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The Robotaxi Movement is in Full Gear:

“ARTS-fully Done TRB!”

Autonomous vehicles (AVs) are rapidly transforming the transportation landscape, with technological advancements leading to increased capabilities and broader applications. Robotaxis, automated buses, and shuttles are among the most prominent examples of these evolving vehicles.

Robotaxis, specifically, have garnered significant attention as a potential solution to urban mobility challenges. For the past few years, companies like Waymo and Cruise have conducted extensive testing and initiated limited commercial operations in cities in California and Arizona. These vehicles promise on-demand, affordable transportation – while also reducing congestion and emissions. The potential benefits of robotaxis are vast, offering a more efficient and sustainable urban mobility solution. However, the widespread adoption of robotaxis faces several challenges, including safety concerns, regulatory hurdles, data privacy issues, accessibility, and interconnectivity.

Ensuring the safety of robotaxis requires rigorous system testing and validation. It also requires addressing potential vulnerabilities and edge cases like adverse weather conditions, unexpected obstacles, complex traffic scenarios, cybersecurity threats, and human error. Data privacy is another critical concern with AVs. Robotaxis, like their non-automated counterparts, collect and process large amounts of data, including passenger information and driving patterns. Protecting this data from unauthorized access and misuse is essential for building public trust – and compliance with a whole host of regulatory requirements.

Accessibility is also a key consideration for the successful deployment of robotaxis, as many regulators are asking for these vehicles to be designed to accommodate passengers with disabilities. This includes features such as wheelchair-accessible ramps, voice-activated controls, and clear signage. However, there is a critical distinction between human-operated wheelchair-accessible vehicles (WAVs) and autonomous robotaxis: human drivers are often required to assist passengers with tasks like securing wheelchairs, providing guidance on entering and exiting the vehicle, and ensuring their safety throughout the ride. In a robotaxi, the absence of a driver could mean that these services may no longer be available, unless alternative solutions, like automated securing mechanisms or on-demand remote assistance, are developed. Additionally, ensuring robotaxis are integrated with existing public transportation systems – like buses and trains – is essential for maximizing their benefits, but they must also address these personal service gaps to avoid creating new barriers for passengers with disabilities.

One issue considered to be the most significant barrier to robotaxi viability is the cost. The profitability of robotaxis, and thus the feasibility for companies to operate robotaxi fleets, hinges on their ability to achieve lower operating costs than traditional taxi and for-hire fleets. While AVs offer the potential for increased efficiency and reduced labor costs, this technological shift also

has significant implications for the workforce. The reduction in labor costs means fewer drivers are needed, which could lead to job losses in the taxi and for-hire vehicle industry—a sector that has long been a source of employment for many diverse and low-income communities. This transformation may create economic challenges for drivers whose livelihoods depend on these jobs, highlighting the need for strategies that address workforce transition and support affected workers.

At the same time, significant upfront investments, ongoing maintenance, and infrastructure costs can pose challenges to achieving lower costs. Maintenance costs are a substantial component of operating expenses, requiring regular sensor calibration, software updates, hardware repairs, and battery maintenance. These tasks can be labor-intensive and expensive. Beyond maintenance, other factors contributing to operating costs include energy consumption, insurance, infrastructure investments, and software development. Current estimates put operating costs for AVs at around \$3.00 per mile,¹ while the estimated cost per mile for a conventional vehicle is around \$0.84.² Industry experts expect operating costs for robotaxis to decline steadily due to technological advancements, economies of scale, and increased efficiency. Nonetheless, balancing these cost reductions with the economic impact on workers remains a key challenge in the broader adoption of robotaxis.

Autonomous vehicles are on the brink of revolutionizing transportation, offering the potential for improved safety, efficiency, and accessibility. The widespread adoption of AVs, while contingent on addressing challenges such as safety, regulations, data privacy, and operating costs, holds the promise of a transformative future. Recent advancements in technology, coupled with ongoing innovation, suggest a promising future for AVs. As these vehicles become more prevalent, we anticipate significant changes in urban mobility, economic development, and social equity.

AVs on the Agenda: Automated Road Transportation Symposium (ARTS)

The Transportation Research Board (TRB) is a unit of the National Academies of Sciences, Engineering, and Medicine. It is a leading organization dedicated to advancing transportation research and providing valuable resources and expertise to transportation professionals and policymakers worldwide. TRB conducts and coordinates transportation research projects, disseminates research findings, organizes conferences and events, and provides policy advice.

