THROUGH THE HANDOFF LENS: COMPETING VISIONS OF AUTONOMOUS FUTURES

Jake Goldenfein[†], *Deirdre K. Mulligan*[††], *Helen Nissenbaum*[†††] *& Wendy Ju*[‡]

ABSTRACT

The development of autonomous vehicles is often presented as a linear trajectory from total human control to total autonomous control, with only technical and regulatory hurdles in the way. But below the smooth surface of innovation-speak lies a battle over competing autonomous vehicle futures with ramifications well beyond driving. Car companies, technology companies, and others are pursuing alternative autonomous vehicle visions, and each involves an entire reorganization of society, politics, and values. Instead of subscribing to the story of inevitable linear development, this paper explores three archetypes of autonomous vehicles—advanced driver-assist systems, fully driverless cars, and connected cars—and the futures they foretell as the ideal endpoints for different classes of actors. We introduce and use the Handoff Model—a conceptual model for analyzing the political and ethical contours of performing a function with different configurations of human and technical actors—in order to expose the political and social reconfigurations intrinsic to those different futures. Using the Handoff Model, we analyze how each archetype both redistributes the task of "driving" across different human and technical actors and imposes political and ethical propositions both on human "users" and society at large. The Handoff Model exposes the baggage each transport model carries and serves as a guide in identifying the desirable and necessary technical, legal, and social dynamics of whichever future we choose.

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† Senior Lecturer at Melbourne Law School, University of Melbourne, Associate Investigator in the ARC Centre of Excellence for Automated Decision-Making and Society, and an Associate at Cornell Tech's Digital Life Initiative.

†† Professor, School of Information, University of California, Berkeley; Faculty Director, Berkeley Center for Law and Technology.

††† Professor of Information Science and Director of the Digital Life Initiative, Cornell Tech.

‡ Associate Professor of Information Science in the Jacobs Technion-Cornell Institute at Cornell Tech. Much appreciation to: organizers, participants, and particularly moderator Madeleine Claire Elish at We Robot 2019; members of the Handoff team, John Chuang, Nick Doty, Daniel Griffin, Adam Wolisz, and Richmond Y. Wong for endless workshopping of the model and feedback on this work; Michael Byrne for his assistance with graphics along with the entire Digital Life Initiative research group for rich feedback, and organizers and participants in the Simons Institute for the Theory of Computer Science Data Privacy: Foundations and Applications semester (Spring 2019) for insightful and helpful comments and discussions, and the luxury of being immersed in an inspiring research community; the participants in the Digital Life Initiative's Spring 2020 Autonomous Vehicles: What is the worst that could possibly happen? workshop; and for generous funding for this research from the MacArthur Foundation and the National Science Foundation under the U.S. NSF INSPIRE SES1537324.

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I. INTRODUCTION

In December 2018, Waymo, the self-driving vehicle subsidiary of Alphabet, launched a commercial passenger transport platform called "Waymo

One."[1] Limited to a group of participants in Waymo's closed testing program, and only in a small, geographic area in Phoenix, Arizona, the launch revealed more about the rhetoric of self-driving vehicles than it illuminated the future of transport. Although Waymo's promotional videos showed passenger vehicles without human drivers in the front seats, the reality was different.[2] Vaunted as the launch of a truly "driverless," commercial transport (i.e., ride-sourcing) system, the Waymo One service still employed specially trained "drivers," "safety supervisors," or "vehicle operators" that travelled with the vehicles. Although the drivers' presence was framed more as a customer service than a legal or safety requirement,[3] it sowed doubt as to the technical *possibility* of fully driverless vehicles[4] and destabilized the terminology behind "self-driving," "driverless," or "autonomous." It also reminded us that autonomous, ride-hailing vehicles, with nobody in the front seat controlling the car, is only one vision for the future of autonomous transport—a vision that includes technology companies pursuing ways to decrease costs of ride-sourcing services.

The entities pursuing that vision, along with the entities pushing for every other configuration of autonomous vehicles, have their own ideas for how these configurations should look and perform and what their business case might be. Just as the "safety driver" in the Waymo One car both exposed and interrupted the imagined trajectory towards fully automated transport, unpacking how respective models of autonomous transport might actually work exposes the stakeholders and political interests, as well as the impacts on human and societal values that they each embed. It is within the specificities of these different visions of autonomous transport futures that their ethical and political consequences are expressed.

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1. Waymo Team, *Riding with Waymo One Today*, MEDIUM (Dec. 5, 2018), https://medium.com/waymo/riding-with-waymo-one-today-9ac8164c5c0e.

2. Whatever degree of fully driverless testing occurring is likely a tiny fraction of all on-road testing; in fact, companies may have halted testing fully driverless vehicles entirely. *See, e.g.*, Timothy B. Lee, *Even Self-Driving Leader Waymo Is Struggling to Reach Full Autonomy*, ARS TECHNICA (Dec. 7, 2018, 8:55 AM), https://arstechnica.com/cars/2018/12/waymos-lame-public-driverless-launch-not-driverless-and-barely-public/ (reporting on the extremely limited public launch of Waymo One and abandonment of plans to launch a fully driverless program).

3. Andrew J. Hawkins, *Riding in Waymo One, the Google Spinoff's First Self-Driving Taxi Service*, THE VERGE (Dec. 5, 2018, 8:00 AM), https://www.theverge.com/2018/12/5/18126103/waymo-one-self-driving-taxi-service-ride-safety-alphabet-cost-app.

4. *See, e.g.*, Neal E. Boudette, *Despite High Hopes, Self-Driving Cars are 'Way in the Future'*, N.Y. TIMES (July 17, 2019), https://www.nytimes.com/2019/07/17/business/self-driving-autonomous-cars.html; Alex Davies & Aarian Marshall, *Are We There Yet? A Reality Check on Self-Driving Cars*, WIRED (Apr. 22, 2019, 6:00 AM), https://www.wired.com/story/future-of-transportation-self-driving-cars-reality-check/.

Each vision includes different conceptions of and roles for "drivers," "passengers," "users," and "occupants"; different systems for communications and control; different systems of spatial organization; different commercial and political arrangements; and different consequences for societal and human values. Each imagination of autonomous automotive transport involves an entire world of reorganization for politics and values—each presenting different challenges for regulators and the public. Reckoning with the implications of these reconfigurations means seeing past terminological obfuscation[5] and beyond the emphasis on discontinuities in the transport experience,[6] instead focusing on how each autonomous transport vision, promoted by various parties, moves toward a different future with particular political and ethical implications.

To perform that analysis, this Article introduces the Handoff Model to complement and help structure existing work exploring the technical, legal, and policy implications of autonomous vehicles. The model rigorously identifies how the *function* of driving is re-configured and delegated to different *components* (human, computational, mechanical, and regulatory) in alternative autonomous driving visions, and, in so doing, the model brings to light the political and ethical propositions captured in these alternative configurations.

For our Handoff analysis of autonomous vehicles, we have found it useful to create a rough classification of three archetypes (or "scripts")[7] of autonomous vehicle deployments, each of which captures a distinctive vision

5. *See generally* Meg Leta Jones & Jason Millar, *Hacking Metaphors in the Anticipatory Governance of Emerging Technology: The Case of Regulating Robots*, *in* THE OXFORD HANDBOOK OF LAW, REGULATION & TECHNOLOGY (Roger Brownsword, Eloise Scotford & Karen Yeung eds., 2017).

6. *See, e.g.*, DEP'T FOR TRANSP., THE PATHWAY TO DRIVERLESS CARS: SUMMARY REPORT AND ACTION PLAN 16 (Feb. 2015) (U.K.), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/401562/pathway-driverless-cars-summary.pdf (defining the difference between existing driver assistance systems and higher levels of automation); Adriano Alessandrini, Andrea Campagna, Paolo Delle Site, Franceso Filippi & Luca Persia, *Automated Vehicles and the Rethinking of Mobility and Cities*, 5 TRANSP. RES. PROCEDIA 145 (2015), https://doi.org/10.1016/j.trpro.2015.01.002; Lawrence D. Burns, *A Vision of Our Transport Future*, 497 NATURE 181 (2013), https://doi.org/10.1038/497181a; Daniel J. Fagnant & Kara Kockelman, *Preparing a Nation for Autonomous Vehicles: Opportunities, Barriers and Policy Recommendations*, 77 TRANSP. RES. PART A: POL'Y & PRAC. 167 (2015), https://doi.org/10.1016/j.tra.2015.04.003.

7. Madeleine Akrich, *The De-Scription of Technical Objects*, *in* SHAPING TECHNOLOGY/BUILDING SOCIETY: STUDIES IN SOCIOTECHNICAL CHANGE 208 (Wiebe E. Bijker & John Law eds., 1997).

of an autonomous vehicle future.[8] These archetypes, while somewhat stylized, express different visions of technical, political, commercial, and economic arrangements in autonomous vehicle deployment. Drawing on similar divisions that appear elsewhere in the literature, we call these archetypes, respectively: driver assist cars, driverless cars, and connected cars. We recognize that the boundaries of these archetypes are contingent, overlapping, and hardly settled. Nonetheless, we consider them to be analytically useful for exposing what is at stake in different autonomous transport implementations. We also note that these archetypes share political and ethical concerns, and that the focus on any one issue in a single archetype will likely have relevance for the others.

The first archetype, driver assist, involves driving tasks being shared between humans and automated systems. It envisions a gradual increase in the degree and competence of automation in privately-owned-and-operated passenger vehicles, but without removal of human drivers and without new demands on other physical infrastructure. This model assumes "existing roadway"—i.e., no major instrumentation of roads and intersections—and "existing ownership"—i.e., cars are largely privately owned by individuals. Here, automation becomes the advanced rendition of Advanced Driver Assistance Systems (ADAS), which currently include capabilities like power steering, cruise control, and automated lane-keeping. This framing is preferred by the incumbent automotive industry.[9] The driver assist model retains a human "driver" (at least some of the time), typically includes less on-board sensing and computation than fully driverless vehicles in order to control cost, and reconfigures the locus of control across onboard human and computational actors. While proponents suggest this approach is safer in the short term, others argue it may be more dangerous in the long term, as it delays the proliferation of fully driverless vehicles, which are argued to be inevitably

8. *See, e.g.*, Sven Beiker, *Deployment Scenarios for Vehicles with Higher-Order Automation*, *in* AUTONOMOUS DRIVING: TECHNICAL, LEGAL, AND SOCIAL ASPECTS 193–211 (Markus Maurer et al. eds., 2018) (describing the "evolutionary" scenario involving the continued improvement of ADAS systems; the "revolutionary" scenario involving the transformation of mobility services through driverless vehicles; and the "transformative" scenario involving the creation of integrated public transport-style urban solutions). These map relatively clearly onto our description of "driverless," "ADAS," and "connected" models. *See id.*

9. Gilles Duranton, *Transitioning to Driverless Cars*, 18 CITYSCAPE: J. POL'Y DEV. & RES. 193, 195 (2016), https://www.huduser.gov/portal/periodicals/cityscpe/vol18num3/ch12.pdf.

safer.[10] Importantly, we analyze the driver assist archetype not simply as a transitional phase, but as a different vision of transport future.

The second archetype, driverless cars, is a model of a fully "driverless" vehicle that removes the occupant's capacity to control (i.e., drive) the car. Like archetype one, the second uses existing roadways. However, it generally envisions new ownership models. The defining exemplar is the (now abandoned) Google Koala car, which featured a vehicle cabin without any human driving controls—no steering wheel and no brake or accelerator pedals.[11] While that model was abandoned,[12] the design philosophy is being replicated in newer models like the General Motors Cruise constructed Chevrolet Bolt[13] (although in June 2019, Cruise also postponed launching its driverless taxi service which used vehicles without internal controls).[14] The potential for such vehicles has long been described as transformative, as they can travel both occupied and unoccupied, meaning they can operate unceasingly in various capacities.[15] Currently, because the sensing and computation needed for such vehicles is prohibitively expensive for the consumer market, fully driverless *passenger* vehicles[16] are viewed as best suited

10. *See, e.g.*, INT'L TRANSP. FORUM CORP. P'SHIP BD., SAFER ROADS WITH AUTONOMOUS VEHICLES? CORPORATE PARTNERSHIP BOARD REPORT 19 (2018), https://www.itf-oecd.org/sites/default/files/docs/safer-roads-automated-vehicles.pdf; Pete Bigelow, *Why Level 3 Automated Technology Has Failed to Take Hold*, AUTOMOTIVE NEWS (July 21, 2019, 9:00 PM), https://www.autonews.com/shift/why-level-3-automated-technology-has-failed-take-hold; Stephen Edelstein, *Audi Gives Up on Level 3 Autonomous Driver-Assist System in A8*, MOTOR AUTHORITY (Apr. 28, 2020), https://www.motorauthority.com/news/1127984_audi-gives-up-on-level-3-autonomous-driver-assist-system-in-a8.

11. Mark Bergen, *Google's Self-Driving 'Koala' Cars Now Out in the Wild*, VOX (June 25, 2015, 12:31 PM), https://www.vox.com/2015/6/25/11563902/googles-self-driving-koala-cars-now-out-in-the-wild.

12. Mike Murphy, *The Cutest Thing Google Has Ever Made Is Dead*, QUARTZ (June 13, 2017), https://qz.com/1005083/the-cutest-thing-google-has-ever-made-is-dead-waymos-firefly-self-driving-cars-goog/.

13. Andrew J. Hawkins, *GM Will Make an Autonomous Car Without Steering Wheel or Pedals by 2019*, THE VERGE (Jan. 12, 2018, 12:01 AM), https://www.theverge.com/2018/1/12/16880978/gm-autonomous-car-2019-detroit-auto-show-2018.

14. Andrew J. Hawkins, *Cruise Postpones Plan to Launch Driverless Taxi Service in 2019*, THE VERGE (July 24, 2019, 8:51 AM), https://www.theverge.com/2019/7/24/20707242/cruise-gm-self-driving-taxi-launch-delay-2019.

15. *See generally* Kevin Spieser, Kyle Treleaven, Rick Zhang, Emilio Frazzoli, Daniel Morton & Marco Povone, *Towards a Systematic Approach to the Design and Evaluation of Automated Mobility-on-Demand Systems: A Case Study in Singapore*, *in* ROAD VEHICLE AUTOMATION 229–45 (Gereon Meyer & Sven Beiker eds., 2018), https://link.springer.com/chapter/10.1007/978-3-319-05990-7_20.

16. Fatemeh Nazari, Mohamadhossein Noruzoliaee & Abolfazl (Kouros) Mohammadian, *Shared Versus Private Mobility: Modeling Public Interest in Autonomous Vehicles*

for transportation network (or "ride-sourcing") companies (TNCs).[17] This would involve a shift away from the current TNC business model, which relies on participating drivers using personal vehicles, towards fleets of driverless vehicles owned by platforms, likely large technology companies such as Google and Uber. Pilot tests along these lines are currently underway in California where both the "driverless" nature of the vehicles and the new ownership models have precipitated a suite of new regulations.[18]

Our third archetype is connected cars. This model positions vehicles as elements of broader "smart city" transport programs. Unlike driverless vehicles that navigate solely on the basis of their on-board sensor arrays and computation, connected vehicles operate in constant communication with one another as well as with other components of a static roadway infrastructure. Connected cars thus involve the most radical re-instrumentation of public space and require complex technical and political coordination. Some variations of the connected car vision include a role for the traditional automotive industry, with privately owned and operated vehicles running through connected infrastructures,[19] while others propose a holistic package of concentrated infrastructure and vehicle ownership offered to the public as a mobility service, analogous to public transport in certain ways.[20] Connected

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Accounting for Latent Attitudes, 97 TRANSP. RES. PART C: EMERGING TECH. 456 (2018); Adam Stocker & Susan Shaheen, *Shared Automated Vehicles: Review of Business Models* (Int'l Transp. Forum, Discussion Paper No. 2017-09, 2017), https://www.econstor.eu/bitstream/10419/194044/1/itf-dp-2017-09.pdf. Note that we focus on passenger vehicles here rather than logistics or other types of vehicles.

17. Transportation Network Company (TNC) is the dominant term used in state regulations. Maarit Moran & Philip Lasley, *Legislating Transportation Network Companies*, 2650 TRANSP. RES. REC.: J. TRANSP. RES. BD. 163, 165 (2017) ("Thirty states define ride-sourcing providers as TNCs."). California was the first to regulate and to define TNCs. *Id.*; *see also* CAL. PUB. UTIL. CODE § 5431(c) (West 2019) (" 'Transportation network company' means an organization, including, but not limited to, a corporation, limited liability company, partnership, sole proprietor, or any other entity, operating in California that provides prearranged transportation services for compensation using an online-enabled application or platform to connect passengers with drivers using a personal vehicle.").

18. Dasom Lee & David J. Hess, *Regulations for On-Road Testing of Connected and Automated Vehicles: Assessing the Potential for Global Safety Harmonization*, 136 TRANSP. RES. PART A: POL'Y & PRAC. 85, 90–91 (2020) (describing U.S. and California-specific rules developed for on-road testing of automated and connected cars—archetype two and three in our framework).

19. *See, e.g.*, *About Us*, 5G AUTOMOTIVE ASS'N, https://5gaa.org/about-5gaa/about-us/ (last visited Aug. 31, 2020) (listing the founding members of the 5G Automotive Association, which includes Audi AG, BMW Group, and Daimler AG, as well as Ericsson, Huawei, Intel, Nokia, and Qualcomm).

20. *See, e.g.*, Linda Poon, *Can Toyota Turn Its Utopian Ideal into a 'Real City'?*, BLOOMBERG CITY LAB (Jan. 24, 2020, 10:39 AM), https://www.bloomberg.com/news/articles/2020-01-24/why-is-toyota-building-a-smart-city-from-scratch.

vehicle proponents emphasize the capability of connected autonomous vehicle systems to choreograph complex driving maneuvers that require centralized or coordinated control, like continuous flow intersections, vehicle "platooning," and ultra-high-speed travel.[21]

These models or archetypes—driver-assist, fully-driverless, and connected-cars—may appear to follow a historical trajectory wherein driver assist eventually succumbs to full automation and all private ownership is replaced by mobility-on-demand services. But the reality is more complex, the players are more tangled and integrated, the role and the location of human drivers or operators are not yet determined,[22] and the path forward is still unclear.[23] Although we acknowledge this complexity and that the landscape is constantly shifting, it remains useful to explore these archetypes as distinctive abstractions for the purpose of explaining how each disturbs the existing politics and values of transport in different ways. For us, the archetypes are a means of exploring deep connections between different technical and architectural designs for achieving ostensibly equivalent functional purposes, on the one hand, and respective political and value propositions for users and society, on the other. We recognize the difficulty of analyzing vehicle systems at a level of abstraction that includes the necessary detail to expose consequences on the political and ethical registers of interest to us. Insufficient detail elides critical elements for understanding the ethical and political implications of each archetype. Too much detail, however, risks venturing into

21. *See, e.g.*, José Víctor Saiáns-Vázquez, Esteban Fernando Ordóñez-Morales, Martín López-Nores, Yolanda Blanco-Fernández, Jack Fernando Bravo-Torres, José Juan Pazos-Arias, Alberto Gil-Solla & Manuel Ramos-Cabrer, *Intersection Intelligence: Supporting Urban Platooning with Virtual Traffic Lights over Virtualized Intersection-Based Routing*18 SENSORS 4054 (2018); Koichi Washimi, *Traffic Management System Toward Connected and Automated Vehicles Era*, 88 SEI TECH. REV. 71 (2019); CONNECTED VEHICLE URBAN TRAFFIC MGMT., https://hub.iiconsortium.org/connected-vehicle-urban-traffic-management (last visited July 31, 2020).

22. *See, e.g.*, SAE INT'L, SURFACE VEHICLE RECOMMENDED PRACTICE: TAXONOMY AND DEFINITIONS FOR TERMS RELATED TO DRIVING AUTOMATION SYSTEMS FOR ON-ROAD MOTOR VEHICLES 16 (2018), https://www.sae.org/standards/content/j3016_201806/ (defining four distinct categories of human actors: driver, passenger, fallback-ready user, and driverless operation dispatcher); Madeleine Clare Elish, *When Your Self-Driving Car Crashes, You Could Still Be the One who Gets Sued*, QUARTZ (July 25, 2015), https://qz.com/461905/when-your-self-driving-car-crashes-you-could-still-be-the-one-who-gets-sued/; Dan Hill, *How Should Humans Really Be 'in the Loop' in Cities Under Autonomous Mobility?*, MEDIUM (Oct. 6, 2016), https://medium.com/butwhatwasthequestion/how-should-humans-really-be-in-the-loop-in-cities-under-autonomous-mobility-d13c04f70bba.

23. *See generally* Eva Fraedrich, Sven Beiker & Barbara Lenz, *Transition Pathways to Fully Automated Driving and Its Implications for the Sociotechnical System of Mobility*, 3 EUR. J. FUTURES RES. (2015), https://doi.org/10.1007/s40309-015-0067-8.

all the diverse forces of people, machines, money, and whatever else that might render such an analysis entirely mundane, if possible at all.[24]

To analyze these systems at a meaningful level of abstraction, we introduce the Handoff model as a means of revealing key differences in the configurations and dynamics of system components that alter the values propositions embedded in respective systems—here, vehicle archetypes.[25] "Handoff" exposes how changes in technological configuration shape both inter-system and inter-social relations and have ramifications for a wide range of political and ethical issues, including control over and access to transport and its infrastructures and related impacts on the environment and surroundings.

The goal of our analysis is to highlight what is at stake in terms of societal values and social relations as configured through these different implementations, and to highlight the need to assess and evaluate these changes. In our Handoff analysis of each archetype, we do not aim to be exhaustive but rather to highlight political and ethical issues that the archetype makes particularly salient. While the issues raised, including distribution of ownership, expectations about data flows, and others, are latent in all three archetypes, we have highlighted those that signal more radical or otherwise more significant breaks with current arrangements in our discussions of each of the archetypes, respectively. This approach allows us more effectively to demonstrate the contingent, political nature of different autonomous futures and reflect on how we might purposefully align them with abiding societal goals and values, instead of passively watching them be shaped by prevailing sociotechnical processes and powers.

Before proceeding with the analysis, we introduce key elements of the Handoff model to our readers.

II. THE HANDOFF MODEL

Handoff is a lens for political and ethical analysis of sociotechnical systems. In recent decades, the delegation of decision-making onto automated systems has inspired widespread attention and anxiety about machines that can label ("recognize") images, process ("understand") and produce ("speak") natural

24. Akrich, *supra* note 7, at 205.

25. For another effort to encourage attention to the social impacts of technology through analytic tools, see Shane Epting, *Automated Vehicles and Transportation Justice*, 32 PHIL. & TECH. 389 (2019) (arguing for a broader vision of the ethical issues raised by mobility infrastructures and specifically for the use of complex moral assessments to evaluate the impact of autonomous vehicles on vulnerable populations, the environment, and historical or culturally significant artifacts).

language, and even anticipate what we will say and do. Inspired by claims about computational systems able to take over tasks previously performed by humans—-especially tasks thought to require human intelligence—the concept of Handoff provides a lens through which to scrutinize them. There is a need for a more detailed critical analysis of evolving systems in which a given function shifts from one type of actor to another and people are inclined to say that the latter actor is performing the same function as the former (i.e., same function, different actor), as is often the case with autonomous vehicles.

The Handoff model draws attention to assertions that systems with new actors and control delegations are performing the same function as in their previous iterations. Such assertions include, for example, that automated call-answering systems perform the same function as human receptionists, or that RFID-based systems collecting road tolls or computational systems distinguishing benign from cancerous skin moles are performing the same function as their human or mechanical counterparts. In addition to important questions about the quality of performance, efficiency, or impact on labor markets, the critical eye of Handoff directs attention towards ethical and political issues that may be disrupted by respective versions of a system, thereby belying facile assertions of sameness before and after functional Handoff or delegation of decision-making. It decomposes the "how" of the function to understand what is different and what that difference means for values. It opens our view not only to what might be the same but also to what may have changed in the reconfiguration of function across component actors.

