2021 Virtual Forum on the Impact of Vehicle Technologies and Automation on Users: A Summary Report

March 2022

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FOUNDATION FOR TRAFFIC SAFETY
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Title

2021 Virtual Forum on the Impact of Vehicle Technologies and Automation on Users: A Summary Report

(March 2022)

Foreword

The global pandemic has brought unprecedented changes to people's travel, work, and lives in general. While these changes have impacted travel behavior and safety, the advancement of vehicle technology and innovation continues at a rapid pace. After pausing for a year, the Forum on the Impact of Vehicle Technologies and Automation on Users returned in 2021 with a three-day virtual format, bringing together many stakeholders to engage in conversations surrounding pressing research needs. This year, the presentations and discussion also featured some of the progress we have made on research needs raised in some of the earliest Forums.

This report summarizes panel discussions, presentations, and discussion from the 2021 Virtual Forum. Stakeholders from academia, industry and government gathered to discuss and exchange information and ideas about the impact that these emerging technologies are having on road users. This report should be of interest to researchers and practitioners who are involved with work related to vehicle technologies and automation.

C. Y. David Yang, Ph.D.

Executive Director
AAA Foundation for Traffic Safety

About the Sponsor

AAA Foundation for Traffic Safety
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Founded in 1947, the AAA Foundation for Traffic Safety is a nonprofit, publicly supported charitable research and education organization dedicated to saving lives by preventing traffic crashes and reducing injuries when crashes occur. Funding for this report was provided by voluntary contributions from AAA/CAA and their affiliated motor clubs, individual members, AAA-affiliated insurance companies and other organizations or sources.

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Introduction

On September 15–17, 2021, the AAA Foundation for Traffic Safety (AAA Foundation) convened a three-day virtual forum, the fourth in the series of forums on the impact of vehicle technologies and automation on users. Consistent with past forums, the main objective was to gather representatives and experts from the research community, government, and industry to discuss issues and to identify research needs and critical considerations regarding the design and safety of vehicle technologies and automation (see Appendix A for list of registered organizations). The forum offered a mixture of panel/webinar presentations (through Zoom) and dynamic, avatar-based interactions among attendees (though Gather). This year, the panel discussions and presentations also included a sampling of AAA Foundation-led or sponsored work on research topics that originated in the earlier forums (2017–2019).

Each day, attendees convened for a two-hour session (see Appendix B for program). The first hour was reserved for a panel discussion or virtual presentations from invited speakers. The second hour involved breakout group discussions on pre-defined topics. Each day was oriented around a different (though not mutually exclusive) theme:

- Day 1: Understanding and Perception of Vehicle Automation
- Day 2: Driver Interactions with Vehicle Automation
- Day 3: Education and Training on Vehicle Automation

This summary report documents the panel and group discussions such that the outcomes can be shared with other stakeholders to improve coordination and encourage collaboration.

A high-level overview of the panel and research presentations are provided in the sections below. This is followed by a careful detailing of the many research questions and discussion points that emerged from the group breakout exercises.

Day 1: Panel on the Understanding and Perception of Vehicle Automation

(Panelists: Dr. Woon Kim, *AAA Foundation;* Dr. Anuj Pradhan, *University of Massachusetts–Amherst*; Dr. John Gaspar, *University of Iowa*; and Dr. John Lenneman, *Toyota Collaborative Safety Research Center (Toyota CSRC)*. Facilitator: Dr. William Horrey, *AAA Foundation*.)

Dr. Kim presented some recent AAA Foundation survey research on public understanding and perceptions of vehicle automation (via the annual Traffic Safety Culture Index—Emerging Transportation Technology survey). She noted that, where costs were no concern, the majority of respondents would prefer owning vehicles equipped with Level 2 or 3 automation and that respondents' self-reported understanding of technology is correlated with their trust in automation. Interestingly, people did not perceive higher-level automation to be more effective in preventing crashes and this was corroborated by increased concerns over technology malfunction.

