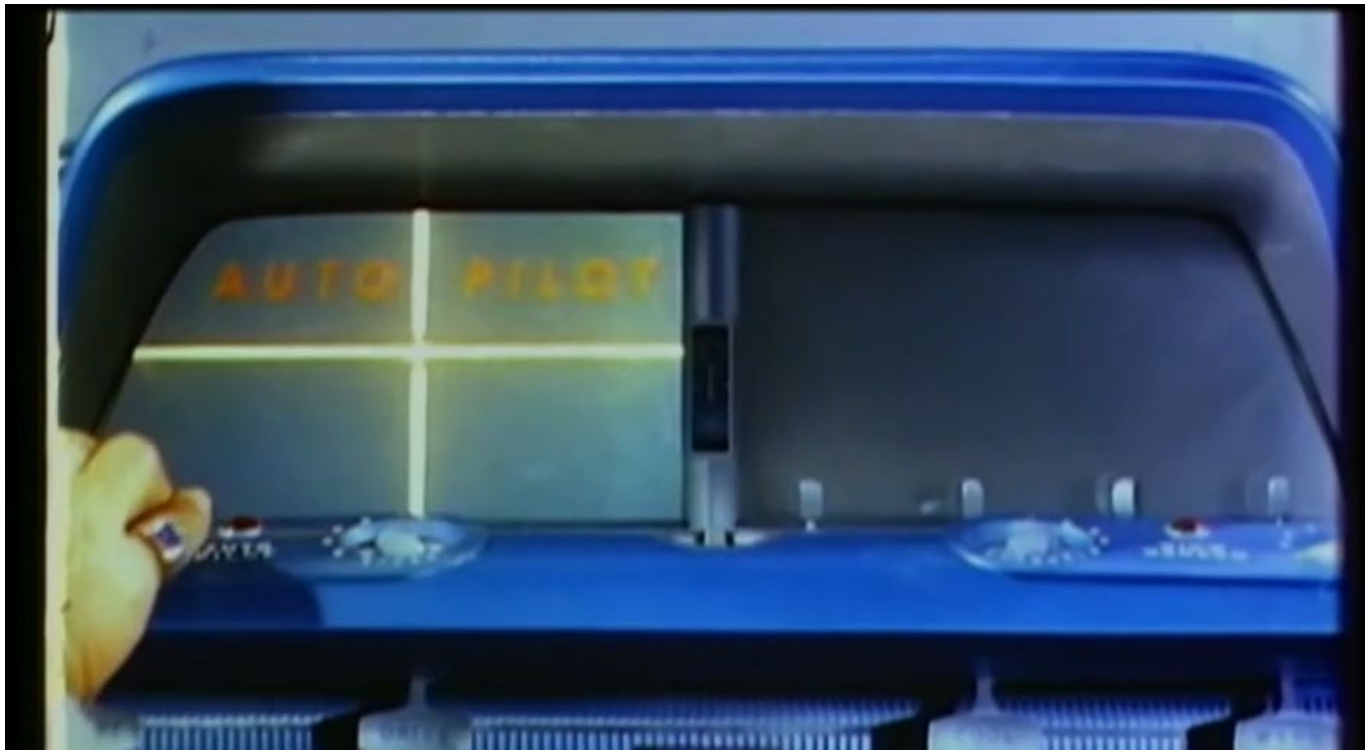
MIT Automated Vehicle Research: Observations from the Field & Implications for the Future

Bryan Reimer, Ph.D. | MIT Center for Transportation & Logistics AgeLab

Automotive Safety Council Annual Meeting | March 17th, 2022

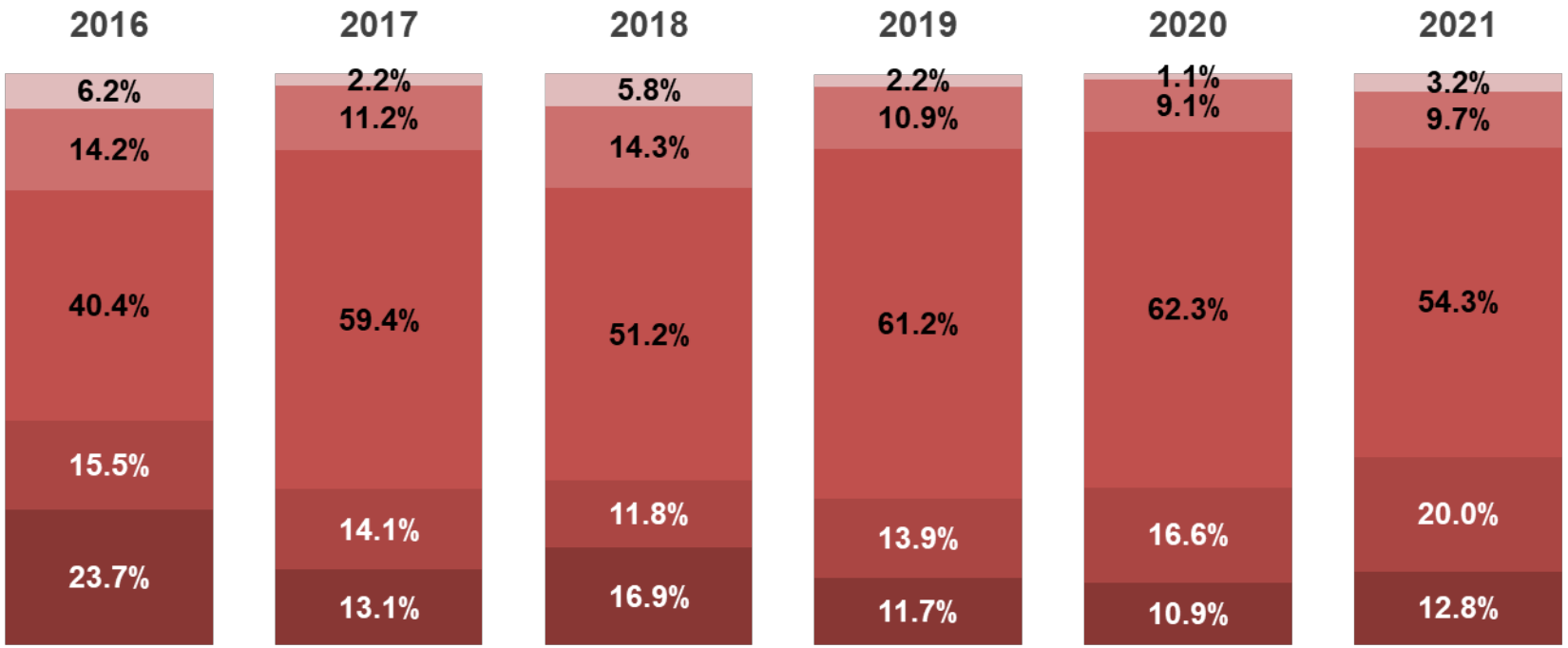
EFFORTS TO AUTOMATE DRIVING ARE NOT NEW

General Motors 1956 Film Highlights Auto Pilot and Systems for Safe Mobility



Source: General Motors 1965 downloaded Dec 6, 2021 from https://www.youtube.com/watch?v=F2iRDYnzwtk

Acceptance of Vehicle Automation: Six Year Trends Show Continued Interest in "Assistance"



- **No automation**
- **Emergency only**
  Features that are usually inactive, but activate only in certain events such as a collision
- **Driver assist**
  Features that actively help the driver while the driver remains in control
- **Partial self-driving**
  Features that that relieve the driver of all control for periods of time
- **Full self-driving**
  Features that completely relieve the driver of all control for the entire drive

Note: Percentages shown are unweighted

Lee, C., Gershon, P., Reimer, B., Mehler, B. & Coughlin, C. (2021). Consumer Knowledge and Acceptance of Driving Automation: Changes Over Time and Across Age Groups. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 65(1), 1395–1399.