We define "Handoff" as the following: given progressive, or competing, versions of a system (S1, S2) in which a particular system function (F) shifts from one type of actor (A) in S1 to another actor (B) in S2, we say that *F was handed off from A to B*.

The purview of our Handoff model is complex systems comprising diverse functional components. Because such systems can be varied, incorporating physical mechanisms, computational subsystems, and even humans, Handoff's units of analysis, more precisely, are "sociotechnical systems." For purposes of this analysis, we accept the theorization of such systems as noncontroversial. Sociotechnical systems are the subjects of our analytical model, even though, for the remainder of this Article, we mostly revert to the term "system." Abstractly conceived, a system may be defined in terms of its function. This function is typically achieved by coordinated functioning of a system's component parts, and themselves may be conceived as systems, which in turn comprise subsystems, or components, and so on. Because systems of interest may comprise multifarious parts, some material and others human, we use the term *component* as neutral between the two.[26] The model assumes that *system* and *component* (or subsystem) are relative terms whose application signals the focus of analysis rather than an ontological statement. In an analogy, someone may think of the human body as a system and the organs as component parts; but for the cardiologist, the heart is the system of interest and the chambers, valves, arteries, etc., are its components. In another example, the system of a conventional automobile performing the driving function comprises a vehicle plus a human driver; in turn, each of these components may be analyzed further—the vehicle is composed of various subsystems, such as braking, safety, ignition, and so on.

As noted, systems perform functions, and it is the redistribution of these functions that interests us, whether this involves Handoffs from a human to a machine (i.e., automation), a human acting in one role to a human in another role, or a machine of one type (e.g., mechanical) to a machine of another (e.g., electronic). What those functions are, in general terms, is answered by the question, "what does a given system do?" Components also perform functions, similarly, beginning the question, "what does it do," expecting the answer will address how the component function contributes to the overall function of the system. Finally, it is important to notice that a system's function can be described at different levels of abstraction: up a level, referring to goals, purposes, or even values; down a level, the way a designer or engineer might explain how it does what it does. The Handoff model provides a sensitive tool for illuminating the interplay between the two ways a reconfiguration of function at levels of implementation can impinge on attainment of higher-order purposes.

To perform a Handoff analysis at the implementation layers, we introduce and define key concepts of the model. To start, an analyst needs to identify and explain how the relevant components work to produce the overall system function, what drives their respective actions (or motions), and how they interact with one another. To this end, we introduce the idea of components *acting-on* or *engaging* other components. Take a traditional automobile (i.e.,

26. Terminology presented a dilemma. While the term "component" does not naturally apply to human actors, for our purposes it is important to be able to refer in like manner to human and non-human components of a system. The Actor-Network-Theory, which most certainly influenced us, came up with "actant" as a way out of the dilemma. But our preference is not to adopt theoretical jargon, which can be off-putting for general readers. *See, e.g.*, BRUNO LATOUR, REASSEMBLING THE SOCIAL: AN INTRODUCTION TO ACTOR-NETWORK-THEORY (2015). Going forward, we will mostly use the term "component" but will sometimes revert to "actor" or "subsystem." In addition to human actors and physical objects that can be or constitute system components, we allow for the possibility of groups and institutions as components.

vehicle plus driver system) driving on a road. Darkness falls and a human driver (i.e., component) pushes a button, which in turn causes the car headlights to illuminate. In this instance we say that the components act on each other to produce an outcome (i.e., fulfill the function), "turn on headlights." The driver decides and pushes a button, and the button then causes the headlights to flash on.

This trivial case requires a further concept, namely, that of the mode of acting-on or engaging. Before elaborating on modes, it is worth noting that the underlying idea is not completely novel; instead, one can find versions of it in disparate works in the field of technology and society. One case in point is Larry Lessig's concept of modalities of regulation,[27] which famously emphasized the similarities among seemingly divergent modalities. By contrast, others have argued that different modalities constitute a normative difference that should not be ignored.[28]

One familiar mode of acting-on another object is physical force, where one physically embodied actor causes an outcome in another.[29] The outcome may be achieved either by producing or preventing action. The human actor pushes a button and sets off a causal chain of actions resulting in the headlights flashing on. Physical (or "material") causation, or—one could say—"brute force," may operate in multiple, different ways. For example, a physical component (or set of objects) may act on another component by constraining its range of action (e.g., a safety overlock) without necessarily causing a particular outcome. Alternatively, there could be far more complex causal interdependencies, as when numerous components function together to produce a complex configuration of outcomes on other components, and so on.

A different mode of acting-on—perhaps more subtle—is affordance. As defined by the cognitive psychologist J.J. Gibson, affordances are relational properties of things in the environment whose meaning or significance is

27. *See, e.g.*, LAWRENCE LESSIG, CODE: VERSION 2.0 (2d ed. 2006).

28. Roger Brownsword, *Lost in Translation: Legality, Regulatory Margins, and Technological Management*, 26 BERKELEY TECH. L.J. 1321, 1328 (2011); Helen Nissenbaum, *From Preemption to Circumvention: If Technology Regulates Why Do We Need Regulation (and Vice Versa)?*, 26 BERKELEY TECH. L.J. 1367 (2011); Margaret Jane Radin, *Regulation by Contract, Regulation by Machine*, 160 J. INSTITUTIONAL & THEORETICAL ECON. 142 (2004); Harry Surden, *Structural Rights in Privacy*, 60 SMU L. REV. 1605 (2007); Karen Yeung, *The Forms and Limits of Choice Architecture as a Tool of Government*, 38 L. & POL'Y 186 (2016).

29. Remaining at the intuitive level for the moment, we must look past the fact that there is nothing simple about causation, as Aristotle well demonstrated. *See* ARISTOTLE, PHYSICS 194b (C. D. C. Reeve trans., Hackett Publishing Company, Inc. 2018) (c. 350 B.C.E.); ARISTOTLE, POSTERIOR ANALYTICS 71b (G. R. G. Mure trans., eBooks@Adelaide 2007) (c. 350 B.C.E).

derived from their service to a given agent's needs or capabilities.[30] When saying that something is nourishing, or is a tool or secure cover, these observed properties must be understood in relation to actors of particular shapes, sizes, abilities, and needs. As adapted and widely popularized by Donald Norman, designers can and should take advantage of affordances in order to create artifacts that are understood by users and elicit desired behaviors required for successful operation of the respective artifacts.[31] According to Norman, an object's affordances suggest uses to us by triggering human cognitive and perceptual capacities.[32] Good designers of material objects, such as doors and switches, are able to elicit correct usage or desired reactions by effectively exploiting human actors' tendencies to respond to cues in systematic ways. The same ideas extend to digital objects, such as websites and appliance controls. For example, a social media site that displays its users' information may enhance the possibility of repurposing it by third parties by supporting an application programming interface (API) that eases data extraction, or it may diminish that possibility through technical or legal rules (for example, a prohibition on scraping) that discourage such extraction. In such cases the language of affordance is more accurate than causation. In the case of autonomous vehicles, affordances constitute a mode of acting-on that can serve designers of vehicle interfaces seeking to convey to users (e.g., drivers and passengers) what range of actions are possible and desirable in relation to the vehicle's operation. Unlike physical force, affordances are perceived and processed by users (human users, in this case) who act in accord with them, often strategically.

Returning to our mini case of a driver switching on headlights illustrates the application between mode and affordance. We observe that the human actor physically exerts force on the button, thereby initiating a causal chain resulting in the lights flashing on. When, further, we ask what made the human push the button, there may be various answers. One such answer may cite acting-on by pointing to the interface, which has successfully exploited the affordance of "push-ability" in its design of the button in question.

Other answers illustrate additional modes of acting-on. Another plausible answer may cite purpose: the driver pushed the button because visibility was poor, night had fallen, and/or it had started raining. A different answer may cite obedience to the law, which prescribes switching on the headlights under

30. *See* JAMES J. GIBSON, THE ECOLOGICAL APPROACH TO VISUAL PERCEPTION 127–28 (1979).

31. *See* DONALD NORMAN, THE DESIGN OF EVERYDAY THINGS (Basic Books rev. ed. 2013) (1988).

32. *See id.* at 1–34.

certain conditions. Each of these cases reports on an intentional action taken by the driver, here, a decision to switch on the headlights. Although the model does not view the law, or light levels, or the miserable weather as components—they do not *act on* the driver—they surely inform the driver's action. The driver chooses to act (i.e., pushes the button) after having identified conditions or pertinent rules, interpreted them, and decided to act accordingly. The driver (user), as a free agent, is the prime mover causing the headlights to flash on by pushing a button.

Now, imagine a subsequent model of the vehicle, in which the operation of headlights is automated via a small computer embedded within the vehicle. In this case, under the appropriate external conditions, the algorithm's expression in lines of software code, implemented in an embodied computer, acts-on relevant components resulting in the lights turning on. The software code (and more abstractly, the algorithm) operates like legal rules. The model does not reify them as component actors; instead, their informational content, expressed as coded instructions, is embodied in material, electronic computers, which act-on other system components, and so on. Without delving into metaphysical questions about the nature of free agency, the Handoff model asserts a difference between automated headlight switches and human-operated switches by noting that in acting-on the coded rules, the material computer is not a prime mover but has been acted-on by those responsible for the code, prior to any particular trigger external to the system. Later in the Article, the implications of some of our choices will become clear.

In the headlights case, we could say that the function of switching on the light had been handed off from human actor to computer controller. As a matter of fact, well before the general hype over autonomous vehicles, a progressive shifting, or handing off, of certain functions from a human controller (driver) to vehicle components had been underway for some time. For example, the Electronic Stability Control System (ESC system) wrests control from the driver when it senses rear wheel activity that indicates "spinning out" (i.e., loss of directional stability) or front wheel activity that indicates "plowing out" (i.e., loss of directional control).[33] In these instances, the car seizes control from the human driver and endeavors to bring the car back under control. The car's lateral acceleration and yaw rate, captured by onboard sensors, are compared to the driver's intended direction inferred from speed and steering angle measurements. If they are inconsistent, the ESC

33. Electronic Stability Control Systems for Light Vehicles, 49 C.F.R. § 571.126 (2015) (requiring ESC systems on passenger cars, multipurpose passenger vehicles, trucks, and buses with a gross vehicle weight rating of 10,000 pounds or less).

system takes over.[34] The ability to adjust brake torque independently on each wheel allows the ESC system to use uneven brake force—rather than steering input—to reestablish a yaw appropriate to the intended direction of the driver. Similarly, protections against dangerous secondary-impact injuries—driver and passenger collisions with the inside of cars caused by a crash—moved from reliance on human actors to engage safety belts to foisting protection upon initially the driver and, over time, the front and backseat passengers, through the introduction of passive restraints, such as airbags. These Handoffs, while aimed at improving safety, have met with a range of value-based resistance, presaging the need for a model such as ours to identify and manage values during functional redistributions.[35]

Finally, considering the impetus or triggering event (what we refer to as "the Trigger") for two competing or sequential Handoff configurations, we highlight specific values that may be both motivating the reconfiguration or implicated by it. Historian Peter Norton offers an account of a shift that took place during the 1960s from a paradigm of traffic safety that emphasized *control* to one that focused on crashworthiness.[36] The control paradigm centered on preventing accidents through expert driver control. It was delivered through engineers designing safer roads, expertly educated drivers and informed pedestrians, and heavy-handed enforcement to prevent reckless driving. While the control paradigm concentrated on reducing the safety risks posed by drivers, pedestrians, and roads, the crashworthiness paradigm, spurred by rising fatalities, ushered in a focus on reducing the damage of inevitable collisions and focused on reducing the damage caused by vehicle occupants colliding with the interior of the automobile. This paradigm put the design of automobiles in service of safety.

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34. For a description of how electronic stability control systems work, see Nat'l Safety Couns., *Electronic Stability Control*, MYCARDOESWHAT.ORG, https://mycardoeswhat.org/safety-features/electronic-stability-control/ (last visited Sept. 1, 2020).

35. Automakers resisted passive restraints based on the belief that *explicitly* removing the driver and passenger from enacting safety through putting on a belt *implicitly* suggested questions about who would be held responsible and ultimately liable for injuries and fatalities. *See* Jameson M. Wetmore, *Redefining Risks and Redistributing Responsibilities: Building Networks to Increase Automobile Safety*, 29 SCI., TECH. & HUM. VALUES 377, 390 (2004) ("[W]hile automakers were wary of accepting the responsibility of making vehicles more crashworthy in the 1960s, they were even more frightened of taking on the liability that would accompany their involvement in an air bag strategy."); *see also* Jameson M. Wetmore, *Delegating to the Automobile: Experimenting with Automotive Restraints in the 1970s*, 56 TECH. & CULTURE 440, 447 (2015) (quoting retired General Motors president: "I do feel that when you have a passive system the responsibility lies more with the manufacturer and the service station that takes care of the system.").

36. *See generally* Peter Norton, *Four Paradigms: Traffic Safety in the Twentieth-Century United States*, 56 TECH. & CULTURE 319 (2015).

The shift from "crash avoidance" through driver control to "crashworthiness" was part of an effort by safety advocates who sought to place greater responsibility for safety on the automobile industry and the automobiles they produced. The paradigm shift ushered in, or, as we would say, triggered, the move from active (e.g., seat belts) to passive (e.g., air bag) restraints. The explicit aim of safety advocates was to reallocate responsibility from the public, whose attitudes and behavior had proved quite resiliently ill-suited to prevent secondary impacts, to technology that could compensate for human failings. Passive restraints were viewed as a response to the moral failings of drivers and were intended to displace immoral human actors. While airbags would not become standard until the 1990s, this 1960s paradigm shift triggered an initial move towards their development. Shifting significant aspects of the safety function away from the human driver to a subsystem of the automobile was not merely a Handoff of functionality, but a reconfiguration of responsibility and potential liability for injuries. We now see further shifts emerging in the ethical relations of a vehicle to occupant, and the social relations of a vehicle system to the broader public.

Our Handoff analysis first examines the reconfiguration of components, from vehicle-plus-driver to the inclusion of additional infrastructural, computational, and communicating components, for each vehicle archetype to achieve functionally equivalent driving. We then explore how each set of reconfigurations produce ethical and political consequences associated with how those systems relate to, constrain, and define individual human components (often within the vehicle), as well as public spaces and their users.

III. AUTONOMOUS VEHICLE FUTURES

Applying the Handoff model to autonomous vehicles moves us beyond the idea of a gradual, linear transition of control from human to computational elements in service of producing a functionally equivalent artefact (i.e., a car) that performs a functionally equivalent task (i.e., driving). The SAE International Standards for vehicle automation, for instance, describe this trajectory from traditional human control, through partial automation such as automated lane-keeping and braking (Level 2), to vehicles capable of operating without humans under constrained conditions (Level 4), to a mythical (or military) fully automated vehicle capable of operating independently under any and all conditions (Level 5).[37] This stepwise model encourages us to think

37. *See* SAE INT'L, *supra* note 22, at 6, 33–34. Notably, the document divides the act of driving into three activities—strategic, tactical, and operational—and explains that the

about vehicles as discrete objects, whose only variable is degree of computational control. The SAE model suggests development along a linear trajectory, mapped with SAE automation levels, as technical and regulatory hurdles are gradually overcome.

But the reality is different. Our claim is that each level in the SAE standards, alongside tracking a level of automation and embodying different configurations of human and technical components, expresses an agenda serving the interests of different stakeholders with different implications for various political and ethical values.[38] In other words, while the SAE levels present the transformations along one dimension, from human driver control to computational control, they occlude the complex re-scripting of components and significant political and ethical dimensions of these transitions. Applying the Handoff analytic to autonomous vehicles is useful here because it directs us to think about these vehicles and the function they perform not only as objects and tasks, but as complex systems of human, digital, and physical infrastructure, with new and transformed components and consequences for politics and ethics. Accordingly, we address the technical formations of autonomous vehicles not in terms of stepwise progress in automation, but in terms of models or archetypes of deployment that represent different systemic visions of the future of autonomous driving.

It is not our intention, here, to expand and extend the scope of work on societal implications of human-driven and autonomous vehicles or to call it into question. Rather, the contribution of the Handoff model is a richer account of cause and effect. Frequently, too much is left out when proponents and critics assert that human-driven or driverless vehicles will result in this or that outcome, respectively, reifying it as a single progression. We give shape to the multiple dimensions of these technologies while we focus on impacts of reorganization and reconfiguration on ethical and political (i.e., societal) values, such as privacy, autonomy, responsibility, and distributions of property. The transition to autonomous vehicles generates consequences for those values

automation at issue in levels 1–5 is focused exclusively on the tactical and operational aspects of driving on the road. *See id.* Though the document acknowledges that strategic driving activities such as trip planning may be delegated to technical components, they are not reflected in the levels of driving automation.

38. Without taking a deterministic view of technology, we agree with Mumford that some material arrangements are better aligned with certain political aims then others. *See generally* Lewis Mumford, *Authoritarian and Democratic Technics*, 5 TECH. & CULTURE 1 (1964) (arguing that some material arrangements—man-centered, relatively weak, resourceful and durable, dispersed, and decentralized—were more aligned with democratic forms of governance while others—immensely powerful, inherently unstable, centralized—were more aligned with authoritarian forms).

that may not be immediately evident or are described without attention to the specific implementation of autonomous driving considered. This causes important parts of the account to disappear, which we attempt to resurface by exploring the specifics of the archetypes through the Handoff model.

A. ARCHETYPE 1: "DRIVER ASSIST"

One autonomous future retains "drivers" in drivers' seats in individually owned, increasingly automated passenger vehicles. This is often described in terms of Advanced Driver Assistance Systems (ADAS), and many vehicle manufacturers are pursuing these technologies in one form or another.[39] We call the archetype associated with this system of transport "driver assist." Driver assistance technologies typically use similar sensor arrays to fully "driverless" vehicles, often including Light Detection and Ranging (LIDAR) (although Tesla notoriously relies more on computer vision rather than LIDAR),[40] ultrasonic, radar, and video cameras for "computer vision."

The driver assist approach involves a dynamic control relationship, with a balance of autonomy, control, and responsibility distributed between a human driver and an autonomous system through an interface.[41] Central to this archetype are "control transitions" between technical and human actors, which are understood to be inevitably necessary in certain situations or contexts. The reliance on a human occupant[42] to engage, disengage, and respond to failures of the automation system means the controlling components and modes are markedly different from those found in fully driverless vehicles, discussed below.

Authors have sought to classify and build taxonomies for different types of control handovers, including: stepwise (e.g., first throttle then steering, etc.), driver monitored (e.g., driver has hands on wheel and a countdown happens), and system monitored (e.g., the vehicle decides when the human is ready to

39. *See, e.g.*, Kelsey Mays, *Which Cars Have Self-Driving Features for 2019?*, CARS.COM (May 22, 2019), https://www.cars.com/articles/which-cars-have-self-driving-features-for-2019-402645/.

40. *See* Kyle Field, *Tesla Achieved the Accuracy of Lidar with Its Advanced Computer Vision Tech*, CLEAN TECHNICA (Aug. 3, 2020), https://cleantechnica.com/2020/04/24/tesla-achieved-the-accuracy-of-lidar-with-its-advanced-computer-vision-tech/.

41. Natasha Merat & John D. Lee, *Preface to the Special Section on Human Factors and Automation in Vehicles: Designing Highly Automated Vehicles with Driver in Mind*, 64 HUM. FACTORS: J. HUM. FACTORS & ERGONOMICS SOC'Y 681, 684–85 (2012).

42. This occupant may be either a driver or a fallback-ready driver depending upon whether the car is engaged in some Dynamic Driving Task. SAE INT'L, *supra* note 22, at 7.

resume control).[43] Other categories include "structured" or "unstructured,"[44] as well as system or user-initiated.[45] Vehicles may also be able to alter how a handover is performed according to an assessment of the attention, capacities of the human driver, or activities taking place within the vehicle. Interfaces designed to enable control transitions may communicate via auditory, visual, mechanical, or haptic channels, or in combinations.[46] These modes of acting, including force and affordance, on the human occupant are intended to elicit human behavior, such as increased alertness or exercise of control. The goal is to generate a feedback loop between the vehicle and the human driver for the sake of ensuring the intentions of the user are safely executed.[47]

Models for transition and Handoff have been evolving rapidly in the automotive design and research communities. The SAE defines the transfer sequence for a handover of autonomous to manual control to have five phases: P0 Original autonomous driving mode; P1 Event condition state change; P2 Request issued; P3 Takeover response; and P4 Full handover.[48] When control transitions occur in the other direction, from manual to automated, the SAE defines four phases: P0 Original manual driving mode; P1 Automation available; P2 Automation enabled; and P3 Automation engaged.[49] However, Wintersberger, Green, and Riener[50] have proposed the following additional states for take-over requests as seen in Tables 1 and 2 below.

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43. *See* Roderick McCall, Fintan McGee, Alexander Meschtscherjakov, Nicolas Louveton & Thomas Engel, *Towards a Taxonomy of Autonomous Vehicle Handover Situations*, PROC. 8TH INT'L CONF. ON AUTOMOTIVE USER INTERFACES & INTERACTIVE VEHICULAR APPLICATIONS 193, 196 (2016).

44. *See* Brian Mok, Mishel Johns, Key Jung Lee, David Miller, David Sirkin, Page Ive & Wendy Ju, *Emergency, Automation Off: Unstructured Transition Timing for Distracted Drivers of Automated Vehicles*, 2015 PROC. IEEE 18TH INT'L CONF. ON INTELLIGENT TRANSP. SYS. 2458, 2459, https://doi.org/10.1109/ITSC.2015.396.

45. Philipp Wintersberger, Paul Green & Andreas Reiner, *Am I Driving or Are You or Are We Both? A Taxonomy for Handover and Handback in Automated Driving*, PROC. 9TH INT'L DRIVING SYMP. ON HUM. FACTORS IN DRIVER ASSESSMENT, TRAINING & VEHICLE DESIGN 1, 3–4 (2017).

46. David Beattie, Lynne Baillie, Martin Halvey & Rod McCall, *What's Around the Corner? Enhancing Driver Awareness in Autonomous Vehicles via In-Vehicle Spatial Auditory Displays*, PROC. 8TH NORDIC CONF. ON HUM.-COMPUTER INTERACTION 189, 191 (2014), https://dl.acm.org/citation.cfm?id=2641206.

47. Evangeline Pollard, Philippe Morignot & Fawzi Nashashibi, *An Ontology-Based Model to Determine the Automation Level of an Automated Vehicle for Co-Driving*, PROC. 16TH INT'L CONF. ON INFO. FUSION 596, 596–97 (2013), https://ieeexplore.ieee.org/document/6641334.

48. *See* SAE INT'L, SURFACE VEHICLE INFORMATION REPORT: HUMAN FACTORS DEFINITIONS FOR AUTOMATED DRIVING AND RELATED RESEARCH TOPICS 18 (2016), https://www.sae.org/standards/content/j3114_201612/.

49. *See id.* at 20.

