Facing Change: Review of Potential Negative Impacts of Automated Vehicles Contrasted with Adopted Legislation

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Introduction

Automated Vehicles (AVs) have come a long way in the past several years. They have logged millions of miles, been the subject of tens of thousands of publications as well as hotly contested debates, and are becoming seen for better or for worse as an inevitability. The transformational potential of AVs cannot be underestimated: our cities, commutes, behavior, health, the fabric of our lives could be changed.

And yet, in their 2017 compilation of literature and research on automated vehicles[1], Milakis, van Arem and van Wee find that "no systematic studies were found about the implications of automated vehicles for public health" and that overall, "the implications of automated vehicles for the economy, public health and social equity are still heavily under-researched" (2017). That same year, academics, non-profit organizations and think tanks published numerous studies and reports with policy suggestions to maximize the public benefits of automated vehicles. Also in 2017, state legislatures passed 20 bills specifically related to AVs.

The purpose of this work is to review primarily academic publications that specifically discuss potential negative public health impacts of AVs and to contrast the findings with current adopted policies and legislation. It builds upon the growing body of work on the subject of AVs and public health, from Guerra's examination of regional long range plans, to Crayton and Meier's call for a public health framework for AVs and Sperling's work of defining the opportunities and pitfalls of contemporary transportation revolutions. In a first part, I review publications treating of AVs and potential public health impacts of AVs. Second, I review adopted AV-related state legislation.

In my review of published works, I find that although there is a broad range of consensus, research and concern on the topic of potential negative health impacts AVs, the scope of current legislative efforts is narrow. Only a handful of local jurisdictions may be starting to adopt goals, principles or even policies, and few to no adopted bills or policies at the state level mention let alone address potential impacts of AVs.

Methodology

The vast and continuously growing volume of literature published on the topic of AVs required limiting the scope of the literature review. The potential impacts of AVs recently and thoroughly covered by Dan Sperling's Three Revolutions by way of "Dream" and "Nightmare" scenarios, I chose to review two public health issues with strong links to cars that affect the most people in the United States.

For the first part of my literature review regarding public health impacts of AVs I searched for publications on Google Scholar, in the UC Berkeley Library Catalog, and in the bibliographies of widely cited work using key word combinations: (Autonomous/Automated Vehicles + Public Health/Health/Obesity/Sprawl/VMT/Non-communicable diseases/etc). I gathered research that explicitly and centrally studied AVs and public health. Therefore, I did not cover, for example, cover the

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1 Although "Autonomous Vehicles" has become the more widely used term to describe fully automated vehicles, I adopt here Sperling's recommendation to use "automated vehicles" to be inclusive of both connected and non-connected automated vehicles. In addition, any references to AVs here assume level 4 and 5 automation per the Society of Automotive Engineers (SAE) defined five "Automation Levels." The first three levels require some level of human intervention, whereas there is no human intervention required at levels 4 & 5.

effects of collisions on active transportation mode share. Nor did I delve into the details of labor issues, ethics, cybersecurity concerns, and many other AV-related issues with potential health.

For the second part, in which I examine adopted legislation, I used the [National Conference of State Legislators](#) database of AV policies and summaries. The legislation categories are the result of conversation with colleagues at the [California Office of Planning and Research](#). This is not an in-depth legal audit or evaluation of state legislation, but rather an overview of primary provisions of adopted legislation to assess intent.

Review of Literature on Potential Negative Health Impacts of AVs

In recent years, ride-hailing services such as Uber and Lyft once heralded as a simple solution - a means to turn single-occupancy vehicles into pooled vehicles – are coming under fire for instead having led to an increase in cars on the road, competing with rather than completing public transit, and increasing total vehicle miles traveled (VMT)[2]. AVs too, when it comes to public health, have long been heralded as a straightforward solution to reducing the number of traffic fatalities. But similar to past technological innovation that spurred mobility revolutions, the potential impacts of AVs are just as complex as the solutions they seek to solve. Today, not only is the actual quantifiable number of collisions averted being speculated upon, but larger and longer-term environmental, health, and socio-economic impacts of AVs are being researched.

Unsurprisingly, authors are writing about AVs and public health stress the importance of acknowledging the links and relationships between the two. Crayton and Meier state that it is an imperative to consider public health issues and involve public health stakeholders as participants in AV policymaking because of the effect of previous transportation innovations on the built environment, individual behavior and other social determinants of health[3]. Others guard against technological optimism and evoke the need to "raise awareness about how the emergence of AVs is being portrayed" (Papa and Ferreira 2018). Docherty writes that "technological change is clearly outpacing the capacity of systems and structures of governance to respond to the challenges already apparent" and that lack of action will lock us into an un-advantageous path dependency (Docherty, Marsden, and Anable 2017). Fleetwood writes of the necessary role public health officials experts have to play: "keep pace with the evolving technology, lead and participate actively in informed discussions, engage communities broadly, advocate rational and consistent regulations, systematically analyze ethical issues, and insist that outcomes be measured and disseminated effectively" (Fleetwood 2017). More generally, efforts such as "Health in All Policies" (HiAP) initiatives implement collaborative approaches to improving the health of all people by

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[2] The promised benefits of ride-hailing services—lower vehicle ownership, less congestion, more efficient transportation—have not come to fruition, especially in New York. The number rideshare vehicles has gone from fewer than 10,000 in 2014 to almost 60,000 today, with over 976 million VMT estimated generated by rideshare vehicles over four years, representing up to 6% of all driving in the city (Schaller 2018).