Dr. Pradhan offered some perspectives on measuring drivers' understanding of vehicle automation (mental models) and how to increase user understanding and knowledge of system capabilities and limitations. He described a multi-dimensional survey designed to assess mental models, which can be useful to determine what naïve users know about the technology and in what areas users tend to have misunderstandings (e.g., specific edge-cases). He also described some ongoing work with AAA Foundation looking at different approaches to visualizing automated systems (e.g., using state transition diagrams). These could possibly benefit future training approaches.

Dr. Gaspar discussed some recent work with AAA Foundation that mapped different qualities of mental model to performance outcomes in a variety of edge cases. They have shown that drivers who have a stronger understanding of the system's function and capabilities show faster and more effective responses in handling situations that the technology is ill-equipped to deal with. Dr. Gaspar and his colleagues are currently examining how drivers' understanding of technology emerges and evolves over the course of the first 6 months of vehicle ownership.

Dr. Lenneman presented some recent work that examined the progression and development of users' mental models of technology. He noted the emergence of different clusters of user types, which were characterized by the level of understanding of the technology but also their propensity to learn. One class of driver was misinformed but demonstrated the ability to learn and adjust their mental model. More concerning was a sub-group of drivers that were misinformed regarding the technology, but also did not appear to be willing to learn (i.e., they already think they have the necessary knowledge). Dr. Lenneman also talked about the dynamics of perceived system utility, trust, satisfaction and different emotional states.

Day 2: Presentations on Driver Interactions with Vehicle Automation

(Presenters: Dr. David Strayer, *University of Utah*; Dr. Naomi Dunn, *Virginia Tech Transportation Institute (VTTI)*; and Dr. Martin Baumann, *Ulm University*. Chair: Dr. Woon Kim, *AAA Foundation*.)

Dr. Strayer presented some recent and ongoing work with AAA Foundation looking at the impact of Level 2 automation on driver attention and workload. The research examined how drivers who are initially naïve to the technology respond by measuring a variety of physiological measurements (e.g., blood pressure, heart and brain activity, other performance and subjective measures). In terms of outcomes, changes in objective workload associated with system use were not observed.

Dr. Dunn presented some recent work with AAA Foundation looking at driver behaviors while using vehicle automation. Specifically, the research examined drivers' tendencies towards engaging in potentially distracting activities while using Level 1 or Level 2 automation. Data were drawn from two different naturalistic driving studies, employing drivers with different degrees of experience with the vehicle automation. Drivers with more experience with the technology were more likely to engage in distracting activities and took longer glances away from the roadway while using the Level 2 systems, compared to similar

driving situations while driving manually. Interestingly, drivers who were new or relatively inexperienced with the technology did not show this pattern and were, in fact, more likely to perform distracting tasks while driving manually than when using the vehicle automation. These results suggest different phases of familiarity/comfort/trust with the technology.

Dr. Baumann described recent work on cooperative driver–vehicle interaction, examining the role of system transparency for trust calibration (i.e., aiming to turn the automated systems into more effective "team players"). He underscored basic requirements for successful human–machine cooperation: shared situation representation, mutual predictability, directability, and calibrated trust (where trust matches system capabilities). He noted that system transparency can support calibrated trust, which along with proper expectations are essential for appropriate system usage.

Day 3: Panel on Education and Training on Vehicle Automation

(Panelists: Dr. William Van Tassel, *AAA*; Dr. Josef Krems, *Chemnitz University of Technology*; Mr. Jerry Singer, *Westat*; and Dr. Wendy Ju, *Cornell Tech*. Facilitator: Mr. Brian Tefft, *AAA Foundation*.)

Dr. Van Tassel pointed to current and widespread driver education programs aimed at new drivers, as well as refresher programs for older drivers. When it comes to new in-vehicle technologies, he noted many inherent challenges for the traditional driver education model, including that most instructors are themselves under-informed regarding the technology, states are not requiring content about vehicle technology, lack of national standards by the National Highway Traffic Safety Administration (NHTSA) and other agencies, as well as the fact that courses tend to be short and already have a lot of content to cover. He noted that new digital approaches will help keep curriculum fresh, compared to traditional paper-based models.