50. Wintersberger et al., *supra* note 45, at 3–4.

Table 1: Handover Taxonomy (SAE 3114 Phases on the Bottom, Additional Phases on Top)

Transfer Control Sequence **AD to Manual Control**			Request Issued			Take-Over Response	Full Handover
		Preparation Scheduled TOR	Perception	Suspension	Sufficient TOR		
Cognitive			Perceive Request to Intervene	Cognitive Suspension of Side Activity	Road Fixation	Control Transition Function	Situation Awareness
Physical				Physical Suspension of Side Activity	Hands on Wheel Foot on Pedal		Longitudinal / Lateral Vehicle Stability
System	Detect Request to Intervene	Prepare Request Driver State Assessment, Workload Management	Detect Request Perception	Adaption of Interfaces & Information Systems	Detection of Motor Readiness		Measure Driving Performance and Situation Awareness
P0	P1		P2			P3	P4

Table 2: Handback Taxonomy (SAE 3114 Phases on the Bottom, Additional Phases on Top)

Transfer Control Sequence **Manual to AD Control**		Automation available	Automation enabled	Automation engaged		Full Handback
		Initialization			Handback	Reengagement
Cognitive		Decision to Activate Automation		Control Transition Function	Cognitive Suspension of Driving Task	Cognitive Reengagement in Secondary Task
Physical		Enable Automation	Set Automation to Active State		Physical Suspension of Driving Task	Physical Reengagement in Secondary Task
System	Detect Availability of Automation	Driver State Assessment	Detect Imminent Need to Activate Automation		Secondary Task Suggestions, Explanation of Transition Reason	Adaption of Interface and In-Vehicle Information System
	P0	P1	P2	P3		

The augmented transition sequences proposed in these frameworks do a better job of taking into account the different cognitive and physical steps the user needs to transition through.

1. *Interfaces*

As these taxonomies make clear, effective control transitions require extremely complex informational interactions between technical and human actors. Timing and clarity of communications affect human capacities to regain control and situational awareness within time to navigate the obstacle.[51] This

51. *See, e.g.*, Brian Ka-Jun Mok, Mishel Johns, Key Jung Lee, Hillary Page Ive, David Miller & Wendy Ju, *Timing of Unstructured Transitions in Automated Driving*, 2015 PROC. IEEE INTELLIGENT VEHICLES SYMP. 1167, https://doi.org/10.1109/IVS.2015.7225841; Brian Mok, Mishel Johns, David Miller & Wendy Ju, *Tunneled In: Drivers with Active Secondary Tasks Need More Time to Transition from Automation*, PROC. 2017 CHI CONF. ON HUM. FACTORS IN COMPUTING SYS. 2840, https://doi.org/10.1145/3025453.3025713 (discussing controlled

raises questions as to how much engagement between the user and vehicle is necessary during routine computer-controlled driving. To what degree is, or *should*, the user be included in the control loop? And what differences in politics and values do respective decisions embody? Authors have commented that "finding the right balance between requiring the human to be ready to intervene at a moment's notice and realizing the benefits of this technology is likely to be a challenge."[52] Indeed, the practical dimension of these transitions is a topic of continuing research, with many questions still unresolved such as:

> In switching to an automated mode, how and when does the vehicle communicate to the driver the tasks for which the system is now responsible? To what extent is the driver monitored to ensure that they are sufficiently engaged with the driving task when the vehicle has control (Eye tracking? One hand on steering wheel?)? How long does the distracted or sleeping driver need to achieve sufficient awareness of the driving situation such that they can safely re-engage with the driving task? What information and cueing mechanisms will be most effective in managing this process? How does the vehicle manage if the driver is unable or refuses to resume control? In returning control to the driver, does the vehicle always return to full manual control (no automation) or does the vehicle step down through automation levels gradually?[53]

Answers to the questions posed above not only implicate safety and enjoyment but also other values. Depending on the various possible triggers for a control transition to occur and the different modes by which the vehicle acts on or engages the human driver—by force or affordance—the human driver occupies a different role in the control loop that also conditions their autonomy, privacy, and responsibility. For example, a vehicle may be compelled to drive when the human driver cannot react fast enough or is drunk, asleep, or otherwise impaired; a human, although not necessarily the human driver occupant, may need to drive, such as with teleoperation or mobility management, in complex situations like driving through a flood or crowd;[54] or a human driver may choose to remain in control for enjoyment

human participant experiments showing that timing of transition warnings and accounting for driver distraction can improve take-over response time); Mok et al., *supra* note 44.

52. JAMES M. ANDERSON, NIDHI KALRA, KARLYN D. STANLEY, PAUL SORENSON, CONSTANTINE SAMARAS & OLUWATOBI A. OLUWATOLA, AUTONOMOUS VEHICLE TECHNOLOGY: A GUIDE FOR POLICY MAKERS 68 (2016).

53. Michael Fisher, Nick Reed & Joseph Savirimuthu, *Misplaced Trust?*, ENGINEERING & TECH. REF. (2015), https://doi.org/10.1049/etr.2014.0054.

54. David Miller, Mishel Johns, Hillary Ive, Nikhil Gowda, David Sirkin, Srinath Sibi, Brian Mok, Sudipto Aich & Wendy Ju, *Exploring Transitional Automated Driving with New and Old*

even when a car is capable of autonomous driving.[55] These each affect the roles of human occupants and their understanding of respective tasks and responsibilities within the system.

With respect to the information transmitted through the interface to the human occupant, if there is no emergency danger, how much information about the surroundings and possible future risks should the vehicle communicate to the human occupant? Does the amount of information transmitted differ when the human is driving or merely supervising? Interfaces might only show sufficient information to demonstrate that the automated system is making clear and correct decisions, making the human occupant more confident in a supervisory role rather than driving. However, does this affect the human's autonomy? Would it be better for the vehicle to communicate in richer detail all of the possible risks and dangers? That might make the task of supervising a vehicle as onerous as actively driving. However, the alternative is for a human to risk not having all the information necessary to decide whether to initiate a control transition or actively drive.

A related question is whether the vehicle ought to demand the human occupant's attention in moderately risky situations, which may lead to habituation, or whether it should hail the human occupant only in clear emergencies. Considering that human attention remains a limited resource even when freed from the driving task, these questions about shifting control authority need to be addressed in situations where in-vehicle attention is focused on other activities, including some alternatives that are provided by the vehicle itself. In the real world, addressing these questions become even more complex because any given vehicle design script and interface must contend with information and control authority flowing not only among humans, software, and hardware, but with a diverse set of stakeholders, including software, hardware, and component vendors as well as traditional vehicle manufacturers.[56]

Further, users are known to appropriate technology in unanticipated ways—for example, using car batteries and mosquito nets for fishing rather than energy or malaria prevention. The ability to envision the divergent scripts users may enact in lieu of those imagined by the manufacturer or regulator can be further complicated when technologies can be combined. For instance, if

Drivers, 2016 PROC. SAE 2016 WORLD CONGRESS & EXHIBITION 2, https://doi.org/10.4271/2016-01-1442; Mok et al., *supra* note 44, at 2458.

55. Brian Mok, Mishel Johns, Nikhil Gowda, Srinath Sibi & Wendy Ju, *Take the Wheel: Effects of Available Modalities on Driver Intervention*, 2016 PROC. 2016 IEEE INTELLIGENT VEHICLES SYMP. 1358, 1358.

56. Akrich, *supra* note 7, at 205.

the driving control software—or some component of it—is an after-market device brought-in by the user, the manufacturer may not have accounted or allowed for the ways in which it may shift performance or user expectations. We caught a glimpse into the complexity of safety in autonomous driving with the Uber fatality; the "safety driver" was castigated for using a personal device at the time of the accident,[57] revealing a confused expectation that users would routinely be performing tasks other than supervising driving yet be on the hook to assume control quickly when circumstances so demand.

As legal and regulatory rules slowly stabilize, they will influence technical configurations. Further, road rules and insurer calculations will affect what tasks a human "driver," "owner," or "user" can or must perform at any particular time and the role we will expect vehicles themselves to play in enforcing desired conduct. Addressing the challenges of safe transitions of control[58] to inform interface design as well as regulatory prescriptions will require a nuanced concept of responsibility.

Assigning responsibility is particularly challenging where vehicle configurations participate in the moral conditioning of the user. While the law controls the conduct of a vehicle operator in one way, over time, control over human conduct has increasingly been delegated to vehicle systems themselves. For instance, vehicles use affordances like irritating beeping when a seatbelt is not engaged or when speed limits are exceeded, and can compel compliance by disabling an engine with an interlock device if a driver is intoxicated.[59] The way in which a vehicle grooms user conduct in the driver assist vehicle model may be radically different, however, involving real-time surveillance and behavior analysis, and triggering different vehicle responses according to situational, environmental, or other contexts. For instance, how a driver physically appears, or other non-driving behaviors like expressions of fatigue or anger, may become modes of engaging with the control system or triggers for additional information flows. Enhanced surveillance is integral to this archetype, as it allows the vehicle—or manufacturer or other provider of the assistive driving technology—to assess the extent to which the *human actor* is

57. *See* NAT'L TRANSP. SAFETY BD., PRELIMINARY REPORT: HIGHWAY HWY18MH010 3 (2018), https://www.ntsb.gov/investigations/AccidentReports/Reports/HWY18MH010-prelim.pdf.

58. *See* Helen Nissenbaum, *Accountability in a Computerized Society*, 2 SCI. & ENGINEERING ETHICS 25 (1996).

59. Bruno Latour, *Where Are the Missing Masses? The Sociology of a Few Mundane Artifacts*, *in* SHAPING TECHNOLOGY/BUILDING SOCIETY: STUDIES IN SOCIOTECHNICAL CHANGE 151, 168 (Weibe E. Bijker & John Law eds., 1992).

performing to the script.[60] Such monitoring is viewed as particularly important in detecting and countering misuse or abuse.[61]

In the driver assist archetype, information collected about the behavior of human and technical actors, primarily to support performance and safety, may secondarily flow to law enforcement for the sake of road rules compliance or to insurers for the sake of liability apportionment.[62] If vehicle manufacturers are presumed *prima facie* responsible for accidents when cars are in autonomous mode under a products liability rather than personal liability approach,[63] they may also desire fine-grained recording of in-cabin behavior during control transitions such that they would be able to subsequently pursue human drivers for negligence. Some authors have described the ways such technical systems condition user behavior as their "moral content."[64] The privacy issues associated with driver assist style vehicles are thus less defined by the commercial norms we might see in fully driverless cars, and more associated with increased policing and road enforcement and a potentially antagonistic relationship between drivers and vehicle manufacturers, as mediated by insurers.

The degree of connectivity between vehicles and vehicle manufacturers or other actors may depend on similar considerations. While autonomous driving modes in driver assist cars may not *require* web connectivity, certain manufacturers do collect different types of data, usually telematics data, when automated modes are enabled.[65] Other manufacturers, like Tesla, are gathering data from vehicle sensors irrespective of driving mode and have provided that data to law enforcement.[66] These issues are not necessarily new. For instance, seatbelt sensors participate in the control environment in non-automated vehicles. "Black box" and telemetry data, as well as dash cam footage, have

60. SAE INT'L, *supra* note 22, at 13.

61. *Id.*

62. *See, e.g.*, Belinda Bennett, Jane Evelyn & Bridget Wier, *Driving into New Frontiers? Data and Driverless Cars*, 2019 UNSW L.J.F. 1, 12; Sarah Aue Palodichuk, *Driving into the Digital Age: How SDVs Will Change the Law and Its Enforcement*, 16 MINN. J.L. SCI. & TECH. 827, 834 (2015).

63. *See, e.g.*, Kenneth S. Abraham & Robert L. Rabin, *Automated Vehicles and Manufacturer Responsibility for Accidents: A New Legal Regime for a New Era*, 105 VA. L. REV. 127, 139 (2019); Stefan Clause, Nicholas Silk & Chris Wiltshire, Bank of Eng. Gen. Ins. Div., *Potential Impacts of Autonomous Vehicles on the UK Insurance Sector*, Q. BULL., 2017 Q1, at 40, 45, https://www.actuaries.org.uk/system/files/field/document/A3%20Supporting%20paper.pdf.

64. Akrich, *supra* note 7, at 219.

65. Julia Orlovska, Casper Wickman & Rikard Soderberg, *The Use of Vehicle Data in ADAS Development, Verification and Follow-up on the System*, 2020 PROC. DESIGN SOC'Y: DESIGN CONF. 2551, 2554.

66. Stefan Jacobs, *Berliner Polizei Greift Immer Härter Gegen Raser Durch*, DER TAGESSPIEGEL (Feb. 25, 2019, 8:18 AM), https://www.tagesspiegel.de/berlin/illegale-autorennen-berliner-polizei-greift-immer-haerter-gegen-raser-durch/24033226.html.

long been used in insurance litigation. However, these practices have the potential to evolve in scale under the driver assist model, and the norms around information flow are unclear, especially between the human user and the vehicle manufacturer or service provider.

2. *Responsibility and Autonomy*

Private vehicle ownership, as preferred in the driver assist archetype, also introduces new responsibilities that seem analogous to those associated with contemporary, non-automated vehicle ownership. For instance, maintenance for autonomous vehicles might require the installation of software or firmware updates.[67] On the one hand, a "user" may be responsible for ensuring that the "driver" is performing at its highest capacity (i.e., using the latest version of its software), in the same way that a person is responsible for the maintenance of a vehicle. On the other, responsibility for the safety of software updates, as well as transparency of features added or removed, may also fall on the manufacturers. Satisfying manufacturer responsibility may require executing updates, irrespective of user knowledge or desire, in turn challenging the scope of owner autonomy analogously with other "tethered" goods.[68] Compelling users to update software may affect consumer rights. With current devices, for example, the choice of whether or not to update an operating system may depend on numerous factors including an assessment of whether the device is powerful enough to run that updated software. It might be necessary however, to remove that consumer choice for the sake of ensuring greater safety for the general public. These choices about what level of engagement with the computational capacities of a vehicle are permitted, encouraged, or obliged affect user autonomy and agency.[69]

ADAS used in driver assist cars reportedly cause drivers to report a loss of control over vehicles, and therefore, potentially, a sense that autonomy has been curtailed.[70] Research also suggests that "user experience" and "user

67. *See, e.g.*, Automated and Electric Vehicles Act, 2018, c. 18, § 4 (Eng.).

68. Chris Jay Hoofnagle, Aniket Kesari & Aaron Perzanowski, *The Tethered Economy*, 87 GEO. WASH. L. REV. 783, 829 (2019).

69. For an overview of the pros and cons of over-the-air software updates in the automotive context, see Dierdre K. Mulligan & Kenneth A. Bamberger, *Public Values, Private Infrastructure and the Internet of Things: The Case of Automobiles*, 9 J.L. & ECON. REG. 7, 7 (2016). For a description of the potential for the security-necessary, over-the-air updates to compromise security, limit competition, and undermine consumer protections and privacy, as well as the need for regulations to address, see *id.* at 20–26.

70. Sven Kraus, Matthias Althoff, Bernd Heissing & Martin Buss, *Cognition and Emotion in Autonomous Cars*, 2009 PROC. 2009 IEEE INTELLIGENT VEHICLES SYMP.; Alexander Meschtscherjakov, Manfred Tscheligi, Dalila Szostak, Rabindra Ratan, Roderick McCall,

acceptance" are at their highest with limited levels of vehicle automation.[71] Measuring autonomy means asking what the interface permits or prohibits and why. The interface of a prestige car, focused on comfort or driving "feel," may be engineered to produce perceptions of control and support for driver intentions.[72] In a ride-sourcing service, by contrast, it may focus on customer experience. In a logistics vehicle such as a long-haul truck, the focus may be efficiency and worker discipline.[73] These agendas will define what inputs from the human are desirable or necessary and the ways in which their behaviors are integrated into the control system. The autonomy question for human drivers in this scenario is thus determined by the capacity and compulsion to perform control inputs, as defined by the triggers and modes of the control feedback loop, but those elements are themselves dependent on broader purposes as well as commercial, political, and regulatory considerations.

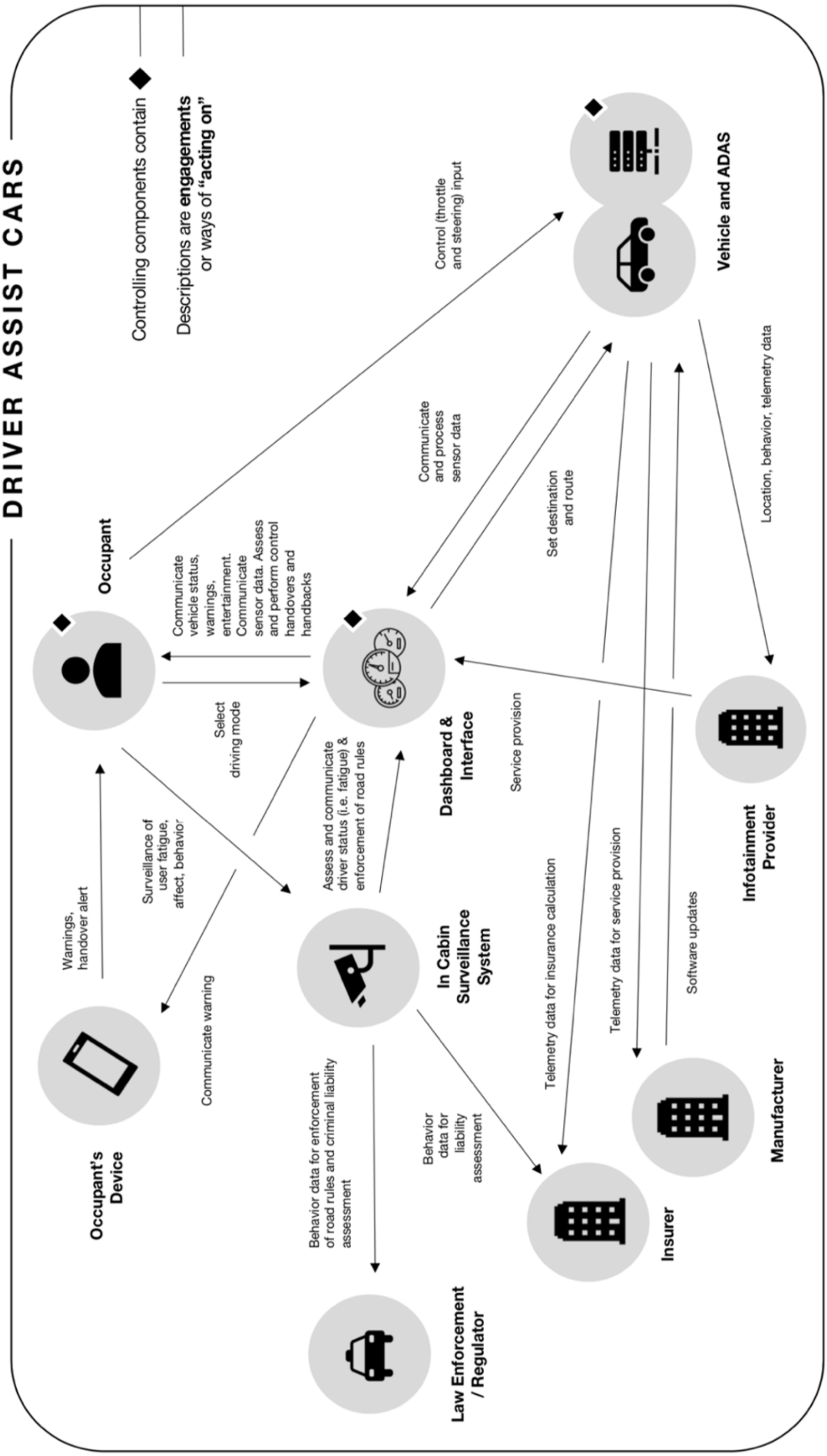
Ioannis Politis & Sven Krome, *Experiencing Autonomous Vehicles: Crossing the Boundaries Between a Drive and a Ride*, 2015 PROC. 33RD ANN. ACM CONF. EXTENDED ABSTRACTS ON HUM. FACTORS IN COMPUTING SYS. 2413, 2414, https://doi.org/10.1145/2702613.2702661.

71. *See* Christina Rödel, Susanne Stadler, Alexander Meschtscherjakov & Manfred Tscheligi, *Towards Autonomous Cars: The Effect of Autonomy Levels on Acceptance and User Experience*, 2014 PROC. 6TH INT'L CONF. ON AUTOMOTIVE USER INTERFACES & INTERACTIVE VEHICULAR APPLICATION 1, 8, https://doi.org/10.1145/2667317.2667330.

72. Fisher, *supra* note 53.

73. Karen E. C. Levy, *The Contexts of Control: Information, Power, and Truck-Driving Work*, 31 INFO. SOC'Y 160, 161 (2015).

Figure 1: Distribution of Components in Driver Assist Cars



B. ARCHETYPE 2: "DRIVERLESS CAR"

For some, the fully driverless vision of autonomous transport is the best approach to capturing the economic and social benefits of autonomous vehicles.[74] Indeed in the taxonomy laid out in the SAE document, fully driverless (Level 5) is the culmination of successive developmental stages.[75] With a fully driverless car, "occupants" (i.e., "users" or "passengers," but not "drivers") would use travel time for non-driving activities with no obligation to pay attention to the road or vehicle controls. Such vehicles typically require legislative fiat, which only a few jurisdictions have provided so far.[76] Some states have created regulatory frameworks to allow such vehicles to be tested.[77] Several laws, however, are being debated (or at least proposed) that go further and enable the sale and use of vehicles without traditional vehicle controls of steering wheels and pedals.[78] This change goes beyond allowing vehicle occupants not to *have* to drive; without controls, they *cannot* drive. The critical change to the vehicle interface in this configuration is the absence of direct controls and the introduction of rich systems of information exchange between human occupants and the entities controlling the carriage of the vehicles (i.e., "operators").[79] As previously mentioned, in the near future the high cost of sensing and computational apparatus necessary for operating these vehicles will likely restrict their usage to "mobility services." Those TNCs might be privately, publicly, or communally operated, or they may be privately-owned and fleet-managed passenger vehicles.

The Waymo Chrysler Pacifica mini-van offers a useful demonstration of the driverless car control distribution designed for commercial ride-hailing.

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74. *See, e.g.*, Hideaki Tomita, *Awaiting the Realization of Fully Autonomous Vehicles: Potential Economic Effects and the Need for a New Economic and Social Design*, VOX EU (Dec. 17, 2017), https://voxeu.org/article/potential-economic-and-social-effects-driverless-cars.

75. *See* SAE INT'L, *supra* note 22, at 23.

76. *See, e.g.*, AV START Act, S. 1885, 115th Cong. (2017); SELF DRIVE Act, H.R. 3388, 115th Cong. (2017); U.S. DEP'T OF TRANSP., THE ROAD AHEAD: NHTSA STRATEGIC PLAN 2016-2020, at 24–26 (2016).

77. *See, e.g.*, Autonomous Vehicles/Self-Driving Vehicles Enacted Legislation, NAT'L CONF. ST. LEGISLATORS, https://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx (last visited July 30, 2020).

78. *See, e.g.*, CAL. VEH. CODE § 38756 (West 2019) (repealed 2018); CAL. VEH. CODE § 38756 (West 2019) (repealed 2020).

79. The SAE term is "driverless operation dispatcher." SAE INT'L, *supra* note 22, at 17. This role is distinct from the "remote driver" who, while not seated in a position to "manually exercise in-vehicle braking, accelerating, steering, and transmission gear selection input devices (if any)," can operate the vehicle. *Id.* at 16. These roles are functional; thus, a driverless operation dispatcher may become a remote driver if they have the means to operate the vehicle remotely. *Id.*

These vehicles still retain traditional vehicle controls (and "safety drivers" for now), but nonetheless demonstrate the trajectory of this transport vision. When the in-car controls are not engaged, the driving function in these vehicles is displaced to a combination hardware and software control system that Waymo calls the "the world's most experienced driver."[80] A closer look at the interfaces and what they facilitate, however, exposes some of the other components and modes of acting embedded in this control Handoff. In the Waymo Chrysler, there is a digital screen for each back-seat passenger providing a bird's eye view (i.e., top-down view with the vehicle in the center) real-time map showing the environment as detected in relatively low resolution, coupled with pulsing higher-resolution images (of still relatively indecipherable dot representations of the physical environment generated from LIDAR sensors). There is also a mechanical interface for back seat occupants, with three buttons: "start ride," "pull over," and "help."[81]

These in-car controls are coupled with the Waymo One App for smartphones, which operates in a similar manner to other commercial ride-sourcing services. Destinations are input,[82] prices are agreed-upon, and feedback is provided following the common model of star ratings and selected responses such as "good route choice" and "clean car" (although "friendly driver" is probably no longer an option). All three interfaces—in-seat, mechanical, and the app—give a "support" option, where an occupant can contact a Waymo employee, likely situated in a control or service center, who can offer guidance on *using* (but not "driving")[83] the vehicle (e.g., instructing users on how to change destinations). This "support" component can both assist the driver to give further input into the driving system as well as direct the driving system itself by resetting the destination.