Unpublished 2021 MIT AVT Survey Data

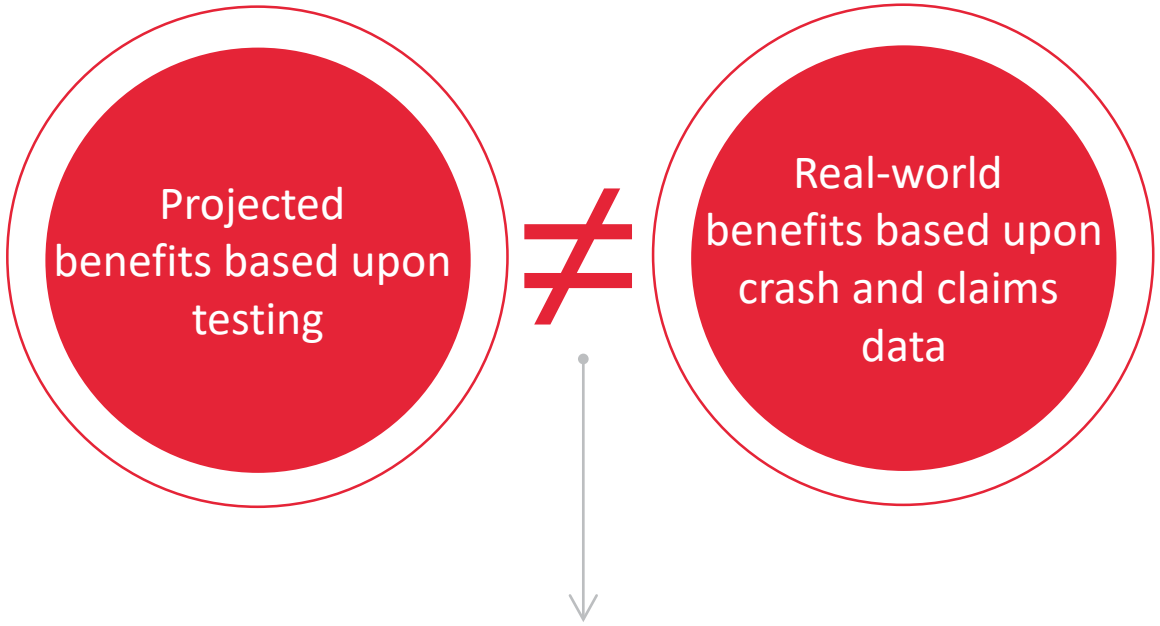
GAP ANALYSIS

The Need for New Data Driven Approaches to Success

Advanced Driver Assistance Systems (ADAS) and Automated Driving Systems (ADS) are predicated on a set of conditional operating characteristics, yet:

- Drivers may not have the understanding and skills necessary to successfully leverage technologies
- Many systems require driver management and oversight
- Technologists often assume ideal performance of both the human and system
- Infrastructure is less than ideal

Past research into ADAS and ADS is limited in scope and context when it comes to understanding how actual consumers interact with such technology.



AVT

The Advanced Vehicle Technology Consortium

Originators: MIT AgeLab, Touchstone Evaluations & Agero

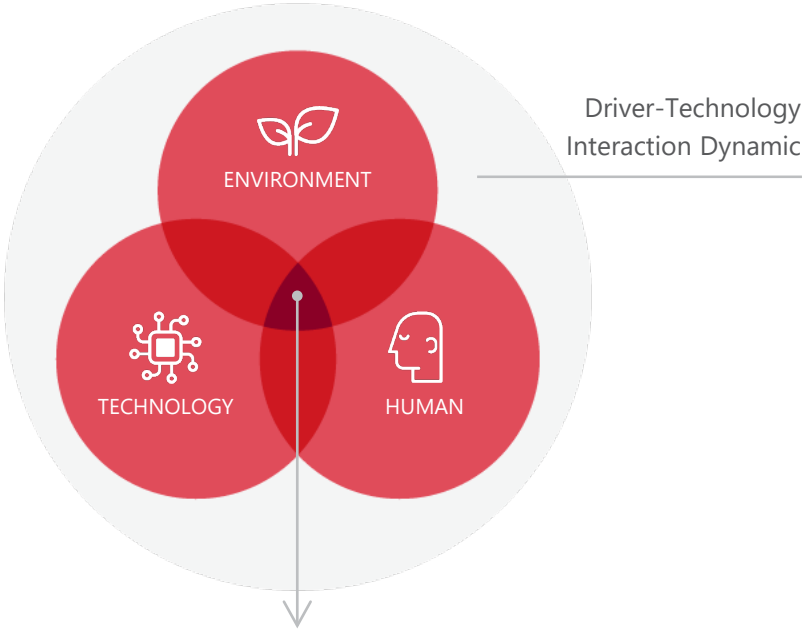
Founding Members: Aptiv, Liberty Mutual, Jaguar Land Rover, Veoneer & Toyota

Current Members*: Agero, Aptiv, Jaguar Land Rover, Veoneer (Arriver), Toyota (TMC, TRI, TIMS), Consumer Reports, Progressive, Insurance Institute for Highway Safety, Google (Waymo), JD Power, Audi (VW, Cariad), Lear, Travelers, Affectiva, The LAB (GIE Stellantis & Groupe Renault), Nissan, Bosch, Autoliv, Seeing Machines, Subaru, Zenseact (Volvo Cars, Polestar), Allstate & Honda

Other Supporters: TravelCenters of America & Santos Family Foundation

Focus: To collect and analyze cutting edge data that objectively characterizes the behavioral and safety benefit of advanced driver assistance systems, higher levels of automation, and other in-vehicle technologies under real-use conditions

Looking Beyond the Technology
Towards Consumer Understanding



To develop: An understanding of system performance and how drivers adapt to, use (or do not use), and behave with advanced vehicle technologies

*member affiliates in parenthesis

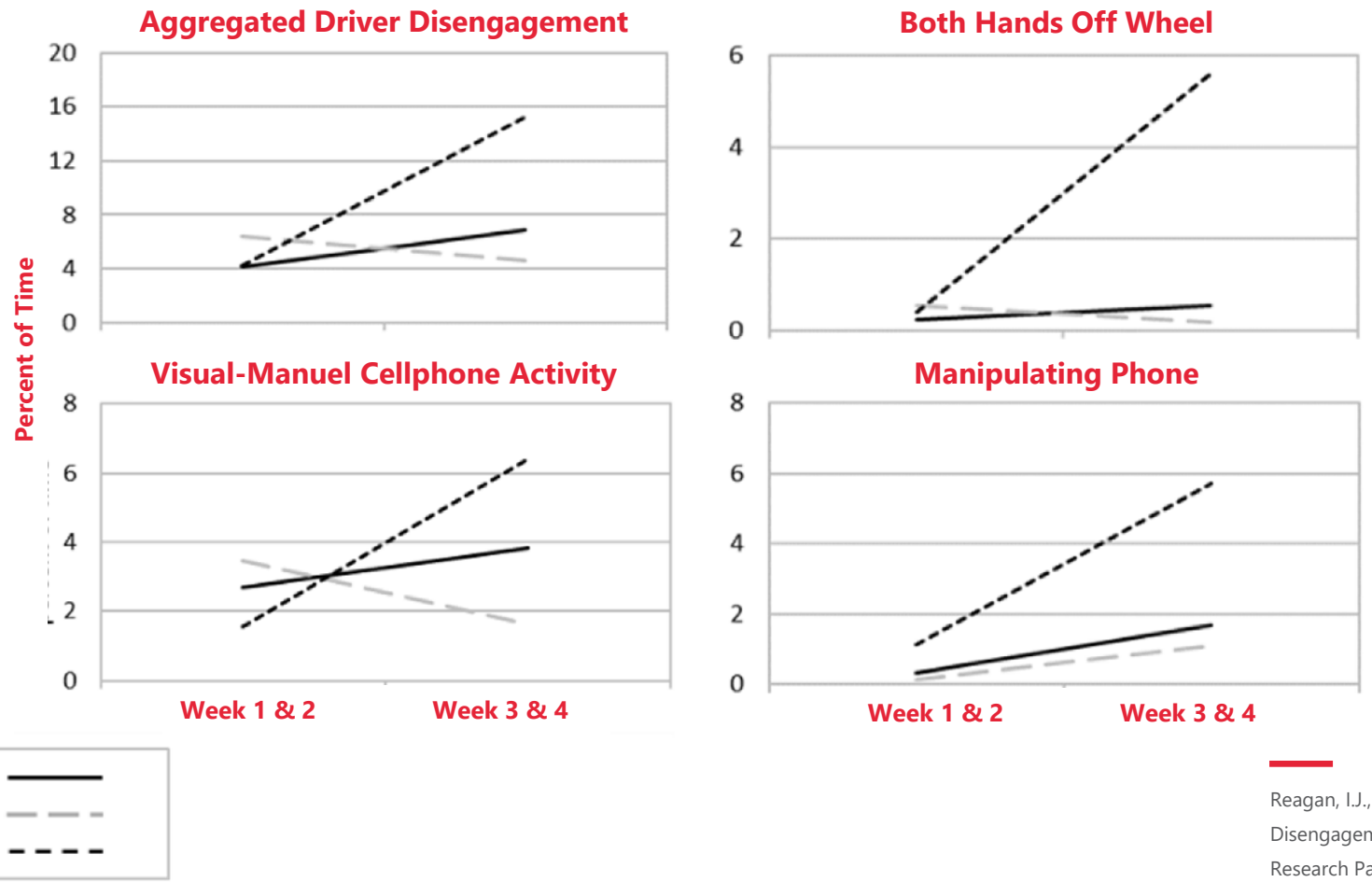
Investigating Automated Technology Use in the Wild

