicles (AVs) to the public so everyone can play a role in shaping our future.
>
> PAVE's goal is purely educational—we don't advocate for a particular technology or specific public policies. Our members believe that we can only achieve the potential benefits of driverless technology if the public and policymakers know the honest facts. PAVE wants to raise public awareness of both what is on the roads today and what is possible for the future.

My Car Does What?, National Safety Council, 2024.
https://mycardoeswhat.org/
Developed through a partnership between vehicle safety researchers at the University of Iowa and the National Safety Council, this safety training resource informs consumers about the "intersection of vehicle technology and traffic safety." Resources available include:

- An overview of available safety features by vehicle type.
- Numerous videos and brief summaries of safety features that address forward collision prevention; braking, tire pressure and anti-rollover systems; driver state monitoring and communication; parking and backing assistance; and lane and side warning assistance.

Advanced Driver Assistance Systems, AAA Exchange, 2024.
https://exchange.aaa.com/automotive/automotive-testing/advanced-driver-assistance-systems/
Guidance for three ADAS technologies—blind spot monitoring and lane departure warnings, rear-view camera, and self-parking technology—is presented.

Clearing the Confusion: Common Naming for Advanced Driver Assistance Systems, "Clearing the Confusion" Coalition, July 2022.
https://article.images.consumerreports.org/image/upload/v1658777041/prod/content/dam/CRO-Images-2022/Cars/07July/Clearing-the-Confusion-7-26-22.pdf
From the publication: Today, most new vehicles are equipped with at least one, but more likely, numerous advanced driver assistance systems (ADAS). The names used to describe them across the industry, however, [vary] greatly, which creates confusion for consumers.

Six leading organizations committed to consumer safety and education—AAA (American Automobile Association), Consumer Reports, J.D. Power, National Safety Council, PAVE and SAE—have come together to develop the standardized naming conventions for ADAS technologies (shown to the right) which are simple, specific and based on system functionality.

The organizations are asking automakers to adopt the standardized ADAS terminology to help reduce consumer confusion about the intent and functionality of these systems. The standardized terms were created to provide clarity to consumers by naming and describing the functions of ADAS in a consistent, easy to understand manner. They are not meant to replace an automaker's proprietary system or package name or those used for marketing purposes.

As part of creating a better understanding, the organizations want consumers to embrace new vehicle technology but also know that these systems are designed to assist and not replace an engaged driver.

SAE J3016 Levels of Driving Automation, SAE International, 2021.
https://cav.mdot.maryland.gov/wp-content/uploads/2022/10/sae-j3016-visual-chart_5.3.21.pdf
In this graphic, SAE International describes six levels of driving automation, distinguishing between driver support and automated driving features:

- **Level 0:** No driving automation. *Examples*: Automatic emergency braking, blind spot warning and lane departure warning.
- **Level 1:** Driver assistance. *Examples*: Lane centering or adaptive cruise control.
- **Level 2:** Partial driving automation. *Examples*: Lane centering and adaptive cruise control at the same time.
- **Level 3:** Conditional driving automation. *Example*: Traffic jam chauffeur.
- **Level 4:** High driving automation. *Examples*: Local driverless taxi, pedals/steering wheel may or may not be installed. Features can drive the vehicle under limited conditions and will not operate unless all required conditions are met.
- **Level 5:** Full driving automation. *Examples*: Same as Level 4, but feature can drive everywhere in all conditions.

State Agency Education and Outreach

The resources in this section offer ideas for public outreach, including a communication plan and activities for National Autonomous Vehicle Day. Also included is a webinar that provides ideas for identifying target populations, selecting information to convey and then disseminating information about ADAS. Public educational messaging about ADAS terminology, capabilities and limitations is presented for the general public and first responders in a 2022 Utah DOT report.

Eastern Transportation Coalition

"All Things ADAS (Advanced Driver Assist Systems): State Projects, Outreach and the State of the Industry," Webinar, Eastern Transportation Coalition, September 27, 2022.
https://tetcoalition.org/wp-content/uploads/2022/10/CAV-Webinar-Final-Slides-09-27-22.pdf
Presenters for this webinar include the administrator of Maryland DOT Motor Vehicle Administration addressing Maryland DOT's efforts in ADAS outreach (slides 19-29) and a senior director from J.D. Power discussing the need for consumer education on ADAS features (slides 33-48).

Ideas for ADAS education (slide 27) include:

- **How to get the word out?** [I]ncorporating in public safety campaign, newsletters, posters, handouts; highlight safety success stories; webinars; committee of speakers; social media; collaboration with many organizations.
- **Who needs to be educated?** [E]ducate internal staff, first responders, dealerships, manufacturers, drivers/consumers, technicians (repair).
- **What education needs to be conveyed?** [A]ppropriate terminology, capabilities of tech, differences of active vs. alerts/warnings for ADAS, differences of ADAS v. ADS [automated driving systems], awareness of tech and benefits, staying in control of the vehicle.

Indiana

Connected and Automated Vehicles, Indiana Department of Transportation, 2024.
https://www.in.gov/indot/emerging-mobility/connected-and-automated-vehicles/
Connected vehicles (CVs) are distinguished from AVs on this webpage. The AV description includes an SAE International graphic of the six levels of driving automation.

Maryland

National Autonomous Vehicle Day Toolkit, Connected and Automated Vehicle Program, State of Maryland, 2024.
https://cav.mdot.maryland.gov/wp-content/uploads/2024/05/National-Autonomous-Vehicle-Day-Toolkit-2024-Final2.pdf
A social media toolkit provides posts to educate consumers about ADAS.

National CAV Day Communications Plan and Strategy, Maryland Department of Transportation, Eastern Transportation Coalition, October 8, 2022.
https://cav.mdot.maryland.gov/wp-content/uploads/2022/10/National-CAV-Day-2022-Toolkit.docx
The goals of National CAV Day are to increase awareness and educate the general public about the benefits of CAVs. Most of the strategy focuses on providing information about ADAS. This outreach effort aligns with three other educational initiatives:

- Eastern Transportation Coalition ADAS outreach effort in partnership with PAVE.
- Ongoing education work with J.D. Power.
- Educational outreach sponsored by Maryland DOT and other regional agencies.

Planning for Connected and Automated Vehicle Readiness, Maryland Transportation Authority, December 2020.
https://cav.mdot.maryland.gov/wp-content/uploads/2022/10/Planning-for-Connected-and-Automated-Vehicle-Readiness-December-2020.pdf
Maryland Transportation Authority's CAV strategic framework includes public education and outreach as one of five key focus areas (page 14 of the report, page 15 of the PDF).

Utah

Development of Educational Materials for the Public and First Responders on the Limitations of Advanced Driving Assistance Systems, Md Ashikur Rahman and Michelle Mekker, Utah Department of Transportation, September 2022.
https://drive.google.com/file/d/1Xgzhy39yL452ReIBvUIMViKEoKmtLnwA/view
From the abstract:

> This study will help TIM [traffic incident management] personnel better understand ADAS technology by providing a database of commercially available vehicles incorporating this technology and training on terminology and limitations of ADAS. These findings can be used by the Utah Department of Transportation to educate both drivers and first responders.

Chapter 5 presents recommended public educational messaging about ADAS terminology, capabilities and limitations (beginning on page 73 of the report, page 74 of the PDF).

Driver Training

The citations in this section examine a range of training practices and describe their efficacy to prepare drivers to use ADAS technologies. Highlighted below are selected findings organized into four categories: national research, state and University Transportation Center research, ADAS training models and demographic differences.

National research. Summarized below are selected driver training practices, protocols and findings:

- Testing on public roads and a test track indicated that "driver training can have an effect on driver engagement on public roads that is independent from vehicle capabilities."
- Recommended training topics include the purpose of ADAS technologies such as risks and benefits; capabilities and limitations of various levels of automation; handling critical situations, including system malfunctions; and familiarity with system components and where they are located.
- Researchers noted that driver license testing systems must be updated to address ADAS technologies, including driver license manuals, driver license knowledge tests, skills tests and examiner training.
- An examination of two training strategies—conventional (self-learning through the owner's manual) and experimental (multimedia)—identified limited differences in knowledge and no difference in driver behaviors or attitudes.

State and University Transportation Center research. A multitiered approach to ADAS education includes reading materials and videos that inform drivers about ADAS technologies, an accompanied ride with a driving instructor who demonstrates technologies and time in a driving simulator to increase a driver's familiarity with ADAS. Massachusetts DOT researchers examining training and learning methods found that "[t]argeting 'higher order skills' shows improvement in drivers' knowledge."

ADAS training models. Highlighted below are selected researchers' conclusions regarding the models and practices used to examine the efficacy of ADAS training:

ADAS limitations. When comparing limitation-focused training with responsibility-focused training, researchers' results "suggest that the responsibility-focused approach may be a reasonable alternative that should be investigated further with behavioral studies." In another study, researchers concluded that "[t]raining that emphasizes a partial driving automation system's capabilities and downplays its limitations can foster overconfidence."

Simulator use. Researchers used surveys, verbal probes and instructions to assess drivers experiencing adaptive cruise control (ACC) in a driving simulator. Another study used a high-fidelity driving simulator to compare responses of drivers with strong and weak mental models of ACC that were established through a combination of screening, training and exposure.