The fully driverless car archetype typically imagines a car travelling on existing roadways, capable of moving from destination to destination relying only on on-board sensing and computational apparatuses. This mode of autonomous transport developed out of the U.S. Defense Advanced Research Projects Agency (DARPA) autonomous vehicle Grand Challenge, beginning

80. WAYMO, https://waymo.com (last visited Sept. 1, 2020).

81. For information about the Waymo Chrysler Pacifica, see WAYMO PRESS, https://waymo.com/press/ (last visited Sept. 1, 2020); Hawkins, *supra* note 3.

82. This is an example of the strategic, user-determined aspects of driving that are excluded from the automation paradigms of the SAE. SAE INT'L, *supra* note 22, at 6.

83. The SAE coined the term "Dynamic Driving Task" to describe "[a]ll of the real-time operational and tactical functions required to operate a vehicle in on-road traffic . . . " and to limit which "driving" tasks are automated under the various levels of automation they define. SAE INT'L, *supra* note 22, at 6 (emphasis omitted). Again, the definition excludes "the strategic functions such as trip scheduling and selection of destinations and waypoints." *Id.*

in 2004, which expressed the goal of accelerating the "development of autonomous vehicle technologies that could be applied to military requirements."[84] That military pedigree meant autonomous vehicle technology would need to be self-reliant, operating in unknown and hostile environments, with potentially limited communications. Such self-sufficiency in a more civilian context might imply a type of independent or even libertarian politics embedded in the mode of vehicle operation, in that it gives near total decision-making power and control to the discrete vehicular unit. That account may not, however, adequately capture the more nuanced political consequences, or consequences for human values, when implementing such vehicles in the real world, or at least in an urban environment. Deploying fully autonomous vehicles in urban spaces necessitates more complex information flows and controlling components shaped by material and commercial realities.

Consider the multiple situations in which a vehicle in urban use cannot rely on autonomous control alone, such as equipment malfunction, unexpected road blockages, natural disasters, etc. It is unlikely that a vehicle could operate in an unpredictable environment without at least some human control input, one way or another. Commercial realities further suggest the use of these vehicles will be so conditioned by respective business models as to make a complete delegation of control to the vehicle itself unlikely. These contingencies might muddy the driverless car archetype; nevertheless, they are the working realities of a driverless vehicle model once its "users" (e.g., individual users and businesses operating the vehicles) are taken into account. We maintain that envisioning how a driverless vehicle actually operates in the world reveals many of its political and ethical consequences.

For a start, it is necessary to widen the lens and acknowledge other controlling actors or components, beyond the "occupant," "operator," or software control system, that are essential to the functioning driverless vehicles. Rarely acknowledged, they are necessary accomplices when the capacity to control a vehicle is removed from its occupants. This setup shares elements with the connected car archetype, discussed next, which in some versions also denies control to the vehicle occupant. The driverless archetype, however, is premised on interventions that control vehicles one-at-a-time, rather than distributing control across a variety of infrastructural systems. Further, in the driverless archetype, these are primarily supplemental control components used for error recovery, rather than structural dependencies for

84. *The Grand Challenge*, DEF. ADVANCED RES. PROJECTS AGENCY, https://www.darpa.mil/about-us/timeline/-grand-challenge-for-autonomous-vehicles (last visited Sept. 1, 2020).

networked distributed control of vehicles that are more integral to connected cars.

It is worth returning to a point made about driver-assist in the real world, namely the interdependencies between design choices and factors such as assumed purposes, material contingencies, and business drivers. We recall, therefore, that DARPA may have envisioned self-reliant vehicles because of the limited communications infrastructures and complex environments they might inhabit. By contrast, a domestic, urban environment offers infrastructures that are more reliable and, potentially, programmable. Regulators seem keen to exploit these infrastructures to define the functionality of driverless cars. For example, pilot tests of driverless vehicles with supervision by remote operators typically require a communications link that can provide information on the vehicle's location and status and supports two-way communication between the occupants and operators.[85] Thus, even driverless vehicles depend upon external infrastructure for political reasons, as well as technical.

Vehicle manufacturer Nissan's development of new controllers, interfaces, and modes of acting for their driverless vehicle control systems offers an example. Their "Seamless Autonomous Mobility" system uses a central control room with human "mobility managers"[86] who can intervene in vehicle control when facing complex obstacles.[87] This relocates an element of the driving interface to a remote location and to a remote person, who makes decisions about vehicle operation. From the promotional material available, however, the interface does not resemble a traditional vehicle interface—i.e., it is not a vehicle driving simulator—but rather it is a mapping system, where new routes can be plotted and then delivered to the vehicle for execution through its own driving software.[88] Thus the interfaces' affordances appear to support the "strategic" aspects of driving specifically cabined off from the "Dynamic Driving Tasks" assigned to vehicles in the SAE taxonomy[89] (the in-

85. *See, e.g.*, CAL. CODE REGS. tit. 13, § 227.38(b)(1) (2018).

86. *See, e.g.*, Lawrie Jones, *Driverless Cars: When and Where?*, ENGINEERING & TECH. MAG. 36 (Mar. 2017); *Seamless Autonomous Mobility*, NISSAN MOTOR CORP., https://www.nissanglobal.com/EN/TECHNOLOGY/OVERVIEW/sam.html (last visited July 30, 2020).

87. These human components fit the category of "(DDT) Fallback-Ready Users"; they are prepared to take on driving tasks if a Level 3 vehicle requests it or if there is evidence of need. When they take over the operational and tactical tasks, these human components become Remote Drivers. SAE INT'L, *supra* note 22, at 17.

88. *See, e.g.*, NISSAN MOTOR CORP., *supra* note 86.

89. SAE INT'L, *supra* note 22, at 6–7 (describing Dynamic Driving Tasks differently automated under the SAE 5-level system as "the real-time operational and tactical functions

the-moment, on-road tasks being thrown, or taken, back by the human). For instance, mobility managers draw a path on a digital map using a regular computer interface (i.e., a mouse). Thus, the human acts on the driving system by determining the route—an informational input—and the software control system on the vehicle translates that informational input and acts on other technical components of the vehicle to follow those directions. Mobility managers are typically engaged when a vehicle encounters an obstacle that it cannot negotiate, i.e., when the vehicle is stationary, rather than an emergency situation.

There are also other forms of remote controllers. Companies like Phantom Auto, for instance, are building a way for autonomous vehicles to be controlled by humans in remote locations using vehicle simulators.[90] These people are not billed as "drivers," but rather as "teleoperators." (Although the job position advertised on their website is for a Class A Driver & Remote Operator.)[91] In this situation, the system affordances allow a teleoperator to assume the controlling function of the vehicle rather than, as in the "mobility manager" example, a source of information to trigger action from the on-board computational controlling components. These two alternative interfaces invite different understandings of the human actors' relationship to the technical actors.

Differences in remote approaches highlight questions about what constitutes "driving" in these systems. They employ different ways to distribute control to new "components," different identities for those new components, different configurations of control across components, different interfaces, and different modes of acting enabled by those interfaces. Importantly, these interfaces invite human actors to visualize their roles in distinct ways. The bird's-eye view offered by the Nissan SAM system foregrounds planning and management, distancing the remote human actor from the lived experiences of the vehicles' human occupants. The Phantom Auto system in contrast foregrounds the operational and tactical aspects of driving. In doing so, it aligns the remote operator more closely with the lived experience of the vehicle's occupants. The interface designs place the remote

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required to operate a vehicle in on-road traffic, excluding the strategic functions such as trip scheduling and selection of destinations and waypoints . . . .") (emphasis omitted).

90. Alex Davies, *Self-Driving Cars Have a Secret Weapon: Remote Control*, WIRED (Feb. 1, 2018, 7:00 AM), https://www.wired.com/story/phantom-teleops/.

91. *See Current Openings*, PHANTOM AUTO, https://phantom.auto/careers/?gh_jid=4073694002 (last visited June 4, 2020). This is unsurprising as regulations that allow pilot tests of such cars require remote operators/DDT fallback-ready drivers to have the proper class of license for the vehicle they operate and undergo manufacturer designed safety training. *See* CAL. CODE REGS. tit. 13 § 227.38(f) (2018).

human actors in scripts with different valences that influence the way they view their respective tasks and make ethically relevant decisions. Finally, requirements of the systems bring new players into the mix, with their own political stakes and incentives. For example, the Phantom Auto system (unlike the Nissan SAM system) requires zero-latency video transmission, which, if technically possible, could also provide a huge financial boon for telecommunications providers, over whose networks that data will flow. This technical requirement may shift the politics in unpredictable ways, including importing structural antitrust questions where mobility providers are also invested in telecommunications infrastructure.

1. *Business Models and Ownership*

The relationship between control, technical configuration, and business model cannot be overstated. For example, one critical difference between the two outsourced control options described above is that the Phantom Auto system requires a remote driver to operate one vehicle at a time. On the other hand, the Nissan SAM interface, while still requiring individual attention, positions a mobility manager more as a fleet manager or dispatch operator. If these become paid services, then they will likely service or facilitate different ownership models for autonomous vehicles. One appears more amenable to infrequent interventions associated with small-scale individual ownership, e.g., with personally owned cars being used on TNC platforms, whereas the other might be more suited to mobility-as-a-service arrangements, or fleet ownership and operation as a TNC. Those ownership models, and their implications for responsibility and control of vehicles, are deeply bound to system design. A fleet ownership model allows for centralized control and responsibility, sharing of and trust in collected information. Concentrated ownership of vehicles allows for greater investment per car as well as for some sensing and computation to be performed in the cloud by a central provider. Ownership and control of autonomous vehicles by a central entity also enables coordinated action such as platooning or other behaviors that take advantage of economies of scale such as calculated vehicle positioning for ride-sourcing, which is not possible, or at least more difficult (i.e., requires using "surge pricing" to incentivize), when individual sub-contractors possess and operate their own vehicles. On the other hand, non-fleet control models might prefer to distribute greater autonomy and control to each vehicle on the roadway. This may also elevate vehicle price because of the additional sensing and computation required. These systems lend themselves to different business cases, while the capital investment required still marginalizes the appeal of fully driverless cars to individual private owners.

At this stage, the leading players in driverless vehicles appear to be large technology companies interested in ride-sourcing, which demonstrates a likely business case and ownership configuration for this archetype moving forward. That said, recognizing the commercial complexity of vehicle manufacturing, these companies also seem ready to partner with vehicle Original Equipment Manufacturers (OEMs). Waymo is not, of course, the only entity exploring fully driverless cars for ride-hailing.[92] Uber has also been experimenting with these vehicles and has partnered with Toyota.[93] Lyft has a partnership with tech company Aptiv, which has a fleet of BMW cars (that include manual controls), operating on a small number of "routes."[94] Lyft also received a $500 million investment from General Motors in 2016,[95] indicating the possibility that General Motors may manufacture vehicles for autonomous ride-sourcing, or that General Motors is becoming a ride-sourcing business. General Motors has also acquired a driverless car company, Cruise, which is, for instance, building a driverless vehicle for Honda.[96] Clearly, companies are adopting new, different, complex positions in the autonomous vehicle ecosystem, which involves new roles for manufacturers, service providers, and platform operators.

Close attention to those complex manufacturing arrangements and business models highlights additional consequences for the property distributions and ownership dimensions of transport services, as well as the tendency towards de-integration of vehicle hardware and control software. Instead of building fully integrated autonomous vehicles, it is possible companies like Uber or Waymo would prefer to build autonomous driving

92. As of July 31, 2020, only three companies have permits to test cars without onboard drivers in California: Waymo LLC, Nuro Inc., and AutoX Technologies Inc. *Permit Holders (Driverless Testing)*, CAL. DEP'T MOTOR VEHICLES, https://www.dmv.ca.gov/portal/dmv/detail/vr/autonomous/driverlesstestingpermits (last visited Sept. 1, 2020).

93. *See, e.g.*, Eric Meyhofer, *Uber and Toyota Team Up on Self-Driving Cars*, UBER NEWSROOM (Aug. 27, 2018), https://www.uber.com/newsroom/uber-toyota-team-self-driving-cars/.

94. Kyle Wiggers, *Aptiv's Self-Driving Cars Have Given Lyft Passengers Over 100,000 Rides*, VENTURE BEAT (Feb. 11, 2020, 3:00 AM), https://venturebeat.com/2020/02/11/aptivs-self-driving-cars-have-given-lyft-passengers-over-100000-rides/.

95. Steve Trousdale, *GM Invests $500 Million in Lyft, Sets Out Self-Driving Car Partnership*, REUTERS (Jan. 5, 2016, 1:04 AM), https://www.reuters.com/article/us-gm-lyft-investment/gm-invests-500-million-in-lyft-sets-out-self-driving-car-partnership-idUSKBN0UI1A820160105.

96. Andrew J. Hawkins, *GM's Cruise Will Get $2.75 Billion from Honda to Build a New Self-Driving Car*, THE VERGE (Oct. 3, 2018, 8:51 AM), https://www.theverge.com/2018/10/3/17931786/gm-cruise-honda-investment-self-driving-car.

software "platforms" to be installed in driverless vehicles built by OEMs.[97] Accordingly, even if such driverless cars were individually owned, it is difficult to imagine autonomous vehicle ownership as approximating traditional vehicle ownership. As the functions of mobility managing and error correction demonstrate, such vehicles would require at the very least a degree of "tethering" to the software vendor as a service provider.[98] Tethered products represent a strategy of "maintaining an ongoing connection between a consumer good and its seller that renders that good in some way dependent on the seller for its ordinary operation."[99] We see this in the automotive world already to a certain extent with ongoing debates over schematics and servicing.[100] The need for infrastructure and legal frameworks to address "over-the-air-updates," commonly viewed as essential to maintaining performance and security in vehicle software, means tethering is essential to this archetype of autonomous vehicle futures.[101]

2. Data Flows and Privacy

The information flows between vehicles, manufacturers, insurers, platforms, regulators, and other parties in a driverless car ecosystem will increase,[102] and their implications for users, the public, and public goals are an

97. *See, e.g.*, ONDREJ BURKACKY, JOHANNES DEICHMANN, GEORG DOLL & CHRISTIAN KNOCHENHAUER, MCKINSEY & CO., RETHINKING CAR SOFTWARE AND ELECTRONICS ARCHITECTURE 3 (2018), https://www.gsaglobal.org/wp-content/uploads/2018/12/3.-Rethinking-car-software-and-electronics-architecture-Feb-2018.pdf (discussing the application of advanced driver assist systems).

98. Hoofnagle, *supra* note 68, at 785.

99. *Id.* at 785.

100. *See, e.g.*, Massachusetts Right to Repair Act, MASS. GEN. LAWS ch. 93J, § 2 (2012) (repealed 2013); AARON PERZANOWSKI & JASON SHULTZ, THE END OF OWNERSHIP: PERSONAL PROPERTY IN THE DIGITAL ECONOMY (2016).

101. *See* Mulligan & Bamberger, *supra* note 69, at 8 (discussing the need for over-the-air updates of software and the complicated set of policy questions that must be resolved to align the need with other values); *see also* Rahul Razdan, *Tesla Decepticons? Is Automotive CyberSecurity a National Defense Issue?*, FORBES (May 2, 2020, 7:33 AM), https://www.forbes.com/sites/rahulrazdan/2020/05/02/is-automotive-cybersecurity-a-national-defense-issue-/#52c6db8c1b75 (describing the lack of attention to cybersecurity implications of over-the-air updates in latest U.S. House Commerce Committee draft bill and giving perspective that this is out of step with the growing use and concerns caused by automated driving systems and with regulatory activity in other countries); H. COMM. ON ENERGY AND COMMERCE, DISCUSSION DRAFT, CYBERSECURITY RISKS TO MOTOR VEHICLE SAFETY (2020), https://assets.documentcloud.org/documents/6775841/DiscussionDraft.pdf.

102. For examples of the data being collected by automobiles in 2015, see OFFICE OF S. EDWARD J. MARKEY, TRACKING AND HACKING: SECURITY & PRIVACY GAPS PUT AMERICAN DRIVERS AT RISK (2015) (finding that information being collected by thirteen auto manufacturers included: geographic location (seven manufacturers); system settings for event

active site of political contest.[103] Dorothy Glancy, for instance, has comprehensively assessed the privacy stakes of different types of autonomous vehicle information flows, including the telemetry data traditionally collected by manufacturers.[104] She makes clear that "interactions between privacy and autonomous vehicles will depend on the design and operation of autonomous vehicles."[105] However, this analysis can be nuanced beyond the division between "self-contained" or "interdependent" vehicles as used by Glancy. Within the self-contained or driverless archetype, for instance, business cases, ownership models, and the vicissitudes of real-world operation further influence system dynamics and components, such as the form and mode of interacting with a ride-sourcing provider, the surveillance of vehicle occupants necessary to ensure safe operation or prevent vandalism, or the action of an error recovery or emergency intervention component. At a general level, moving the monitoring responsibility to a remote location requires a communication link, which in turn involves additional nodes with potential back and forth access to information flows. A real-time error correction and mobility management by remote drivers and operators further extends privacy and security considerations to vehicle sensor data.

These are subtly new types of information flows involving multiple distributed controlling components. While remote access to vehicle sensor data is not novel and relevant privacy implications have been discussed,[106] inclusion of remote human operators as shadow drivers that "tele-occupy" the same space as the vehicle "user" or "occupant" introduces novel information flows for which appropriateness must be evaluated. Again, clearly the mode of acting-on the vehicle and the triggers behind the engagements of these components, such as obstacles, emergency road conditions, or destination changes, constitute important contextual information. How those external components are represented in the system will depend on connectivity design

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data recorder (EDR) devices, which can include data such as sudden changes in speed, steering angle, brake application, seat belt use, air bag deployment, and fault/error codes (five manufacturers); operational data, including speed, direction or heading of travel, distances and times traveled, fuel level and consumption, status of power windows, doors, and locks, tire pressure, tachometer and odometer readings, mileage since last oil change, battery health, coolant temperature, engine status, and exterior temperature and pressure (seven manufacturers)). Eight of the twelve companies reported transmitting and storing driving history data on external servers. *Id.* at 8.

103. *See* discussion *infra* Section IV.C.3.

104. *See* Dorothy J. Glancy, *Autonomous and Automated and Connected Cars – Oh My: First Generation Autonomous Cars in the Legal Ecosystem*, 16 MINN. J.L. SCI. & TECH. 619 (2015).

105. Dorothy J. Glancy, *Privacy in Autonomous Vehicles*, 52 SANTA CLARA L. REV. 1171, 1173 (2012).

106. *See, e.g.*, *id.* at 1178–81.

choices. For instance, acknowledging cyber-security threats, Waymo vehicles do not require or use constant connectivity for "driving."[107] They do, however, require certain levels of connectivity for other functions, such as following instructions that users express in the app interface. Privately-owned, non-commercial vehicles may require even less connectivity but may still retain some way to facilitate inputs from external control.

3. *Responsibility and Autonomy*

The responsibilities of the various component actors in these driving systems also requires rethinking. While a human occupant should perhaps not be considered a "driver" in any meaningful sense, they may have different obligations as a "passenger," "user," or "occupant," as may the other controlling components. Numerous commentators have analyzed the potential impacts of autonomous vehicles on both civil and criminal liability and likely consequences for the insurance industry.[108] Clearly, apportioning

107. Jamie Condliffe, *Why Some Autonomous Cars Are Going to Avoid the Internet*, MIT TECH. REV. (Jan. 10, 2017), https://www.technologyreview.com/2017/01/10/154642/why-some-autonomous-cars-are-going-to-avoid-the-internet/.

108. *See, e.g.*, CTR. FOR CONNECTED & AUTONOMOUS VEHICLES, PATHWAY TO DRIVERLESS CARS: CONSULTATION ON PROPOSALS TO SUPPORT ADVANCED DRIVER ASSISTANCE SYSTEMS AND AUTOMATED VEHICLES (2017) (discussing a proposal for a "single insurer" model, where a single insurer covers both driver and manufacturer); John Villasenor, Ctr. for Tech. Innovation, *Products Liability and Driverless Cars: Issues and Guiding Principles for Legislation*, *in* THE ROBOTS ARE COMING: THE PROJECT ON CIVILIAN ROBOTICS (2014); Sabine Gless, Emily Silverman & Thomas Weigend, *If Robots Cause Harm, Who Is to Blame? Self-Driving Cars and Criminal Liability*, 19 NEW CRIM. L. REV. 412 (2016); Sunghyo Kim, *Crashed Software: Assessing Product Liability for Software Defects in Automated Vehicles*, 16 DUKE L. & TECH. REV. 300 (2017–2018) (considering questions of product liability associated with increased criticality in software function compared to hardware); Alexander G. Mirnig, Rod McCall, Alexandra Meschtscherjakov & Manfred Tscheligi, *The Insurer's Paradox: About Liability, the Need for Accident Data, and Legal Hurdles for Automated Driving*, 2019 PROC. 11TH INT'L CONF. ON AUTOMOTIVE USER INTERFACES & INTERACTIVE VEHICULAR APPLICATIONS 113 (highlighting that insurers lack sufficient data about how to make decisions apportioning liability in SAE3+ applications); Fabian Pütz, Finbarr Murphy, Martin Mullins & Lisa O'Malley, *Connected Automated Vehicles and Insurance: Analysing Future Market-Structure from a Business Ecosystem Perspective*, 59 TECH. SOC'Y 101182 (2019), https://doi.org/10.1016/j.techsoc.2019.101182 (discussing the competitive disadvantage for insurers who may not be able to access the rich in-vehicle and telemetry data streams these vehicles generate and that are otherwise captured by OEMs and other service platforms, and arguing for regulatory intervention to address these information asymmetries). We also note the complication of identifying software defects in machine learning systems and increased security risks associated with higher levels of connectivity. *See, e.g.*, Abraham & Rabin, *supra* note 63 (arguing that, mirroring the movement to strict liability in workers compensation claims, we need a radically new legal regime to deal with torts questions in the context of automated vehicles; setting out a "Manufacturer Enterprise Responsibility" model for SAE level 4 and 5 vehicles that have no

liability according to whether a car is in autonomous mode or not, as attempted in the U.K. Vehicle and Technology Aviation Bill,[109] is insufficient. The different degrees of control, processes for control transitions, and user interfaces, as well as varied regulatory environments, complicate this distinction too radically. Beyond that observation, we do not intervene in these debates except to note that we agree with Glancy that "determinations such as fault or causation [become] so exceedingly complex technologically that fault and cause concepts are for all practical purposes illusory."[110] As these issues become more complex, it appears pragmatic solutions that avoid the need to apportion liability on a granular level become more likely. To that end, we address these questions with a view to a philosophical rather than legal account of responsibility.