Fridman, L., Brown, D., Glazer, M., Angell, W., Dodd, S., Jenik, B., Terwilliger, J., Kindelsberger, J., Ding, L., Seaman, S., Abraham, H., Mehler, A., Sipperley, A., Pettinato, A., Seppelt, B., Angell, L., Mehler, B. & Reimer, B. (2018). MIT Autonomous Vehicle Technology Study: Large-Scale Deep Learning Based Analysis of Driver Behavior and Interaction with Automation. Massachusetts Institute of Technology, Cambridge, MA. https://arxiv.org/pdf/1711.06976.pdf

An Attention Epidemic?

Drivers have long multi-tasked, but perhaps what appears on our roads now is pushing boundaries we would not have imagined even a few years ago.

Use of SAE Level 2 Automation Increases Driver Disengagement



The use of early versions of Volvo's Pilot Assist is associated with changes over time in the odds of driver disengagement.

Reagan, I.J., Teoh, E.R., Cicchino, J.B., Gershon, P., Reimer, B., Mehler. B. & Seppelt, S. (2021). Disengagement from driving when using automation during a 4-week field trial. Transportation Research Part F: Psychology and Behaviour, 82.

What Is an “Acceptable” Off-Road Glance?

Tesla Autopilot use in a construction zone

Glance:

On-Road

Glance Length (s):

2.50

Percent Off-Road:

41

Max Off Road Length (s):

1.53

Long Off-Road Glances are Increasingly Common

Texting while using Volvo Pilot Assist

Glance:

Off-Road

Glance Length (s):

3.07

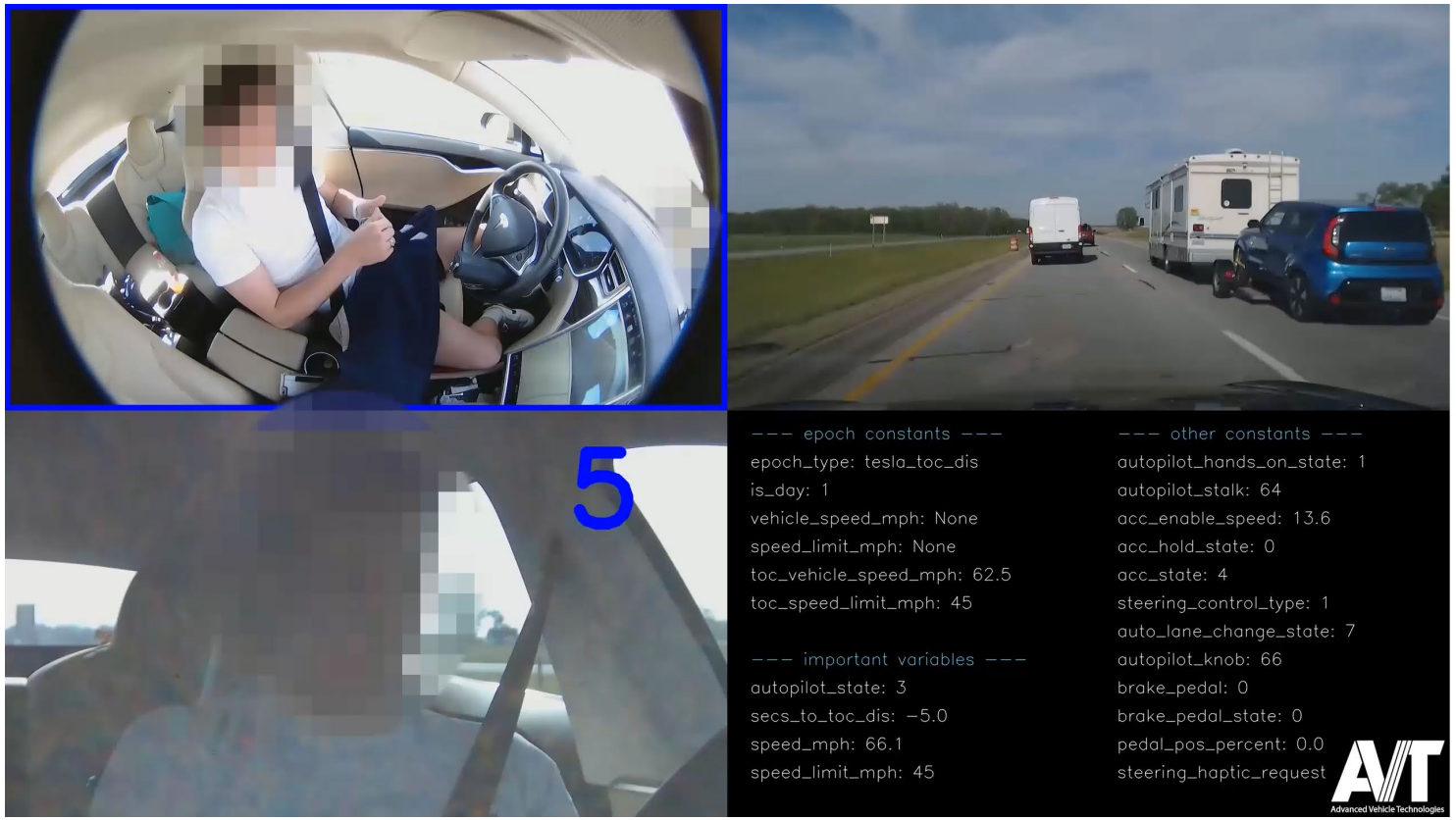
Percent Off-Road:

87

Max Off Road Length (s):

3.07

Did Looming Save the Day?