Comparing training methods. Assessments of users' perceptions of training and change in trust after training identified that "although training did not affect users' trust, a qualitative examination showed that users preferred the [t]ext-[b]ased method rather than the [v]isualization method." Another study compared formal and informal training practices, concluding that "[p]articipants who received formalized training reported it to be significantly more effective than those who received informal overviews of their systems."

Demographic differences. A range of studies considers demographic differences in learning preferences and driving habits based on age, gender and other demographic factors. Several of these studies conclude that ADAS training can be most effective when tailored to specific driver demographics.

National Research

Driver Expectations for System Control Errors, Driver Engagement and Crash Avoidance in Level 2 Driving Automation Systems, Sheldon Russell, Jon Atwood and Shane McLaughlin, National Highway Traffic Safety Administration, January 2021.
https://rosap.ntl.bts.gov/view/dot/54443
From the abstract: This project tested 96 participants in vehicles equipped with SAE Level 2 driving automation systems of different capabilities. To evaluate the effects of driver expectations, participant training was either congruent or incongruent with system capabilities, creating a four-condition, between-subjects factor. Testing was conducted on public roads and on the Virginia Smart Road test track. While on the test track, participants were asked to complete nondriving tasks while driving, and midway through the driving session experienced a surprise event (crash-imminent scenario). Analyses focused on summary measures of driver engagement behaviors such as driver hands-on steering wheel behavior and subjective measures of automation acceptance and engagement. Response times to surprise events were also compared between expectation levels. Results indicate that driver training can have an effect on driver engagement on public roads that is independent from vehicle capabilities.

Guidelines for Testing Drivers in Vehicles with Advanced Driver Assistance Systems, American Association of Motor Vehicle Administrators, August 2019.
https://www.aamva.org/getmedia/d67c7501-df04-4c7d-b454-5b59d0de0889/Guidelines-for-Testing-Drivers-in-Vehicles-with-ADAS.pdf
From the executive summary: As the AAMVA [American Association of Motor Vehicle Administrators] community became more informed, it began to understand the impact vehicle technologies, found in SAE-defined levels 0, 1 and 2 are already having on driver licensing programs. It became clear that there was a need to update driver license testing systems, including driver license manuals, driver license knowledge tests, skills tests and examiner training, by incorporating information and testing procedures that address the technology, referred to as [a]dvanced [d]river [a]ssistance [s]ystems (ADAS). ADAS are becoming increasingly common and in some cases assist the driver but do not perform the driving function. ADAS are designed to help drivers with certain driving tasks (e.g., staying in the lane, parking, braking, avoiding crashes, reducing blind spots and maintaining a safe space cushion). ADAS are designed to improve vehicle and road safety.

Driver License Testing Materials
Most jurisdictional driver's manuals do not currently contain information on ADAS and will need to be updated to include pertinent information on vehicle technology. Knowledge tests will also need to be updated to include questions on vehicle technology contained in the driver's manual.

Driver Training Research and Guidelines for Automated Vehicle Technology, Michael P. Manser, Alexandria M. Noble, Sahar Ghanipoor Machiani, Ashley Shortz, Sheila G. Klauer, Laura Higgins and Alidad Ahmadi, U.S. Department of Transportation, July 2019.
https://vtechworks.lib.vt.edu/server/api/core/bitstreams/4323f9ea-476c-47f4-bade-ebccca0371e3/content
From the abstract:

> The aim of the project was to develop training protocol guidelines that could be used by advanced driver-assistance system trainers to optimize driving safety. The guidelines were developed based on the results of three activities that included the development of a taxonomy of the knowledge and skills necessary to operate advanced driver-assistance systems, a driving simulator study that examined the effectiveness of traditional training protocols, and a test track study that examined the efficacy of a vehicle-based training protocol. Results of both studies suggest that differing training protocols are most beneficial in terms of driver cognitive load and visual scanning as opposed to short-term changes in performance.

Recommended training topics are presented on page 18 of the report (page 25 of the PDF):

- Purpose of using ADAS systems (risks and benefits).
- Understanding levels of automation (capabilities and limitations).
- Transition between ADAS and manual mode and handling critical situations (system malfunctions).
- Familiarity with system components and placement (sensor, radar, camera, etc.).
- Understanding limitations of driver assistant systems (ACC), LKAS [lane keep assist system], AEB [automatic emergency braking], etc.).

Appendix F (page 33 of the report, page 40 of the PDF) summarizes key vehicle-based training topics from a Tesla Model S and a brief description of information to include.

"Driver Training for Automated Vehicle Technology: Knowledge, Behaviors and Perceived Familiarity," Alexandria M. Noble, Sheila G. Klauer, Zachary R. Doerzaph and Michael P. Manser, *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, Vol. 63, Issue 1, pages 2110-2114, 2019.
Citation at https://journals.sagepub.com/doi/epdf/10.1177/1071181319631249
From the abstract: The purpose of this study was to determine the effectiveness of two training strategies on drivers' knowledge and perceived familiarity of vehicle automation as well as their environment monitoring behaviors during system use. Forty volunteers participated in a multi-stage research study in which they were exposed to either a conventional training protocol, self-learning through the owner's manual or an experimental (multimedia) training protocol, using the in-vehicle display technologies as training tools. Results indicate training strategy elicits limited differences in knowledge and no difference in driver behaviors or attitudes. Behaviors and attitudes were heavily influenced by time and experience with the driving automation system while knowledge of the vehicle systems remained unchanged.

State and University Transportation Center Research

University Transportation Center

Training Drivers to Automated Vehicles, Rahul Mangharam, Helen Loeb and Zhijie Qiao, Mobility21 (University Transportation Center), July 2023.
https://ppms.cit.cmu.edu/media/project_files/Final_Report_-_342.pdf
The efficacy of an in-car, mixed-reality driving simulator was tested to assess the need to train drivers to use ADAS and the tools and methods needed to encourage skeptical drivers of various ages to trust automation and self-driving technology. Thirty-six participants operated the simulator in three scenarios: rural, city and highway environments. Researchers found that driving simulators can be "a valuable tool for driver's training and education." Study results showed that the simulator "successfully improved participants' attitudes toward autonomous vehicles in terms of perceived risk, perceived usefulness, perceived ease of use, trust and behavioral intention." Researchers recommended that ADAS training take a multitiered approach, beginning with a curriculum based on reading materials and videos that inform drivers about ADAS technologies. Next, an accompanied ride by a dealership or driving instructor could demonstrate technologies. Finally, a time in a driving simulator would give drivers an opportunity to increase their familiarity with ADAS.

Massachusetts

Impact of Advanced Driver Assistance Systems (ADAS) on Road Safety and Implications for Education, Licensing, Registration and Enforcement, Anuj K. Pradhan, Apoorva Hungund and Daniel Sullivan, Massachusetts Department of Transportation, March 2022.
https://www.mass.gov/doc/impact-of-advanced-driver-assistance-systems-adas-on-road-safety-and-implications-for-education-licensing-registration-and-enforcement-final-report/download
From the executive summary:

C. While drivers may have a generally reasonable awareness of ADAS, fewer than 80% of (surveyed) drivers knew how the technology worked before they bought a vehicle. Training offered is minimal, and, alarmingly, most drivers reported a "trial and error" learning process. Such a process has safety consequences on public roads, both to the drivers of these vehicles and to other road users. There is a recognized need to explore how awareness of the benefits and/or pitfalls of ADAS can be raised and to understand potential unintended effects of popular media representation on the drivers' expectations of ADAS.

D. The role of driver training is an important one in ensuring drivers have the correct understanding of ADAS. Targeting "higher order skills" shows improvement in drivers' knowledge. Experimental evaluation shows that training holds promise for improved understanding. This report recommends expanded examination of training as an approach to improve drivers' knowledge and use of these technologies to maximize the promised benefits of advanced vehicle technologies.

A discussion of training and learning methods in this study (page 26 of the report, page 44 of the PDF) noted that fewer than 80% of participants understood how ACC worked before they bought a vehicle equipped with the system. Although a limited number of these drivers received "some kind of training or information" from the dealer when they purchased a vehicle, those participants who did receive the training found that it was "satisfactory" and enabled them to use the technology.

Related Resource:

Impact of Advanced Driver Assistance Systems (ADAS) on Road Safety and Implications for Education, Licensing, Registration and Enforcement, Research Summary, Massachusetts Department of Transportation, June 2022.
https://www.mass.gov/doc/impact-of-advanced-driver-assistance-systems-adas-on-road-safety-and-implications-for-education-licensing-registration-and-enforcement-project-summary/download
From the use of findings: [T]he research shows that targeted training improves drivers' understanding of these systems, with some indication of improved safety behaviors as well. This can be translated to driver training efforts at various levels, including at driver ed[ucation] programs, and using "train the trainer" approaches. This also will serve to improve awareness about novel advanced vehicle technologies among law enforcement and first responders.