In addition to its Annual Meeting, one of the largest transportation conferences in the world, drawing over 10,000 attendees from over 80 countries, TRB also organizes a variety of other symposia and conferences throughout the year. These events cover a wide range of transportation topics, providing opportunities for researchers, policymakers, practitioners, and

¹ <https://www.goldmansachs.com/insights/articles/partially-autonomous-cars-forecast-to-comprise-10-percent-of-new-vehicle-sales-by-2030>

² <https://www.itskrs.its.dot.gov/2018-sc00406>

industry representatives to delve into specific areas of interest, share their expertise, and collaborate on solutions to pressing transportation challenges. Some of the most popular TRB symposia and conferences include the National Cooperative Highway Research Program (NCHRP) Symposium, the Public Transportation Conference, the Transit Safety Symposium, the International Bridge Management Symposium, and the Intelligent Transportation Systems (ITS) Conference.

This past summer, I spoke at one of the TRB's most exciting events - the Automated Road Transportation Symposium (ARTS) in San Diego, California. ARTS convenes global thought leaders from the industry, government, and research communities to collaborate on the opportunities and challenges associated with automating road transportation. ARTS provided updates on current research and development, advanced engineering progress, and field deployment results. ARTS also focused on issues impacting the U.S. Department of Transportation and state transportation departments resulting from road vehicle automation advancements.

Throughout the symposium, I had the privilege to participate in four panels, which covered the economic impact of automated vehicles, global governance models for shared mobility, rule of the road compliance for AVs, and innovative approaches to urban curb management in the era of autonomous pick-ups and drop-offs. These discussions underscored the potential of autonomous driving technologies and the crucial need for thoughtful policies and partnerships to maximize their benefits while addressing emerging challenges. Each of us has a role to play in this transformative journey.



From Left: Matt Daus; Jane Lappin, *Partner at Blue Door Strategy and Research*; and Kim Ramkishun, *Membership Director of the International Association of Transportation Regulators*

I want to specifically acknowledge **Jane Lappin**, the co-founder of ARTS, for coordinating an innovative and insightful event on behalf of TRB. Jane is a partner with Blue Door Strategy and Research, where she focuses on automated vehicles, and is Chair of the National Academies Transportation Research Board Vehicle-Highway Automation Committee.³ She recently retired as Director of Public Policy and Government Affairs for Toyota Research Institute where she monitored global regulatory affairs related to highly automated vehicles. Previously, Jane worked for the U.S. DOT Volpe Center managing large research projects assessing public response to advanced vehicle technologies and the impact of those technologies on network performance. Jane served as U.S. DOT secretariat to the trilateral US-EU-JPN international research collaboration on intelligent transportation, and as the U.S. co-chair of the US-EU-Japan Automation in Road Transportation Working Group. Through Jane's efforts, and that of the TRB volunteer team, including **Valerie Shuman** and many others, this event keeps better and better - year after year.

³ https://trb.secure-platform.com/a/page/AutomatedRoadTransportationSymposium/ARTS_Committee

Are AVs the Next Big Growth Engine?



Left: Matt Daus; Mansoureh Jeihani, Professor and Director of the National Transportation Center and the Urban Mobility & Equity Center at Morgan State University; and Richard Willder, Global Head of Regulatory and Autonomous Policy at Uber
Right: Matt Daus, and Richard Willder

In the ARTS session “*Beyond Safety: Are Automated Vehicles the Next Big Growth Engine?*” we delved into AVs’ economic potential and their possible impacts on productivity, freight, and urban mobility. The discussions explored whether AVs could generate growth similar to past transformative transportation investments like the Interstate Highway System. The session panel, “Passenger Impact,” in which I participated, was moderated by **Dr. Mansoureh Jeihani**, a **Professor and the Director of the National Transportation Center and the Urban Mobility & Equity Center at Morgan State University**. **Richard Willder**, **Global Head of Regulatory and Autonomous Policy at Uber**, was my co-panelist.

We focused on how AVs are now becoming a part of the transportation ecosystem as one of several ways to get around. AVs are being phased in not as a disruptive replacement, but as one of many modal choices. For example, the partnership between Waymo and Uber to launch autonomous ride-hailing services in Austin and Atlanta showcases how AVs can become a part of the fore-hire transportation ecosystem.⁴ Instead of completely replacing traditional ride-hailing services, AVs are being integrated to enhance the experience for riders. By offering additional options, AVs can provide more flexibility, convenience, and potentially improved safety. This approach aligns with the idea of AVs as a valuable addition to the transportation landscape, rather than a disruptive force that displaces existing modes