"Out-of-the-loop" behavior while using Autopilot approaching a construction zone

Glance:

Off-Road

Glance Length (s):

0.00

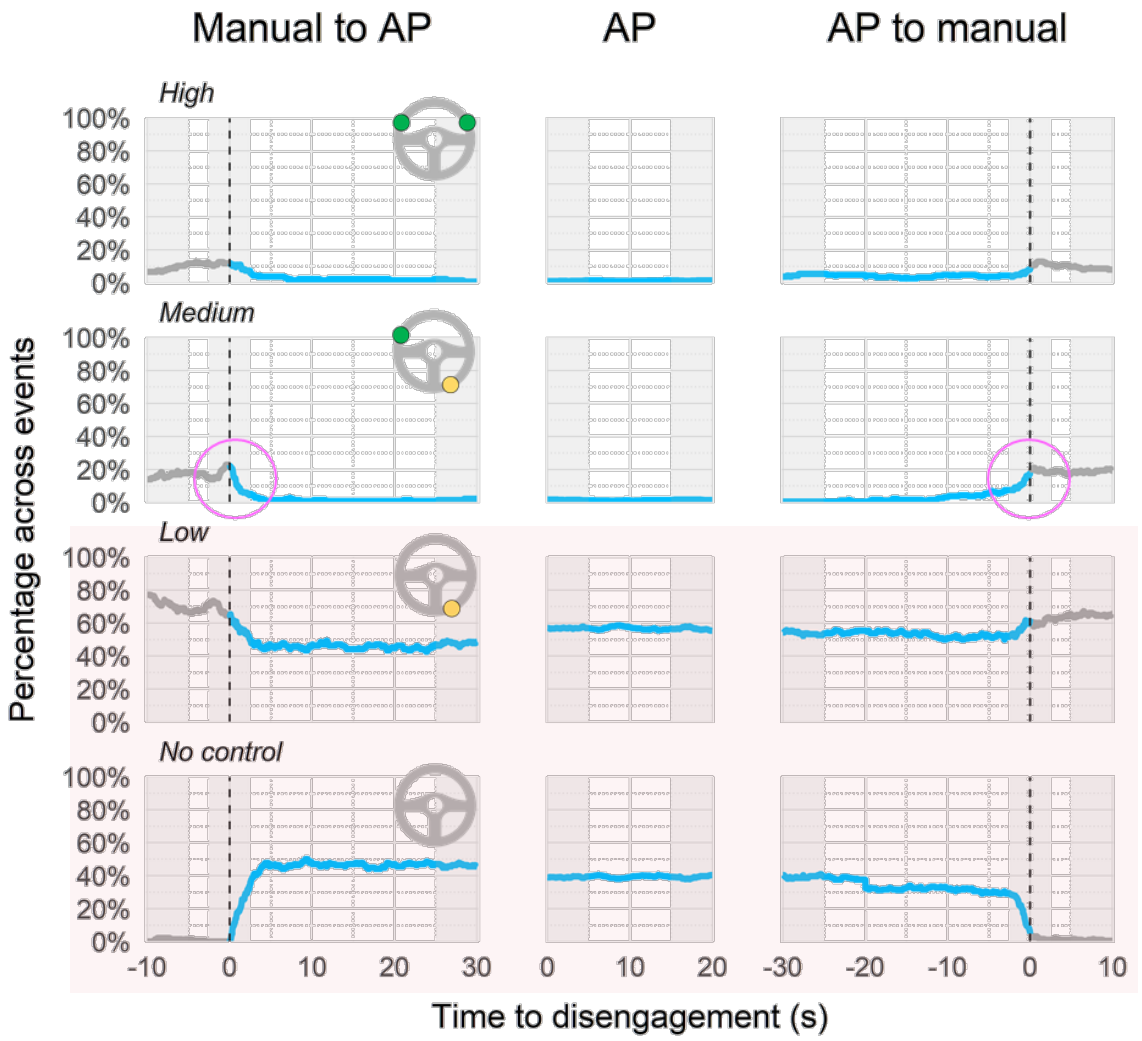
Percent Off-Road:

100

Max Off Road Length (s):

0.00

Hands-on-Wheel and Automation Use

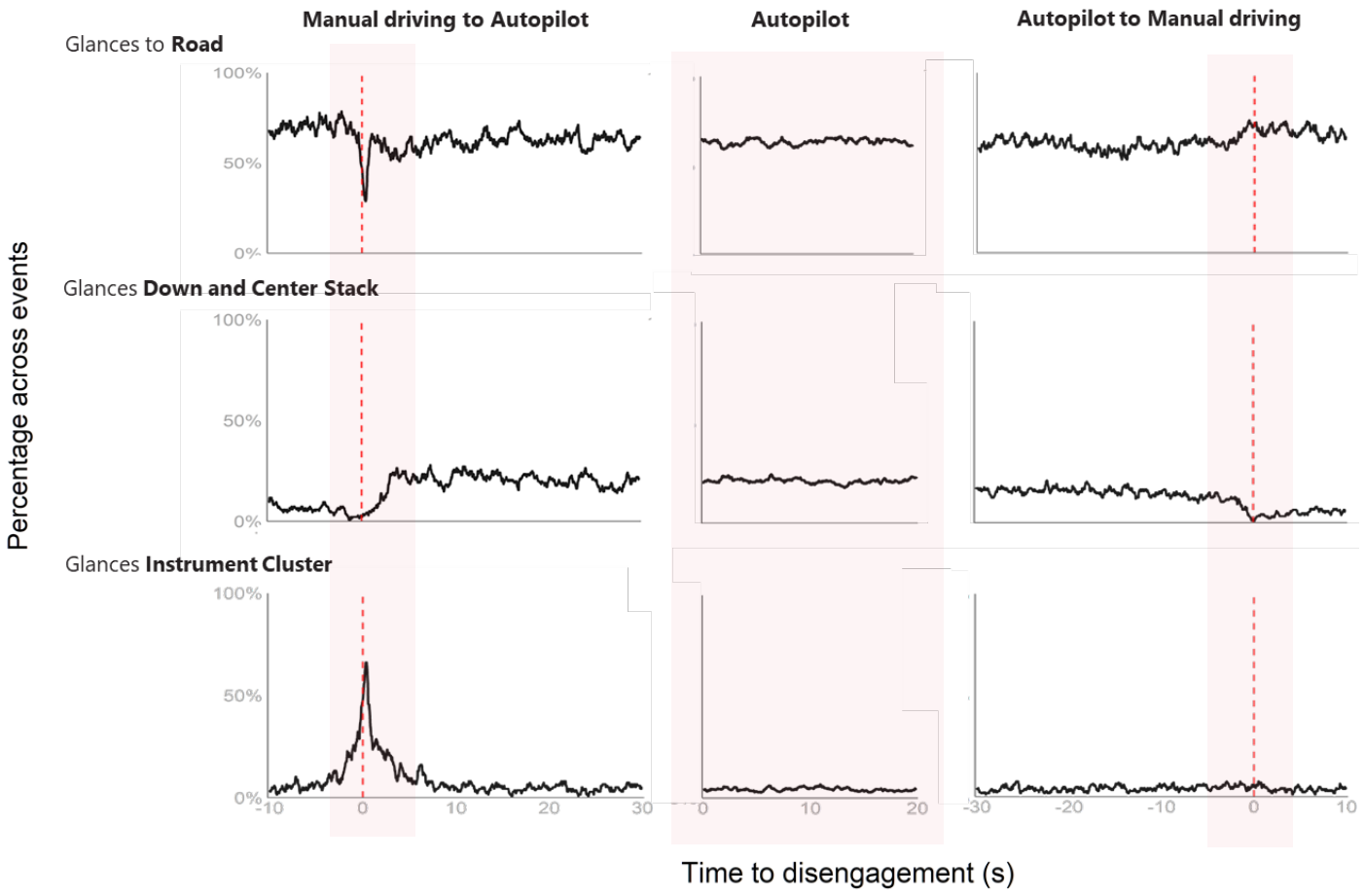


Rapid increase in hands-free driving (no control) from 1% to 46% soon after engagement in AP and throughout AP use.

Low hand placements dominate after AP disengagement.