ADAS Training Models

"Limitation-Focused Versus Responsibility-Focused Advanced Driver Assistance Systems Training: A Thematic Analysis of Driver Opinions," Chelsea DeGuzman, Suzan Ayas and Birsen Donmez, *Transportation Research Record 2677*, Issue 7, pages 122-132, 2023.
Citation at https://journals.sagepub.com/doi/full/10.1177/03611981221151022
From the abstract: Training for advanced driver assistance systems (ADAS) generally aims to teach drivers various system limitations. However, limitation-focused training has disadvantages, such as drivers having difficulty remembering a long list of limitations over time. The current study compared limitation-focused training with responsibility-focused training, which aims to teach drivers how they should be using ADAS and the consequences if they do not use the systems appropriately. … [D]rivers in both training groups thought the videos were helpful and both training approaches were associated with reduced intention to engage in distractions while using ADAS. Results also showed that decreased interest in ADAS and reports of not wanting to use ADAS were more common after the limitation-focused training, with drivers in the limitation-focused group highlighting the number of limitations and unclear benefits as reasons why they would not use ADAS. Given the drawbacks associated with limitation-focused training, our results suggest that the responsibility-focused approach may be a reasonable alternative that should be investigated further with behavioral studies.

"Driver Expectations of a Partial Driving Automation System in Relation to Branding and Training," Jeremiah Singer, Brian C. Tefft, Aaron Benson, James W. Jenness and William J. Horrey, *Human Factors: The Journal of the Human Factors and Ergonomics Society*, Vol. 66, Issue 5, December 2022.
https://doi.org/10.1177/00187208221143024
From the abstract:

> **Objective**
> The current study examined whether differences in the branding and description or mode of training materials influence drivers' understanding and expectations of a partial driving automation system.
> ….
>
> **Results**
> Immediately after training, those who received information emphasizing the system's capabilities had greater expectations of the system's function and crash avoidance capability in a variety of driving scenarios, including many in which the system would not work, as well as greater willingness to utilize the system's workload reduction benefits to take more risks. Most but not all differences persisted after driving the vehicle. Expectations about collision avoidance differed by training mode pre-drive but not post-drive.
>
> **Conclusion**
> Training that emphasizes a partial driving automation system's capabilities and downplays its limitations can foster overconfidence.

"Longer-Term Exposure vs Training: Their Effect on Drivers' Mental Models of ADAS Technology," Cher Carney, John G. Gaspar and William J. Horrey, *Transportation Research Part F: Traffic Psychology and Behaviour*, Vol. 91, pages 329-345, November 2022.
Publication available at https://www.sciencedirect.com/science/article/pii/S1369847822002145?via%3Dihub
From the abstract: This study recruited 39 new owners of vehicles equipped with ADAS technology to which the owners were naive. The initial mental model of these owners was evaluated using a mental model assessment. To understand changes in mental models over time the assessment was repeated six times over the course of approximately [six] months. Weekly mileage, technology usage and information regarding their exposure to edge case scenarios [were] also collected. At the end of the [six] months, participants completed a simulator drive using adaptive cruise control (ACC) that included several edge cases. Over the course of the first [six] months of vehicle ownership, drivers' scores on the mental model assessment improved. These improvements were largely due to increased understanding of the technology's limitations as opposed to improvements in knowledge about system function. With respect to driving performance in the simulator session, the mental model scores were not predictive of responses to the edge cases. However, a comparison of those mental model scores against weak and strong mental model benchmark scores gathered in a previous study revealed that mental models improve over [six] months (for some drivers), but not to the level of understanding of a group that received a short but extensive introduction to ACC. This suggests that there is room for improvement in how drivers gain understanding about driver support features and further underscores the need of training and education for proper use and interactions.

"Using Training to Improve Drivers' Knowledge and Understanding of Advanced Driver Assistance Systems: An Experimental Study," Apoorva Hungund, Jaji Pamarthi, Ganesh Pai and Anuj K Pradhan, *Traffic Injury Prevention*, Vol. 23, Issue Supplement 1, September 2022.
https://www.tandfonline.com/doi/full/10.1080/15389588.2022.2119028
From the objectives: Use of [a]dvanced [d]river [a]ssistance [s]ystems (ADAS) has increased exponentially in the past decade. However, ADAS features are complex, and drivers must understand the limitations and conditions in which ADAS should be used. ADAS today is not capable of taking over driving indefinitely and should only be used as a support system (SAE 2021). Drivers need to monitor their surroundings and be ready to take control of the car whenever necessary. Previous studies show drivers using multiple methods to understand ADAS. Owner's [m]anual is the preferred method (McDonald et al. 2016); however, it is lengthy and not user-friendly (Mehlenbacher et al. 2002). Providing compact and essential training can help drivers understand when and how to use ADAS and help calibrate trust (Beggiato and Krems 2013). To examine improvement in drivers' understanding and use of ADAS, we evaluated [the] impact of three methods using a randomized controlled experiment in an advanced driving simulator. We measured knowledge of [a]daptive [c]ruise [c]ontrol (ACC) via surveys, verbal probes and instructions while experiencing ACC in a driving simulator.

"Users' Perception of Training Approaches for Advanced Driver Assistance Systems (ADAS)," Ganesh Pai, Apoorva Hungund, Sarah Widrow and Jaydeep Radadiya, *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, Vol. 65, Issue 1, pages 279-283, September 2021.
Publication available at
https://www.researchgate.net/publication/356168052_Users%27_Perception_Of_Training_Approaches_For_Advanced_Driver_Assistance_Systems_ADAS
From the abstract: Advanced [d]river [a]ssistance [s]ystems (ADAS) provide safety and comfort while driving. However, to effectively use ADAS, it is necessary for users to have proper knowledge of the systems and to trust the system to operate safely. Providing knowledge about operational capabilities and limitations of a system may help improve drivers' mental models and calibrate their trust resulting in proper use of ADAS. Traditionally system information is provided via the owner's manual, which is known to be tedious and time-consuming and underscores the need for alternate training approaches. This study evaluates two training methods, [t]ext-[b]ased and [s]ystem [v]isualization, to examine users' perceptions of training and change in trust after training. Results show that although training did not affect users' trust, a qualitative examination showed that users preferred the [t]ext-[b]ased method rather than the [v]isualization method.

"Driver Trust In and Training for Advanced Driver Assistance Systems in Real-World Driving," Steven D. Lubkowski, Bridget A. Lewis, Valerie J. Gawron, Travis L. Gaydos, Keith C. Campbell, Shelley A. Kirkpatrick, Ian J. Reagan and Jessica B. Cicchino, *Transportation Research Part F: Traffic Psychology and Behaviour*, Vol. 81, pages 540-556, August 2021.
Citation at https://doi.org/10.1016/j.trf.2021.07.003
From the abstract: Two-hundred and twenty-three participants completed an online survey regarding their experiences with advanced driver assistance systems (ADAS) on their personal vehicles, with focus on 1) drivers' trust in 13 ADAS technologies, and 2) perceived effectiveness of currently used methods of training. Eighteen drivers participated in focus groups designed to probe more deeply into survey responses. Results of the survey showed that participant ratings of trust increased significantly with longer vehicle ownership, but participants who experienced unexpected ADAS technology behavior rated their trust over time significantly lower on ADAS technologies with the exception of rear collision avoidance. The majority (75.8%) of participants reported receiving some ADAS instruction at their vehicle dealership, but only 16.6% indicated it was formal. Participants

who received formalized training reported it to be significantly more effective than those who received informal overviews of their systems. Use of trial and error and the owner's manual were the most frequently reported methods of learning outside of dealership training. Responses indicated that the lack of content tailored to trim-specific vehicle features in owner's manuals was a barrier to effective use.

"Mapping Drivers' Mental Models of Adaptive Cruise Control to Performance," John G. Gaspar, Cher Carney, Emily Shull and William J. Horrey, *Transportation Research Part F: Traffic Psychology and Behaviour*, Vol. 81, pages 622-638, August 2021.
Citation at https://doi.org/10.1016/j.trf.2021.07.012
From the abstract: Driver support features (DSF) have the potential to improve safety, but they also change the driver-vehicle relationship —as well as their respective roles and responsibilities. To maximize safety, it is important to understand how drivers' knowledge and understanding of these technologies—referred to as drivers' mental models—impact performance and safety. This simulator study examined how drivers with different mental models of adaptive cruise control performed in edge cases. The study compared the responses of groups of drivers, with strong and weak mental models of ACC, established through a combination of screening, training, and exposure, in edge case situations in a high-fidelity driving simulator. In general, participants with strong mental models were faster than those with weak mental models to respond in edge-case situations—defined as cases where the ACC did not detect an approaching object, such as a slow-moving motorcycle. The performance deficits observed for drivers with weak mental models appear to reflect uncertainty surrounding how ACC will behave in edge cases.

"Advanced Vehicle Technology: Mapping Mental Model Accuracy and System Exposure to Driver Behavior," Aaron Benson, Joanne But, John Gaspar, Cher Carney and William Horrey, *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, Vol. 65, Issue 1, pages 1072-1076, 2021.
Citation at https://journals.sagepub.com/doi/epdf/10.1177/1071181321651086
From the abstract: This study sought to explore how the quality (accuracy) of drivers' mental models of adaptive cruise control (ACC) impacted their behavior and interactions while using the system. Seventy-eight participants drove in a high-fidelity driving simulator while operating an ACC system in normal conditions and while interacting with the system interface. Participants with stronger (more accurate) mental models glanced to the road ahead more often during normal conditions early on compared to drivers [with] less accurate mental models; however, these differences diminished with increased system exposure. Glance behavior while interacting with the system and time to complete the interactions were less affected by the strength of the participant's mental model. Results are discussed in the context of driver education and training.

