



Introduction: The Automated Road Transportation Symposium 2022

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Abstract. In 2022, the Automated Road Transportation Symposium returned to a traditional face-to-face meeting format after two years of virtual meetings caused by the global pandemic. The plenary presentations and breakout discussions continued to provide the meeting participants with the most up-to-date and authoritative information about the current international state of development and deployment of road vehicle automation systems, retaining its standing as the essential global meeting for industry, government and research practitioners in the field.

Keywords: Road vehicle automation · Road transport automation · Automated vehicles · Autonomous vehicles · Self-driving vehicles

1 Overview

The 2022 Automated Road Transportation Symposium (ARTS22) was organized and produced by a large team of professional volunteers working under the auspices of the National Academies of Science, Engineering and Medicine (NASEM) Transportation Research Board (TRB). The meeting was organized to serve the participants' interests in understanding the impacts, benefits, challenges and risks associated with increasingly automated road vehicles and the environments in which they operate. It brought together key government, industry and academic experts from around the world with the goal of identifying opportunities and challenges and advancing Automated Driving System (ADS) research across a range of disciplines.

The symposium was held at the Hyatt Regency Orange County Hotel in Garden Grove, CA from 18–21 July 2022. The plenary sessions were scheduled for the full mornings of the second and fourth days and half of the morning on the third day. The afternoons of the first three days were devoted to full-length breakout sessions, and half-length breakout sessions were held on the morning of the third day. Five parallel

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breakout sessions were held in each of the breakout time slots, for a total of twenty breakout sessions.

The breakout sessions were organized by committees of volunteers to address a wide range of topics. These were clustered into three thematic tracks to make it easier for attendees to identify the sessions of strongest interest to them:

- Policy
- Operations
- Safety.

The plenary and breakout session programs were planned and produced by the ARTS22 Planning Committee, which included a mixture of TRB volunteers and support staff from Noblis:

John Craig, Noblis; Richard Cunard, Engineer of Traffic and Operations, TRB; Raymond Gerte, Noblis; Cynthia Jones, Drive Ohio; Jane Lappin, TRB Vehicle-Highway Automation Committee Chair; Steven Shladover, University of California PATH Program (and former chair of the TRB Vehicle-Highway Automation Committee); Valerie Shuman, Shuman Consulting Group, LLC and Chair, TRB CORVA Subcommittee; Egan Smith, U.S. DOT Intelligent Transportation Systems Joint Program Office, and Edward Straub, SAE.

2 Keynote Talks

The plenary program began with pre-recorded welcoming remarks by Secretary of Transportation Pete Buttigieg, followed by a more detailed in-person presentation of the U.S. DOT perspective by Dr. Vinn White, Senior Advisor for Innovation in the Office of the Secretary of the U.S. DOT. Secretary Buttigieg identified a goal for automated vehicles to achieve safety better than human drivers, and emphasized the importance of seeking equity in the job opportunities that would be available for workers in the automated driving industry and industries affected by driving automation. Dr. White described automated driving as “how we move better” and emphasized the importance of safety in planning for widespread deployment.

Dr. Steven Cliff, the Administrator of the National Highway Traffic Safety Administration, gave the keynote talk to kick off the third day of the symposium. He noted that NHTSA is studying the crashes that have occurred involving automated driving systems to try to understand whether they were caused by potential defects, which could be cause for recalls. He advocated for a broad “safe systems approach” in automated driving system development, including careful consideration of equity issues related to who is likely to be injured in crashes during development and testing as well as deployment.

The final day of the Symposium began with a keynote talk by Dr. Robert Hampshire, the Deputy Assistant Secretary for Research and Technology and Chief Scientist of the U.S. DOT. He gave a comprehensive overview of the R&D activities that the U.S. DOT is sponsoring to accelerate progress toward deployment of automated driving systems across the various transportation modes, under the broad theme of “transformation”. Dr. Hampshire reviewed the existing research programs as well as the relevant new DOT initiatives such as the Highly Automated Systems Safety Center of Excellence (HASS-COE) and the ARPA-I program to create more intelligent transportation infrastructure.

3 Plenary Panel Sessions

ARTS22 extended the trend from previous years of devoting a majority of the plenary program time to panel discussion sessions on important topics, featuring groups of speakers responding to questions from the moderator and interacting with each other, with only a limited number of formal presentations. These sessions also provided opportunities for audience members to submit questions through a web-based service. The panel discussion sessions covered a wide range of topics in policy, technology and applications of road transportation automation.