Morando, A., Gershon, P., Mehler, B. & Reimer, B. (2021). Visual attention and steering wheel control: From engagement to disengagement of Tesla Autopilot. *Proceedings of Proceedings of the 65th Annual Meeting of the Human Factors and Ergonomics Society.*

Visual Attention and Automation Use



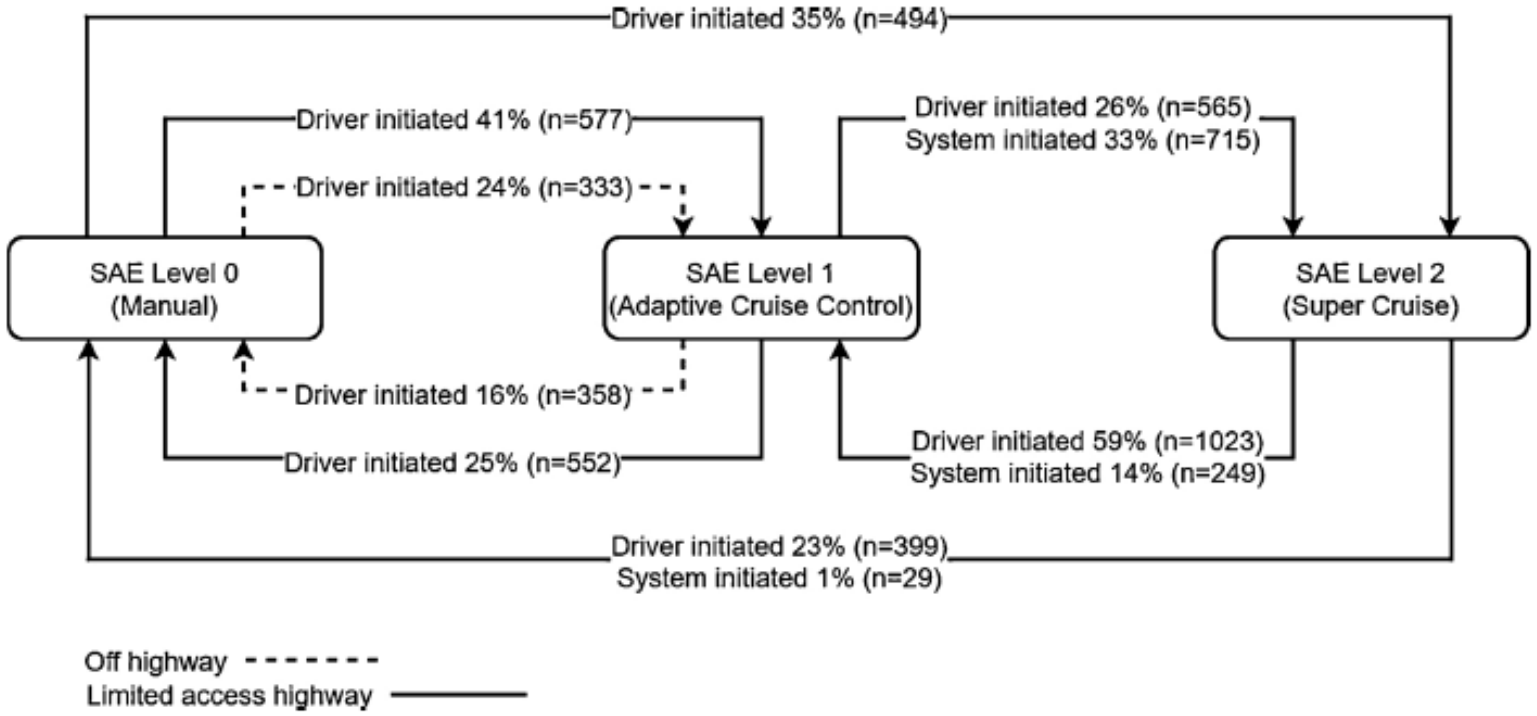
The proportion of off-road glances exceeding 2s (historically considered long glances away from the road) during Autopilot use was 22%.

This compares to 4% just after disengagement. Prior work with ACC + Lane Centering found 8 – 11%

Morando, A., Gershon, P., Mehler, B. & Reimer, B. (2021). Visual attention and steering wheel control: From engagement to disengagement of Tesla Autopilot. *Proceedings of Proceedings of the 65th Annual Meeting of the Human Factors and Ergonomics Society.*

Morando, A., Gershon, P., Mehler, B. & Reimer, B. (2021). A model for naturalistic glance behavior around Tesla Autopilot disengagements. *Accident Analysis and Prevention, 161.*

Transitions Between Automation Levels in Cadillac CT6

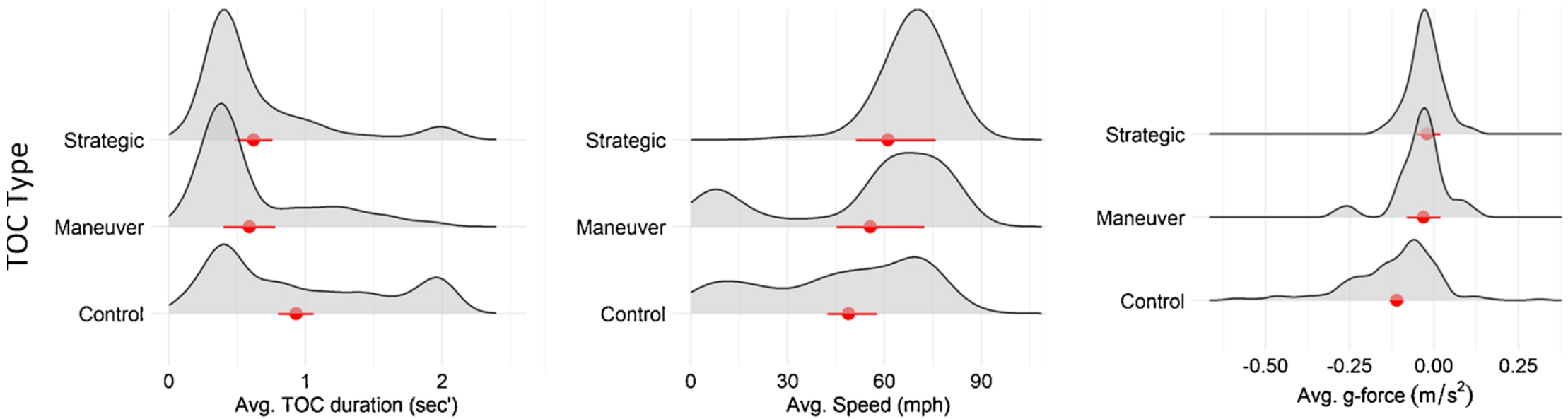


There are frequent transitions between automation levels. Most Super-Cruise (SC) disengagements are driver-initiated.

The rare system-initiated transitions from SC to manual driving are related to a driver's attention or the vehicle exiting the ODD.

Gershon, P., Seaman, S., Mehler, B., Reimer, B., and Coughlin, J. (2021). Driver behavior and the use of automation in real-world driving. Accident Analysis and Prevention 158.

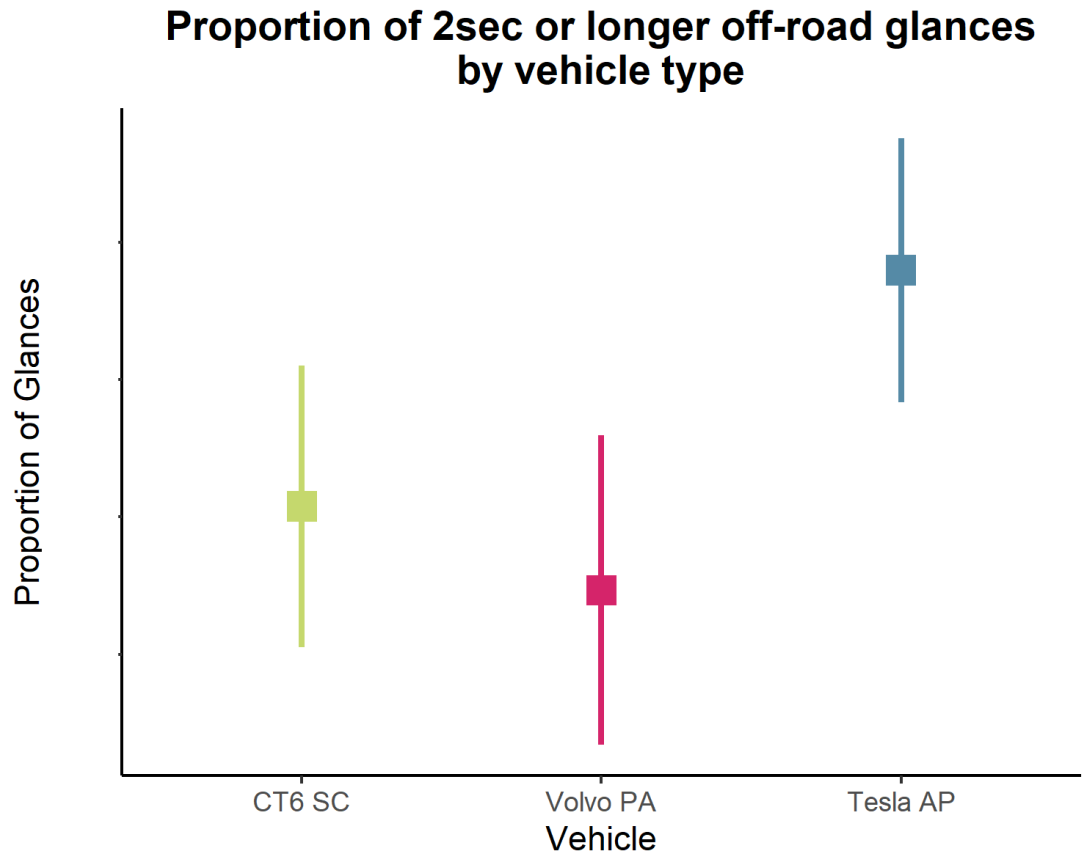
Transitions of Control are Not All The Same