"Driver Training for Advanced Driver Assistance Systems: Who Needs It, Who Wants It and Will It Make a Difference?" Steve Casner, *TR News*, Issue 326, pages 25-29, March-April 2020.
https://onlinepubs.trb.org/onlinepubs/trnews/trnews326DriverTraining.pdf
From the abstract: Drivers and technology need to work together as a team, each making a unique contribution and helping to overcome the limitations of the other. However, as examples in this article show, often drivers are using ADAS as a substitute for their participation. Drivers tend to overestimate what computers can do, believe that automation is more capable than it is, and underestimate the role of passengers in their driving decisions. Driver training focused on vehicle automation could improve driver performance and safety. The author examines the research currently underway that explores driver training for automated vehicles.

"Effects of Training and Display Content on Level 2 Driving Automation Interface Usability," Alexandra Mueller, Jessica Cicchino, Jeremiah Singer and James Jenness, *Transportation Research Part F: Traffic Psychology and Behaviour*, Vol. 69, pages 61-71, February 2020.
Citation at https://www.sciencedirect.com/science/article/abs/pii/S1369847819303997
From the abstract: [SAE] Level 2 driving automation features, such as adaptive cruise control (ACC) combined with lane centering, primarily communicate their operating statuses through the instrument cluster. It remains unclear how interface-specific training and display content influence the ability to understand Level 2 activity in production vehicles.

Eighty participants viewed videos recorded from the driver's point of view in a variety of driving scenarios with Level 2 activity displayed in the instrument cluster of a 2017 Mercedes-Benz E-Class. Half viewed one of two instrument cluster layouts (simple or complex), and half received an orientation to the interface before the experiment. After each video, they were asked about the scenario they had just seen. The authors then examined what information in the displays participants used to identify Level 2 activity and the usability of the displays.

Training improved recognition accuracy of when lane centering was temporarily inactive and understanding of why it was inactive. Neither training nor display content affected the ability to recognize when ACC had adjusted the vehicle's speed or detected a vehicle ahead, or when ACC initially did not detect a lead vehicle and understanding of why it had not detected it. Both factors influenced which sources of information participants used to determine Level 2 activity. Recognition accuracy of system activity improved when participants used valid sources of information. Training, but not display content, improved lane centering usability, but not ACC usability.

Basic training improves detection of notifications that potentially require further driver action, but not of those that display persistent status information. Training does not result in full understanding of all system notifications or functional limitations, which reinforces the need for intuitive, salient communication about system behavior and its limitations.

"What Do We Tell the Drivers? Toward Minimum Driver Training Standards for Partially Automated Cars," Stephen M. Casner and Edwin L. Hutchins, *Journal of Cognitive Engineering and Decision Making*, Vol. 13, Issue 2, pages 55-66, June 2019.
https://journals.sagepub.com/doi/epub/10.1177/1555343419830901
From the abstract: Each year, millions of automobile crashes occur when drivers fail to notice and respond to conflicts with other vehicles, bicyclists and pedestrians. Today, manufacturers race to deploy automation technologies to help eliminate these mishaps. To date, little effort has been made to educate drivers about how these systems work or how they affect driver behavior. Driver education for automated systems amounts to additional pages in an owner's manual that is known to be a seldom-used glove box reference. In this article, we review the history of automation deployed in the airline cockpit decades ago. We describe how automation helped avoid many common crash scenarios but at the same time gave rise to new kinds of crashes. It was only following a concerted effort to educate pilots about the automation, about themselves and about the concept of a human-automation team that we reached the near-zero crash rate we enjoy today. Drawing parallels between the automation systems, the available pilot and driver research, and operational experience in both airplanes and automobiles, we outline knowledge standards for drivers of partially automated cars and argue that the safe operation of these vehicles will be enhanced by drivers' incorporation of this knowledge in their everyday travels.

"Examination of the Effectiveness of Multiple Training Methods on Supporting Drivers' Better Understanding Towards Level 2 Automated Vehicle Systems," Shan Bao, Fred Feng, Anuj Pradhan, Yu Zhang, Bochen Jia and John Sullivan, *Transportation Research Board 98th Annual Meeting*, Paper #19-01321, January 2019.
Citation at https://trid.trb.org/View/1572720
From the introduction: Vehicle automation aims to improve driving safety and reduce the workload and stress of a human driver by transferring the driving task from the driver to control devices. As all automated vehicle control systems have limitations, improper expectations and trust can decrease the effectiveness and safety benefits of an automated system. If a driver overtrusts the system, he or she may use the automation when conditions exceed the capacity of the system, compromising safety. Although previous studies suggest that providing accurate knowledge to users may help train them to establish appropriately calibrated trust of automated systems, limited effort has been done to examine how training can improve drivers' understanding of the systems, and to develop appropriate training programs for this purpose. The main objective of this study is to develop and evaluate the efficacy of different training methods to promote a driver's safe operation and trust calibration of automated vehicle (AV) systems. Two AV systems were examined in this study: [a]daptive [c]ruise [c]ontrol (ACC) and [l]ane [k]eeping [a]ssist (LKA). Both knowledge- and skill-based training strategies were developed to describe the AV system functionalities and limitations associated with the two systems. These strategies were later evaluated to determine their impact on producing accurate mental models [of] each AV system, and were compared with training based on use of the owner's manual. It was hypothesized that both knowledge- and skill-based training lead to better understanding of system limitations and functionalities compared to exclusive reliance on the owner's manual.

Demographic Differences

Mapping Comprehension of ADAS Across Different Road Users, Justin Mason, Cher Carney, John G. Gaspar, Woon Kim, Alicia Romo and William J. Horrey, AAA Foundation for Traffic Safety, SAFER-SIM (University Transportation Center), October 2023.
https://aaafoundation.org/wp-content/uploads/2023/09/202310-AAAFTS-Mapping-ADAS-Comprehension.pdf
From the executive summary:

> The current study employed a national online survey that examined experiences with ADAS, learning preferences and driving habits from 2,528 participants based on age, race and gender. Road users' understanding of ACC [adaptive cruise control] and LKA were evaluated using mental model assessments. Four distinct clusters (weak confident, strong confident, weak unconfident, strong unconfident) of road users emerged, based on road users' mental models as well as confidence in their mental models[,] revealing some important patterns pertaining to their consumer education preferences, use of ACC and LKA, and driving self-efficacy. Findings suggest that road users with a strong understanding of ADAS are younger and preferred relying on videos and the internet to find educational material compared to learning about vehicle systems from the owner's manual or by trial and error. Road users in the strong confident and weak confident clusters reported driving safer and had more positive perceptions of technology. They also reported higher levels of familiarity, trust and ownership of ACC and LKA systems compared to the strong unconfident and weak unconfident clusters. While experience can aid drivers' understanding about the systems, it may not necessarily lead to sufficient and accurate assessment on how the U.S. population is using ADAS. The current results also underscore the importance of targeted education about vehicle technology.

Survey topics included preferred ADAS learning methods and mediums, such as trial and error, friends and family, dealership offerings, owner's manual and driver education. Bar charts on pages 22 and 23 of the report (pages 28 and 29 of the PDF) compare the use of various learning methods and the preferred learning methods of the four participant clusters.

"Pilot Study: Effect of Roles and Responsibility Training on Driver's Use of Adaptive Cruise Control Between Younger and Older Adults," Haolan Zheng, Justin R. Mason, Sherrilene Classen and Wayne C. W. Giang, *Transportation Research Part F: Traffic Psychology and Behaviour*, Vol. 94, pages 53-66, April 2023.
Citation at https://www.sciencedirect.com/science/article/abs/pii/S1369847823000256?via%3Dihub
From the abstract: This study investigates the effects of additional training on drivers' roles and responsibilities when using [a]daptive [c]ruise [c]ontrol (ACC, SAE Level 1) for younger and older drivers. Thirty-nine adults (20 younger + 19 older) were trained on one of two ACC training protocols: basic (system functionality, operational procedure and limitations) and comprehensive (basic training + ACC background and roles of responsibilities). Participants' situational trust and ACC usage [were] evaluated before, during and after experiencing an emergency event while using ACC in a driving simulator study. Results showed that the comprehensive training promoted drivers' situational trust in ACC, ACC usage and the acceptance of FAVs [fully automated vehicles]. Compared to younger drivers, older drivers used ACC less [and] reported less dynamic situational trust, higher levels of workload and lower acceptance. Overall, comprehensive training resulted in older drivers behaving similarly to younger drivers. The comprehensive training also promoted the acceptance of FAVs for both younger and older drivers. In conclusion, training of drivers' roles and responsibilities has an impact on drivers' usage of ACC and may be particularly useful for older drivers.