3.1 Real-World Automated Trucks: What It Takes to Integrate with Today's Fleet Operations

Richard Bishop organized and moderated this panel of speakers from Waymo and TuSimple and their respective fleet customers C.H. Robinson and Loadsmith. They discussed their ongoing field testing hauling freight for commercial customers using their automated driving systems under the supervision of test drivers. They agreed that the adoption of the technology would initially be focused on the larger carriers, and that it would be a gradual process, beginning with limited long-haul routes and gradually expanding to more routes. One of the main themes was the improvement of work-life balance for drivers, particularly with the shift of driving assignments from long-haul toward local drayage operations. The labor impact of the introduction of intermodal freight using trailers and containers on railroad flatcars for long-haul routes was cited as an analogy – creating a larger number of driving jobs in other parts of the logistics chain than the jobs that were eliminated in the long-haul operations.

3.2 Automated Transit Projects

Henriette Cornet from UITP introduced the large-scale European project SHOW, which is field testing automated transit vehicles in multiple cities in Europe, and offered that as a basis for discussion by representatives of transit automation projects that are being initiated in Jacksonville, Trenton and Connecticut. The Jacksonville and Connecticut projects simplify the technical challenges by operating the automated buses in dedicated facilities avoiding mixed traffic interactions, while the Trenton project aims at a more challenging application in mixed traffic but at low speeds. The developers of these projects explained some of the surprising challenges that they encountered as they worked toward implementation of their systems.

3.3 State and Local Government Approaches to Regulating Automated Driving

Steven Shladover organized and moderated this panel of speakers representing the states of Texas, Arizona and California and the City and County of San Francisco, providing diverse perspectives on regulating the testing and public deployment of automated driving systems. Together, these jurisdictions are hosting a large majority of the current automated driving mileage in the U.S. All of them expressed interest in protecting their

citizens and visitors from unreasonable risks associated with automated driving, while encouraging automated driving innovations that are expected to produce long-term benefits in mobility and safety, but they adopted different approaches to achieving those goals.

3.4 Private Sector Perspectives on AV Public Policy

Ariel Wolf of Venable LLP organized and moderated this panel of representatives from Aurora, Embark, Waabi and Waymo discussing their perspectives on the key public policy issues that they face. The trucking automation applications face some additional regulatory concerns based on FMCSA requirements, but the NHTSA safety regulatory issues that apply to all vehicles are likely to be more complicated. There was general agreement that the regulatory approach will need to be phased, and there was broad interest in having NHTSA define a consistent national approach, with a single set of data reporting requirements, but they were also reluctant to share much data, especially if the data were to be made public. The panelists were receptive to having active federal regulations to facilitate public acceptance and protect the industry as a whole from potential “bad actors” working in this field.

3.5 Implementation of SAE Automated Vehicle Safety Consortium (AVSC) Best Practices

The Automated Vehicle Safety Consortium (AVSC) was established as one of SAE’s Industry Technologies Consortia (ITC) to provide a mechanism for companies to cooperate on pre-competitive aspects of AV safety. Amy Chu, the Director of AVSC, moderated a panel discussion with representatives from member companies Ford, Volkswagen, Honda and Aurora. They discussed topics that they have worked on in AVSC, including how to allow passengers to interrupt an automated driverless trip for an emergency, what automation-relevant data to save in event data recorders for crash reconstruction, how to develop Safety Management Systems (SMS) and how ADS-dedicated vehicles should interact with vulnerable road users.

3.6 Discussion of Primary Technology Challenges to Widespread Deployment of Automated Driving Systems

Steven Shladover moderated this discussion with representatives of Apex.AI and Edge Case Research, companies that provide services to automated driving system developers. They discussed the primary technological issues that remain unresolved in developing verifiably safe automated driving that can work under a wide enough range of conditions to be commercially viable. The topics included software safety design, verification and validation; hazard perception and prediction; safety assurance for machine learning systems; scalability and portability of systems to new locations and vehicle platforms; high-fidelity simulation development and validation; and identification of sufficient scenarios to support robust safety cases.

3.7 Building a Win/Win: AV/Infrastructure Collaboration

Valerie Shuman moderated a discussion with representatives from Cavenue, MAPtm, The Eastern Transportation Coalition (TETC) and General Motors. A fundamental issue going forward is how AVs and the infrastructure can share both real-time and analytics data to make the whole transportation system safer and more efficient. The panel discussed how data can be used to enable AVs (e.g., by extending ODDs) and what we are doing in this area already, including solutions that augment sensor perception range and provide complementary/redundant sensor information; how data will be used to support IOO safety and efficiency goals and what we are doing in this area already, including using vehicle data to support data-driven decisions and to provide complementary/redundant sensor information; current challenges, such as determining appropriate data for AV use and expected outcomes, data quality, usability and trustworthiness, standards across geographies and vehicles, coverage, business models and data vs insights; and the need for practical collaborative research and strong stakeholder communication and buy-in.