Strategic, Maneuver, and Control TOCs were associated with significantly different patterns of vehicle kinematics, automation disengagement modality (not shown), and TOC duration.

Gershon, P., Seaman, S., Mehler, B., Reimer. B. & Coughlin, C. (2021). Driver behavior and the use of automation in real-world driving. Accident Analysis and Prevention, 158.

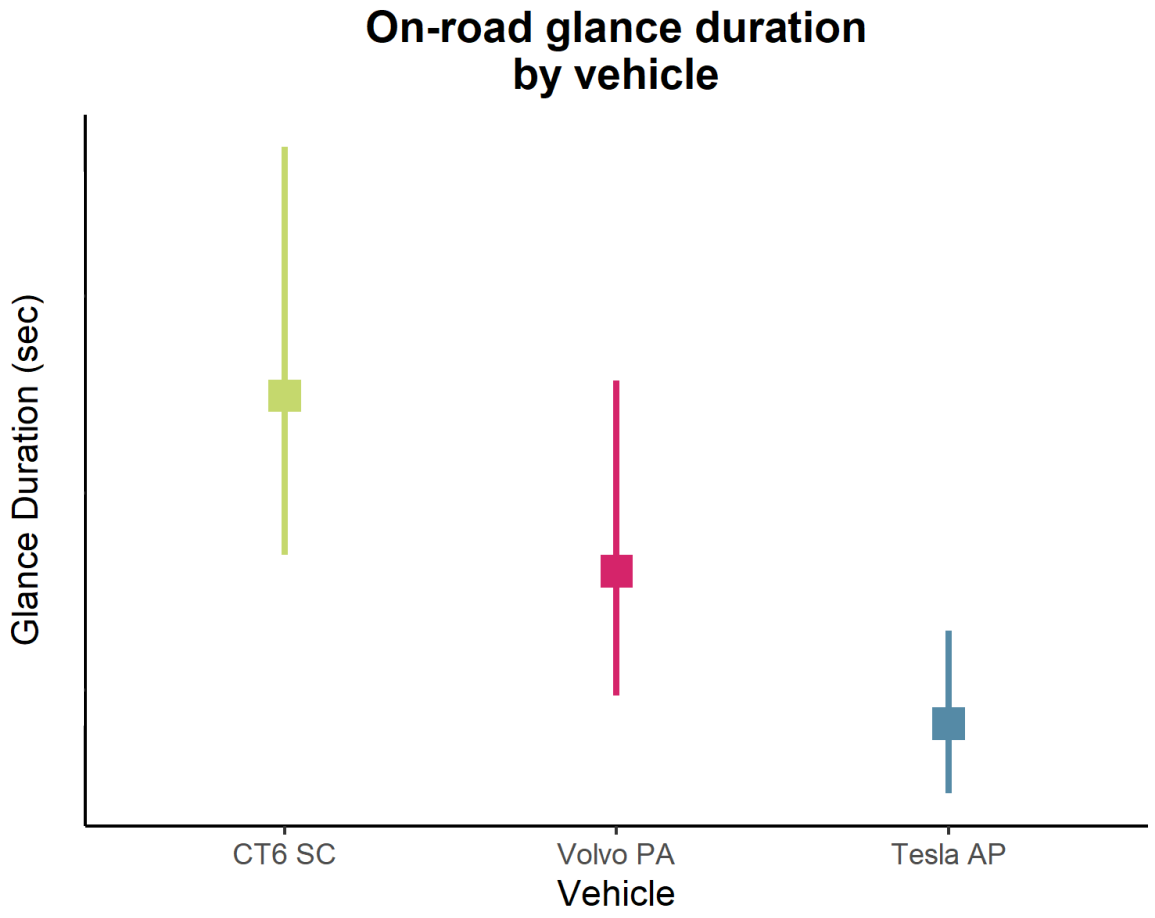
Visual Attention Across Driver Management Systems



Model estimates show that Tesla drivers have a significantly higher proportion of 2 sec or longer off-road glances compared to CT6 and Volvo drivers.

Gershon et al., 2021. Confidential Unpublished AVT DATA

Super Cruise Associated with Greater Attention to the Road

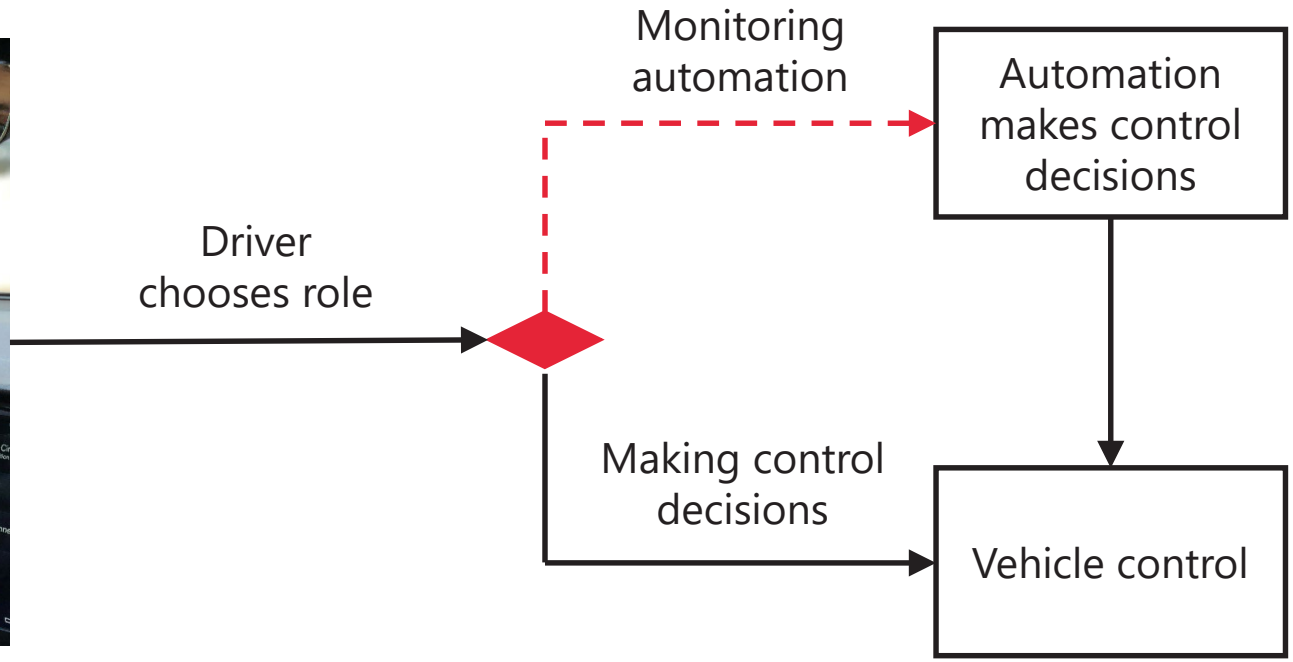


Model estimates of on-road glance duration, under Super Cruise, Pilot Assist and Autopilot, with 95% confidence intervals.