"Advanced Driver Assistance Systems (ADAS): Demographics, Preferred Sources of Information and Accuracy of ADAS Knowledge," Pamela Greenwood, John Lenneman and Carryl Baldwin, *Transportation Research Part F: Traffic Psychology and Behaviour*, Vol. 86, pages 131-150, April 2022.
Citation at https://www.sciencedirect.com/science/article/abs/pii/S1369847821001820
From the abstract: There is little previous research on drivers' knowledge of ADAS and even less on sources of information drivers use to inform their knowledge. The present study addressed this gap, testing hypotheses about influences on understanding of seven ADAS in 634 licensed U.S. drivers (aged 18 to 82). Multiple regression to predict self-assessed driver characteristics revealed: (a) [d]rivers who rated themselves as more technically sophisticated tended to be young and male, to be at once less objectively knowledgeable and more confident of their knowledge of ADAS, to avoid car dealers for ADAS information, and to value brand status; (b) [d]rivers who rated themselves as faster to adopt new technology also tended to be male but to be more objectively knowledgeable about ADAS and to prefer learning about ADAS from owner manuals; (c) [d]rivers who rated themselves as more confident in using novel vehicle technology tended to be young males with greater objective knowledge of ADAS who valued "hands-on" ADAS experience; (d) [d]rivers who rated themselves as more concerned about vehicle safety tended to be female, to value crash data and to rely on hands-on experience to learn about ADAS; (e) [d]rivers who rated themselves as having greater aesthetic concerns tended to rely on information on styles, colors, wheels when buying a new car and preferred specific ADAS components. Neither of the latter two differed in objective ADAS knowledge. These results make a novel contribution in revealing how driver demographics and characteristics are related to preference for specific sources of information on ADAS and objective knowledge of ADAS. These results can inform future efforts to increase driver understanding of the capabilities and limitations of ADAS and hence increase public safety.

"Learning to Drive: Parental Attitudes Toward Introducing Teen Drivers to Advanced Driver Assistance Systems," Rebecca Weast, Alexandra Mueller and Kristin Kolodge, *Traffic Injury Prevention*, Vol. 23, Issue 1, pages 1-5, 2022.
Citation at https://doi.org/10.1080/15389588.2021.2004401
From the abstract: This study examined how parental attitudes toward ADAS influence how and when parents introduce their teens to these systems when teaching them to drive. Three web-based focus groups were conducted with parents who owned ADAS-equipped vehicles and who either had a teen with either a learner permit or a teen who recently began driving independently. The moderator-led discussion examined participant attitudes about teen driving risk, the perceived benefits or risks associated with teen use of ADAS, and parents' teaching strategies for ADAS. Researchers generated a list of likely themes from a review of existing literature and then coded participant responses according to those themes. Parents who chose to introduce ADAS to their new teen drivers did so while also reporting conflicting opinions about the reliability of vehicle technologies and the impact of such systems on driving safety and skill acquisition. Many parents reported some distrust of ADAS and concerns that some features could hinder the development of good driving habits, although most participants stated that ADAS have had a positive impact on their teen drivers' safety. Opinions were split about the best point at which to introduce ADAS to teens, with half preferring introduction at the outset and half preferring to wait until the teen had mastered basic driving skills. Attitudes varied according to individual vehicle systems, with a preference for blind spot monitoring and a general dislike of lane-keeping assistance. Specific concerns about the potential impact of ADAS on teen driving safety and skill acquisition do not prevent parents from using such systems, although the teaching strategies parents use vary according to their preferences for individual systems.

Related Resource:

"Parents Worry Vehicle Tech Might Prevent Teens from Mastering the Basics," Insurance Institute for Highway Safety, Highway Loss Data Institute, *Status Report*, Vol. 56, Issue 1, page 7, February 26, 2021.
https://www.iihs.org/api/datastoredocument/status-report/pdf/56/1
From the abstract:

> This brief article reports on a recent study conducted by the Insurance Institute of Highway Safety (IIHS) entitled "Learning to Drive: Parental Attitudes Toward Introducing Teen Drivers to Advanced Driver Assistance Systems." The article interviews IIHS [Insurance Institute for Highway Safety] Research Scientist Rebecca Weast, who notes that parents are concerned that teens will not learn the basics of watching for blind spots, lane-keeping and other strategies of good driving if they use advanced driver assistance features. The study included three focus groups of parents who discussed driver assistance features, including blind spot monitoring, forward collision warning, front or rear automatic emergency braking (AEB), lane departure warning and lane departure prevention. Parents' opinions were divided about when to introduce teenage drivers to these driver assistance features.

The article concludes by acknowledging that more research is needed to determine the role of ADAS features in learning to drive and "how to ensure new drivers use these features properly," especially since many owners of vehicles with ADAS "don't understand their capabilities and limitations."

"Effect of Advanced Driver-Assistance System Trainings on Driver Workload, Knowledge and Trust," Maryam Zahabi, Ashiq Mohammed Abdul Razak, Ranjana K. Mehta and Michael Manser, *Transportation Research Part F: Traffic Psychology and Behaviour*, Vol. 76, pages 309-320, January 2021.
Citation at https://www.sciencedirect.com/science/article/abs/pii/S136984782030588X?via%3Dihub
From the abstract: The objective of this study was to evaluate the impact of two ADAS training approaches (i.e., video-based and demonstration-based training) on older drivers' subjective and objective measures of mental workload, knowledge and trust considering drivers' demographic information. Twenty older adults, balanced by gender, participated in a driving simulation study. Results indicated that the video-based training might be more effective for females in reducing their mental workload while driving, whereas the demonstration-based training could be more beneficial for males. There was no significant difference between the video-based and demonstration-based trainings in terms of drivers' trust and knowledge of automation. The findings suggested that ADAS training protocols can potentially be more effective if they are tailored to specific driver demographics.

"Evaluating Advanced Driver-Assistance System Trainings Using Driver Performance, Attention Allocation and Neural Efficiency Measures," Maryam Zahabi, Ashiq Mohammed Abdul Razak, Ashley Elizabeth Shortz, Ranjana K. Mehta and Michael Manser, *Applied Ergonomics*, Vol. 84, April 2020.
Citation at http://dx.doi.org/10.1016/j.apergo.2019.103036
From the abstract: There are about 44 million licensed older drivers in the U.S. Older adults have higher crash rates and fatalities as compared to middle-aged and young drivers, which might be associated with degradations in sensory, cognitive and physical capabilities. Advanced driver-assistance systems (ADAS) have the potential to substantially improve safety by removing some of driver vehicle control responsibilities. However, a critical aspect of providing ADAS is educating drivers on their operational characteristics and continued use. Twenty older adults participated in a driving simulation study assessing the effectiveness of video-based and demonstration-based training protocols in learning ADAS considering gender differences. The findings revealed video-based training to be more effective than demonstration-based training in improving driver performance and reducing off-road visual attention allocation and mental workload. In addition, female drivers required lower investment of mental effort (higher neural efficiency) to maintain the performance relative to males and they were less distracted by ADAS. However, male drivers were faster in activating ADAS as compared to females since they were monitoring the status of ADAS features more frequently while driving. The findings of this study provided an empirical support for using video-based approach for learning ADAS in older adults to improve driver safety and supported previous findings on older adults' learning that as age increases there is a tendency to prefer more passive and observational learning methods.

This report seeks to examine the perceptions, understanding and behaviors of other road users in relation to advanced driving features. The results offer some insights regarding important differences across road users. The report should be of interest to researchers and other stakeholders.

Driver Understanding

The citations in this section, including those highlighted below, explore the differences in driver understanding of ADAS technologies:

- A September 2023 journal article noted that "age, gender, prosocial driving scores, aggressive driving scores and education level were significant predictors of participant understanding outcomes surveyed after system training."
- In another September 2023 journal article, researchers commented that, while hands-on experience with a new ADAS technology "may improve driver's understanding or confidence in their understanding of the system, consumer education may strengthen the relationship between their understanding and confidence in their understanding of ADAS."
- Researchers sought to dispel common ADAS myths in a June 2023 conference paper by developing recommended public messaging "to provide simplified, neutral statements for the purpose of driver education." A September 2020 report described results of an investigation of "how seemingly small differences in marketing and training materials can influence consumers' initial understanding and expectations of a partially automated driving system."
- The authors of a 2019 *Transportation Research Record* article noted that observing ADAS during a demonstration drive resulted in "more positive perceptions relative to those who only read about [ADAS technologies], particularly for ADAS that provide vehicle control."

"Exploring Individual Differences in Consumer Understanding of Partially Automated Driving Systems Before and After Exposure," Jessica McDonough and Brian Tefft, *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, Vol. 67, Issue 1, pages 1726-1730, September 2023.
https://journals.sagepub.com/doi/epub/10.1177/21695067231192418
From the abstract: With the driver responsibilities that are required to safely operate ADAS driving systems, it is critical that users understand the capabilities and limitations of these systems. The present study was a secondary analysis of data from a previous study that examined driver understanding and expectations of an SAE L2 [Level 2] driving system after brief training and after brief on-road experience using the system. The current analysis examined the role of demographic and individual difference factors on driver understanding and perceptions of the system immediately after training as well as changes after brief experience using the system. Models were used to examine relationships between the demographic and individual difference factors and various outcomes related to understanding and expectations of the system. It was found that age, gender, prosocial driving scores, aggressive driving scores and education level were significant predictors of participant understanding outcomes surveyed after system training. Gender, employment status, race and ethnicity, prosocial driving scores and aggressive driving scores were relevant individual differences for significant changes in perceptions of the L2 system capabilities and limitations after experience using the system themselves. These findings have implications for training and other approaches to address knowledge gaps.