Dr. Krems discussed the progression of driver responsibilities as vehicle automation advanced to higher levels and that, up to Level 3, all of the competencies relevant for Level 0 will still be necessary. Moreover, new competencies will have to be acquired, such as the active monitoring of system function to resume or transfer control back and forth. He noted the importance of good interfaces in support of these new tasks, as well as how performance and system understanding progress with more exposure and system interaction. Given that education approaches lead to better initial performance he raised several important questions about how education and training might be realized.

Mr. Singer described some recent work with AAA Foundation that looked at how drivers' mental models of a partially automated driving system can be impacted by the branding and tone of different education material related to the system. This research found that for the same system (an actual Level 2 system given a fictitious name for the purpose of the study), different descriptions of the system (even accurate descriptions without omitting any key information) led to very different expectations regarding the system capabilities. The outcomes underscored the importance of words and emphasis in promotional and educational material related to advanced systems. He also reflected on some important

research questions, including (i) what is the most important training content and what is the best way to administer it, and (ii) how does education interact with real-world experience with the systems?

In her remarks, Dr. Ju described some recent work in her laboratory at Cornell Tech that has documented the progression of sleepiness in drivers using a Level 3 system, along with the dynamics surrounding near system failures. While noting that there is a paucity of studies that have looked at training in this space, her recent work underscores the importance of teaching people not only how automation works but also how to deal with some of the natural outcomes or shortcomings of the technology (e.g., experiencing sleepiness).

Breakout Discussions and Outcomes

As in previous years, the 2021 Virtual Forum included breakout discussions where small groups discussed some select questions. Following the panel discussions or presentations on each day, attendees of the forum were directed to the Gather platform for the breakout discussions. Four to six groups (depending on the number of attendees) of up 10 people considered one of two questions, which were tailored to the theme for the particular day. The questions were as follows:

- *What are the most important recent developments in research, product development, policy, outreach, or other areas concerning the (Day 1) understanding and perception of, (Day 2) driver interactions with, or (Day 3) education and training on vehicle automation?*
- *What are the most pressing research needs or current barriers related to (Day 1) understanding and perception of, (Day 2) driver interactions with, or (Day 3) education and training on vehicle automation?*

(Please see Appendix C for complete questions and group instructions.)

Information from the group discussions and the related notes have been distilled and synthesized in the sections below. While this captures many of the main themes, it does not do justice to the rich, dynamic, and interconnected threads comprising the group discussions. Further, as there was some overlap in the scope of the questions and discussions across the different days, the summary has combined the information from all three days arranged under different topics.

What are the most important recent developments in research, product development, policy, outreach, or other areas?

Research

The group discussion highlighted a number of important recent developments in research, some general and some specific. These included on-road and naturalistic work that is shedding insight into how people are using the technologies, the implications on driver attention, and the errors they can make (e.g., work by MIT AgeLab, Virginia Tech Transportation Institute (VTTI), Insurance Institute for Highway Safety (IIHS)). The breakout groups also noted advancement on a variety of broad topics, including public opinion and general awareness of ADAS and automated shuttles (e.g., survey work in Canada; automated shuttle initiatives in Utah and Iowa). Work on user mental models and system understanding was also emphasized, including work delineating different types of users' (e.g., Toyota CSRC) considerations of demographic and individual differences, cultural norms, and expectations. They also noted important research regarding naming conventions for ADAS features, as well as work looking at how branding and information shape driver expectations (e.g., AAA Foundation/Westat).

The groups also pointed out some ethical concerns or barriers to critical real-world studies, including challenges associated with institutional review boards (IRB). There was also some caution advised when researching new technology to minimize social desirability bias, as is often the case with other negative-risk behaviors (e.g., alcohol). Lastly, there was some consensus that research on automation hand-offs and takeover time had become saturated.

Technological Developments, Marketing, and Rollout

Many noteworthy technological developments and issues were identified in the group discussions, representing either new developments or areas of continued importance in this space.