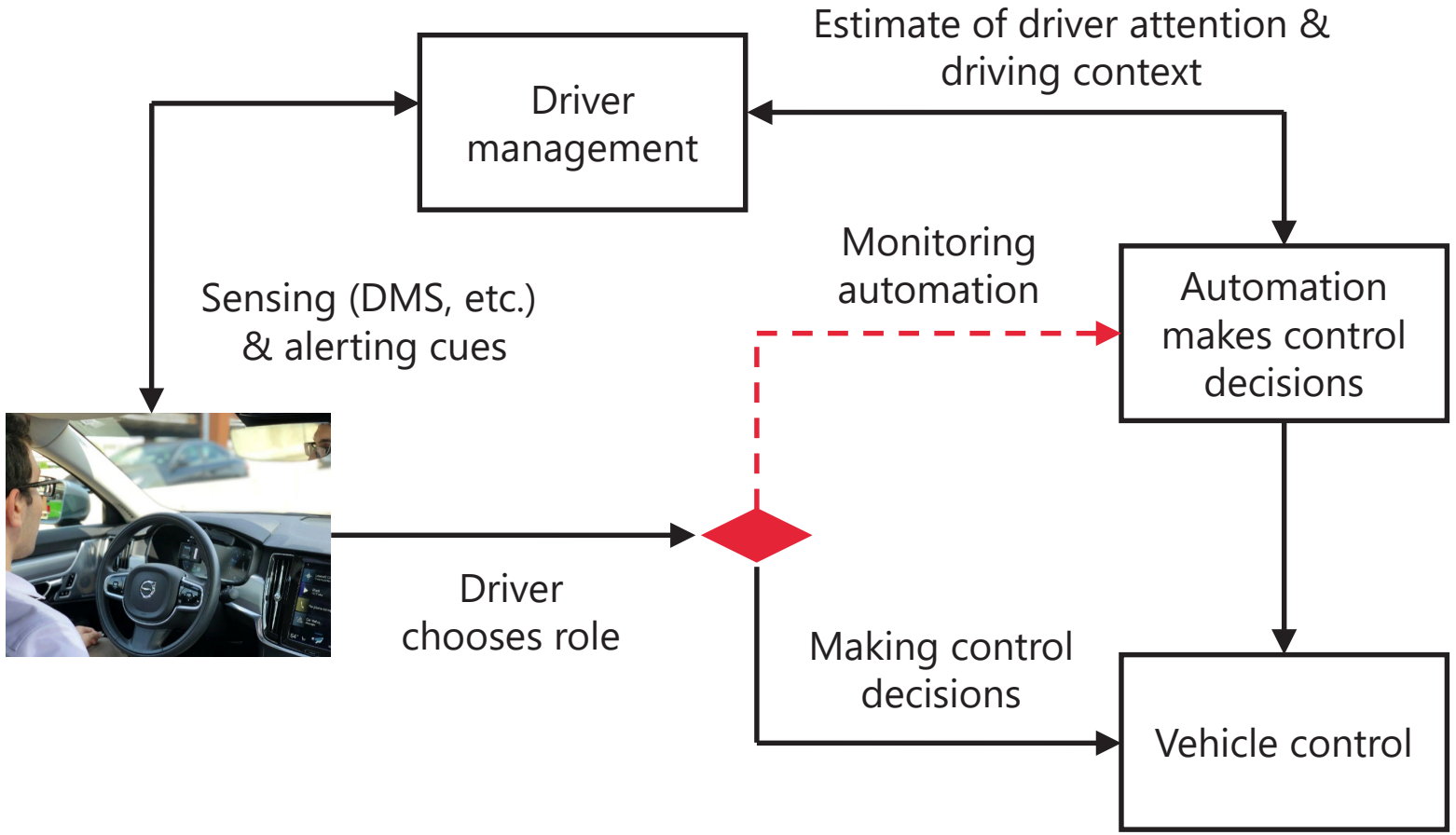
Significantly lower on-road glance duration in AP compared with SC and PA.

Gershon et al., 2021. Confidential Unpublished AVT DATA

Can a Driver Maintain Sustained Attention Monitoring Automation?



Collaborative Driving May Be More Realistic



Will the driver be more comfortable, more trusting, and more successful if they have support in fulfilling their role?

Driver Monitoring & Support Systems

- Driver attention may be at a historic low and there are clear risks that assistive automation may exacerbate this problem.
- Driver monitoring and support can offer benefits under all automation levels, but the impact of production implementations on risk is unknown.
- Increased automation needs to be coupled with increased comfort, convenience, reduced environment impact, and safety, but also requires that systems help support a "driver's" new role.
  - Monitoring
  - Collaboration
  - Readiness to take-over
- DMS data may be critical to risk and liability management, but new approaches are needed to leverage data beyond the car to monitor, manage and motivate drivers as part of a more encompassing safety system.


AUTOMOTIVE PERVASIVE COMPUTING

Monitoring, Managing, and Motivating Driver Safety and Well-Being

The AwareCar platform uses ambient intelligence concepts and pervasive computing technologies to detect driver state (stress, fatigue, inattention), display this information to the driver, and support in-vehicle systems to improve driver performance and safety.

Members of the "baby boom" generation (individuals born between 1946 and 1964) are now well into middle age and confronting the challenges of aging. As the largest generation in the United States, their concern with health has made well-being a public issue. Wellness—the pursuit of optimal personal performance—is therefore receiving significant attention from consumers and businesses alike. As one sports apparel manufacturer noted, the aging baby boomers are now experiencing the aches and pains of middle age, but they also have the desire and resources to manage them.

Typically associated with health, wellness involves the realization of multiple performance goals—optimal physical health, low stress, balance, and emotional well-being. Borrowing from sports psychology, a wellness perspective should include a strategy to achieve these goals. Toward this end, wellness can be translated into a design feature that can be engineered into products to actively engage the user in monitoring, managing, and optimizing their performance in the home, workplace, clinic, retail environment, and so on.[1] Wellness, therefore, can been viewed as a system with three functional components:

- a process and desire for continuous improvement,
- a means to determine individual well-being and progress, and
- tools or strategies to improve and achieve optimal performance.

The ultimate goal of such a system is to refresh and renew the user, improving his or her overall well-being.

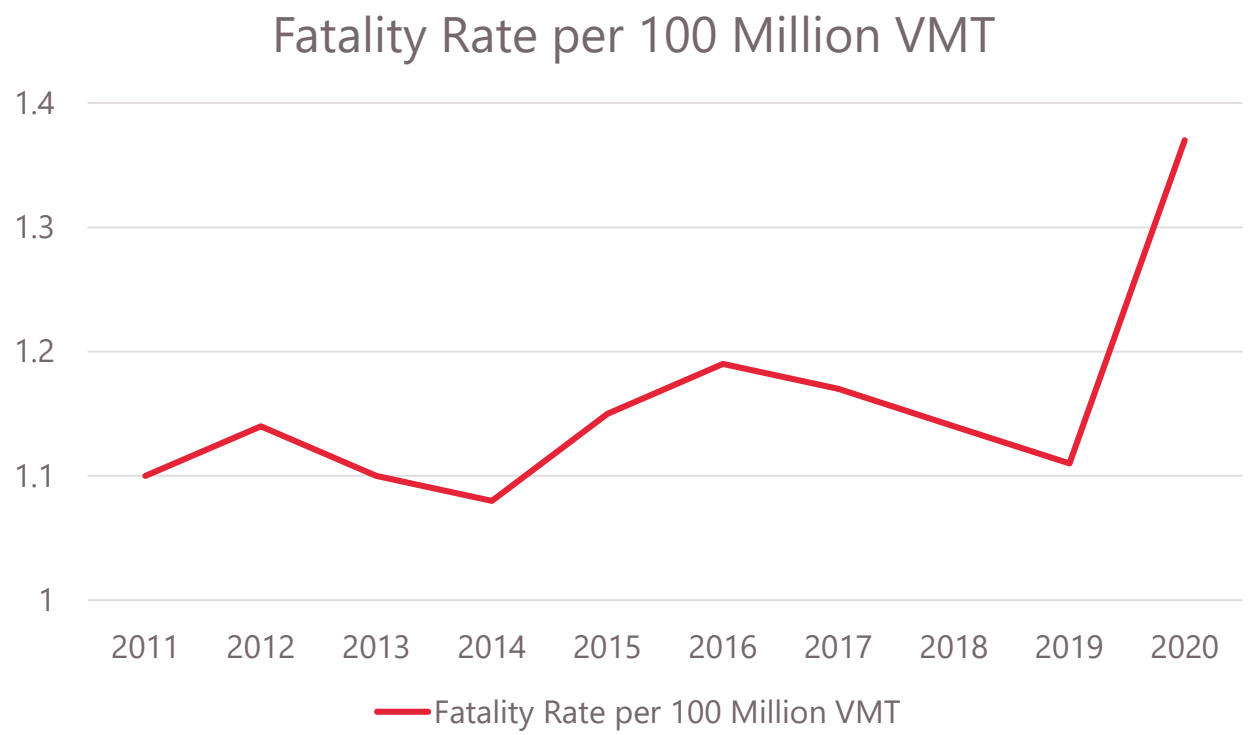
Although health and well-being are important in every part of life's activities, driving can be considered an extreme activity that depends on the driver's awareness and performance in a fast-moving dynamic environment. Today's driving population is older, managing more chronic disease, and balancing competing demands on their attention. How might wellness be applied to the driving experience and engineered into the vehicle? If integrated into the driving experience, could wellness-inspired systems improve the driver's situational awareness; reduce impairment from fatigue, stress, and distraction; and thereby improve driver performance and overall highway safety? Could a wellness-based system facilitate the safe transition from manual control to partially autonomous vehicle functions and, eventually, full autonomy?