⁴ <https://waymo.com/blog/2024/09/waymo-and-uber-expand-partnership/>

Global Business and Governance Models

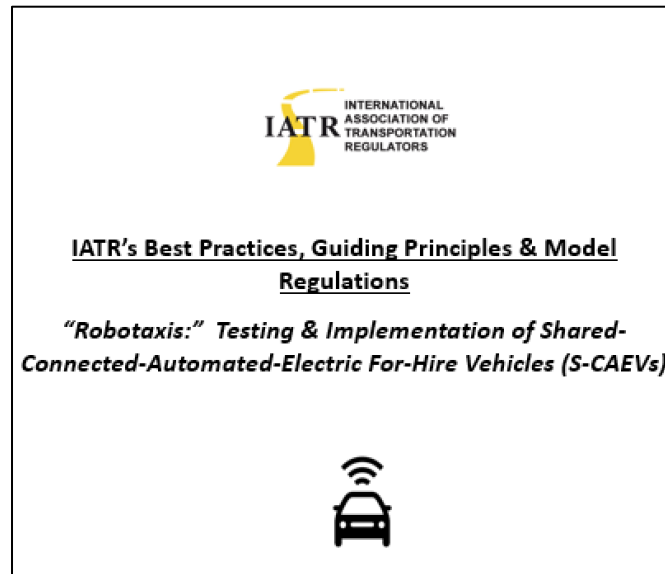


From Left: Matt Daus; Benjamin Lindborg, *Manager, Strategic Tendering & Analysis, Ruter AS*; Guido Di Pasquale, *Managing Director, PAVE Europe*; and Alison Pascale, *Director of Governmental Affairs and Community Relations at the Volkswagen Group of America*

In the session ***“Business and Governance Models Over the World: An Open Forum on Success Factors and Expectations,”*** we delved into the diverse business and governance models shaping shared autonomous mobility, emphasizing public-private partnerships (PPP) and how cities can work with private mobility providers to achieve sustainability and equity goals. **Henriette Cornet, an *Adjunct Professor at the University of San Francisco***, moderated the session. The panel included myself, **Alison Pascale, *Director of Governmental Affairs and Community Relations at the Volkswagen Group of America***; and **Guido de Pasquale, *Managing Director at PAVE Europe***.

I presented the International Association of Transportation Regulator’s **“Best Practices, Guiding Principles & Model Regulations for Robotaxis.”** These best practices emphasize that self-driving connected and autonomous electric vehicles (S-CAEVs) should aim to exceed current safety standards for conventional taxis and for-hire vehicles. The best practices highlight advancing environmental goals through zero-emission fleets, ensuring accessibility for passengers with disabilities, and protecting data privacy. The best practices also focus on equitable access to AV services for vulnerable communities and the need for a business model that supports low-income and unbanked populations.

I focused on the importance of promoting Vision Zero principles for AV implementation. As AVs play a more significant role in transportation, we must ensure they are designed and deployed with safety as a top priority. While many stakeholders and advocates may be more focused on automated enforcement and alternative modes of transportation, AVs must be considered a key component of Vision Zero narratives. By incorporating Vision Zero principles, we can help ensure that AVs are developed and deployed in a way that reduces traffic fatalities and injuries, ultimately making our roads safer for everyone.



[Read More on the Best Practices Here](#)

I also touched on robotaxi and AV governance examples from around the world, including Singapore’s Land Transport Authority, which requires a rigorous safety protocol and operator insurance; Dubai’s Road Transport Authority, with its licensing and liability requirements; and the UK’s recent AV Bill that mandates safety standards and operator responsibilities.

Automated Vehicle Rule of the Road Compliance



The following session, “*Automated Vehicle Rule of the Road Compliance: Theory, Practice, and Policy*,” addressed the evolving standards for AV compliance with traffic regulations, focusing on governance, technical approaches, and real-world implementation challenges. I moderated the final panel of this session, “*Keep on Complyin’ in the Free World*.” I was joined by **Henriette Cornet**, **Roxane Mukai**, **Operations Engineer at the Maryland Transportation Authority**, and **Kevin Gay**, **Director and Head of Safety for Autonomous Mobility and Delivery at Uber**. Our conversation centered on the practicalities of ensuring AVs follow the rules of the road. The panel discussed the complexities of rule compliance in various jurisdictions, the role of law enforcement in overseeing these technologies, and the strategies needed to maintain public trust in AV deployments.