"Do Drivers Require Education After Over-the-Air ADAS Updates?," Justin Mason, John Gaspar, Cher Carney, Jimin Kim, Josh Domeyer, John Lenneman and Dan McGehee, *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, Vol. 67, Issue 1, pages 2150-2151, September 2023.
https://journals.sagepub.com/doi/epub/10.1177/21695067231192206
From the abstract: Over-the-air (OTA) advanced driver assistance systems (ADAS) updates may require drivers to adjust their mental models to maintain appropriate system use. Based on the magnitude of change to the ADAS, hands-on experience with the updated system may not require consumer education or training. In this study, 96 drivers experienced adaptive cruise control in the NADS-1 [National Advanced Driving Simulator] and received an OTA update with either pedestrian detection (PD) or traffic jam (TJ). Drivers that experienced PD had a higher confidence in their understanding of PD whereas drivers that experienced TJ had a better understanding of TJ. However, their confidence was not correlated with their understanding of the system for either TJ or PD. Although hands-on experience with a new system may improve drivers' understanding or confidence in their understanding of the system, consumer education may strengthen the relationship between their understanding and confidence in their understanding of ADAS.

Related Resource:

> **The ADAS Experts**, Driving Safety Research Institute, University of Iowa, News Post, February 12, 2024.
> https://dsri.uiowa.edu/news/2024/02/adas-experts
> This new post describes the recently completed research about drivers' responses to changes in ADAS functionality, described in the publication cited above. The news post underscores project findings, noting that "if the system update was simple, the education may actually decrease drivers' confidence in their own understanding." *From the website*:
>
> > **Consumer education for ADAS**
> > Sponsored by Toyota Collaborative Safety Research Center (CSRC)
> > In a recently completed study, investigators looked at the impact of over-the-air (OTA) updates on drivers' understanding of ADAS features and their performance.
> >
> > > Part 1 of the study: In the NADS-1 simulator, OTA updates were made to the vehicle's system without any training to the drivers. This was meant to identify gaps in their understanding.
> > >
> > > What they found: A more complicated OTA update that changed the driver's role (i.e., increased automation) caused larger gaps in understanding, making it difficult for drivers to safely use the system. The addition of an automatic braking system resulted in smaller gaps in understanding.
> > >
> > > Part 2: The results from Part 1 were used to design educational materials that were then tested in this second part of the study.
> >
> > What they found: The educational material, which included information about the driver's responsibility, was helpful when the system update was complicated. However, if the system update was simple, the education may actually decrease drivers' confidence in their own understanding.

"Common ADAS Myths Assumed by Drivers and Perpetuated by Vehicle Advertising," Md Ashikur Rahman and Michelle Mekker, *Proceedings of the International Conference on Transportation and Development 2023*, June 2023.
Citation at https://ascelibrary.org/doi/10.1061/9780784484876.018
From the abstract: With the advancement of the automated vehicle technologies, it is critical to understand the knowledge gap among drivers on the limitations and capabilities of existing advanced driving assistance systems (ADAS) that may contribute to dangerous driving habits and misjudgment. For example, some ADAS include adaptive cruise control (ACC), but many drivers do not know that this feature may not function as expected in response to stationary objects. Variation in terminology, feature capabilities, and advertising [has] resulted in driver misconceptions and confusion regarding ADAS. This paper reviews these common misconceptions of ADAS capabilities and shortcoming[s] in driver education and behavior. Recommended public messaging was developed to provide simplified, neutral statements for the purpose of driver education.

"New and Used Vehicle Buyers' Awareness, Understanding and Trust in Advanced Driver Assistance Systems," Ian J. Reagan, Jessica B. Cicchino, Eric R. Teoh and Aimee E. Cox, *Transportation Research Part F: Traffic Psychology and Behaviour*, Vol. 92, pages 44-55, January 2023.
Citation at https://doi.org/10.1016/j.trf.2022.11.009
From the abstract: There is concern that the effectiveness of crash avoidance systems will decrease or the potential benefits of adaptive cruise control (ACC) will fail to emerge as motor vehicles with the systems age. This is partly based on assumptions that these vehicles will eventually be bought on the used vehicle market, and the experience of buyers who purchase them used will differ from that of the first owners. But there is a lack of research on the topic. The purpose of this study was to compare driver trust, understanding and awareness of crash avoidance systems and ACC between owners who purchased new versus used vehicles.

An Examination of How Longer-Term Exposure and User Experiences Affect Drivers' Mental Models of ADAS Technology, Cher Carney, John Gaspar, Cheryl Roe and William J. Horrey, AAA Foundation for Traffic Safety, SAFER-SIM (University Transportation Center), March 2022.
https://aaafoundation.org/wp-content/uploads/2022/03/Longer-Term-Exposure-and-Drivers-Mental-Models-of-ADAS-Technology.pdf
From the foreword: New vehicle technology continues to evolve, along with the role and responsibilities of drivers. Sophisticated forms of automation can control many aspects of driving: the vehicle's speed, headway, and lane position, and these capabilities continue to grow. Past research has documented gaps in drivers' understanding of these technologies as well important safety implications of such. Less is known about how drivers' understanding of new technology—sometimes referred to as mental models—develop and evolve over time.

This technical report summarizes a study examining how the understanding of an advanced driver assistance system, adaptive cruise control (ACC), changes over the first [six] months of ownership in a sample of new owners of vehicles. The results should help researchers, the automobile industry, and government entities better understand driver performance, behavior, and interactions in vehicles with advanced technologies.

Impact of Information on Consumer Understanding of a Partially Automated Driving System, Jeremiah Singer and James W. Jenness, AAA Foundation for Traffic Safety, September 2020.
https://aaafoundation.org/wp-content/uploads/2020/09/ImpactOfInfoOnUnderstandingPartiallyAutomatedDrivingSystem_FinalReport.pdf
From the foreword: Recent advances in technology have made it possible for some vehicles, under certain circumstances, to control their speed and direction for an extended period of time without any input from the driver. These partially automated driving systems may give the impression that the car can "drive by itself," however, no vehicle available to consumers currently is designed to be used without an attentive driver who is ready and able to retake control of the vehicle at any time. Thus, it is imperative that drivers properly understand the capabilities and limitations of the technology in their vehicles. This report describes the results of an experimental study designed to investigate how seemingly small differences in marketing and training materials can influence consumers' initial understanding and expectations of a partially automated driving system. The information provided in this report should be of interest to automobile manufacturers and dealers, consumer advocates, driver training professionals, and drivers of new vehicles with advanced technologies.

"Proposed Framework for Identifying and Predicting Operator Errors When Using Advanced Vehicle Technologies," Anuj Pradhan, Ganesh Pai, Jaydeep Radadiya, Michael Knodler, Cole Fitzpatrick and William Horrey, *Transportation Research Record 2674*, Issue 10, pages 105-113, 2020.
Citation at https://journals.sagepub.com/doi/10.1177/0361198120938778
From the abstract: Advanced vehicle technologies include systems that are defined by the Society for Automotive Engineers as automated driving features or driver support features. The latter are increasingly available in late model vehicles in the form of advanced driver assistance systems (ADAS). ADAS features remove some responsibilities from drivers, but still depend on the drivers for safe operation. This can result in drivers committing errors while using ADAS, especially if their understanding of these systems, that is, their mental model, is incorrect. To understand how these systems could be used incorrectly it is necessary to have an insight into these mental models. One approach is to characterize users' mental representations of systems based on the errors that they commit during system use. Such an approach necessitates a classification of potential errors that may be committed, and the underlying cognitive and behavioral reasons for such errors. To that end, a framework is proposed that can, among other goals, help predict user errors while using ADAS based on human factors and task analysis techniques. A methodology is detailed for mapping operator-system interactions using state diagrams, error identification techniques using task analysis are proposed, and a categorization scheme based on classic error taxonomies is described. This proposed framework can subsequently be expanded for error identification for a wider range and versions of ADAS, as well as for future automated driving systems. Moreover, the framework provides a systematic approach that can be used toward operationalizing mental models, forming the basis for structured user training and for human-centered design of advanced vehicle technologies.

"Impacts on Driver Perceptions in Initial Exposure to ADAS Technologies," Ashley B. Nylen, Michelle L. Reyes, Cheryl A. Roe and Daniel V. McGehee, *Transportation Research Record 2673*, Vol. 10, pages 354-360, 2019.
Citation at https://journals.sagepub.com/doi/abs/10.1177/0361198119847975
From the abstract: Advanced driver assistance systems (ADAS) offer great promise in improving the safety of our roadways. Although ADAS have rapidly entered the U.S. passenger vehicle market, little is known about driver understanding and attitudes toward ADAS, especially the impact of their initial exposure to the technologies. Whereas some ADAS may be easy to learn and use, others are more complex and have limitations that may not be obvious to the driver. The [t]echnology [d]emonstration [s]tudy was conducted to evaluate how the ways in

which drivers learn about ADAS affect their knowledge and perceptions of the technology. Two base learning methods were utilized for the study, both of which are traditional forms of learning for the average driver: reading the owner's manual and making observations inside the vehicle. From these base learning methods, four learning protocols were developed, two of which included both methods. This paper investigates how drivers' perceptions of usefulness, apprehension and trust with regard to ADAS functionality were affected by initial exposure to the technology. Participants who observed ADAS during a demonstration drive had more positive perceptions relative to those who only read about them, particularly for ADAS that provide vehicle control.