To address the allocation of responsibility for harms within a driverless car archetype means addressing a cascade of questions. If the vehicle interface *does* include a mechanical system for directing a vehicle to "pull over," does that impose an obligation on the passenger to supervise the "driver" (i.e., vehicle) to the extent that if the vehicle is behaving absurdly, there is a responsibility to stop it? Does this depend on whether it is privately owned and operated or operated as a corporate, ride-sourcing vehicle? At what point does it become unreasonable or tortious for an occupant of an autonomous vehicle to not command the vehicle to stop? Does the passenger have an obligation to the broader public to ensure that the "driver" or controlling component is not acting dangerously or malfunctioning? When would this become the responsibility of a mobility operator, tele-operator, or control center manager? The distribution of control and control authority will proactively determine the roles of the various components in the system. These different roles will each have different levels of responsibility for system operation.

As discussed in the driver assist context, some vehicle interfaces reflect transitions of control through on-board mode lights. Others change the

fault element and does not retain existing standards for defining a defect under product liability, because the authors claim it becomes difficult to understand the concept of a defect without comparison with redundant designs; and providing an "exclusive remedy" remedy); Melinda Florina Lohmann, *Liability Issues Concerning Self-Driving Vehicles*, 7 EUR. J. RISK REG. 335 (2016) (discussing the utility of strict liability models and how they will relate to product liability models); Dorothy J. Glancy, *Sharing the Road: Smart Transportation Infrastructure*, 41 FORDHAM URB. L.J. 1617, 1644 n.140 (2013); Carrie Schroll, *Splitting the Bill: Creating a National Car Insurance Fund for Accidents in Autonomous Vehicles*, 109 NW. U.L. REV. 803 (2015) (arguing for establishment of a national scheme funded by a monthly road-users tax that operates as a no-fault compensation scheme that pays out compensation similar to Medicare and Social Security); Andrew D. Selbst, *Negligence and AI's Human Users*, B.U.L. REV. (forthcoming 2020).

109. Vehicle and Technology Aviation Bill 2016–17, HC Bill [143] (Gr. Brit.).

110. Glancy, *supra* note 104, at 670.

interface more definitively such as by color-coding the steering wheel or even changing the shape of the steering wheel.[111] But for vehicles where the person in the car is *always* a passenger, vehicle designers often try to signal the change in the person's status by removing the driver interface elements altogether. Waymo and Cruze, for example, have been petitioning the U.S. National Highway Traffic Safety Administration (NHTSA) to permit the removal of the steering wheel and driving pedals from the cabin. Another common move is to turn the front seat around to face the interior of the cabin (e.g., Magna)[112] or to reduce the size of the windows so that people inside cannot easily see out (e.g., Mercedes).[113] Many vehicle interior designs for fully autonomous vehicles harken back to planes or trains, with seats that lean back far enough to sleep. Volvo's driverless 360c concept, for example, is depicted with a person lying on a flatbed with sheets pulled up.[114] This vision makes a feature of one of the driverless cars' most troublesome features—they put people to sleep.[115] Sometimes though, it is the addition of screens throughout the interior cabin[116]—screens people could not look at if they had to attend to the road—that mark the departure between current day automobiles and driverless vehicles. Where an occupant is structurally disabled from exercising control over the vehicle, the design and efficacy of mobility management and tele-

111. Rain Noe, *Experimental Automotive Interface Design: How Should Autonomous Cars Hand Off Control to the Driver?*, CORE77 (Jan. 23, 2017), https://www.core77.com/posts/60023/Experimental-Automotive-Interface-Design-How-Should-Autonomous-Cars-Hand-Off-Control-to-the-Driver; *see also* Mishel Johns, Brian Mok, Walter Talamonti Jr., Srinath Sibi & Wendy Ju, *Looking Ahead: Anticipatory Interfaces for Driver-Automation Collaboration*, 2017 PROC. 20TH INT'L CONF. ON INTELLIGENT TRANSP. SYS. 2122; Brian Mok, Mishel Johns, Stephen Yang & Wendy Ju, *Reinventing the Wheel: Transforming Steering Wheel Systems for Autonomous Vehicles*, 2017 PROC. 30TH ANN. ACM SYMP. ON USER INTERFACE SOFTWARE & TECH. 229; CARJAM TV, *Mercedes Retractable Steering Wheel Is Art! Mercedes Driverless Cars*, YOUTUBE (Apr. 8, 2015), https://www.youtube.com/watch?v=1pOAAJZAjPU.

112. Drew Winter, *Magna Unveils Flexible Interior for Autonomous Vehicles*, WARDS AUTO (Dec. 11, 2018), https://www.wardsauto.com/autonomous-vehicles/magna-unveils-flexible-interior-autonomous-vehicles.

113. Molly Wood, *Video Feature: Inside the F 015, Mercedes's Self-Driving Car*, N.Y. TIMES (Mar. 19, 2015), https://www.nytimes.com/2015/03/20/automobiles/video-feature-inside-the-f-015-mercedess-self-driving-car.html.

114. *360c: A New Way to Travel*, VOLVO CAR CORP., https://www.volvocars.com/intl/cars/concepts/360c?redirect=true (last visited Sept. 1, 2020).

115. David Miller, Annabel Sun, Mishel Johns, Hillary Ive, David Sirkin, Sudipto Aich & Wendy Ju, *Distraction Becomes Engagement in Automated Driving*, 2015 PROC. HUM. FACTORS & ERGONOMICS SOC'Y ANN. MEETING 1676, 1679.

116. *The Mercedes-Benz F 015 Luxury in Motion*, MERCEDES-BENZ AG, https://www.mercedes-benz.com/en/innovation/autonomous/research-vehicle-f-015-luxury-in-motion/(last visited Sept. 1, 2020).

operation systems become more important because of the degree of responsibility distributed to those remote actors.

Questions of responsibility become more complex yet again if automated vehicles perform driving maneuvers too complex for humans to supervise, such as very high-speed driving or using continuous flow intersections. These possibilities raise the question: at what point on the spectrum of fully driverless vehicle activities might we abandon the idea of human responsibility altogether?

These questions of responsibility are connected to how any reconfiguration of components might impact human autonomy or agency. However, when we think of autonomy in a privately-owned, traditionally-controlled vehicle, the dramatic rearrangement of components and modes of acting in driverless vehicles inevitably challenge any meaningful connection between control, intention, and autonomy or agency.[117] That is not to say autonomous vehicles necessarily undermine autonomy. Rather, they shift what autonomy means and how it may be expressed in the automotive context. Indeed, ceding control over vehicle functionality may not necessarily eliminate any autonomy or agency for a human occupant. One example associated with the proliferation of ride-sourcing services is the shift towards use of shortest path algorithms. In combination with GPS mapping, those algorithms alter traditional taxi norms where passengers would typically have an influence, or at least say, over the route taken by the vehicle.[118] Users of ride-sourcing services, especially in the case of ridesharing or pooling, no longer express control in that way, and neither do drivers who instead follow directional commands from the automated direction system. The normalization of shortest path algorithms chosen by TNC platforms thus establishes a baseline that further automation does not necessarily disturb. Where loss of control over a route may become an issue, however, is where that route is influenced by agendas other than the passenger's intention of travelling most directly to a destination. One can imagine commercial incentives taking people past particular destinations or restaurants in the same way that entities could pay the Niantic Pokémon Go platform for Pokémon to be spawned near their

117. Sven Krome, Jussi Holopainen & Stefan Greuter, *AutoPlay: Unfolding Motivational Affordances of Autonomous Driving*, *in* AUTOMOTIVE USER INTERFACES 483 (G. Meixner & C. Muller eds., 2017).

118. *See, e.g.*, Jody Rosen, *The Knowledge, London's Legendary Taxi-Driver Test, Puts Up a Fight in the Age of GPS*, N.Y. TIMES (Nov. 10, 2014), https://www.nytimes.com/2014/11/10/t-magazine/london-taxi-test-knowledge.html.

commercial establishments to increase foot traffic.[119] Autonomous vehicles might also have their routes or destinations influenced by "public safety" agendas prohibiting travel to or through certain places or, as Elizabeth Joh has discussed, "policing" incentives that use autonomous vehicles for the sake of *de facto* arrest.[120]

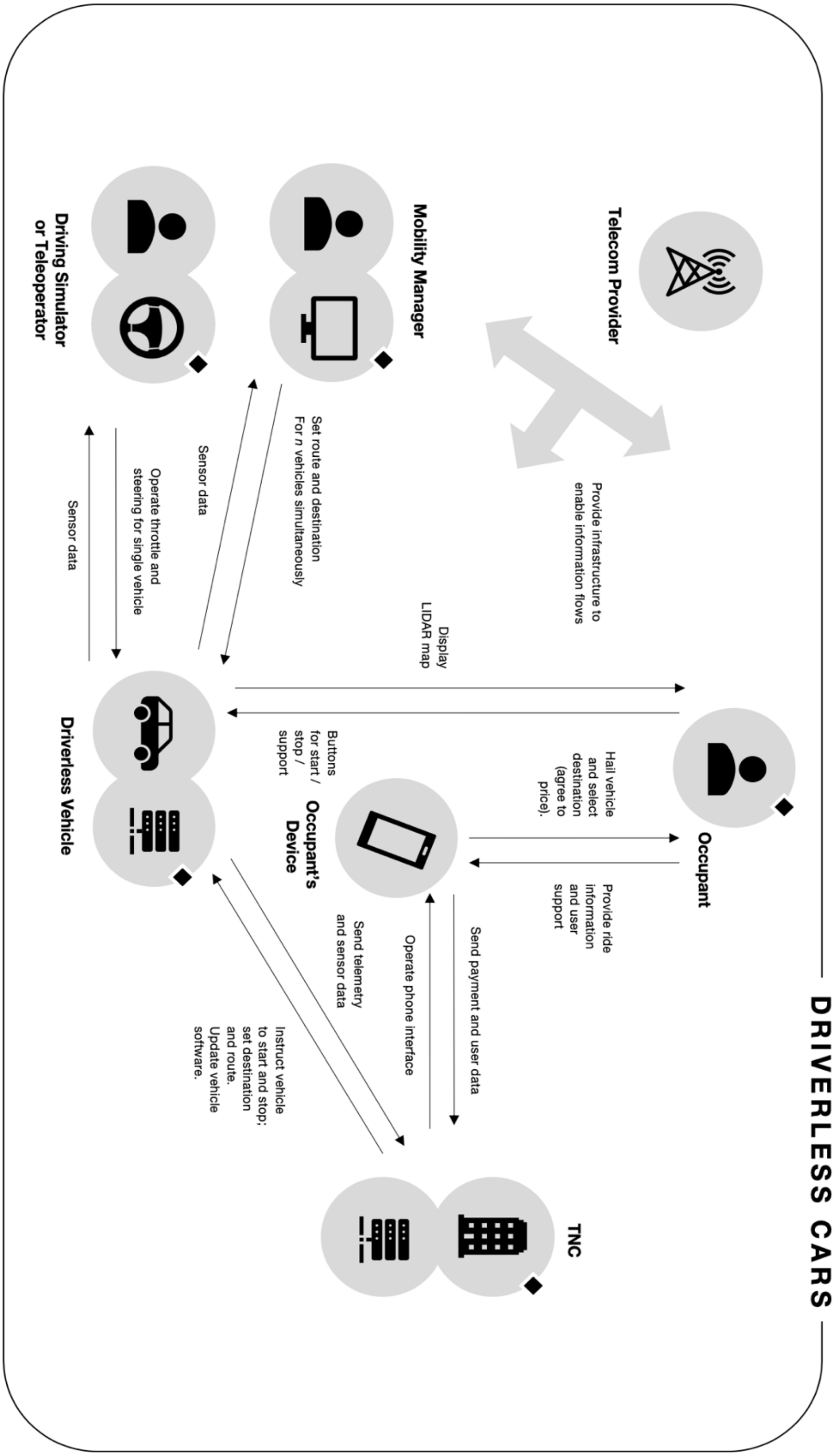
If we think of vehicles merely as another tool for transportation, the means may not matter to feelings of agency. If efficiency is the agenda, it may be that increasing transport efficiency is autonomy enhancing. Because autonomy means or requires different things for different users, designing to ensure the capacity to choose the "agenda" of the vehicle—that is to select how and for what purpose the vehicle's functions are optimized—may be more important. Some users may be satisfied with power to select a destination, or a route, while others may desire control over other operational and tactical driving decisions. It may be that occupants' interest in agency is satisfied by determining the strategic aspects of driving—where and when to go—along with the decision about what modality of transportation to use at the outset, as it is in numerous other transportation contexts. However, it may be that occupants will want the ability to tailor routes, speeds, driving styles, or the mix of values to optimize for—the scenic route rather than the fastest—or at the very least want protection against driving decisions that serve the non-safety related needs of others. Other methods may satisfy those with greater desire for the sense of freedom and autonomy associated with driving today. For instance, situational awareness and meaningful orientation, as well as connection to the environment and the driving task, may be achieved by enhancing information flows into the vehicle cabin but still without enabling control over a vehicle in a traditional way. Alternatively, it may be that those methods can be used to redirect occupants desire for agency. For instance, researchers have explored how non-driving in-vehicle activities associated with work or leisure might maintain user agency (in the sense of competence) in different ways.[121]

119. *See* Paul Tassi, *'Pokémon GO' Is Charging Sponsored PokéStops up to 50 Cents Per 'Visit,' Which Seems Like a Bad Deal*, FORBES (June 2, 2017), https://www.forbes.com/sites/insertcoin/2017/06/02/pokemon-go-is-ripping-off-its-sponsored-pokestops-charging-up-to-50-cents-per-visit/#72b826252159.

120. *See* Elizabeth E. Joh, *Automated Seizures: Police Stops of Self-Driving Cars*, 94 N.Y.U.L. REV. 113 (2019) (discussing the various ways in which autonomous vehicles could be subject to policing actions).

121. Krome, *supra* note 117.

Figure 2: Distribution of Components in Driverless Cars



C. ARCHETYPE 3: "CONNECTED CARS"

The connected cars archetype descends from the oldest vision of autonomous transport. The earliest imaginings of autonomous cars involved roadways acting as part of the communications and control system for vehicles. An exhibit at the 1939 World's Fair, sponsored by General Motors, displayed electric cars running on a roadway embedded with electric circuitry.[122] In the late 1950s, tests on short stretches of highway included detector circuits buried in the pavement that transmitted radio signals to guide the position and velocity of vehicles equipped with appropriate receivers and actuators.[123] In the 1960s, the Ohio State University pursued research in autonomous vehicles that again used electronic devices embedded in roadways; similar research was done in the U.K. with magnetic cables that successfully transported a Citroen DS at 130km/h around a test track.[124] The U.S. Bureau of Public Roads investigated the construction of electronically controlled highways in multiple jurisdictions in the 1970s and 1980s.[125] In the early 1990s, the U.S. Congress explored "intelligent vehicle highway systems."[126] At the same time, Daimler-Benz claimed to have constructed vehicles that could travel on highways for thousands of kilometers at high speed, effecting lane changes with minimum human intervention.[127]

While there is, of course, substantial overlap among driverless, driver assist, and connected cars visions, the connected cars archetype represents an alternative to "autonomous," fully driverless models where vehicles rely primarily on their own sensor arrays to navigate the physical world. In the connected cars vision, the control environment includes all vehicles continuously sharing information with one another, along with cloud computing and road infrastructures interacting, diverting, directing, and controlling vehicles by producing, receiving, and processing data. This requires

122. Gijsbert-Paul Berk, *Self-Drive Cars and You: A History Longer than You Think*, VELOCE TODAY (Aug. 5, 2014), https://velocetoday.com/self-drive-cars-and-you-a-history-longer-than-you-think/.

123. Keshav Bimbraw, *Autonomous Cars: Past, Present and Future: A Review of the Developments of the Last Century, the Present Scenario and the Expected Future of Autonomous Vehicle Technology*, 2015 PROC. 12TH INT'L CONF. ON INFORMATICS CONTROL, AUTOMATION & ROBOTICS 191, 192.

124. *Id.* at 193.

125. *Id.*

126. Intermodal Surface Transportation Efficiency Act of 1991, Pub. L. No. 102-240, § 105 Stat. 1914; *see also* Glancy, *supra* note 108, at 1624.

127. Reinhold Behringer & Nikolaus Muller, *Autonomous Road Vehicle Guidance from Autobahnen to Narrow Curves*, 14 IEEE TRANSACTIONS ON ROBOTICS & AUTOMATION 810, 813 (1998); Uwe Franke, S. Gorzig, Frank Lindner, D. Mehren & Frank Paetzold, *Steps Towards an Intelligent Vision System for Driver Assistance in Urban Traffic*, 1997 PROC. IEEE CONF. ON INTELLIGENT TRANSP. SYS. 601.

a massive proliferation of controlling components, operating through coordinated infrastructural clouds. The pure connected cars vision thus involves vehicles following trajectories controlled and decided by distributed infrastructure. At the extreme, connected cars would physically resemble driverless cars, needing just a minimal controlling interface within the vehicle. Whereas the driverless car relies on its own sensing and computational power to negotiate a virtually untouched environment, the control authority for connected cars rests with a distributed vehicular and infrastructural network orchestrated by the roadway environment itself.

Real world implementations of the connected car visions do not articulate that pure vision—at least not yet. They include different forms and scales of Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), and Vehicle-to-X (V2X) connectivity, with different ways of delegating control among components.[128] Unlike driverless or driver assist approaches, continuous connectivity in connected cars is absolutely necessary because of the multiple elements exercising "direct control for time-critical, flow-related interventions—for which some degree of system-level coordination is required for safe operation."[129]

V2V protocol standardization has been the focus of agencies like the NHTSA, which has been investigating the dynamics of making V2V capabilities mandatory in vehicles.[130] Standardizing transmission of basic safety messages (BSM) between vehicles to facilitate warnings to drivers has been on the regulatory agenda since at least 2014 (although the NHTSA has been researching these questions for a decade more—even acquiring dedicated vehicle communications radio spectrum from the FCC in 1997).[131] The

128. Presently, very few vehicles use robust V2V or V2I communications. Bryant Walker Smith, *A Legal Perspective on Three Misconceptions in Vehicle Automation*, *in* ROAD VEHICLE AUTOMATION 85, 89–91 (Gereon Meyer & Sven Beiker eds., 2014). V2V communications technology has been primarily tested and promoted in the context of "road train," "peloton," or "platoon" style transport configurations, designed to reduce environmental pollution by using the aerodynamic efficiencies of vehicles travelling closer together or behind a truck. *See generally* Hani S. Mahmassani, 50th Anniversary Invited Article, *Autonomous Vehicles and Connected Vehicle Systems: Flow and Operations Considerations*, 50 TRANSP. SCI. 1140 (2016). Nonetheless, engineers argue that almost every aspect of "driver" decision making would be improved by V2X connectivity. *See id.* at 1140.

129. *Id.* at 1160.

130. *See, e.g.*, OFFICE OF REGULATORY ANALYSIS & EVALUATION, NHTSA, PRELIMINARY REGULATORY IMPACT ANALYSIS: FMVSS NO. 150 VEHICLE-TO-VEHICLE COMMUNICATION TECHNOLOGY FOR LIGHT VEHICLES (2016) [hereinafter "V2V COMMUNICATION"].

131. *See, e.g.*, JOHN HARDING, GREGORY POWELL, REBECCA YOON, JOSHUA FIKENTSCHER, CHARLENE DOYLE, DANA SADE, MIKE LUKUC, JIM SIMONS & JING WANG,

NHTSA proposal would require all light vehicles manufactured after 2023 to include short range radio (Wi-Fi-like) devices to transmit information that receiver vehicles then process and display for drivers.[132] Under the proposed NHTSA V2V rules published in 2017, BSM would include: time, location, elevation, speed, heading, acceleration, yaw rate, path history, exterior lights, event flags, transmission status, steering wheel angle, and vehicle size (with brake status optional).[133] It is then up to vehicle manufacturers to build safety applications into vehicles that translate this data into useful information.[134] Likely safety implementations are forward collision warnings, do not pass warnings, left turn assistance, intersection movement assistance, and blind spot lane change warnings.

The NHTSA V2V regulation, however, has little to do with vehicle control automation or autonomous transport. The connected cars archetype focuses on distribution of vehicle control throughout an infrastructural environment, whereas the above V2V applications are more about improving vehicle sensing by including information broadcast from other vehicles about their status—they do not interrupt the distribution of control or degrade the driver's control over the vehicle. This system therefore introduces new triggers for communicative action (safety warnings) operating on a driver but does not include the introduction of new control components. That said, using these communications systems does require standardizing the messaging languages and ensuring spectrum availability, which could be understood as regulatory precursors to more comprehensive V2X applications.[135]

An example of V2V communication that does complicate questions of control is truck platooning. In a truck platoon, two trucks drive one behind the other on a highway. By establishing a secure and encrypted wireless link, the lead vehicle is able to communicate acceleration and braking so that the trucks can safely drive closer together than they would if they were depending upon visual cues and driver response time alone. This allows the trucks to draft off of one another, saving approximately five percent in fuel consumption rates for the lead vehicle, and ten percent for draft vehicles.[136] In future

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U.S. DEP'T OF TRANSP., VEHICLE-TO-VEHICLE COMMUNICATIONS: READINESS OF V2V TECHNOLOGY FOR APPLICATION (2014)*; see also* Glancy, *supra* note 108, at 1644 n.140.

132. *See* V2V COMMUNICATION, *supra* note 130.

133. Federal Motor Vehicle Safety Standards; V2V Communications, 82 Fed. Reg. 3854 (proposed Jan. 12, 2017) (to be codified at 49 C.F.R. pt. 571).

134. V2V COMMUNICATION, *supra* note 130.

135. *Id.*

136. MICHAEL LAMMERT, KENNETH KELLY & JANET YANOWITZ, NAT'L RENEWABLE ENERGY LAB., CORRELATIONS OF PLATOONING TRACK TEST AND WIND TUNNEL DATA 3–5 (2018).

systems, both longitudinal and latitudinal control for the following truck could be operated through a combination of autonomous driving technology and intervehicle communication. This would enable drivers of the trailing vehicles to supervise vehicles rather than actively drive, which can reduce driver fatigue. As the technology progresses, the intent is for truck platooning protocols to converge so that trucks from different fleets using different manufacturers' platooning hardware and software will nevertheless be able to platoon.[137] Following that, the intent is for the drivers of trailing vehicles to be able to rest or even sleep when their vehicle is in a platoon.[138] In this case, we can track a redistribution of control across the vehicles in the platoon as they become components in a system. However, moving from V2V to V2I and V2X has the potential to radically expand the number of components and the complexity of their action, which requires substantial new infrastructure.

Driverless cars are being built to work with existing infrastructures, while building in error-correction mechanisms to deal with inevitable problems. Proponents of connected cars, on the other hand, are pushing for massive re-instrumentation of urban environments. Distributed vehicular control and orchestration introduce benefits that only infrastructural coordination can bring, like advanced traffic management (vehicles no longer needing to stop and go), ultra-high-speed travel, and continuous flow intersections. While these benefits will require the implementation of new infrastructures, the result will transcend the capacity of human "driver" supervision.[139] In fact, these high-level coordinated actions are likely unachievable on roadways shared with manually controlled vehicles.[140] That need for a hundred-percent adoption, however, represents a primary limitation for this vision in existing urban environments. At the same time, it rationalizes the idea that single providers ought to be in charge of developing "smart city" infrastructures in new, ground-up developments where infrastructures can be built from scratch, like

137. *See, e.g.*, PLATOONING ENSEMBLE, https://platooningensemble.eu/ (last visited Sept. 6, 2020).

138. Sarah-Maria Castritius, Heiko Hecht, Johanna Möller, Christoph J. Dietz, Patric Schubert, Christoph Bernhard, Simone Morvilius, Christian T. Haas & Sabine Hammer, *Acceptance of Truck Platooning by Professional Drivers on German Highways: A Mixed Methods Approach*, 85 APPLIED ERGONOMICS 103042, 103042 (2020), https://doi.org/10.1016/j.apergo.2019.103042.