Several comments related to developments in the technology itself or related barriers and challenges:

- Concerns over the impact of over the air updates (e.g., overnight) on system use, safety, and the implications for education/training
- Perceptions that the development of automation is more technology driven and less user driven
- Challenges with interoperability and the parallel evolution of vehicle electrification
- The importance of broadband function (5G) as a critical infrastructure component for connectivity and catalyst for getting things going, awareness, interest
- Importance of system transparency: Need to provide system feedback to communicate current system state to the driver (e.g., whether a system is not operational); current perceptions are that there is a lack of clear, specific feedback (as in Super Cruise) and that this impedes learning through exposure. Also, it is difficult to learn limitations through experience because edge cases are rare. However, it is unclear if an intuitive human-machine interface (HMI) is sufficient for accurate mental model and performance.
- Importance of system design: Some participants felt like the designers of the system expect the people to immediately know the system. That is, designers expect drivers to intuit their systems, even though they remain a black box. In general, training should not be considered a panacea for poor or flawed design.

Several comments were specific to the implementation of driver state monitoring (DSM) systems in vehicles, which were seen by many as an important piece to ensure safe deployment of automated systems.

- Implementation of different DSM system designs, especially those concerning gaze-based or direct-driver monitoring versus non-gaze or indirect monitoring.
- Driver strategies to circumvent current DSM systems (e.g., taping tennis balls to steering wheel).
- Blatant examples of inattentiveness due to over-trust where DSM would be useful.
- Potential for vehicles to create one or more “driver profiles” that learn how an individual driver(s) regularly drives. The system can send drowsiness alerts, etc. if it detects variance from that norm (increased lane deviation, etc.).
- DSM could be useful for easing drivers into new automation, slowly adding on layers as they become more comfortable with it, and could potentially play a role in individual differences in risk tolerance.

The design and implementation of the technology notwithstanding, many other topics dealt with the marketing and rollout of the technology.

- Questions over how the market will react to the new ways of developing pricing structure and, consequent, how automated vehicles will continue to penetrate the fleet
- Perceptions that existing education by dealerships is not adequate and competes with dealerships' other priorities for their bottom line
- Articulated need for education, but acknowledged that users still engage in bad behaviors
- Expressed the need to differentiate between blatant mistakes versus minor mistakes
- Perceptions that training needs to overcome the challenge that automation makes driving more difficult: from active operators to passive monitoring, which is not ideal. Training for monitoring is a completely different challenge.
- Understanding how systems see; also important for service and repair to recognize issues like blocked or moved sensors
- Truth in advertising was seen as a major factor in ensure consumers properly understand system capabilities and that it does not mislead beyond limitations
- Automakers outreach efforts including apps, on-site training, and other opportunities for asynchronous learning were identified as important avenue
- Diversity in technology, naming, etc. were seen as too vast, raising questions whether there is a lowest common denominator training that would be helpful without being specific to one device or system.
- MyCarDoesWhat and similar campaigns were identified as important elements for public awareness and understanding, especially to reach buyers of mass market vehicles who may not be seeking out new automated technologies on purpose

Media, Outreach and Stakeholders

Breakout group participants were encouraged by the growth of different consortiums and organizations like PAVE (Partners for Automated Vehicle Education), along with continued efforts by NHTSA, research organizations such as AAAFTS and Toyota Collaborative Safety Research Center (Toyota CSRC), AAA Foundation, and others to continue to advance research and dialogue concerning advanced automation.

One salient development and concern expressed by the groups was how the technology is portrayed in advertising as well as in the media. Some suggested that government agencies charged with the protection of consumers might be involved in order to ensure truth in advertising. Media was another area where there were concerns over portrayal of technology, especially in regards to the terminology being used (e.g., often using "self-driving" or "autonomous vehicles" to describe Level 2 driver support features). Certain terminology can continue to feed into public misperceptions and misunderstanding about the technology. More media training was advocated so accurate information can be provided, especially local news outlets (e.g., through media days).

The issue of nomenclature also came up in discussion surrounding joint efforts to help standardize some of the system naming. The breakout groups cited work by Consumer Reports, AAA, SAE, along with others, on common nomenclature; although, the groups noted that more work is needed.

The emergence of many YouTube videos that instruct users on how to disable or trick systems was especially concerning to many discussants as these promoted and facilitated inappropriate and unsafe system usage.

Driver state monitoring (DSM) was the topic of several discussion threads, noting the need to articulate for the public how important DSM is to the successful introduction of more and more vehicle automation if safety benefits are to be maximized along with consumer trust.