3.8 The Last Word: An Informed Discussion with Veteran Industry Journalists

Jane Lappin organized and moderated this discussion with journalists from Bloomberg and Forbes who have extensive experience following developments in the automated driving industry. They emphasized the significance of the ongoing industry consolidations and the parallel dearth of new investment capital, forcing the industry to concentrate on generating near-term revenues. They agreed that package delivery is a more promising near-term target than automated ride-hailing, particularly given the current public reluctance to share rides. They thought that regulations will be needed on labeling or naming of systems in order to reduce the current level of consumer confusion about system capabilities. Looking forward, they saw the industry as fragile because of the combination of technological vulnerabilities and lack of profitable business models.

4 Plenary Presentations

Individual presentations were distributed across the plenary program in between the panel discussions to avoid Powerpoint fatigue from too long a sequence of consecutive presentations. Three of the presentations were given by speakers who were invited to cover specific topics that the planning committee believed to be important for the audience to learn about and the other three presentations were progress reports on some of the most important public-sector activities around the world related to automation (the U.S., European Commission and Japan).

4.1 Presentations on Specific Topics

- Laura Fraade-Blanar, Waymo – What is “Good” Driving? Framing Evaluation of Autonomous Driving Behavior through Drivership
- Raquel Urtasun, Waabi – Waabi’s AI-first Approach to Scaling Self-driving Safely and Rapidly
- Chaiwoo Lee, MIT AgeLab – Public Knowledge of and Attitudes toward Vehicle Automation: Trends and Implications

4.2 National and International Government Activities Relevant to Automated Driving

- Earl Adams, Federal Motor Carrier Safety Administration – ADS Trucks – The FMCSA Perspective on Road Safety
- Andrea DeCandido, European Commission DG-RTD – The European Experience: A Structured Approach to Cooperative, Connected and Automated Mobility (CCAM)
- Yoichi Sugimoto, SIP-adus Program (Japan) – Towards Social Deployment of Automated Driving – SIP-adus Activity in Japan

5 Breakout Sessions

ARTS breakouts gather key experts from around the globe for more in-depth consideration of specific topic areas. The goal of the breakout sessions is to collaboratively answer the questions: *What needs to be true to make the AV vision become a reality? How can our research help drive progress year on year?* The 2022 program included 20 sessions and covered a wide range of specialized topics from across the field to enable this discussion for the industry as a whole (see program list below).

The primary findings from each afternoon’s breakout discussions were reported back to the plenary the following day. The combined summaries provided in these Daily Roundups distill the latest insights from across the industry. The major focus for 2022, which cut across breakouts in all three tracks, was *integration*. In an evolution from prior years, which focused on collaboration, many discussions highlighted the need for integration in three dimensions:

- **Geographic.** Isolated local solutions are not the way forward. We need global, national, and regional approaches for all of the core AV industry building blocks, including strategies, roadmaps, frameworks, standards, terminology and definitions, and policies.
- **System-level.** The role of infrastructure as both a support for AV operation and a beneficiary of AV insights was highlighted this year. We need to leverage the strengths and address the weaknesses of human, ADS *and* infrastructure performance for a successful overall system. This need for three-way coordination came up in a wide range of topic areas, including trucking, teleoperation, traffic management, first responders, construction and inspection zones, rural use, climate change, transit, digital infrastructure, and cybersecurity.
- **Data.** The critical need for effective data-sharing continued to be a key area of discussion in 2022. Data types of interest included test data, live and historical road network operational data, asset and road environment data, monitoring data, and modeling data. Research, Planning, and Operations were all viewed as both producers and audiences for this data, while challenges around data capture, communications, and developing the open standards and specifications necessary to enable sharing continue to be important areas for ongoing work.

Breakout participants collaborated to develop new ideas, such as a CAV cybersecurity ecosystem map. Other sessions used Design Thinking and Wargames methodologies to

spark high-energy discussions among the participating experts. Additional highlights included:

- The developers of safety assurance framework standards reported good progress.
- The NHTSA Partnership for Analytics Research in Traffic Safety (PARTS) has established a much-needed safety data sharing model, with initial crash analysis data expected in fall 2022.
- First responder groups are now coordinating to develop common use cases.
- The NIST OES has developed a structured description of the operating environment to support testing & certification.