[3] Crayton and Meier illustrate this point with lessons from past transportation revolutions: Electric streetcars replaced the horsecar era, solving the manure disposal problem, and enabling the development of suburbs, which reduced risk of infectious diseases and improved air quality. The spatial distribution of cities as influenced by transportation investments continued to ostensibly create cleaner living conditions and improved health in lower density suburbs, before traffic fatalities and health impacts of land use and air pollution brought automobile use under scrutiny (Crayton and Meier 2017).

incorporating health, equity, and sustainability considerations into decision-making across sectors and policy areas (Rudolph et al. 2013).

Traffic Safety Uncertainty

37,461 people were killed in crashes on US roadways in 2016, over 100 a day (NHTSA 2017). Road traffic collisions are one of the top ten causes of death globally (WHO 2015). The most highly anticipated and widely touted benefit of AVs, promoted “life-saving technology”, is a significant reduction in the number of fatalities due to collisions[4] (Sperling 2018). And while for a time many, including the National Highway Traffic Safety Administration, expected programmers to deliver fully “crash-less cars” (Silberg 2012), expectations are currently being lowered both by real event and by the industry. Sixty-four percent of Americans were worried in 2017 about sharing the road with AVs, and 56% stated they would not ride in one (*The Economist* 2018). At the 2018 AV Symposium in San Francisco, participants spoke of the importance of acknowledging the fallibility of technology, calling expectancy of zero road fatalities a “fantasy” that threatens public acceptance (Marshall 2018).

One of the most cited studies on AVs, by Fagnant and Kockleman, estimates that at 90% market penetration we could see a reduction by 90% of all car crash fatalities. Indeed data shows that human error (driver distraction, intoxication, etc) is a contributing factor to 93% of severe and fatal crashes in the United States. However, many variables may affect this outcome – from machine learning capability, to infrastructure adaptation, human behavior change, etc (Sun et al. 2016). For example, as long as AVs and human-driven vehicles share the road these benefits are not less assured: at a 10% market penetration, Fagnant and Kockleman expect a reduction in crash and injury rates by 50%, reflecting estimated savings due to fewer legal violations like running red lights. Some are more conservative in their estimates of the number of fatalities avoided: Sperling puts the numbers of lived saved by 2040 at 30,000, or approximately 80% reduction in crashes, citing KPMG’s 2012 report (Sperling, 2018), while Strategy Analytics declines to assume more than a 5% overall reduction in collisions by 2045 (Lanctot 2017).

Others ask whether we should differentiate between the net reduction in vehicle crashes and the overall reduction in collisions: “Autonomous driving technologies will almost certainly cause accidents due to unexpected conditions, probably including dramatic c rashes that harm other road users. These technologies may still provide net safety gains—their crash rates may be lower than human-driven vehicles—but don't expect the 90% crash reductions that is often claimed”(Litman 2017). If AVs prevent 35,000 deaths of a certain type but cause 20,000 deaths of a new type; is that acceptable? Is increased safety to some users at the expense of others a clear-cut benefit (Lin 2013)?

To complicate matters, authors like Millard Ball speculate that human behavior will not remain constant in the face of innovation, echoing Walker Smith’s use of the Jetson’s Fallacy[5] to challenge policymakers’

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[4] Language is important, and the choice of using the word “Collision” throughout this paper is intentional. “Accident” suggests the unforeseen, incidents without blame and without solution. Seeing crashes as preventable helps move beyond their inevitability and start seeking solutions, for example improved street design, education, and technological innovation (Badger 2015; Stewart and Lord 2002; Richtel 2018).

[5] The Jetsons fallacy, writes Walker Smith, “describes predictions made by extrapolating individual items of interest into the future while holding everything else in the world—other technologies, laws, norms, values, and markets—constant. In this way, although the Jetsons (a 1960s television show set a century in the future) features flying cars,

assumptions of the future (Millard-Ball 2018). Others, like Kalra and Paddock, speculate that actually test-driving our way to safety may be out of the question: “The bar has been set particularly high for self-driving vehicles given the amount of decision making and reaction to changing circumstances that human drivers complete. (…) Autonomous vehicles would have to be driven hundreds of millions of miles and sometimes hundreds of billions of miles to demonstrate their reliability in terms of fatalities and injuries.” (Nidhi Kalra and Susan M. Paddock 2016).