One group posed the question of what is the best approach for certifying compliance with standards or lack thereof. Because words matter, there might be the need to adjust the terminology for the waiving of safety standards for automation or perhaps in the introduction of another set of standards that would apply. In parallel, groups underscored the potential role of New Car Assessment Program (NCAP) to assess/rate advanced technology.

Policy

The groups noted that in general there is little guidance in policy and this puts manufacturers in a tough situation. Currently the development and implementation of automation is largely motivated by a race among automakers rather than public interest. They called out the need for leadership to recognize best practices or standards. Along these lines, legal experts and researchers may help get some of the policy questions answered sooner to avoid unintended consequences. Particularly sobering was the realization that there is a lack of policy at all levels of vehicle automation, but systems are evolving at such a rate that legislators and research may not catch up (e.g., draft legislation on requiring driver attention management in Level 2 systems—time scale is on order of several years while systems are on roads now). Some suggested that the call to action would be more effective if directed to the original equipment manufacturers (OEMs), in lieu of policy.

DSM was discussed in some groups, representing a tough task for regulators to mandate. Federal Motor Vehicle Safety Standards do not require DSM, thus regulators cannot stop companies from selling a vehicle due to lack of DSM or ineffective DSM. Echoing comment above, the fastest route was believed to be having companies implement DSM on their own. Participants were also concerned that DSM systems may face barriers to public acceptance, both due to privacy concerns (e.g., whether data indicating that they were inattentive could be stored and used against them) as well as its intended function (to prevent the driver from engaging in behaviors that they might want to engage in).

Lastly, policy concerning driver education was brought up. NHTSA, for example, has been making content available but use is not mandatory, thus the quality of any formal instruction is likely to vary significantly across providers. Additionally, driver education programs, as structured today, can provide only general information about new vehicle technologies (e.g., Level 2 automation), as there is inadequate time to provide detailed vehicle-specific information (e.g., Cadillac Super Cruise versus Tesla Autopilot). Concerns were also raised that the current driver education paradigm is poorly suited to keeping drivers up to date on vehicle technologies that are introduced or changed long after a given individual completes a driver training course. Finally, over the air updates, which might change important aspects of the user interface or vehicle behavior from one day to the next,

were identified as a particularly difficult challenge from the standpoint of education as well as policy.

What are the most pressing research needs or current barriers?

Many related research needs were brought up over the course of the breakout group discussions across the three days. In the sections, these have been organized into broad (and non-mutually exclusive) categories.

Mental Models, Education and Training

By far, the majority of pressing research needs related to user understanding (mental models) of technology as well as how to educate or train drivers on the different technologies. Many such questions implicated the scope, substance, or content of user training to increase this understanding:

- How important is it for people to understand how the technology works? Alternately, how much training and what particular information will ensure appropriate system use?
- What is most important to understand for a new user of an automated vehicle - information about the purpose of it, or capabilities/limitations and what effect does context have on the performance of the automated vehicle?
- What kinds of information are needed early on and how might information needs change over time as user continues to drive vehicle?
- How much can drivers learn in one long sitting (i.e.4 hours)? Can training be effectively parsed into smaller bits that hit on important topics?
- Is there value in narrowing the scope of such training to only the most important topics so that the module is shorter and more likely to be completed? If so, what are those topics?
- General content about vehicle automation might be useful, but consumers want to learn about the vehicle in their driveway. The lack of standardization in these features across OEMs exacerbates this challenge. Can/should training be technology agnostic (e.g., mycardoeswhat.org)? How can training approaches effectively balance general versus specific vehicle information?
- How do you train or design systems given their reliability in different conditions (e.g., weather)? Concern that people will generalize overall perception of system's capability and expect function when it will not work (or possibly worse, work but work poorly). How best to help drivers manage expectations in specific use cases?
- How can training accommodate system updates and feature changes? What about car sharing vehicles with these features? Similarly, need more research on transfer of training.
- How do we effectively balance end user's wants versus their needs? Different people want different levels of information; some just the basics, others are tinkerers.
- How to develop calibrated mental model and understanding of how automated vehicle "perceives" its environment?