5.1 ARTS22 Breakout Sessions

5.1.1 Policy Sessions

- Unscrambling the Automated Vehicle (AV) Policy Puzzle: AV Policy Development and Regulation Under a New Normal
- Mitigating Climate Change with ART Technologies
- Shark Tank: Is it Time for AVs to Grow Up?
- Beyond the DriveTrain: Achieving Efficiency in CAVs through Technologies and Regulations

5.1.2 Operations Sessions

- Automated Trucking Research and Development
- Digital Infrastructure for Roadway Transportation and Automation Integration
- Inconsistency of AV Traffic Flow Impacts: Predictions in Literature
- Automated Vehicle Technologies for Crowd-Sourced Roadway Environment Assessment
- Remote Assistance and Teleoperation for Automated Vehicle Operations
- AVs in Rural America: What Can We Learn from the Data?
- Enhancing Mobility with Automated Shuttles and Buses
- How Connected Vehicle Deployment Lessons Lay the Groundwork for Highly Automated Vehicles
- Evaluating First Responder Interactions as the AV Market Expands
- Interactive Traffic Management for Highly Automated Vehicles

5.1.3 Safety Sessions

- Safety Assurance of Automated Driving
- ADS Standards Hot Topics: Operational Design Domain (ODD) & Operating Envelope Specification (OES)
- Cybersecurity Hot Topics
- AV Testing and Data Collection
- Adapting War Games to Explore Safety Measurement: An Interactive Exercise
- Understanding the Human Factors of Teleoperation

6 General Cross-Cutting Observations

As the field of road vehicle automation has advanced and the level of knowledge of the issues has grown over the past several years, the areas of emphasis within the Symposium have continued to evolve. Based on the discussions at this most recent meeting, three broad categories of observations are worth noting:

6.1 Existing Trends that Accelerated Based on the COVID-19 Pandemic

- The urgency of identifying robust business models to achieve commercial success with automated driving products and services became more acute. New investments in automated driving businesses declined more dramatically than previously, as more investors became conscious of the development challenges and electrification became a more attractive market opportunity. Because of the difficulty of attracting additional investments, the existing companies experienced a more urgent need to generate revenue and shift attention to nearer-term and less technically ambitious market opportunities.
- The consolidations within the industry through mergers, acquisitions and corporate failures accelerated. This was related to growing recognition of the technological challenges to achieving high levels of automation and of identifying market niches that are both technologically and commercially feasible.
- The pandemic-inspired shift to work from home, online shopping and home delivery of fresh food and prepared meals accelerated the shift of interest from passenger movement to goods movement. The decline of commuting travel and the health concerns associated with ride sharing had severe impacts on the ride hailing and public transit markets, reducing the attractiveness of automated ride hailing. At the same time, the growing need for package delivery and concerns about person-to-person contacts in home delivery settings accelerated interest in automated local package delivery. These trends accelerated consideration of the workforce implications of automated driving, particularly among heavily unionized truck and bus drivers.
- The trends noted above also accelerated the growing recognition of how gradual the deployment rollout is likely to be for higher levels of automation. This motivated growing interest in identifying specialized use cases for automated driving that could be deployed earlier and generate nearer-term revenues, even if they represent modest-size markets such as ports, mines, or logistics hubs.

6.2 New Themes and Topics of Interest

- This year's meeting generated a higher level of interest and direct engagement from senior management at the U.S. DOT, including the welcoming remarks from the Secretary of Transportation and substantive participation throughout the meeting by senior DOT management officials.
- The leading participants from the industry appear to be converging on consistent frameworks for ensuring the safety of their automated driving systems. They are combining technical safety cases with consideration of organizational safety culture and attention to the full life cycles for their systems, for a robust and comprehensive approach to the safety challenges.

- The state and local government representatives appear to share common goals for their automated driving regulatory frameworks, even when those frameworks differ in specific implementations.
- The need for remote human support for higher levels of automated driving is receiving more attention, which is highlighting the safety, human factors and policy challenges of remote support to a greater extent than in the past.
- Infrastructure support for automated driving also attracted more attention than in the past, including both physical aspects (such as separations from other traffic) and digital support.

6.3 Public-Private Sector Interactions

- The international presentations and discussions highlighted significant differences in the public agency roles relative to the private industry roles. The private roles were most prominent in the Americas, the public most prominent in the Asia/Pacific, with Europe somewhere in the middle.
- The industry representatives appeared to be more willing than in the past to engage in a consultative process with other stakeholders to develop a broader consensus on regulatory approaches for automated driving.
- U.S. industry representatives expressed support for government playing the roles of developing measures of effectiveness for evaluating automated driving systems and for requiring “truth in labeling” on automation systems in order to enhance public confidence.
- U.S. industry representatives expressed reluctance to participate in public pilot projects that would require disclosure of significant technical or safety-related data, while recognizing that it will be necessary to share a certain amount of data to earn public trust. This tension regarding the appropriate amount of data sharing is likely to be an important issue for the future.