The panel delved into various aspects of AV regulation and deployment, touching on large-scale European projects and efforts to harmonize regulations, including vehicle type approvals and the interaction of AVs with other road users. The discussion also covered the evolving role of AVs within existing transit infrastructure, the alignment of AV performance with current design standards, and how AVs might integrate with emergency response operations. Legal and regulatory challenges were highlighted, particularly regarding the definition of the “driver” in AV operations, enforcement practices, and the ongoing tensions between state and local authorities in regulating rideshare and AV services. Industry perspectives on safety standards and user experience for AV platforms were also addressed, emphasizing the need for emerging standards to ensure reliable and secure AV services.

Unlocking Better Curb Allocation with Autonomous Pick-up/Drop-off



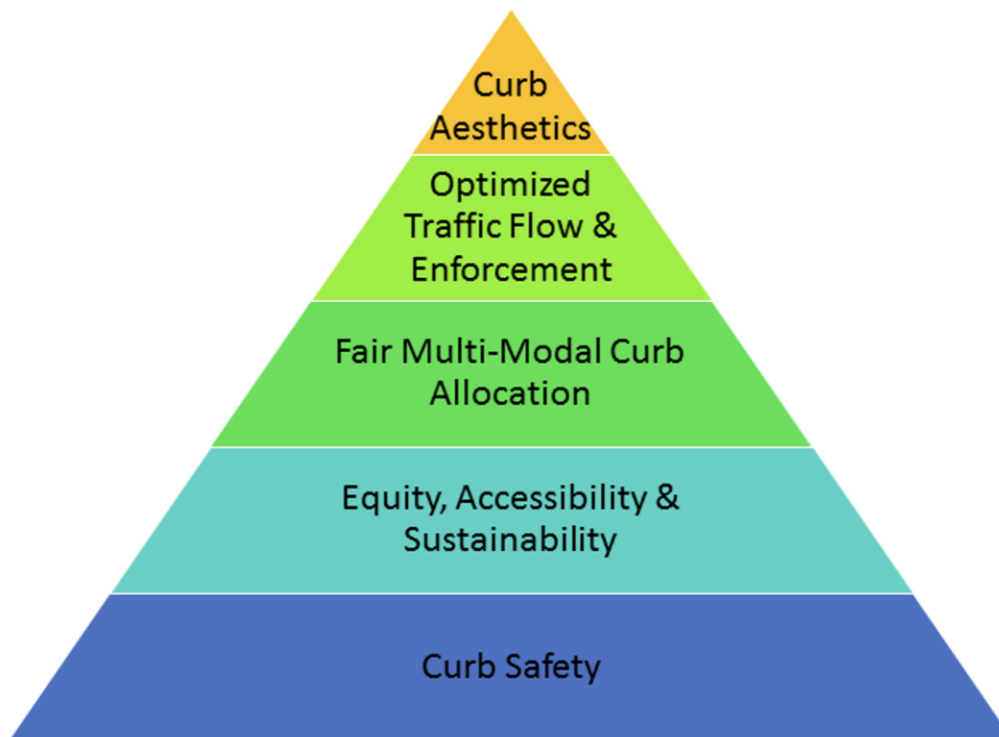
From Left: Andrew Glass Hastings, *Executive Director of the Open Mobility Foundation*; Matt Daus; Arielle Fleisher, *Policy Development and Research Manager at Waymo*; and Billy Riggs, *Professor and Director of the Autonomous Vehicles and the City Initiative and the Master of Public Administration program at the University of San Francisco*

One lively session and workshop was entitled “*Curbs: How Will Autonomous Pick-up/Drop-off Unlock Better Curb Allocation?*” which explored how autonomous vehicle operations could influence urban curb management, focusing on optimizing pick-up/drop-off zones through data-driven approaches. The first panel in this session, “*Exploring Opportunities and Challenges in Curb Digitization and ADS Data Sharing*,” included me, **Billy Riggs, a Professor and the Director of the Autonomous Vehicles and the City Initiative and the Master of Public Administration program at the University of San Francisco**; **Arielle Fleisher, Policy Development and Research Manager at Waymo**; and **Andrew Glass Hastings, Executive Director of the Open Mobility Foundation**.

Our discussion highlighted the need for improved data-sharing standards and the role of ADS (Autonomous Driving Systems) operators in digitizing the curb. The session emphasized balancing curb space allocation with urban mobility demands and creating open data standards that support dynamic curb pricing and planning for future urban environments.