Another subset of questions related to the manner in which training is delivered to users, including by whom and what format. These also included some consideration of how to target different populations of users who vary in their willingness to complete training, accessibility, etc.:

- What is the best method of training? (e.g., car dealership, seminar, immersive driving simulator, phone-based apps, emails)?
- What are the best strategies for dealing with users who are not motivated to take any training? Are there ways to get drivers more excited in training (e.g., incentivize)?
- Some vehicles/technologies require customers to take a seminar and pass a test to gain access to Level 2 functionality. Others monitor driver profiles before they can access features to ensure they are good/responsible drivers. What is the success of such approaches in ensuring good system understanding and appropriate use?
- What should be the role for driver education, dealerships, and auto manufacturers?
- Would a combination approach be more successful and better received by consumers?
- How to develop effective train-the-trainer programs for use by a range of folks including auto salespeople to help facilitate delivery of effective consumer training and education?
- When educating consumers about vehicle automation, how should we approach people differently if they are uninformed versus misinformed?
- How to overcome equity issues with language, access/time for training, etc.?
- How to address training needs for everyone who drives an equipped vehicle (which includes other people besides the original purchaser)?
- Android Auto provides tool tips when the app is opened. Similarly, many video games provide training as the user progresses through the game. Can such approaches be employed for vehicle automation? How to support on-the-spot learning while not burdening users to be unsafe while driving?
- How to initiate training when most training occurs for new licensing?
- How to appropriately train media, repair shops, and other parties?

Questions about measurement also emerged, including the measurement of peoples' mental models in general as well as the measure of training efficacy.

- What are ways of measuring people's real-time understanding of vehicle automation?
- How to improve upon metrics of driver understanding of technology, going beyond survey instruments?
- What is the role and influence of system naming on user understanding of system capabilities? Would standardization across manufacturer facilitate the development of general training regimens?
- What is the impact of different user mental models on risk, including crash and near crash outcomes?
- Which outcome measures should be used to evaluate the effectiveness of consumer education and training relative to vehicle automation (recognizing that crashes, injuries and deaths are rare events that may not be realistic indicators to use)?

- Would these outcome variables be different for near term versus long-term post training effects?
- How to implement and leverage training that adapts to the users mental model? What are the strengths and limitations of training that is adapted to an individual's mental model regarding vehicle automation?

User Perceptions and Trust in Technology

- Are there more effective names or terms to describe "driver state monitoring" that will lead to greater acceptance among the public? (i.e., potential rejection because of big brother-type privacy concerns invoked by the word "monitoring")
- Were adaptive or customizable automation considered? How can we measure and use an individual driver's risk tolerance/aversion in order to titrate the degree of vehicle automation made accessible to him/her at any time? Would age and experience with vehicle automation be factors in this equation as well?
- What is the role and importance of general public trust versus individual user trust? What strategies are needed to best address each?
- Humans are poor judges of relative risk, generally, and this can shape their reliance on and use of vehicle automation. Is there a better way to help humans weigh these risks?
- There are more questions concerning vehicle platooning, personal vehicles sharing road with highly automated large trucks and platoons of highly automated trucks (e.g., how do you merge?). What do users expect? How will this work?
- How to effectively build trust in safety systems that have minimal driver involvement, such as connected intersections and red-light violation warnings?
- How does negative news impact perception, acceptance, and buy-in of the technology?
- How to better address the lack of uniformity between industry and government on description of technologies and names for technology?

Technology and Policy Considerations

- What is the ideal Human-Machine Interface (HMI) or the appropriate features that will not overwhelm the driver?
- How do we develop an intuitive design that requires no training in the first place?
- How to increase our understanding of and the quality of exposure to edge cases in real-world driving with these systems and how often they are encountered.
- How to establish clearer use cases and operational design domains (ODD)—and their limits. How to communicate this information to the user?
- Does a person really understand the system and accept responsibility (e.g., "the system works well, but you are still responsible")?
- How do we verify the safety of the technology (what measures, approaches, and use cases) and ensure it meets needs of user?
- What are the best approaches to DSM to ensure an appropriate level of engagement? In what ways do people defeat the current systems? What approaches can be used to mitigate these workarounds?
- Is it better to design system to support the human or to substitute for the human?