Joseph F. Coughlin, Bryan Reimer, and Bruce Mehler
Massachusetts Institute of Technology

Published by the IEEE CS ■ 1536-1268/11/$26.00 © 2011 IEEE

Coughlin, J.F., Reimer, B. & Mehler, B. (2011). Monitoring, Managing and Motivating Driver Safety and Well-Being. IEEE Pervasive Computing.

Current Trends are Alarming: Is this Sustainable or an Under-Treated Health Crisis Coming to a Head?



Early estimates of 2021 fatalities appear to parallel those observed 2020.

Will this stimulate industry or regulatory efforts? Or will this become an accepted norm? Is this truly an acceptable level of risk?

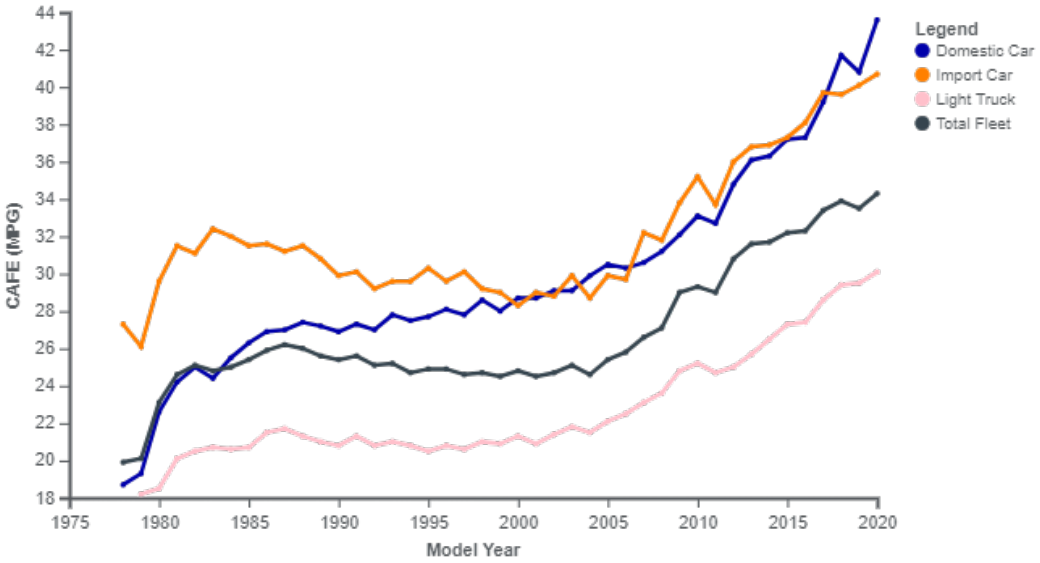
Data drawn from: USDOT Traffic Safety Facts, Early Estimate of Motor Vehicle Traffic Fatalities for the First Half (January–June) of 2021 (DOT HS 813 199). Note: 2020 and 2021 data are statistical projections.

AN ALTERNATIVE APPROACH

Can We Learn From CAFE?

Taking the level of accidents, serious injuries and fatalities as they exist as a baseline, could a target of yearly improvement in the level of safety be established?

- Perhaps supported by combination of technological and behavioral innovations
- A system that is calibrated to key operational considerations (e.g., highway technologies need to be measured in highway risk)
- Industry and government taking shared responsibility
- Realistically managed consumer expectations
- Consumer owned and fleet specific automation systems may operate under different safety targets



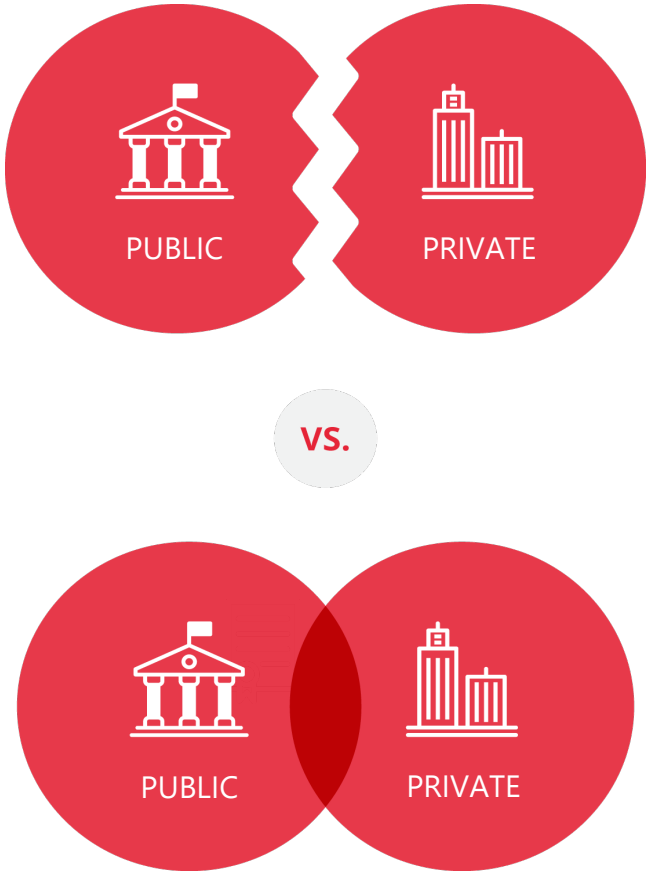
Observed CAFE by Regulatory Class

Data drawn from NHTSA via Wikipedia on Dec 6, 2021 - https://en.wikipedia.org/wiki/Corporate_average_fuel_economy

THE FUTURE MAY BE AUTONOMOUS, BUT…

An Agreement on a Safety Target Is a Key to Success

- Safety targets are life and death decisions that impact a range of costs for suppliers, manufacturers, consumers, and other stakeholders
- Waiting for enhanced safety requirements can minimizes benefits useful in mitigating harm today, while ignoring needs risks an erosion of consumer trust and a continued health crisis
- Society needs a common pathway to safer roads with clearer, collaboratively set and communicated goals. Automation offers an opportunity to develop a better system
- Government needs to take a active role, with all parties needing to be willing to collaborate
- The CAFE framework for continual process improvement offers an opportunity because **what is safe enough today will not be tomorrow!**



Reimer, B. (2018). There's more to the safety of driverless cars than AI. TEDx Waltham.

QUESTIONS?

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