139. *See* Sven Krome, David Goedicke, Thomas J. Matarazzo, Zimeng Zhu, Zhenwei Zhang, J.D. Zamfirescu-Pereira & Wendy Ju, *How People Experience Autonomous Intersections: Taking a First-Person Perspective*, 2019 PROC. 11TH INT'L CONF. ON AUTOMOTIVE USER INTERFACES & INTERACTIVE VEHICULAR APPLICATIONS 275, 282–83.

140. *See, e.g.*, Kwok J. Leung, *Synergistic Traffic Intersection – A Method for Coordinating Vehicles and Facilitating the Introduction of Autonomous Vehicles*, 8 INT'L J. TRAFFIC & TRANSPORT ENGINEERING 1 (2019).

the (now abandoned) Toronto Waterfront.[141] This takes the fleet-car ownership model in the driverless car archetype and expands it to include ownership of static infrastructure in public space.

1. Political Coordination for Connected Cars

The fragmentation of control across innumerable human, vehicular, and infrastructural components raises as many questions about societal values. Alongside questions about privacy, responsibility, autonomy, and human freedom, the connected cars archetype highlights deeply political questions about the governance of public space—who is entitled to interact with it and in what ways? A careful balance between governance by commercial actors who own various components and governance by politically legitimate actors will be essential to achieving a workable and just system.

Whereas Lewis Mumford saw an authoritarian tendency in automobiles as a challenge to the human agent as "walker,"[142] these new infrastructural constellations require a new calculus of political rationality and ethical consequences. The coordinating infrastructural cloud may appear to embody what Mumford called "theological-technological mass organization,"[143] an authoritarian rather than democratic technological arrangement. But the question of whether to pursue centralized or decentralized technologies must include questions about who that central coordinating entity might be, who might control the coordinator, and toward what ends. Put another way, thinking about these transport infrastructures as democratic, libertarian, collectivist, or authoritarian does not adequately address the dynamics of private and public governance also at play. At stake here is the question of the degree to which democratic control can be exercised over the shape and function of a complex sociotechnical system that occupies public space. We must analyze the degree to which a private provider of that system becomes able to control how that system configures social relations in accordance with its own interests. That means understanding how different configurations of private and public providers—i.e., of what entity owns and controls what part of a transport system—affect ethical and political outcomes. Of particular concern is how these ownership arrangements might affect who has control

141. *See, e.g.*, Ben Spurr, *Sidewalk Labs Wants to Create a New Transportation Authority*, THE STAR (June 25, 2019), https://www.thestar.com/news/gta/2019/06/25/sidewalk-labs-wants-to-create-its-own-transportation-authority-in-quayside.html (discussing proposals for a Waterfront Transportation Management Authority to take over certain dimensions of traffic governance presently under city jurisdiction).

142. Mumford, *supra* note 38, at 8.

143. *Id.* at 2.

over deciding the conditions by which individuals are able to interact with transport systems. But again, the specifics of the system are critical.

Consider a few of the governance alternatives. One might resemble existing arrangements: the connected transport infrastructures are communally (state) owned but host mostly privately owned (or leased) vehicles.[144] In the pure connected car vision however, we would need to consider what it would mean to own a connected car when very little control can be exercised, apart from selecting a destination. Another governance arrangement might hybridize connected and driver assist models: individual control over vehicles may be necessary to manage transitions into connected car environments, such as a continuous flow intersection, and out of these environments when a human driver takes back the helm.[145] In such a case, a driver may prefer to have property rights in the vehicle, with the capacity to exclude others, rather than a license to occupy that vehicle only for the duration of a trip. In a third model (transportation totalitarianism), developers of smart city infrastructure may seek to unify ownership of the infrastructure with the vehicles that use it, rendering the transport system a form of public transport that provides mobility more as a service. The distinction between this scenario and the mobility as a service arrangement of driverless cars is that here, there is potentially control over both vehicles and infrastructures, which translates into the power to define the terms by which private actors engage with and access that infrastructure.

In any of these, democratic societies should embed sufficient oversight by legitimate governing bodies to ensure the maintenance of democratic values, such as equity and transparency with regard to resources and data management. Public transport services are typically offered to the public at large with relatively few barriers to entry and on relatively egalitarian terms.[146] Democratically governed infrastructure might privilege the goal of equality in service provision over profit.[147] The values associated with public transport are primarily connected to the utility of transport as an integral public service, *ideally* privileging holistic values like mobility, safety, equality, or environmental concerns. Private corporations may supply that utility for a fee or with the support of advertising revenues and may sometimes include unjustifiable levels

144. One must acknowledge, of course, that there is a large degree of private ownership of transport infrastructures, varying according to jurisdiction and political system.

145. Krome, *supra* note 139, at 103042.

146. *See, e.g.*, ROEL NAHUIS, THE POLITICS OF INNOVATION IN PUBLIC TRANSPORT: ISSUES, SETTINGS, DISPLACEMENTS 19 (2007).

147. *See, e.g.*, Ashim Kumar Debnath, M. Mazharul Haque, Hoong Chor Chin & Belinda Yuen, *Sustainable Urban Transport: Smart Technology Initiatives in Singapore*, 2243 TRANSP. RES. REC.: J. TRANSP. RES. BD. 38 (2011).

of surveillance. However, the primary function ought to remain the provision of a public service. Private mobility services, on the other hand, may deploy more market mechanisms and ways to stratify users in order to optimize for profit. For instance, there is already discussion of how market-based mechanisms (i.e., willingness to pay) might allocate rights and priorities in environments like continuous flow intersections.[148] Similarly, if infrastructural control were vested in a single private entity, they may be able to take advantage of their monopoly position to implement preferential access to roadways or TNC participation for vehicles using their driving (i.e., vehicle control) software platforms, even if individually owned.

To the degree that autonomous transport systems follow the existing political and ethical alignment of "smart cities," they may therefore replicate or amplify pathologies existing in capitalist political economy.[149] As described by Francesca Bria and Evgeny Morozov, for example, this means data extractivism and accumulation, which involves treating both individual and urban data as commodities to be bought and sold on secondary markets, using machine learning systems that treat cities and transport as optimization problems, and rejecting equality and social justice as legitimate goals of public policy.[150] Several cities in the United States are already subsidizing ride-sourcing firms rather than investing in state-owned public transport infrastructure, thus further privatizing public transport systems.[151] As private firms move into autonomous transport models in the connected car vision, their commercial logics may continue to define infrastructural arrangements, the types and volumes of information flows, and the social configurations that follow.

Private entities, even those with significant power, may still be subject to regulatory oversight in the public interest, and this oversight capacity should not be relinquished. The California Public Utilities Commission (CPUC)

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148. *See, e.g.*, Muhammed O. Sayin, Chung-Wei Lin, Shinichi Shiraishi, Jiajun Shen & Tamer Başar, *Information-Driven Autonomous Intersection Control via Incentive Compatible Mechanisms*, 20 IEEE TRANSACTIONS ON INTELLIGENT TRANSP. SYSTEMS 912 (2019); Heiko Schepperle & Klemens Böhm, *Auction-Based Traffic Management: Towards Effective Concurrent Utilization of Road Intersections*, 2008 PROC. 10TH IEEE CONF. ON E-COMM. TECH. & 5TH IEEE CONF. ON ENTERPRISE COMPUTING, E-COMM. & E-SERVS. 105; Matteo Vasirani & Sascha Ossowski, *A Market-Inspired Approach for Intersection Management in Urban Road Traffic Networks*, 43 J. ARTIFICIAL INTELLIGENCE RES. 621 (2012).

149. Rob Kitchin, *The Ethics of Smart Cities and Urban Science*, 374 PHIL. TRANSACTIONS ROYAL SOC'Y A. 11–12 (2016).

150. *See generally* EVGENY MOROZOV & FRANCESCA BRIA, ROSA LUXEMBURG STIFTUNG, RETHINKING THE SMART CITY: DEMOCRATIZING URBAN TECHNOLOGY (2018).

151. *Id.* at 16.

regulates TNCs as common carriers,[152] which affords it some leverage to demand satisfaction of social goals, such as equity and environmental considerations. It has pursued ways to decrease vehicle emissions and ensure access for disabled users.[153] CPUC is even able to demand the provision of data by TNCs that can be used to develop regulatory policy. The point is that through regulating industries, elements of public interest can be advanced without full public ownership of infrastructure. Indeed, nationalization or socialization of infrastructure is not the only lever by which to manipulate the political economy of autonomous transport. That said, whatever distributions of power and control are achieved over transport systems, there is a great deal at stake in the connected car context.

2. *Machine Readable Spaces and People*

Systematic arrangements of control over transport infrastructures have both practical and ethical implications. In the connected car vision, control authority is delegated throughout the infrastructure and cars become individual nodes in a distributed information-processing and decision-making transport network. For example, an ordinary traffic light acts on an autonomous vehicle through light emanations that are sensed by a camera and then interpreted to indicate traffic rules. This is somewhat analogous to the traffic light indicating, by affordance, a normative or legal obligation on a driver to stop a car. A "smart" traffic light might communicate that instruction via radio signal, understood by both the vehicle and the human occupant that supervises the driving task. In the connected car archetype, however, a "smart" traffic light might stop a vehicle by directly disabling its motion. Versions of this paradigm that circumvent the need for visual signals that are meaningful to humans acutely raise Handoff questions: although we may believe human-visible signals are not necessary for functional purposes, their absence may result in systems that are inscrutable.

On one hand, this progression ameliorates the need for vehicles to directly sense physical infrastructure designed and built for human readability. That may be desirable considering the ease with which computational approximation of human sensing, like vision, can be fooled or hacked. There is evidence that computer vision processors on board autonomous vehicles might be tricked to not recognize road signs with a simple application of black

152. *See* CAL. PUB. UTIL. CODE § 5440 (West 2019).

153. *See generally* SIMI ROSE GEORGE & MARZIA ZAFAR, CAL. PUB. UTIL. COMM'N, ELECTRIFYING THE RIDE-SOURCING SECTOR IN CALIFORNIA: ASSESSING THE OPPORTUNITY (2018).

and white stickers.[154] On the other hand, infrastructures designed to computationally control vehicles may de-humanize roadways. This may mean that roadways and infrastructure privilege vehicles over other entities like pedestrians by making the experience of transport spaces less legible to non-networked humans. A road that no longer includes "stop" signs or traffic lights would be far more difficult to navigate as a pedestrian or cyclist. A more extreme example can be seen in cases like continuous flow intersections, which may have to exclude pedestrians from the space altogether. In other words, complex transport spaces may become "human exclusion zones."[155]

An alternative way of addressing these issues under the connected car vision is to ensure the machine readability of humans on roadways.[156] That is, require that humans become part of the machine-readable transport infrastructure. The development of Vehicle-to-Pedestrian (V2P) connectivity is an expression of that trajectory.[157] Designed to improve the sensing of humans (as pedestrians and cyclists) in shared spaces, V2P uses devices like smartphones as collision estimation modules.[158] In the same way that safety narratives shifted through the twentieth century from crash avoidance to vehicle crashworthiness, concentrations of infrastructure and vehicle ownership and control may produce a shift back to a technical paradigm of crash *avoidance*.[159] In other words, as infrastructure becomes a more dominant, controlling component, humans may have to become part of that controlling infrastructure to participate in public space. While visibility of humans in space has always been a trigger for a driver to engage with and control a vehicle, the point here is that concentrations of power in vehicle infrastructure enable

154. Kevin Eykholt, Ivan Evtimov, Earlence Fernandes, Bo Li, Amir Rahmati, Chaowei Xiao, Atul Prakash, Tadayoshi Kohno & Dawn Song, *Robust Physical-World Attacks on Deep Learning Visual Classification*, 2018 PROC. IEEE/CVF CONF. ON COMPUTER VISION & PATTERN RECOGNITION 1625, 1632.

155. Jesse LeCavalier, *Human Exclusion Zones: Logistics and New Machine Landscapes*, 89 ARCHITECTURAL DESIGN 48 (2019) (regarding logistical environments like warehouses).

156. The term "machine-readable humans" was first introduced in Daniel Howe & Helen Nissenbaum, *Engineering Privacy and Protest: A Case Study of AdNauseam*, 1873 CEUR WORKSHOP PROC. 57, 64 (2017).

157. *See generally* JOHN L. CRAIG, JANET FRASER & JASON CAMPOS, U.S DEP'T OF TRANSP., USDOT VEHICLE-TO-PEDESTRIAN RESEARCH: WHITE PAPER 3 (2017).

158. *See, e.g.*, Zishan Liu, Zhenyu Liu, Zhen Meng, Xinyang Yang, Lin Pu & Lin Zhang, *Implementation and Performance Measurement of a V2X Communication System for Vehicle and Pedestrian Safety*, 12 INT'L J. DISTRIBUTED SENSOR NETWORKS 1 (2016) (describing an architecture for such a system).

159. Jerry L. Mashaw & David L. Harfst, *From Command and Control to Collaboration and Deference: The Transformation of Auto Safety Regulation*, 34 YALE J. REG. 167, 257–58 (2017) (noting that autonomous vehicle technologies tend toward crash-avoidance and suggesting a return to the crash avoidance safety paradigm).

those actors to express their will over the physical world and to make it more machine-readable if that suits their agenda. This changes an individual's capacity to choose their relationship to a transport infrastructure and public space and to exist in public without technological augmentation and associated surveillance. Forcing cars to carry transmitting devices for the sake of road safety makes sense and clearly falls within the regulatory purview of governing road use. Building static infrastructure that can identify pedestrians that may wander into harm's way and communicate that to vehicles, such as computer vision systems at intersections or bus stops, goes further but has limited additional ethical impacts. Compelling pedestrians or cyclists to transmit their own location and movement, however, raises a markedly different question. This is a question that more closely hinges on the power of different entities to articulate their vision of the world.

This is very much the essence of the connected car conundrum. It is necessary to either remove elements of the roadway that are not amenable to infrastructural control (i.e., people) or to instrument and monitor them so that they become manageable for computational systems. These changes may be the product of democratic deliberation, or they may be the product of coercive, private infrastructural power.[160]

3. *Data Governance*

Data governance questions are similarly acute in the connected vehicle paradigm, with obvious implications on privacy. Clearly, the transmission of data is essential to the proper function of all the vehicles within a connected cars network. The data produced and distributed in a connected vehicle may include "technical data regarding the car and its components, data about the road, weather and traffic conditions, the driving behavior of the car drivers, location data, as well as data concerning the use of entertainment, navigation, and many other services by the car users."[161] Mass quantities of data streaming between vehicles and infrastructure create profound opportunities for third parties to participate in a new vehicular/infrastructural data economy, with the capacity to interact with vehicles (and the people within them) in real-time, for new purposes.

Beyond the mere functioning of vehicles, data governance will be influenced by commercial imperatives and thus provoke data protection and antitrust regulation, as well as competition over vehicle information architectures. To that end, proposed models for data architectures include

160. *See, e.g.*, Howe & Nissenbaum, *supra* note 156.

161. Wolfgang Kerber, *Data Governance in Connected Cars: The Problem of Access to In-Vehicle Data*, 9 J. INTELL. PROP. INFO. TECH. & E-COMM. L. 310, 312 (2019).

"shared servers," "in-vehicle"—i.e., consumer choice—data storage, manufacturer-controlled servers, and even "peer-to-peer" proposals, amongst others.[162] Where vehicle data is part of a continuing system of information flow between the vehicle and the vehicle manufacturer's servers, vehicle manufacturers would prefer to exclude third parties. Excluding third parties gives manufacturers more control over the vehicle interface and a commercial position in downstream markets like insurance.[163] More pro-market approaches prefer open access to vehicle data. This enables downstream actors like insurance companies to make the calculations relevant for designing their policies. Cautious consumers, on the other hand, might reject open access, preferring "in-vehicle" data storage systems that excludes third parties all together.

These various data governance approaches and architectures extend to the internal informational environment of the car. Indeed, in vehicles where humans express less control, the freed-up human attention will become the subject of market competition. In some information architectures, only the vehicle manufacturer controls the informational experience. Other approaches give multiple parties access to the infotainment system. In the United States, a group of twenty vehicle manufacturers have agreed to a voluntary regimes of privacy principles,[164] but vehicular information ecologies are already changing. Car manufacturers are already ceding control over vehicle interfaces to third parties.[165] As discussed above, it is possible this may extend to technologies actively controlling (i.e., driving) vehicles. If these types of mixed systems follow prevailing commercial logics, they could enable location and user-specific commercial messaging and otherwise radically different transport experiences.

4. *Responsibility and Autonomy*

This diffusion of car and driver components into a broader network of vehicles, infrastructure, manufacturers, and platforms also complicates questions of responsibility. Some have talked about how the introduction of

162. EUR. COMM'N, BIG DATA AND B2B PLATFORMS: THE NEXT BIG OPPORTUNITY FOR EUROPE (2019) (Workshop Brief, Second Workshop on "Fair and Equal Data Sharing for Cooperative, Connected and Automated Mobility"), https://www.ceps.eu/wp-content/uploads/2019/08/09172019-Brief_second_workshop_WP1_automotive-1.pdf.

163. Kerber, *supra* note 161.

164. *About Automotive Privacy*, ALL. OF AUTO. MFRS., https://autoalliance.org/connected-cars/automotive-privacy/ (last visited Sept. 6, 2020).

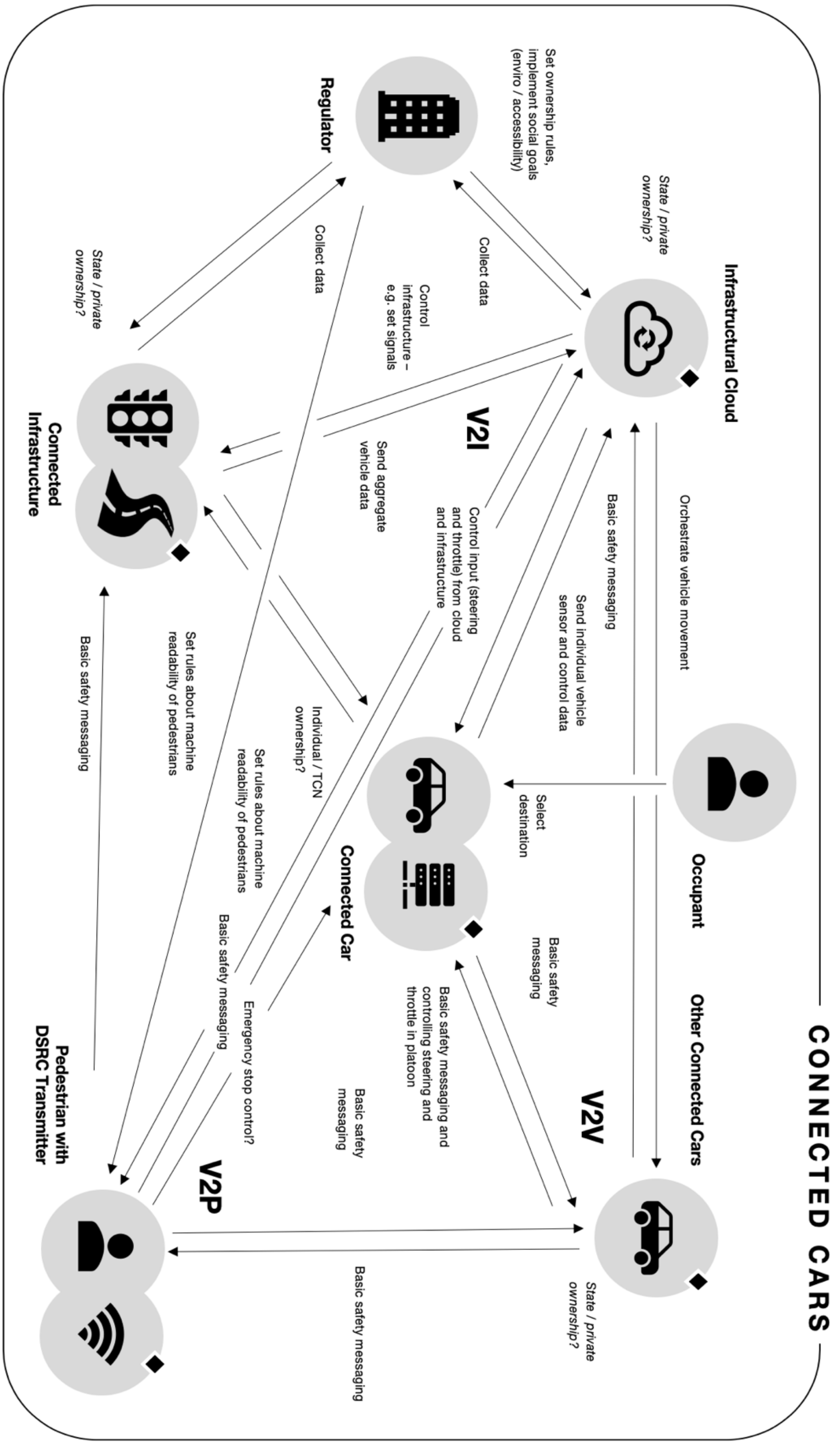
165. *See, e.g.*, Sean O'Kane, *GM Will Use Google's Embedded Android Automotive OS in Cars Starting in 2021*, THE VERGE (Sept. 5, 2019, 12:15 PM), https://www.theverge.com/2019/9/5/20851021/general-motors-android-auto-google-infotainment.

autonomous vehicles will transform the driving behavior of all road users into a single "driver"—the operating system of all vehicles operating on a certain network.[166] This represents a dramatic reconfiguration of what was once a relatively individualistic and private exercise into a broader technological network. But what would the reciprocal obligations between an individual and the network generally be? What if the sensors in one car fail because of improper maintenance, causing damage to other vehicles relying on that communications network? What if the network itself fails? In the division of fault and responsibility between vehicles and drivers, the conditions of transport infrastructure often implicate roads agencies in accident litigation. Claimants often sue over issues such as whether a road was appropriately designed, signaled, or maintained. Perhaps the camber of the road was too steep for the curve. Perhaps the speed limit was too high for the visibility. These questions will inevitably have to be reformulated in the connected roadways context. For instance, was there too much latency in the communications network? Why was a specific class of communications privileged over another class in any particular situation? Did a piece of infrastructure not transmit powerfully enough? Did the agent managing an intersection give inappropriate priority to a particular vehicle? What responsibility will the various components in the system, like state agencies or the entities operating the transport "platforms," bear for the proper operation of static infrastructure and communications networks? And, as discussed above, what responsibility will non-vehicle users of those infrastructural environments have to ensure their legibility to the ubiquitous, governing, infrastructural system?

166. *See, e.g.*, Mark A. Geistfeld, *A Roadmap for Autonomous Vehicles: State Tort Liability, Automobile Insurance, and Federal Safety Regulation*, 105 CAL. L. REV. 1611, 1621 (2017). The question of responsibility is discussed here primarily in philosophical rather than legal terms. Insurance and legal liability rules are designed to apportion risk and fault according to a specific economic or behavioral calculus. The novel questions around both civil and criminal legal responsibility have been subject to a great deal of insightful analysis. *See* sources cited *supra* note 108. While the question of human responsibility is an element of that calculus, the necessity of finding fault is also often avoided in liability systems through the introduction of no-fault or strict (product) liability systems. On the other hand, these systems often work in concert with negligence actions seeking to apportion fault to an appropriate party. The technical complexity of control hand-overs suggest the apportioning of legal liability between a vehicle manufacturer and human driver according to standards of performance (or negligence) may be difficult unless there are extreme examples of negligence or product failure. This may result in product liability approaches, single insurance schemes where a single insurer covers both the driver and the manufacturer, or even no-fault compensation schemes. Ascertaining an appropriate liability regime is not the goal of this analysis, however. Instead, we explore the question of how the information interface may result in defining the experience of responsibility for the operation of a vehicle.