- What is the role (if any) for remote driving as a solution? How could this be implemented in different use cases (e.g., highly-automated shuttle)? How does a vehicle do all the non-driving tasks that a bus operator does?
- Systems should forgive and be resilient when humans make mistakes—how resilient are the systems to account and compensate for human mistakes?

Driver Interactions with Vehicle Automation

- What is the feasibility of having physiological measures in a vehicle?
- Do we need more naturalistic driving research to examine what people actually do in their vehicles with these systems?
- What action should a system take upon driver monitoring determining that the driver is insufficiently attentive? How should repeat occurrences of inattention within and across drivers be handled?
- There is an adaptation period for new users of the technology. How long is this period and how does behavior change after experiencing different events?
- How does understanding evolve with more hands-on experience? How do usage patterns develop and emerge (i.e., long-term effects, including possibilities that drivers can become complacent and develop bad habits, even with good system understanding)?
- Can misuse and abuse of vehicle technology observed in natural settings be related back to lack of automation understanding?
- What is the range of appropriate system adaptation to individual drivers and context? How can systems inform the user and increase confidence that the system is aware of current and specific needs (i.e., system is able to respond to the driver's current situation versus some average/generic user in a generic setting)?
- Lack of accountability for drivers when they use systems inappropriately, which creates user overconfidence due to lack of negative consequences when engaged in bad driving behaviors (similar to drunk drivers who do not get pulled over and decide to continue engaging in bad driving behaviors). Can systems provide feedback to reduce positive reinforcement of bad behaviors? What other strategies can be considered?
- What are the best approaches to keeping people more alert, awake, or aware when using the systems?
- How will safety outcomes and research needs change as more people adopt the technology?
- How do we achieve the right balance between reducing a driver's mental workload to avoid distractions, and that same driver's alertness/arousal such that they are actively engaged in monitoring the driving environment? Is that balance the same for all of us, or does it vary by person?

Closing Remarks

While the global pandemic inevitably changed the approach to this forum, the aim of the meeting remained fixed: to promote engagement and discussion amongst key stakeholders from research, industry, government, and other entities. Many research needs identified in the 2021 Virtual Forum, along with carryover topics from past forums continue to be

relevant, underscore the importance of more research efforts in order to keep step with the technological advancements and implementation. It is our sincere wish that many of the questions listed in this report can spark imagination, interest, and pursuit—whether by students and faculty, research organizations, other practitioners, or even the system developers themselves.

Appendix A: List of Organizations Registered for the 2021 Virtual Forum

AAA - The Auto Club Group
AAA Foundation for Traffic Safety
AAA Minnesota-Iowa
AAA National
AAA Oregon/Idaho
AAA Washington
AAA Western and Central New York
Alliance for Automotive Innovation
Arizona Commerce Authority
Audi of America
Auto Club Enterprises
Chalmers University of Technology
Cornell Tech
DRIVE SMART Virginia
Dynamic Research Inc.
Exponent
Ford Motor Company
Google
Granite Automation, Inc.
Honda
Hyundai-Kia American Technical Center
Insurance Institute for Highway Safety
Intel Corporation
Iowa Department of Transportation
Kia
Maryland Department of Transportation
Mazda
Mecanica Scientific Services Corporation
National Highway Traffic Safety Administration
National Institute for Occupational Safety & Health
National Institute on Aging
National Transportation Safety Board
North American Subaru. Inc.
Purdue University
Rivian Automotive
San Diego State University
Southern Methodist University
Subaru
Toyota Motor North America
Transport Canada
Transportation Research Center, Inc.
Tufts University
Universität Ulm
University of Alabama
University of California Berkeley
University of California San Diego
University of Central Florida
University of Iowa
University of Massachusetts Amherst
University of Michigan Transportation Research Institute (UMTRI)
University of Nebraska-Lincoln
University of Puerto Rico at Mayaguez
University of South Florida
University of Toronto
University of Utah
U.S. Department of Transportation
Virginia Tech Transportation Institute (VTTI)
Volkswagen
Westat
WSP USA
Yale University