"Driver Understanding of ADAS and Evolving Consumer Education," Ashley McDonald, Michelle Reyes, Cheryl Roe and Daniel McGehee, *25th International Technical Conference on the Enhanced Safety of Vehicles (ESV)*, Paper #17-0373, June 2017.
Citation at https://trid.trb.org/view/1485197
From the abstract: Advanced driver assistance technologies are making striking market penetration into the American passenger vehicle fleet. However, little is known about driver understanding and knowledge of these technologies. These advanced driver assistance systems (ADAS) not only have the ability to alert the driver of hazards and lapses of attention but, in some instances, can intervene to prevent or lessen the severity of a crash. If drivers do not accurately understand a technology's purpose, function and limitations, the full safety benefit may not be realized and translated to our roadways. This study was part of a broader data-driven national education campaign to help fill consumer knowledge gaps regarding ADAS technologies. Previous research from a nationally representative sample found that most consumers were uncertain about new and emerging vehicle safety technologies, as well as technologies that have been standard for years (McDonald et al., 2015). The [t]echnology [d]emonstration [s]tudy was developed to understand how the way in which consumers learn about ADAS technologies for the first time affects their knowledge of and attitudes about the technologies. This study reports how drivers' knowledge of a technology is influenced by their initial exposure method to the technology. Two base learning methods were utilized for the study, both of which are traditional forms of learning for the average driver: reading the owner's manual and riding in a vehicle. From these base learning methods, four learning protocols were developed, two of which combined the methods. Evaluation of [p]re- and [p]ost-[v]isit [s]urveys showed that drivers' knowledge of the technologies increased at the end of the study. This paper reports the effects of driver knowledge by each of the four learning protocols and discusses the implications that should be considered when educating consumers on new and emerging ADAS technologies.

Other Road Users

The study cited below sought to better understand the behaviors of pedestrians, bicyclists and other road users in relation to advanced driving features.

Expectations and Understanding of Advanced Driver Assistance Systems Among Drivers, Pedestrians, Bicyclists and Public Transit Riders, William J. Horrey, Aaron Benson, Zhaomiao Guo, Fatima Afifah, Cara Hamann and Kelvin Santiago, AAA Foundation for Traffic Safety, SAFER-SIM (University Transportation Center), June 2021.
http://safersim.nads-sc.uiowa.edu/final_reports/Understanding-of-ADAS-among-Different-Road-User-Types.pdf
From the foreword: The advancement of vehicle technology is reaching a point where advanced driver

assistance systems and other automation can control many of the driving tasks. While these technologies have clear implications for drivers, they also impact other road users who routinely interact with vehicles as they navigate the transportation network, including pedestrians and bicyclists, among others. In light of this, the knowledge base concerning other road users is relatively sparse compared to that of drivers.

This report seeks to examine the perceptions, understanding and behaviors of other road users in relation to advanced driving features. The results offer some insights regarding important differences across road users.

Commercial and Large Vehicles

Numerous resources from the Federal Motor Carrier Safety Administration showcase TechCelerate Now, a program that promotes the adoption of ADAS technologies in commercial vehicles. Supplementing these resources are two citations that consider a more holistic approach to large vehicle safety that includes ADAS as one of several components in driver training to improve safety.

National Agency Resources

TechCelerate Now, Federal Motor Carrier Safety Administration, undated.
https://www.fmcsa.dot.gov/Tech-CelerateNow
From the website:

> TechCelerate Now is a Federal Motor Carrier Safety Administration (FMCSA) program, with funding and technical support from the [USDOT's] Intelligent Transportation Systems Joint Program Office, for accelerating the adoption of advanced driver assistance systems (ADAS) in the commercial motor vehicle (CMV) industry.

TechCelerate Now categorizes ADAS technologies into four functional groups for education outreach efforts:

- **ADAS braking systems**, including automatic emergency braking and adaptive cruise control systems.
- **ADAS steering systems**, including lane keep assist, lane centering and adaptive steering control.
- **ADAS warning systems**, including lane departure warning, forward collision warning and blind spot detection.
- **ADAS monitoring systems**, including driver- and road-facing cameras and camera-based mirror systems.

Publications and other ADAS educational resources available at this website include:

> **Accelerating the Adoption of Advanced Driver Assistance Systems (ADAS): "Tech-Celerate Now" Phase 1**, Barbara Staples, James Chang, Ned Schweikert, Dan Murray, Claire Evans, Alex Leslie, Matt Camden, Susan Soccolich, Robert Braswell, Kevin Grove, Thomas Weakley and Andrew King, U.S. Department of Transportation, Federal Motor Carrier Safety Administration, January 2024.
> https://rosap.ntl.bts.gov/view/dot/73052
> *From the report's introduction*: FMCSA's Tech-Celerate program is planned for execution over two phases—with this [r]eport summarizing results from the first phase. The first phase was conducted over 29 months and consisted of five components:
>
> - Conducting research on technical and market barriers to adoption.
> - Developing outreach and educational materials oriented toward fleets and owner/operators.

- Developing ATA's TMC [American Trucking Associations' Technology and Maintenance Council] [r]ecommended [p]ractices and [p]osition [p]apers for fleet owner/operators relative to the adoption, use and maintenance of ADAS technologies.
- Conducting a national outreach campaign for fleets to encourage ADAS awareness and adoption.
- Completing data collection and analysis of industry trends, technology trends and deployment rates from surveys of drivers and motor carrier executives.

Task 3 of this study developed two guides and four videos to inform fleet managers and owner-operators about the benefits of ADAS technologies (see *Related Resources* below). A planned second phase will include an expanded national outreach and education campaign, measure ADAS safety impacts and the effectiveness of the campaign, and provide annual reporting on activities.

Related Resources:

Accelerating the Adoption of Advanced Driver Assistance Systems (ADAS): "Tech-Celerate Now" Phase 1 Report Brief, U.S. Department of Transportation, Federal Motor Carrier Safety Administration, January 2024.
https://rosap.ntl.bts.gov/view/dot/73053
A summary of the methods and findings of the Phase 1 activities is presented. Page 2 of the brief describes the key findings of the report: improved awareness and perception, increased driver focus, importance of outreach channels, benefits of warning systems, increasing ADAS adoption, and the need for more insurance education and industry participation.

A Truck Operators' Guide to Advanced Driver Assistance Systems (ADAS), TechCelerate Now, Federal Motor Carrier Safety Administration, undated.
https://www.fmcsa.dot.gov/sites/fmcsa.dot.gov/files/2022-02/ADAS_SAFETY_GUIDE_DRAFT6_081621_508-FINAL.pdf
Technologies in four ADAS performance categories are presented that have the most potential to prevent fatalities, injuries and crashes: braking, steering, warning and monitoring. Systems in each category are summarized in this two-page pamphlet.

A Return on Investment (ROI) Guide to Advanced Driver Assistance Systems (ADAS), TechCelerate Now, Federal Motor Carrier Safety Administration, undated.
https://www.fmcsa.dot.gov/sites/fmcsa.dot.gov/files/2021-04/ADAS_ROI_GUIDE_4PANEL_FINAL.pdf
This two-page pamphlet highlights the return on investment (ROI) of investing in ADAS technologies and includes an ROI example and online tool for calculating ROI.

ADAS Technology Videos, TechCelerate Now, Federal Motor Carrier Safety Administration, undated.
https://www.fmcsa.dot.gov/tech-celerate-now/adas-technology-videos
Short videos highlight the technologies in each of the four ADAS performance categories (braking, steering, warning and monitoring).

Related Research

"Reversing Poor Safety Records: Identifying Best Practices to Improve Fleet Safety," Matthew C. Camden, Jeffrey S. Hickman and Richard J. Hanowski, *Safety*, Vol. 8, Issue 1, 2022.
https://www.mdpi.com/2313-576X/8/1/2
From the abstract: To identify best practices [in commercial motor vehicle safety], researchers completed case studies with nine commercial motor vehicle fleets that successfully improved their safety performance. A content analysis was performed, and the successful strategies were organized into the Haddon Matrix. Results showed that there was no one single strategy that fleets used to improve safety. Instead, fleets relied on a comprehensive approach focusing on pre-crash countermeasures, including addressing hiring practices, driver training, fleet safety culture, safety technologies, scheduling, and maintenance. However, an enhanced safety culture and advanced safety technology were identified as critical components to their safety improvement. Results from this study may help fleets understand what their peers have used to successfully improve safety and which strategies may not be as helpful.

Optimizing Large Vehicles for Urban Environments: Advanced Driver Assistance Systems, Jonah Chiarenza, Margo Dawes, Alexander Epstein, Donald Fisher and Katherine Welty, National Association of City Transportation Officials, December 2018.
https://nacto.org/wp-content/uploads/2018/12/NACTO-Volpe-Optimizing-Large-Vehicles_ADAS.pdf
From the abstract: Numerous technologies exist to improve [large truck] drivers' abilities to operate their vehicles safely, including in complex, multimodal, urban environments. The key findings of this research show [a]dvanced [d]river [a]ssistance [s]ystems (ADAS) on the market, which use cameras, radar and other sensors can reduce reaction times and mitigate crashes with other vehicles; current [f]orward [c]ollision [w]arning (FCW) and automatic emergency braking (AEB) systems in large vehicles are limited in their ability to detect pedestrians and bicyclists on city streets; coupling ADAS systems with driver training and education is essential to avoid overreliance and worsened safety outcomes; FCW systems can be retrofit onto existing vehicles; and ADAS can be linked with telematics systems to provide driver training tools and to identify "hot spots" where unsafe vehicle behaviors occur.