The autonomy question is more complex still. Connected car approaches inevitably involve loss of individual control over cars, as well as a potential loss of control over the general informational environment. This is presented as part of the trade-off associated with using a "smart city" style platform. For instance, in order to obtain the greater public benefits of high-speed travel or continuous flow intersections, the loss of autonomy becomes the cost of obtaining access to the benefits of the "smart city." Taking our continuous flow intersection example further, one could imagine a stratification of users with respect to waiting times for cars, quality or age of vehicles, and efficiency of routes being informed by commercial imperatives. As discussed, the agreeability of that trade-off will depend on the general agenda of the "smart city." This may be highly commercialized, or it may be a primarily public arrangement. However, the consequences will inevitably include a shift away from a human driver in a vehicle and into either a public, communal, social infrastructure designed for common benefit or a corporate infrastructure designed for profit.

Figure 3: Distribution of Components in Connected Cars



IV. VALUE CHOICES IN AUTONOMOUS VEHICLE FUTURES – GUIDANCE FOR POLICY-MAKERS

The Handoff model has helped us flesh out key value propositions latent in possible autonomous vehicle futures. In contrast to the traditional tale of neat, linear building blocks towards full autonomy, suggested by the SAE taxonomy,[167] our analysis foregrounds a range of values beyond security in play across all autonomous vehicle futures. It reveals that the structural, legal, and normative constraints that stabilize the meaning and relative protection of particular values are unsettled or even upended in distinct autonomous vehicle futures.

Each autonomous future breaks more radically with certain current arrangements, unmooring particular values. Driver assist upends traditional expectations of agency and responsibility as assigned to human and technical actors. It requires cars to be more responsive to the specific lived realities of human drivers. Doing so requires new data flows, interaction patterns, and demands enhanced policy attention to human-machine-interface issues.

Driverless vehicles rearrange current understandings of what physical relationships must exist for a human to drive a vehicle. This disjuncture between physical presence and driving creates new questions about human responsibility and liability creating the need for real-time observation and communication to support remote humans when called on to drive.

If driverless cars destabilize the relationship between physical presence and driving, connected cars destabilize the boundary of the "car" itself. Bringing cars into a connected city infrastructure requires radical changes to the physical and informational environment, as well as the behaviors of the humans who occupy it. The complex coordination inherent in connected cars leans toward centralized models of vehicle ownership and data collection, opening up new questions about competition and data governance. Because the state has the potential to be an owner or to have broader regulatory authority, this archetype may open up some distinct opportunities to enhance the extent to which equitable access and environmental issues are considered to be within the frame of autonomous vehicle futures policy.

By allowing us to more clearly see and understand the political nature of each autonomous vehicle future, the Handoff analysis makes space for designers, policymakers, and the public to reflect on the values we seek to maintain and foster in autonomous vehicle futures. Rather than leaving values to fallout from processes that center the technical, the Handoff model emphasizes the "three-way intersections between design, practice, and policy

167. SAE INT'L, *supra* note 22 (setting out five levels of automation).

[that] show up with particular complexity and importance during periods of formation and emergence,"[168] and directs our gaze to the values that ought to be centered in the "policy knots"[169] of specific autonomous vehicle futures. Whether or not they are in sight, the values at stake in these futures will be addressed through design, practice, and policy. By shaking them loose, these values become not only a lens through which we choose among autonomous vehicle visions to pursue but also explicit goals to be stabilized through the technical, legal, and social practices necessary to enact desired autonomous vehicle futures. Below we discuss key policy issues raised by each archetype.

A. DRIVER ASSIST

Norms and laws expect humans to watch and audit technical actors and to read and act on technical interfaces. Yet the coordination essential for safety in the driver assist archetype and the evolving standards and regulatory frameworks require cars to be more aware of and responsive to the specific lived realities of human driving partners. The complex interactions of Handoffs (the human assessing whether the technical driver can be assigned driving tasks under existing conditions) and throwbacks (when the technical driver determines the boundary conditions that define its license to drive have been reached) demand new modes of acting-on and acting with. To enable this coordination, technical actors are required to monitor and groom human actors, and human actors are expected to monitor and heed technical actors. New data flows arise to support such interaction patterns between human and technical drivers.

1. *Agency, Responsibility, and the Changing Roles for Human and Technical Actors*

The complex coordination required as human actors shift into the role of driver, either when technical components reach their limits or because they simply wish to drive, raises important questions about how to maintain or secure necessary levels of human attention. Users performing any action in a vehicle that vehicle designers did not intend can contribute to a safety problem. If a vehicle does not actively monitor and engage the attention of the driver,

168. Steven J. Jackson, Tarleton Gillespie & Sandy Payette, *The Policy Knot: Re-Integrating Policy, Practice and Design in CSCW Studies of Social Computing*, 2014 PROC. 17TH ACM CONF. ON COMPUTER SUPPORTED COOPERATIVE WORK & SOC. COMPUTING 588, 592.

169. The "multiple gatherings and entanglements through which worlds of design, practice and policy are brought into messy but binding alignment." *Id.* at 589.

the driver is likely to perform in ways the vehicle designers did not anticipate.[170] This raises issues of a vehicle manufacturer or operator's responsibility for the driver's role in the safety system of the vehicle and how a vehicle ought to condition the conduct of its occupants. These questions of responsibility in driver assist cars are different, and perhaps more complex, than in fully driverless implementations.

The complex, coordinated action demanded in the driver assist archetype challenges the stepwise safety progress presented by the traditional autonomous vehicle narrative. While autonomous driving futures are generically and uniformly portrayed as decreasing the risk of accidents due to distracted, intoxicated, or otherwise impaired drivers by transferring responsibility to the sober and stalwart technical driver, the story in the driver assist archetype is more complicated and contingent.[171] The driver assist archetype positions the human driver—even when not driving—as the ultimately responsible and always available driver: the driver of first and last resort. While the human driver can make the first move—i.e., by calling the technical driver into being—the technical driver can always demand that the human resume driving.[172]

The ability of the technical actor to pass driving back to the human presents unique safety challenges. First, the Handoffs themselves—even with a fully awake and attentive human in the driver's seat—happen in short time frames and under challenging conditions. As the child's game of "hot potato" teaches us, even handling a simple object and managing a simple objective becomes difficult under conditions of uncertainty and pressure. In the context of driving throwbacks, the objects are large, heavy, and may behave in ways that humans find difficult to predict. At the same time, the conditions are

170. Miller et. al., *Distraction Becomes Engagement*, *supra* note 115, at 1679 (explaining the complex relationship between different media, different modes of delivery, drowsiness and re-engagement time and the design challenge this presents for the autonomous vehicle media environment).

171. *See* CASUALTY ACTUARIAL SOC'Y AUTOMATED VEHICLES TASK FORCE, RESTATING THE NATIONAL HIGHWAY TRANSPORTATION SAFETY ADMINISTRATION'S NATIONAL MOTOR VEHICLE CRASH CAUSATION SURVEY FOR AUTOMATED VEHICLES 14 (2014) (stating that the results of the National Highway Transportation Safety Administration's 2008 National Motor Vehicle Crash Causation Survey "do not conclusively determine the number of accidents automated vehicles will eliminate" because "the driver remains a vital part of the accident-reduction equation," and "[d]river behavioral issues may interfere with optimal implementation of the technology in over 30% of the accidents").

172. Our driver assist archetype captures levels 1–3 in the SAE taxonomy in which the driver is always responsible for driving, must be ready to immediately resume whatever driving tasks the car has been assigned when the car determines it is necessary, and is designated the "fall-back driver." *See* SAE INT'L, *supra* note 22.

variable and complex, and are made more so by the behaviors of other humans also driving on the road. Freeing the human occupant from the mundane task of driving and inviting them to relax and potentially even turn their attention to other tasks is a key selling point of automated vehicles. However, in a driver assist scenario, this invitation to relax or reduce focus can be in tension with the need to quickly and unexpectedly have a human become the driver. While research suggests some interesting, counterintuitive relationships between human attention to other tasks and transitions into the driving role:[173] 15.3% of all accidents are caused by distractions or inattention today.[174] In the driver assist archetype, safety demands successfully navigating these Handoffs between human and technical actors.

Second, an inebriated or intoxicated human is less able to handle the cognitive and physical demands of a call to action. While driving drunk causes accidents, being unexpectedly and jarringly called to drive may cause more. Inebriated humans are unlikely to foresee a call to drive and may get behind the wheel, lulled by the belief that they will not need to drive, rather than rely on a designated driver or call a cab. This might lead the driver assist archetype to increase the number of inebriated humans behind the wheel even if it decreases accidents caused by drunk drivers.[175] At the same time, it introduces the possibility that vehicles place less faith in their human occupants as controllers and prioritize the authority of the technical system. Problems associated with that approach are apparent with the example of two Boeing 737 MAX passenger planes crashing in 2018 and 2019.[176] In each case, it appears that the pilots fought unsuccessfully against a malfunctioning automation system that repeatedly pushed the nose of the plane downward.[177]

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173. *See, e.g.*, Miller et. al., *Distraction Becomes Engagement*, *supra* note 115 (finding that, contrary to common assumption that in-car entertainment would increase accidents due to distraction, watching videos or reading tablets reduced behaviors indicative of drowsiness and did not impair reaction time: discussing other work suggesting that engaging fallback drivers in "mentally activating activities" may be safer because it reduces the chance of a drowsy individual being asked to assume the wheel).

174. CASUALTY ACTUARIAL SOC'Y AUTOMATED VEHICLES TASK FORCE, *supra* note 171, at 13.

175. *Id.* at 11.

176. *See* NAT'L TRANSP. SAFETY BD., SAFETY RECOMMENDATION REPORT: ASSUMPTIONS USED IN THE SAFETY ASSESSMENT PROCESS AND THE EFFECTS OF MULTIPLE ALERTS AND INDICATIONS ON PILOT PERFORMANCE 2–3 (2019) (describing the Lion Air Flight 610 and Ethiopian Airlines Flight 302 accidents, both of which involved Boeing 737 MAX 8 planes).

177. *Id.*

The difficulty of coordinating between human and technical drivers has led some manufacturers to pursue other autonomous vehicle futures.[178]

Existing case law and guidance interpreting the National Traffic and Motor Vehicle Safety Act (NTMVSA)[179] provides guidance on the extent to which vehicle manufacturers and others need to anticipate divergent—even deviant—behavior, including interactions between original, replacement, and after-market components. NTMVSA establishes that, for purposes of a recall under NTMVSA, a motor vehicle contains a "defect" when it fails in normal operation,[180] including failures resulting from reasonably expected or "ordinary abuse."[181] However, NTMVSA provides an affirmative defense where a manufacturer can show that "the failures were attributable to gross and unforeseeable owner abuse or unforeseeable neglect of vehicle maintenance."[182] The law therefore requires vehicle manufactures to consider "reasonably foreseeable," "reasonably contemplatable," and "ordinary abuse,"

178. *Id.*; *see also* John R. Quain, *Makers of Self-Driving Cars Ask What to Do with Human Nature*, N.Y. TIMES (July 7, 2016), https://www.nytimes.com/2016/07/08/automobiles/wheels/makers-of-self-driving-cars-ask-what-to-do-with-human-nature.html (describing Google's conclusion that "the only safe way to proceed is to take the driver out of the equation" and Volvo's pursuit of "Level 4 cars . . . that don't require any driver input aside from setting a destination" to reduce the safety risks posed by human driving error).

179. National Traffic and Motor Vehicle Safety Act of 1966, 15 U.S.C. §§ 1381, 1399, 1411 (1966) (repealed 1994) (requiring manufacturers that obtain knowledge of a safety-related defect to notify the Secretary of Transportation and remedy the defect, as well as authorizing the Secretary to order a manufacturer to remedy a safety-related defect).

180. *United States v. Gen. Motors Corp.*, 518 F.2d 420, 427 (D.C. Cir. 1975). A defect under the NTMVSA is distinct from a defect under products liability law because the showing of defect required for purposes of regulatory-inspired notification is less than that required to prove a defect for product liability purposes. *See id.* However, recall letters and evidence are generally admissible for the limited purpose of showing that the defect existed or arose in a product while in the hands of the manufacturer. 5 Products Liability § 57.05 (2020); *see also* James T. O'Reilly, *Dialogue with the Designers: Comparative Influences on Product Design Norms Imposed by Regulators and by the Third Restatement of Products Liability*, 26 N. KY. L. REV. 655, 666 (1999) (explaining that, while the Third Restatement recognizes violation of a product safety requirement as a basis for liability, this alone is not enough to prevail, as "the court would examine the law or rule; determine whether it applies (taking into consideration the exclusions and qualifiers that the law or rule provides); explore the historical record of the statutory findings, statutory purpose clause, or rulemaking preamble explaining the purposes of the regulation; and compare the law's or rule's purposes of preventing risk, with the scenario of actual harm [the] plaintiff has suffered").

181. *Gen. Motors Corp.*, 518 F.2d at 434, 438 ("The protection afforded by the [Safety] Act was not limited to careful drivers who fastidiously observed speed limits and conscientiously complied with manufacturer's instructions on vehicle maintenance and operation. . . . [The statute provides] an added area of safety to an owner who is lackadaisical, who neglects regular maintenance . . . .").

182. *Id.* at 438.

thus taking into account the expected range of actual operations, past experiences with comparable vehicles, and information provided to owners about the capabilities of a vehicle. The regulatory framework's focus on defects that arise from reasonably foreseeable misuse is particularly significant in that, if the government can establish the existence of more than a *de minimis* number of failures in a safety related component, it neither needs to show what caused the failure nor rule out misuse by the user if it was "reasonably foreseeable."

NHTSA's most recent guidance document on autonomous vehicle policy gives an indication of the potential importance of its recall authority,[183] including the associated record-keeping and reporting requirements in the autonomous vehicles landscape.[184] It requests that manufacturers provide it with a "safety assessment letter" that details how they are attending to fifteen broadly defined areas that might affect safety.[185] The NHTSA issued an "Enforcement Guidance Bulletin" affirming the performance orientation of defect analysis in its recall authority,[186] stating

> Unreasonable risks due to predictable abuse or impractical recalibration requirements may constitute safety-related defects. Manufacturers have a continuing obligation to proactively identify and mitigate such safety risks. This includes safety risks discovered after the vehicle and/or equipment has been in safe operation.[187]

This Bulletin, while only a guidance document, offers insight into how NHTSA views its existing regulatory authority ought shape the autonomous vehicle landscape. The Bulletin emphasized the breadth of the NHTSA's authority over original, replaced, and after-market vehicle components, including software.[188] It also noted that NHTSA' s authority covers devices "manufactured, sold, delivered, or offered to be sold for use on public streets, roads, and highways with the apparent purpose of safeguarding users of motor vehicles against risk of accident, injury, or death," which could cover software

183. *See* NHTSA, U.S. DEP'T OF TRANSP., FEDERAL AUTOMATED VEHICLES POLICY: ACCELERATING THE NEXT REVOLUTION IN ROADWAY SAFETY 11, 50 (2016) [hereinafter "HAV POLICY"].

184. *See id.* at 50.

185. *Id.* at 15–16.

186. *See* NHTSA Enforcement Guidance Bulletin 2016-02: Safety-Related Defects and Automated Safety Technologies, 81 Fed. Reg. 65705, 65708 (Sept. 23, 2016) (explaining that the agency can rely on an engineering defect or technical cause of a safety defect, but "merely a 'non-de minimis' quantity" of failures could be sufficient to support a defect finding).

187. *Id.* at 65705–06 (citations omitted).

188. *See id.* at 65707 ("software (including, but not necessarily limited to, the programs, instructions, code, and data used to operate computers and related devices), and after-market software updates" are motor vehicle equipment within the meaning of the Act).

"that enables devices not located in or on the motor vehicle to connect to the motor vehicle or its systems."[189] For these reasons, it reminded suppliers of equipment that they too were bound by the notification duties for safety-related defects set out in the Act.[190] Importantly for this "driver assist" archetype, the Bulletin focused on the issue of human-machine coordination, emphasizing "[a] system design or configuration that fails to take into account and safeguard against the consequences of reasonably foreseeable driver distraction or error may present an unreasonable risk to safety."[191] Tort liability further shores up NHTSA's position that manufacturers cannot merely warn drivers to stay alert but must design for the foreseeable risks of distraction and inattention. Manufacturers and others must adopt fault-tolerant designs for driver assist whenever doing so would be a cost-effective method for reducing the risk of driver error.[192]

Beyond clarifying that known and foreseeable human failings must be accounted for in autonomous design, NHTSA has provided limited guidance. NHTSA's autonomous vehicle policy directs manufacturers and other entities to document processes for assessing, testing, and validating the human-machine interface issues so important in the driver assist archetype.[193] However, beyond directing that autonomous vehicles should include indicators that inform humans that the system is properly functioning, engaged, unavailable, malfunctioning, or requesting the human resume driving, it points manufacturers and others elsewhere for concrete guidance.[194]

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189. *Id.* (citations omitted).

190. *See id.*

191. *Id.* at 65709 (offering three examples that touch on the safety implications of shifting interfaces and affordances including: a gearshift lacking standard tactile cues offered without a safety or method of effective warning to prevent a driver from exiting a vehicle that is not in park; a driver assist archetype that does not account for "reasonably foreseeable situations where a distracted or inattentive driver-occupant must retake control"; and a software system that is expected to last the life of the vehicle but does not receive secure updates which results in a safety risk).

192. Geistfeld, *supra* note 166, at 1627–28 (explaining that product liability requires "fault-tolerant product designs" ("[W]hen a safer design can reasonably be implemented and risks can reasonably be designed out of a product, adoption of the safer design is required over a warning that leaves a significant residuum of such risks.") and that the standard requires application of the risk-utility test, "which requires the product design to incorporate any safety feature costing less than the associated safety benefit").

193. *See* HAV POLICY, *supra* note 183, at 22. In addition to the human driver, manufacturers and others are directed to consider the human factor and communication needs of passengers, other vehicles, and pedestrians. *See id.*

194. *See id.* (directing entities to the SAE International, ISO, NHTSA, American National Standards Institute, and the International Commission on Illumination).

The core technical standard defining levels of automation provides very little direction on human-machine interactions. It describes actions essential to the coordination (such as monitoring),[195] roles (such as the "fallback-ready user"),[196] and aspects of humans ("receptivity"),[197] but provides little guidance about the intricacies of the delicate, interactive dance required of the human and technical actors. In levels 1 through 3, existing guidance emphasizes human authority (requiring technical actors to "disengage[] immediately upon driver request") and human responsibility (stating that human drivers must "supervise . . . and intervene to maintain safe operation" at levels 1 and 2 and must "verif[y] . . . readiness" and "determine[] . . . appropriate[ness]" of engaging the autonomous vehicle, remain "receptive to a request to intervene," and "determine[] whether and how to achieve minimal risk condition," at level 3).[198] At levels 4 and 5, the guidance emphasizes the greater authority of technical actors, allowing them to "permit[] engagement" of the driving automation system and "delay user-requested disengagement."[199] A 2016 NHTSA report found that, despite the importance of human-machine interaction issues to safety in increasingly autonomous vehicles, existing standards provided very limited guidance on human factors for safety.[200]

The importance of the complicated, coordinated actions between humans and technical actors for human life demands greater attention and activity by the NHTSA. More can be done to enable sound human-machine interaction research and design processes. As the autonomous policy requires, the NHTSA should hold public workshops and solicit external peer review to gather information to support the development of additional human-machine interaction guidance. Workshops and expert reviews should seek to import guidance from aviation safety, where recent events have starkly revealed the risks of misunderstandings between human and technical actors who share operational tasks. However, experts caution against use of the "aviation precedent" as "take-over procedures that might work effectively in aviation

195. SAE INT'L, *supra* note 22, at 12–13.

196. *Id.*

197. *Id.* at 14 (defining receptivity as "an aspect of consciousness characterized by a person's ability to reliably and appropriately focus his/her attention in response to stimulus").

198. *Id.* at 21–22.

199. *Id.* at 22–23.

200. *See* QI D. VAN EIKEMA HOMMES, NHTSA, ASSESSMENT OF SAFETY STANDARDS FOR AUTOMOTIVE ELECTRONIC CONTROL SYSTEMS 22 (2016) (reviewing ISO 26262: Road Vehicles–Functional Safety, MIL-STD-882E: Department of Defense Standard Practice–System Safety, DO-178C: Software Considerations in Airborne Systems and Equipment Certification, FMVSS: Federal Motor Vehicle Safety Standard, AUTOSAR: Automotive Open System Architecture, and MISRA C: Guidelines for the Use of the C Language in Critical Systems).

simply do not transfer to the ground vehicle case, regardless as to how much designers might like to think so or try to make it so."[201]

Addressing what's been historically called the "hours of boredom and moments of terror" problem[202]—but now manifests as the "months of monotony to milliseconds of mayhem" problem[203]—requires experts to distill insights. This problem also requires the NHTSA and others to produce guidance from the slim but growing set of autonomous vehicle crashes and the disengagement reports required by states such as California. These real-world autonomous vehicle case studies allow designers and policymakers to better understand the human-machine interaction challenges arising from the operational conditions in which different manufacturers are testing autonomous vehicles. Pursuing the driver assist archetype creates an urgent need to put human-machine interface issues "at the forefront of conceptualizing our future through technology, as opposed to 'sweeping up after the parade has gone by.' "[204] To date, policy makers in the United States have neglected the urgency and importance of this task.

B. DRIVERLESS CARS

Driverless autonomous vehicles sever the physical relationship between human drivers and vehicles. Human occupants cannot drive; instead, humans at physically distant locations can and at times must. Human occupants are freed of responsibility and liability. The car's occupants remain in the physical crumple zone, but the distant human fallback driver is now in the "moral crumple zone."[205] The real-time observation and communication needs of this physically distant human "fallback driver" destabilizes the role the car as a "place" plays in protecting privacy.[206]

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201. Peter A. Hancock, *Some Pitfalls in the Promises of Automated and Autonomous Vehicles*, 62 ERGONOMICS 479, 484–85 (2019).

202. PETER A. HANCOCK & GERALD P. KRUEGER, NAT'L DEFENSE UNIV., CTR. FOR TECH. & NAT'L SEC. POL'Y, HOURS OF BOREDOM, MOMENTS OF TERROR: TEMPORAL DESYNCHRONY IN MILITARY AND SECURITY FORCE OPERATIONS (2010).

203. *Id.* at 3.

204. D. D. Woods, Presidential address of the Human Factors and Ergonomics Society: Watching People Watch People at Work (1999).

205. *See generally* Madeleine Clare Elish, *Moral Crumple Zones: Cautionary Tales in Human-Robot Interaction*, 5 ENGAGING SCI. TECH. & SOC'Y 40 (2019).

206. *See* Dorothy J. Glancy, *Privacy in Autonomous Vehicles*, 52 SANTA CLARA L. REV. 1171, 1219–25 (2012) (discussing protection for privacy rights associated with vehicles on public roads).

1. *Repositioning the "Moral Crumple Zone"*

While the scholarly consensus is "that elimination of a human driver will shift responsibility onto manufacturers as a matter of products liability law, with most tort litigation involving claims for design or warning defects,"[207] our attention here is one step down. It seems unlikely that even the driverless archetype will completely delegate control to the technical actors.[208] Within the car manufacturer, the human operator *qua* "fallback driver"—who must exist in the current testing environment, and, as we posit above, will inevitably persist in the driverless archetype due to material obstacles, equipment malfunctions, and unexpected events including hostile attacks—seems positioned in what Madeleine Clare Elish named the "moral crumple zone."[209] The displacement of the human in the car, coupled with their role as "fallback," or shall we say "failsafe," for a system presented as "driverless," brings attention to a particular set of political and ethical consequences.