Appendix B: 2021 Virtual Forum Agenda

Wednesday, September 15, 2021, 1:00-3:00 PM EDT (GMT-4)
Focus Topic: *Understanding and Perception of Vehicle Automation*

12:30 PM	Virtual Social Activities
01:00 PM	Welcome, Event Background, & Opening Remarks
01:15 PM	Panel Discussion
01:55 PM	Breakout Group Overview & Instruction
02:05 PM	Breakout Group Discussions
02:35 PM	Breakout Group Reporting
02:55 PM	Preview of Day 2
03:00 PM	Adjournment for Day 1

Thursday, September 16, 2021, 1:00-3:00 PM EDT (GMT-4)
Focus Topic: *Driver Interactions with Vehicle Automation*

12:30 PM	Virtual Social Activities
01:00 PM	Review of Day 1 & Introduction of Day 2
01:05 PM	Presentations
01:50 PM	Breakout Group Overview & Instruction
01:55 PM	Breakout Group Discussions
02:30 PM	Breakout Group Reporting
02:55 PM	Preview of Day 3
03:00 PM	Adjournment for Day 2

Friday, September 17, 2021, 1:00-3:00 PM EDT (GMT-4)
Focus Topic: *Education & Training on Vehicle Automation*

12:30 PM	Virtual Social Activities
01:00 PM	Review of Day 2 & Introduction of Day 3
01:05 PM	Panel Discussion
01:50 PM	Breakout Group Overview & Instruction
01:55 PM	Breakout Group Discussions
02:30 PM	Breakout Group Reporting
02:50 PM	Closing Remarks & 2022 Forum Plan
03:00 PM	Conclusion of the 2021 Forum

Appendix C: Breakout Questions from Days 1–3

Day 1: Understanding and Perception of Vehicle Automation

1. **What are the most important recent developments in research, product development, policy, outreach, or other areas concerning the understanding and perception of vehicle automation?**
   The main purpose of this question is to get a pulse check on important happenings related to people's understanding and perceptions of vehicle technology, in research as well as other areas. This relates both to users of the technology as well as among the public at large. The discussion can include recent published (or soon-to-be-released research), government or stakeholder initiatives, technological developments, media coverage, etc.

2. **What are the most pressing research needs or current barriers related to the understanding and perception of vehicle automation?**
   The main purpose of this question is to identify pressing needs from different stakeholders or to identify important challenges that they are facing or foresee related to people's understanding and perceptions of vehicle technology. Research needs identified may or may not tie directly to some of the challenges or barriers identified. Conversely, barriers might call for additional research but may also identify other needs.

Day 2: Driver Interactions with Vehicle Automation

3. **What are the most important recent developments in research, product development, policy, outreach, or other areas concerning driver interactions with vehicle automation?**
   The main purpose of this question is to get a pulse check on important happenings related to drivers' and other road users' interactions with vehicle automation and their behaviors with this technology, in research as well as other areas. This could include recent published (or soon-to-be-released research), government or stakeholder initiatives, technological developments, media coverage, etc.

4. **What are the most pressing research needs or current barriers related to driver interactions with vehicle automation?**
   The main purpose of this question is to identify pressing needs from different stakeholders or to identify important challenges that they are facing or foresee related to drivers' and other road users' interactions with vehicle automation and their behaviors with this technology. Research needs identified may or may not tie directly to some of the challenges or barriers identified. Conversely, barriers might call for additional research but may also identify other needs.

Day 3: Education & Training on Vehicle Automation

5. **What are the most important recent developments in research, product development, policy, outreach, or other areas concerning education and training on vehicle automation?**
   The main purpose of this question is to get a pulse check on important happenings related to education and training on vehicle automation, in research as well as other areas. This could include recent published (or soon-to-be-released research), government or stakeholder initiatives, technological developments, media coverage, etc.

6. **What are the most pressing research needs or current barriers related to education and training on vehicle automation?**
   The main purpose of this question is to identify pressing needs from different stakeholders or to identify important challenges that they are facing or foresee related to education and training on vehicle automation. Research needs identified may or may not tie directly to some of the challenges or barriers identified. Conversely, barriers might call for additional research but may also identify other needs.