During our conversation, I touched on elements of the IATR’s “[*Best Practices, Guiding Principles & Model Regulations for Robotaxis*](#)” that focus on curbs. First, S-CAEVs should integrate with existing transportation services to provide seamless connectivity for travelers, including first-and-last-mile services and Mobility-as-a-Service (MaaS). Second, S-CAEV implementation should include dedicated curb space for electric vehicle charging infrastructure and vehicle queuing (robotaxi stands). Local governments should develop a zoning or master plan that designates areas of operation and ensures passenger pick-up and drop-off in a manner

consistent with congestion mitigation principles. This could include closing central business districts to only S-CAEVs and public transit.



I also highlighted my idea of “[Curbtopia](#),” where curb space is utilized more efficiently, accommodating various transportation modes and creating a more sustainable and livable urban environment. The remaining workshop discussions were based on this theme and the concepts of “Curbtopia”, and where AVs fit in at the curb. Curb space can be repurposed to accommodate bikes, scooters, electric vehicles, and public transportation, rather than being dominated by parked cars. Central to this idea is the hierarchy of curb needs:

- Reduce parking for private motor vehicles in dense CBDs.
- Incentivize sustainable delivery practices and expand electric vehicle charging infrastructure.
- Implement automated enforcement to ensure compliance with curb usage rules.
- Prioritize multi-modal transportation options at transportation hubs.
- Balance resident parking needs with community-focused initiatives in residential areas.

The panel discussed data sharing using the examples of the Los Angeles Department of Transportation (LADOT) Mobility Data Specification (MDS). While many U.S. cities have adopted data protection principles to address privacy concerns, LADOT took a notable lead by implementing MDS in 2019. LADOT categorizes some MDS data as confidential and applies de-identification and access controls to safeguard this data. Mobility service providers in Los

Angeles, including bike-share and scooter-share operators, must comply with MDS, providing real-time location data without capturing riders' identities. We noted the importance of data in managing the curb, and that AVs should indeed have a place at the curb, at transit hubs, and as key elements of first and last-mile transportation.

ARTS and the Future of AVs



From Left: Matt Daus; Selika Josiah Talbott, *CEO of Autonomous Vehicle Consulting, LLC*; and Alex Roy, *General Partner & Co-Founder of New Industry VC*

ARTS contributes to policy development, industry advancement, public awareness, and global collaboration by providing a space for open dialogue and knowledge sharing. ARTS provides policymakers valuable insights into AVs' technical, economic, and societal implications. This enables policymakers to develop effective regulations and guidelines. ARTS also showcases advancements in AV research and development, driving innovation and progress within the industry; builds trust and support for AV adoption by raising public awareness about AV technology and addressing misconceptions; and facilitates international cooperation on AV standards, regulations, and best practices, promoting a harmonized approach to deployment and ensuring global interoperability.

The IATR's "[**Best Practices, Guiding Principles & Model Regulations for Robotaxis**](#)" aim to be a part of that same policy development and knowledge sharing by preparing for the deployment and mainstream adoption of shared connected and automated electric vehicles in taxi and for-hire passenger ground transportation services, including ride-sourcing by Transportation

Network Companies (TNCs). These model regulations aim to provide regulators with specific rules, policies, principles, and guidelines based on best and accepted practices that can be implemented through legislative or rulemaking processes.



Matt Daus; and Annabel Chang, *Head of State Policy & Government Relations at Waymo*

The IATR's guiding principles are comprehensive, addressing safety, sustainability, accessibility, equity, multimodal connectivity, data privacy, and governance. These guidelines aim to ensure that AVs meet high safety standards and environmental goals, and promote equitable access and seamless integration with existing transportation systems. The IATR places a strong emphasis on transparency and collaboration, advocating for robust data-sharing frameworks and clear liability structures to manage risk. Notably, the recommendations also highlight workforce development as a crucial consideration, calling for retraining and support programs to help existing drivers transition into new roles in the evolving mobility ecosystem. This focus on minimizing job displacement reflects the IATR's commitment to ensuring that the benefits of automation are shared broadly and that workers are supported as the industry advances.

The future of AVs is poised to revolutionize transportation, offering significant benefits in terms of safety, efficiency, accessibility, and economic opportunities. As technology advances, we can anticipate a surge in the adoption of AVs, with applications ranging from passenger transportation and freight delivery to public transit. AVs have the potential to reduce traffic accidents and optimize traffic flow. Beyond safety and efficiency, AVs can also improve accessibility for individuals who cannot drive, especially those living in underserved areas.

However, the widespread adoption of AVs is not without its challenges. Technical limitations, ethical considerations, and regulatory hurdles must be carefully addressed to ensure this technology's safe and responsible deployment. Overcoming these challenges will require collaboration among industry stakeholders, policymakers, and researchers to develop robust standards, guidelines, and infrastructure that support the integration of AVs into our transportation systems.