Who are the remote "fallback drivers" in the driverless car future? Are these the content moderators and crowd workers of the future? Like the crowd workers performing a vast range of "microwork" behind the scenes and screens of today's AI driven platforms, as documented by Mary L. Gray and Siddharth Suri, these humans will be called into action to exercise human judgment where computation fails.[210] This work is likely to be a catastrophic mix of boring and high stakes. Like the "safety driver" implicated in the Uber fatality described above, will these humans, bored by the monotony of supervising machines designed to perform largely without supervision, find themselves asleep at the wheel, mired in guilt, and blamed for being unready or unable to quickly assume control for driving when the car demands?

As described above, the interfaces and affordances may do a better or worse job positioning or priming these "fallback drivers" for the quick action required. Will interfaces for remote human "fallback drivers" be designed like cockpits and aligned with the bespoke one-on-one driving experience elicited by the driverless car archetype, perhaps keeping them on edge and aware of the lived experience of passengers hurtling down a winding mountain road or

207. Geistfeld, *supra* note 166, at 1619–20.

208. *See id.* at 1630 (explaining that the NHTSA's ruling that Google's self-driving car is the equivalent of a human driver for federal regulatory purposes, and that this logic resolves the associated tort questions necessary to establish manufacturer liability despite the absence of case law "recognizing that a manufacturer incurs a tort duty for defective software").

209. Elish, *supra* note 205, at 41 (arguing that the "moral crumple zone" represents the misattribution of a failure in a complex socio-technical system to a human actor who had limited control over the behavior).

210. *See generally* MARY L. GRAY & SIDDHARTH SURI, GHOST WORK: HOW TO STOP SILICON VALLEY FROM BUILDING A NEW GLOBAL UNDERCLASS (2019).

inching through streams of rubbernecking traffic? Or will they mimic the bird's-eye view, inviting a more disinterested and less embodied experience of "fallback" driving? Given the presumption of minimal intervention captured in the term "fallback driver," one can imagine a single human safety operator managing numerous cars. Yet the stakes can be extraordinarily high if any single car requires human intervention, let alone several at once in the event of a disengagement due to a system malfunction or cybersecurity exploit that affects numerous vehicles.

The mindset and role evoked by the job description and requirements, employee training, and interface design will shape this new, online-crowd-workers perception of the fallback drivers' work. While rules in states like California currently set guidelines about job requirements—requiring drivers to obtain appropriate licenses and show competency with the skills relevant to particular driverless vehicles and requiring companies to submit training materials—it is unclear whether and how such requirements will persist when autonomous vehicle manufactures claim their driverless cars satisfy NHTSA safety standards.

The "last mile" of AI functionality in the driverless car archetype seems as likely to rely on human judgment as content management, facial recognition, and furniture identification. The question is whether these human drivers, though removed from the car, will nonetheless remain in the hot seat.

While many legal scholars have opined on the shift of liability to manufacturers for driver assist and driverless cars,[211] none have considered which specific humans within the manufacturer will bear the blame. The "moral crumple zone" "call[s] attention to the ways in which automated and autonomous systems deflect responsibility in unique and structural ways, protecting the integrity of the technological system at the expense of the nearest human operator."[212] As both the Volkswagen emissions scandal and the Arizona Uber crash that Elish reviews in her discussion[213] reveal, manufacturer liability for technical wrongdoing can be placed on different internal actors. There is a high likelihood that "fallback drivers" will be very low on the food chain, even more so than the Uber "safety-driver"—perhaps, at best, akin to the Uber and Lyft drivers of today and, at worst, akin to the

211. *See* Geistfeld, *supra* note 166, at 1619 n.25 (noting scholarly consensus that elimination of a human driver will shift responsibility onto manufacturers with respect to products liability law but divergence about exactly how liability claims will be sorted out and how to apportion responsibility among the manufacturer and other entities within the supply chain).

212. Elish, *supra* note 205, at 51–52.

213. *See id.* at 52–53 (describing how video footage of the safety-driver glancing down into her lap led both police and reporters to blame her for the accident).

low wage offshore workers of today's *Ghost Work* force. Battles over the legal status and rights of today's AI-backstopping workforce may seem more central when lives hang more fully off their work and the consequences of holding them accountable for failures—placing them in the crumple zone—seems less commensurate with their pay and more personally and legally disastrous.

C. CONNECTED CARS

If driverless cars destabilize the relationship between physical presence and driving, connected cars destabilize the boundary of the "car" itself. Connected cars are more appropriately viewed as one element of a connected city or environment. The physical, informational, and legal dependencies needed to stabilize a connected vehicles future present the most radical break from current arrangements. It requires material and human elements to actively support vehicle mobility. From embedding streets and signs with computation and communication to rerouting pedestrian and bike traffic, the connected cars archetype demands legibility and predictability of other human and material actors. This archetype places intelligence and action largely outside of the vehicles themselves. The complex coordination inherent in the connected cars archetype depends upon a bird's-eye view and complex algorithms. This in turn leans heavily toward centralized models of vehicle ownership and data collection, which creates questions about competition and data governance. Because the state has the potential to be either an owner or a regulator of private owners, this centralization opens up some distinct opportunities to enhance the extent to which equitable access and environmental issues are considered within the frame of autonomous vehicle futures policy.

1. *Legibility*

The complexity of coordination required for streaming traffic flows and other imagined goods of the connected car archetype rely heavily on algorithms. These algorithms demand consistent, predictable, and machine-readable environments. The heightened levels of dependence on the accuracy and reliability of data coming into the connected car environment places a larger burden on the built environment and human and other occupants to be legible. In this archetype, cars, roads, and street signs may all be viewed as critical infrastructure.

This portends either a massive re-instrumentation of urban environments or a tight alignment between connected cars and new urban environments such as the now defunct Sidewalk Labs Toronto Waterfront project that can be architected from the ground up and the network down. Retrofitting existing environments is cumbersome and expensive, and coexistence with non-connected cars is difficult and dangerous.

It is easy to imagine that small acts of rebellion—tagging stop signs—previously viewed as low level crimes could be viewed and prosecuted more seriously due to the potential implications for human safety. While a human can readily comprehend the meaning of a stop sign despite many forms of graffiti, machine learning algorithms are less resilient. As on the internet, where tagging websites has at times been considered and prosecuted as a federal crime, the meaning and effect of graffiti may change as safety depends more and more on legibility. As in the airport where we perform for security screening machines by taking off shoes, removing certain items of clothing, and items from pockets and bags to make ourselves and our belongings more legible, the connected cars environment might require us to enact our humanness in prescribed ways.

Perhaps norms will evolve as parents urge their children to carry smart phones set to signal human presence to the connected car network. Perhaps such signaling will be legally required in some contexts or efforts at obfuscation subject to criminal charges. If human safety hangs in the balance, all sorts of soft and hard demands for cooperation could arise.

2. Ownership and Centralization

Each archetype is currently more aligned with particular ownership models—of vehicles or of infrastructure and information flows. While driver assist models support private individual ownership and driverless models lend themselves to TNC fleet management, connected cars models extend beyond the vehicle to also include static infrastructure. Ownership and business models influence the ability of regulators to foster public goods, such as equitable access to transportation, or reduce the production of negative externalities, such as pollution.

The connected car archetype offers perhaps the starkest example of this. The communication, control, and data processing platforms that control vehicles, as well as the vehicles themselves in this archetype, may be offered by technology companies or alternatively by—or in cooperation with—cities, states, roads organizations, or other governing bodies. Either way, this archetype seems certain to discourage today's dominant personal ownership model and position data about mobility as a collective resource.

3. Privacy

As in the smart city and smart grid context, issues of data governance will demand renewed attention. The privacy issues arising from massive collections of individuals' data demand close scrutiny, but so do questions about the extent to which analysis and use of these new data troves could serve public purposes.

The robust, real-time monitoring and data collection from the user and continuous access to the software ecosystem of cars presented in each archetype create new privacy and security challenges, as well as issues for competition and consumer protection.[214] Even where connectivity will not be essential for active control, it will likely continue to be an intrinsic part of the vehicle "service" due to the need to update software to address emerging security and safety risks, which raises further ethical and political questions. Some have argued that if Android driving platforms—or some equivalent—became the norm for private vehicles, we might see "platform economy" surveillance dynamics at work even in those privately owned and operated vehicles.[215] Current battles around consumers' and non-manufacturers' rights to repair machinery with embedded code will no doubt escalate.[216]

There is little question that data produced through interaction with the applications and platforms of TNCs, as well as communications between human occupants and remote operators/drivers, will be collected and used by companies to optimize performance and improve safety. Whether they can or must be transmitted to other entities for the sake of informing or enforcing public policies, supporting ancillary commercial activities such as behavioral advertising, or increasing competition is less settled. Questions about the identifiability, retention, and permitted uses of data transmitted among automobiles and between automobiles and infrastructure are an active site of policy making and remain unsettled.[217]

For instance, driverless cars will likely record video footage from inside the cabin. Today's in-cabin recording systems and dash-cams typically only retain footage for a short time before overwriting older data.[218] Retention of video footage is triggered by events like heavy braking or driver intervention. Without a driver to ensure important footage is maintained, for instance, after

214. *See generally* Mulligan & Bamberger, *supra* note 69 (describing potential for the security-necessary, over-the-air updates to compromise security, limit competition, and undermine consumer protections and privacy, and the need for regulations to address such potential risks).

215. *See, e.g.*, Luis F. Alvarez León, *Eyes on the Road: Surveillance Logics in the Autonomous Vehicle Economy*, 17 SURVEILLANCE & SOC'Y 198 (2019).

216. *See generally* Mulligan & Bamberger, *supra* note 69.

217. *See* HARDING, *supra* note 131, at 144–57 (2014) (discussing privacy issues, draft privacy impact assessment, conflicts between privacy and other goals such as recalls, and the range of potential technical and policy controls).

218. *See, e.g.*, *Garmin Offers Dash Cam*, FLEETOWNER (Mar. 19, 2014), https://www.fleetowner.com/technology/article/21687441/garmin-offers-dash-cam (describing Garmin dash cam recording practices as: "When an incident—like hard braking or a collision—is detected by the built-in G-Sensor, Dash Cam knows to save the current, last and next recordings, preserving a complete record of the event").

an accident, commercial autonomous vehicle in-cabin surveillance will likely require computational pattern recognition or computer vision systems that continuously evaluate or profile the behavior of all occupants without necessarily transmitting or continuously recording all content. But if in-cabin video footage is streamed and potentially captured to support remote operation, it may be an attractive method for evaluating the experience of users and deterring property damage or other forms of undesirable behavior.[219]

Various state and federal actions have been taken to address some of the privacy issues arising from increased data collection in increasingly automated and connected cars. Existing federal law governing access and use of data collected by "event data recorders" (EDRs) set important privacy precedents.[220] California law requires either notice to users of the personal information collected by the autonomous technology that is not necessary for the safe operation of the vehicle and how it will be used or the anonymization of any such data.[221] This recent action builds on California's strong history of protecting privacy in the automotive sector. For example, California enacted the first law requiring automobile manufacturers that install EDRs in vehicles to disclose that fact in the owner's manual and limit the access and use of EDR data to either vehicle service and repair or for public safety purposes after the removal of identifiers.[222] California has also enacted legislation that limits abusive use of GPS data in the rental car market.[223]

Unfortunately, existing federal protections do not address the privacy issues raised by autonomous vehicles, and the NHTSA continues to shirk responsibility for addressing them. The privacy protections afforded by federal law address data that is captured by EDRs, which are defined as being *within*

219. *See* Meredith Broussard, *The Dirty Truth Coming for Self-Driving Cars*, SLATE (May 16, 2018, 9:00 AM), https://slate.com/technology/2018/05/who-will-clean-self-driving-cars.html.

220. *See* 49 U.S.C. § 30101 note (2015) (Driver Privacy Act of 2015) (establishing that data retained by an EDR is the property of the owner or lessee of the car and generally requires a court order for others to access it).

221. *See* CAL. CODE REGS. tit. 13, § 227.38(b)(1) (2018).

222. CAL. VEH. CODE § 9951 (West 2019).

223. CAL. CIV. CODE § 1939.23 (West 2019). The law was preceded by an action by the California Attorney General's Office under the state Business and Professions Code against a rental car franchise for failing to adequately notify renters of the presence of a GPS device in their rental vehicles. *See* Press Release, Office of the Att'y Gen., Attorney General Lockyer Announces $700,000-Plus Consumer Protection Settlement with State's Largest Independent Car Rental Firm (Nov. 9, 2006), https://oag.ca.gov/news/press-releases/attorney-general-lockyer-announces-700000-plus-consumer-protection-settlement.

the car.[224] In addition, the protections explicitly exclude audio and video data.[225] As described above, autonomous vehicles transmit data outside the car and rely on a range of data, including audio and video data, to support safety and other functionalities.[226] The privacy implications of this detailed data about the drivers and occupants of cars being streamed and stored outside vehicles require new regulations.[227]

The NHTSA's most recent guidance document on autonomous vehicle policy not only omits privacy guidance[228] but also eschews responsibility for it, stating that "privacy is not directly relevant to motor vehicle safety."[229] Furthermore, while the guidance document contains "best practices for states," it does not mention the privacy issues nor recommends approaches to address them.[230] In stark contrast, the NHTSA has provided detailed consideration of the privacy issues raised by proposed regulations for V2V and V2I communications.[231]

On the other hand, the Federal Trade Commission (FTC), the lead federal consumer protection agency, has indicated that privacy and security issues related to cars are fully within their sights and authority.[232] The transparency

224. *See* 49 C.F.R. § 563.5(b) (2011) ("Event data recorder (EDR) means a device or function in a vehicle that records the vehicle's dynamic time-series data during the time period just prior to a crash event . . . or during a crash event . . . , intended for retrieval after the crash event . . . [where] the event data do not include audio and video data.").

225. *See id.* ("[T]he event data do not include audio and video data.").

229. *See* discussion *supra* Section III.C.

227. Shane Prevost & Kettani Houssain, *On Data Privacy in Modern Personal Vehicles*, 2019 PROC. 4TH INT'L CONF. ON BIG DATA & INTERNET OF THINGS 1, 2–3 (describing the wealth of telematic and other data that a Tesla vehicle generates and transmits and the limitations of current federal privacy laws).

228. NHTSA, U.S. DEP'T OF TRANSP., AUTOMATED DRIVING SYSTEMS 2.0: A VISION FOR SAFETY (2017) [hereinafter "VISION FOR SAFETY"]. This is an about-face from the 2016 policy guidance which addressed privacy issues, reflecting the Obama Administration's commitment to privacy as stated in the *White House Consumer Privacy Bill of Rights*, as well as ethical implications of AV algorithms. *See* HAV POLICY, *supra* note 183, at 19. The 2016 guidance requested companies provide information about privacy and ethical implications in Safety Assessment Letters filed with NHTSA's general counsel's office for each autonomous vehicle. *See id.* at 15.

229. *Automated Driving Systems: FAQ*, NHTSA, https://www.nhtsa.gov/vehicle-manufacturers/automated-driving-systems#automated-driving-systems-faq (last visited Sept. 1, 2020) (noting the important role the Federal Trade Commission plays in protecting consumer privacy in the connected car space).

230. VISION FOR SAFETY, *supra* note 228, at 19–24.

231. *See* Federal Motor Vehicle Safety Standards; V2V Communications, 82 Fed. Reg. 3854 (proposed Jan. 12, 2017) (to be codified at 49 C.F.R. pt. 571).

232. *See, e.g.*, Ashkan Soltani, *Booting Up a New Research Office at the FTC*, FED. TRADE COMM'N (Mar. 23, 2015, 11:00 AM), https://www.ftc.gov/news-events/blogs

recommendation in the 2016 NHTSA autonomous vehicle policy, which called on manufacturers and other relevant entities to "provide consumers with accessible, clear, meaningful data privacy and security notices/agreements which should incorporate the baseline protections outlined in the White House Consumer Privacy Bill of Rights and explain how [they] collect, use, share, secure, audit, and destroy data generated by, or retrieved from, their vehicles,"[233] provided an important hook for the FTC's enforcement authority.[234] While companies may nonetheless provide some information about their privacy practices, the omission of privacy from NHTSA's current guidance sidelines privacy protection. In the absence of federal standards, states will fill the gap, creating an increasingly complex privacy regulatory framework for manufacturers, other vendors, and consumers.

4. *Changing the Values Aperture: Transportation Access and Environmental Impact*

At stake in these different formations is control over system functionality, residing in the hands of either highly efficient actors animated by profit or bureaucratized public entities responsive to a potentially distinct set of public goals, while subject to different forms of regulation and oversight or some hybrid of both. At first glance, one might view this as hinging fully on private versus public ownership of cars, infrastructure, and data, but such a view would miss an important site of action.

The different business models that might arise under the three archetypes invite in different potential regulators with different abilities to push for public

/techftc/2015/03/booting-new-research-office-ftc (describing the Office of Technology Research and Investigation's research on the Internet of Things, including connected cars); Donald S. Clark, Director, FTC, Comment Letter on the Advance Notice of Proposed Rulemaking Regarding Federal Motor Vehicle Safety Standards: Vehicle-to-Vehicle (V2V) Communications Pursuant to Chapter 301 of the Department of Transportation, Motor Vehicles and Driver Programs (Oct. 20, 2014), https://www.ftc.gov/system/files/documents/advocacy_documents/federal-trade-commission-comment-national-highway-traffic-safety-administration-regarding-nhtsa/141020nhtsa-2014-0022.pdf (raising privacy and cybersecurity issues); STEPHANIE GILLEY, FED. TRADE COMM'N, INTERNET OF THINGS WORKSHOP 235–91 (2013), http://www.ftc.gov/sites/default/files/documents/public_events/internet-things-privacy-security-connected-world/final_transcript.pdf.

233. HAV POLICY, *supra* note 183, at 19.

234. *See* Jessica L. Rich, FED. TRADE COMM'N, Comment Letter on "Federal Automated Vehicles Policy," at 3 (Nov. 21, 2016), https://www.ftc.gov/system/files/documents/advocacy_documents/comment-jessica-l-rich-director-bureau-consumer-protection-ftc-national-highway-traffic-safety/ntsb_letter_comment112116.pdf (explaining that the "transparency principle, which requires OEMs to have public-facing privacy policies, is an important one because it would permit the FTC to take action against companies that misstate their information collection and use practices").

priorities—private or public ownership is only the start of the conversation. The connected cars archetype invites in distinct regulators, with unique ambits, tools, dispositions, and relationships with stakeholders. For example, in California, the connected cars archetype will bring the CPUC into the mix. The CPUC's authority includes environmental, equity, and other public concerns intertwined with mobility, not just safety. Unlike the driver assist archetype and driverless car archetype, the connected cars archetype may allow public entities to prioritize agendas beyond safety—including equitable access and urgency—in vehicle routing. The CPUC has also broken new ground dealing with privacy and security issues in the context of demand response energy systems (the "smart grid"), giving them a sound basis for considering privacy and security issues in the "smart grid" of cars. Where NHTSA has deferred privacy at the federal level to the FTC, the CPUC could step in to establish farther reaching data governance policies, as it has in other areas. This could include policies that address access to data for public purposes—such as evaluating impact, research, or oversight—and privacy rules that address issues of data identifiability, purpose limitations, portability, and limitations on government use for non-transportation law enforcement activities, like policing or immigration. The NHTSA and the California Department of Motor Vehicles (DMV), like other state motor vehicle departments, lack the same breadth of authority.

For example, while the California DMV regulates many relevant aspects of autonomous vehicles, the CPUC has extraordinarily broad regulatory authority over TNCs and Charter-Party Carriers—both likely actors in this archetype—and can create new regulations where they believe necessary.[235] Today, CPUC regulations tackle important political and ethical issues. For example, the CPUC requires TNCs to submit annual reports with detailed information on aspects of their operations necessary to address public safety and to advance equitable access across racial and ethnic demographics.[236] CPUC regulations also require TNCs offering fare-splitting services to report on the environmental impact of fee-splitting operations as part of their annual reports.[237] Some suggest that reducing car ownership could lower the

235. The Charter-Party Carriers' Act states in part that "the commission may supervise and regulate every charter-party carrier of passengers in the State and may do all things . . . which are necessary and convenient in the exercise of such power and jurisdiction." CAL. PUB. UTIL. CODE § 5381 (West 2019).

236. *See* Decision Adopting Rules and Regulations to Protect Public Safety While Allowing New Entrants to the Transportation Industry, Rulemaking 12-12-011, CPUC Decision 13-09-045, at 29–33 (Sept. 19, 2013).

237. *See* Decision on Phase II Issues and Reserving Additional Issues for Resolution in Phase III, Rulemaking 12-12-011, CPUC Decision 16-04-041, at 59 (April 21, 2016).

environmental impacts of transportation in comparison to current individual ownership models, but research suggests a more complicated environmental calculus.[238] The CPUC's authority over TNCs gives it the ability to obtain data to make independent assessments about the environmental impacts of current models. Consistent with its broad mandate, the CPUC also has the authority to potentially adopt additional regulations to advance public values, despite the business model which may well concentrate ownership of vehicles, data, and infrastructure in private hands. Regardless, these dynamics are complex and clearly constitute a spectrum with different ownership and operating configurations that have different implications for public goods, are subject to different regulators with different powers, and are likely to be found in different applications instituted in different geographies and jurisdictions.

5. *Coda: Redefining Safety*

We previously introduced historian Peter Norton's argument that the meaning of safety is fluid and contingent.[239] Regardless of which autonomous vehicle future society pursues, we are poised once again for a paradigmatic shift in the meaning of safety from crashworthiness back to crash avoidance. While the shift—from crash avoidance to crashworthiness—that Norton documented was triggered by safety advocates who sought to place greater responsibility for safety on the automobile industry and the automobiles they produced, today's shift is triggered by technology. Each archetype reallocates some responsibility from the driver to the manufacturer. The driverless car archetype and connected cars archetype shift responsibility and liability quite heavily toward manufacturers. We have come full cycle from crash avoidance to crashworthiness back to crash avoidance again.

V. CONCLUSION

In this Article, we introduced the Handoff model and attempted to demonstrate its utility through an analysis of autonomous vehicles. The goal has been to demonstrate how the Handoff model affords unique and critical insights into the operation of these systems—in terms of new components and modes of acting—that have dramatic consequences for both human and

238. *See* REGINA R. CLEWLOW & GOURI SHANKAR MISHRA, DISRUPTIVE TRANSPORTATION: THE ADOPTION, UTILIZATION, AND IMPACTS OF RIDE-HAILING IN THE UNITED STATES (2017) (associating TNC use with a net six-percent reduction in overall public transit use in seven major metropolitan areas (Boston, Chicago, Los Angeles, New York, the San Francisco Bay Area, Seattle, and Washington, D.C.) and concluding that forty-nine to sixty-one percent of trips taken by TNC would not have been made at all, or would have been made by walking, biking, or public transit).

239. *See supra* 115 and note 36.

societal values. In our view, this is a critical ameliorant to the focus on the ongoing transition of control into computational components, instead showing the structural, political and ethical stakes of those changes. In the autonomous vehicles context, it takes us beyond the abstract political claims associated with different transport models and their different ideas of utopia and, in breaking down how those different systems actually work, reveals the more nuanced political and ethical implications. Today the *lingua franca* of autonomous vehicle policy centers technology, framing increased automation as the goal and the good. But values should lead and the choice of which autonomous vehicle future to pursue is first a political and ethical one. Leading with values tools like the Handoff model helps us see past the technological to the political and ethical stakes. The entangled and contingent nature of values and specific regulatory institutions in the United States makes the landscape particularly fraught. Choosing one autonomous vehicle future need not be better or worse for privacy, for example, but some will surely require the adoption of more new policies. While some political goals may be better served by particular autonomous futures, it is more likely that, by carefully reasoning about Handoffs and coupling technical innovation with an equal share of policy innovation, we can co-create visions of autonomous vehicles that suit our ethics and politics.