Chapter 3 Survey of Practice

Introduction

An online survey distributed to members of the American Association of State Highway and Transportation Officials (AASHTO) State CAV Community of Practice sought feedback from a national pool of potential respondents. The distribution list also included the Eastern Transportation Coalition, a regional collaboration of Eastern states that conducted recent work on ADAS public education and outreach.

Refer to page 11 for information about the Eastern Transportation Coalition's work on ADAS education and outreach.

To supplement responses from this respondent group, the survey was also distributed through a mailing list of state public safety agency contacts. Survey questions are provided in Appendix A.

The survey received 11 responses. Nine respondents represent state or district transportation agencies, one respondent is from a regional consortium, and one is affiliated with a state highway safety program:

- Arizona DOT
- District of Columbia DOT
- Eastern Transportation Coalition
- Missouri DOT
- Nebraska DOT
- Nevada DOT
- North Carolina DOT
- North Dakota DOT
- Oklahoma DOT
- Pennsylvania DOT (PennDOT)
- West Virginia Governor's Highway Safety Program

Of these, only one respondent (PennDOT) reported experience with developing educational materials on ADAS.

Results from the survey are presented below in three topic areas:

- Agency experience with ADAS education and outreach
- Agencies considering ADAS education and outreach
- Agencies not considering ADAS education and outreach

Agency Experience with ADAS Education and Outreach

PennDOT is the only responding agency to report experience with ADAS education and outreach. The agency's educational effort has produced conference presentations, a multipage brochure and social media posts. (***Note***: The respondent was unable to provide links to these publications and a search of the agency's Automated Vehicles website did not identify them.)

Staff from the agency's Automated Vehicles unit and agency leadership worked together to identify needs when developing a plan for ADAS education and outreach. PennDOT's Office of Transformational Technology worked with consultants from Michael Baker International and Drive Engineering Corp. to develop educational materials that were posted on the agency's website and distributed at conferences. The respondent described this collaboration with engineering consultants, established through existing open-end agreements, as "very effective" and noted that the consultants were the most valuable resource in the ADAS outreach effort. Original equipment manufacturers were not part of the collaboration.

While PennDOT has not attempted to formally gauge the effectiveness of its ADAS outreach, the respondent highlighted the value of delivering the ADAS message during conference sessions. The most challenging aspect of ADAS public outreach has been connecting with a wider and more diverse population. Other agencies seeking to develop and implement ADAS educational materials are advised to "try to be as all-inclusive as possible," take time to craft your message and seek out a wide audience to receive the ADAS outreach.

Agencies Considering ADAS Education and Outreach

Of the four agencies considering developing ADAS educational materials, only one—the District of Columbia DOT—indicated that an ADAS educational effort, if undertaken, could begin within the next six months. In another possible effort that could be initiated in 12 months, Nebraska DOT may develop a customizable brochure for statewide use. The remaining two agencies (Missouri and Oklahoma DOTs) considering ADAS outreach reported interest but shared no specifics on how that outreach might be structured and when it might begin. Survey responses are summarized below.

- *District of Columbia DOT*. The agency is interested in developing educational materials that address AVs more generally and might expand the scope of that communication to specifically address ADAS. The respondent noted that the agency "might need to work with [its Department of Motor Vehicles] to get a handle on how widely ADAS features are likely present in the current vehicle fleet in our city/state. This might be better as a regional initiative in our context." Development of these materials would likely be addressed by the agency's Highway Safety Office/Vision Zero team. This team is responsible for behavioral safety practices and most public training for these issues. Such an effort might get underway in six months.
- *Missouri DOT*. The respondent reported "moderate" interest in ADAS materials but noted that public education could be driven by vehicle manufacturers.
- *Nebraska DOT*. The agency may develop a customizable brochure to share with partners across the state that provides basic information about ADAS and where to find resources. Development of this publication, if pursued, could begin in 12 months.
- *Oklahoma DOT*. The respondent reported interest in participating in the development of ADAS-related materials but noted that such an effort is currently on hold. When developed, the educational materials would not address the use of ADAS in passenger vehicles. Instead, any educational materials would likely address the agency's recent deployment of an automated truck-mounted attenuator (ATMA) and lead vehicle. U.S. DOT's Intelligent Transportation Systems Joint Program Office described a Florida ATMA pilot demonstration and evaluation:

The automated (driverless) ATMA system operates in a multivehicle leader-follower configuration where the truck-mounted attenuator truck is retrofitted with a variety of sensors and cameras that enable its automated capability. The human-driven leader vehicle transmits navigation data to the follower (driverless) ATMA vehicle using vehicle-to-vehicle (V2V) communications.

Agencies Not Considering ADAS Education and Outreach

The six organizations below, which include state DOTs, a regional consortium and state public safety agency, are not considering developing ADAS educational materials:

- Arizona DOT
- Eastern Transportation Coalition
- Nevada DOT
- North Carolina DOT
- North Dakota DOT
- West Virginia Governor's Highway Safety Program

Two of the respondents offered additional comments, with the Eastern Transportation Coalition respondent noting that interest has “migrated towards CV awareness and away from AV awareness.”

Formerly the I-95 Corridor Coalition, the Eastern Transportation Coalition is a partnership of 19 states and the District of Columbia “focused on connecting public agencies across modes of travel to increase safety and efficiency.” Refer to page 11 for information about the coalition’s webinar that addressed the need for consumer education on ADAS features and offered ideas for ADAS education.

The North Dakota DOT respondent commented that interest in ADAS education and outreach may intensify when the majority of vehicles are equipped with ADAS features.

Appendix A: Survey Questions

The survey below was distributed to two stakeholder groups:

- *State transportation agencies.* This pool of potential respondents included members of the American Association of State Highway and Transportation Officials (AASHTO) State CAV Community of Practice. The distribution list also included the Eastern Transportation Coalition, a regional collaboration of Eastern states that conducted recent work on public education on ADAS.
- *State public safety agencies.* A national mailing list of state public safety agencies sought survey responses from this pool of potential respondents.

MnDOT Survey on Public Education on Automated Driver Assistance Systems

(Required) Has your agency prepared materials that educate the public on the use of automated driver assistance systems (ADAS)?

- My agency has developed educational materials on ADAS. (Skipped the respondent to **Agencies Conducting ADAS Outreach**.)
- My agency is considering or interested in developing educational materials on ADAS. (Skipped the respondent to **Agencies Considering ADAS Outreach** and **Wrap-Up**.)
- My agency is not interested in developing educational materials on ADAS at this time. (Skipped the respondent to **Wrap-Up**.)

Agencies Considering ADAS Outreach

1. Please describe your agency's interest in developing educational materials on ADAS.
2. What is needed for your agency to act on this interest?
3. Please estimate how soon your agency could begin to develop an ADAS educational outreach program.

Agencies Conducting ADAS Outreach

Educational Materials

1. Please identify the types of materials your agency has developed to educate the public on ADAS. Select all that apply.
    - Conference presentation
    - Content for driver's licensing exam
    - Multipage brochure
    - One-page flyer
    - Poster
    - Social media
    - Video
    - Web-based content
    - Other (Please describe.)
2. Please identify the parties determining what was needed for the ADAS educational effort. Select all that apply.
    - Staff from my agency's connected and automated vehicles division or unit
    - Other agency divisions or units

- Agency leadership
- Other state agencies
- Private sector partners
- Federal agency representatives
- Peer agencies (other state DOTs)
- Other (Please describe.)

3. Who is responsible for **developing** educational materials on ADAS for your agency?
4. Who is responsible for **implementing** educational materials on ADAS for your agency?
5. Please identify the data sources your agency used to develop ADAS educational materials.
6. Please describe how your agency implemented the ADAS educational materials.
7. How does your agency address updates to these educational materials as ADAS technology evolves?
8. What initiatives, other than educational outreach, has your agency undertaken in connection with ADAS? Please include in your description your assessment of the success of each initiative.
9. (Required) Has your agency partnered with other organizations on ADAS educational efforts?
    - Yes (Skips the respondent to **Partnering Practices**.)
    - No (Skips the respondent to **Assessment**.)

Partnering Practices

1. Please identify the partners your agency has worked with on ADAS educational materials.
2. How did your agency identify each partner?
3. How effective were the partnerships?
4. What could be done to improve future partnering efforts?
5. What role did original equipment manufacturers play, if any, in your development of educational materials on ADAS?

Assessment

1. Has your agency attempted to gauge the impact of your ADAS educational materials on the people you're trying to reach?
    - No
    - Yes (Please describe how you've attempted to make this assessment and the results.)
2. Which resources have proved to be most valuable in your agency's development of ADAS educational materials?
3. Which ADAS outreach implementation activities have been most valuable?
4. What has proved to be most challenging with regard to your agency's ADAS public outreach?
5. What are your top three lessons learned for other agencies preparing to develop and launch an ADAS educational campaign?
    - Lesson 1
    - Lesson 2
    - Lesson 3
6. Please share communication products and other documentation associated with your agency's ADAS educational campaign by providing links to electronic documents below. Please send any files not available online to chris.kline@ctcandassociates.com.

Wrap-Up

Please use this space to provide any comments or additional information about your previous responses.