Perhaps as result of the challenged facing proving AV safety, there has been significant debate on liability and ethics that I will not cover here. Some philosophical disputes may never be resolved empirically (Walker Smith 2016b). Some may only be decided by lawyers and public opinion (Casey 2017). However, the debates around assessing or proving the safety of AVs illustrates a need to reckon with public perception as well as what can, or should, be mandated.

For example, there is some consensus that in order to have a more streamlined public understanding and acceptance of AVs, there should be no equivocation of full automation (SAE automation levels 4 or 5) with partial automation (SAE automation levels 2 or 3). Automation levels 2 and 3 are seen as more likely to cause new collisions, prompting the suggestion that for safety concerns Level 3 Automation in should be skipped entirely (Google 2015; Gain 2017; Reese 2016) or even banned (Sperling 2018).

Some, but not many, have written specifically about the potential impact of AV deployment on bicycle and pedestrian collisions. Fagnant and Kockleman estimate only a 50% reduction for vehicle collisions involving a pedestrian and bicyclists since “just one of the two crash parties (the driver) relies on the AV technology”. Active transportation advocates have expressed wariness with regards to AVs. After a bicycle flummoxed an AV in Austin by track standing at a stop sign (McFarland 2015) and AVs in San Francisco were seen running red lights and incorrectly turning through bike lanes (Wiedenmeier 2016) more attention was given to the effectiveness of AVs in interacting well with vulnerable road users. This contributed to the requested requirement that AVs ability to “not contribute to traffic crashes” be proven first (Wiedenmeier et al. 2017), or to the recommendation to learn from Federal Aviation Administration standards in establishing AV certification standards [6](Kulisch 2018). In contrast, some call for the burden of responsibility to be placed more squarely on the pedestrian, or bicyclist’s shoulders: through behavior enforcement or wearable technology for example (Schmitt 2018). Another concern is for unconscious bias in programming to create a racialized code, as occurred with facial recognition software (Breland 2017), which was both unforeseen and unexpected. These represent important equity issues that require an answer.

If self-certification becomes the norm, it presents its own host of questions in regards to compliance with regulation, adoption of best practices, and setting industry-wide safety standards. On March 18 2018, Elaine Herzberg became the first recorded pedestrian to be killed by an AV. The AV, owned and operated by Uber, was later found to have had certain safety functions (driver alertness detector, road sign information detection, and emergency braking) disabled while the vehicle was not in manual mode (Grossman 2018). If not mandated, what will ensure that AVs are as safe as possible? When and if mandated, how will we enforce safety standards? Will different companies continue to be able to have

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these cars are manually driven by men, and an entire episode revels in the sexist trope that women are bad drivers. The writers essentially launched the 1960s into space.” (Walker Smith 2016a)

[6] The FAA oversees “millions of flights a year with zero casualties in the US since 2009 and zero casualties worldwide in calendar year 2017 all while handling ever increasing flight and passenger loads” (LADOT 2018)

different approaches, ethics and standards for safety? For example, where Tesla deems it "morally wrong to withhold functionalities that improve safety simply in order to avoid criticisms or for fear of being involved in lawsuits," Waymo abides by a more conservative premise that self-driving cars should not be sold until human action isn't required at all. (Plungis 2017).

In 2015, Volkswagen was exposed for having programmed its cars to evade emissions tests, provoking public outrage and demonstrating disregard for industry standards in favor of profit and competitiveness (J. Smith 2017). Already, it is public knowledge that Tesla has gone back and forth in regards to allowing cars to go over the speed limit while in auto-pilot, and that the deciding factor to allow for speeding was consumer demand (Hern 2017). None of the reviewed articles on this subject found a comment from a state or federal agency on this programmed law breaking. Elaine Herzberg's death caused a tightening of standards and heightened security from otherwise lenient legislators (Roberts 2018). How many more fatal collisions will cause such an uproar before they become as normalized as today's human-caused "accidents"? Will consumer demand influence other ethical questions, such as AV interations with people outside of cars, other laws, etc? There is no special regulation mandating that an AV's program render it unable to leave the scene of a collision. California's DMV, for example, does not expect to create specific reporting requirements outside of what currently exists for AVs (Said 2018). Based on the direction of current literature, traffic safety, one of AVs' most vaunted promises, is not guaranteed to remain a priority.

Long Term Health Impacts

Non-communicable diseases (NCDs) account for an estimated 88% of total deaths in the United States (World Health Organization 2014). Heart diseases alone cause 23 percent of all deaths in the United States and chronic lower respiratory diseases cause six percent of all deaths. Twenty nine million people in the US have diabetes (Center for Disease Control), more than one-third of adults and almost one-fifth of children in the United States are obese, and obesity rates more than doubled for adults and tripled for children since 1980 (Rudolph et al. 2013). Air quality, the built environment, transportation mode, physical activity levels, and many other facets of our daily lives play a significant role in the prevalence of these NCDs.

The development of sedentary lifestyles and obesogenic environments[7] are direct outcomes of the advent of privately owned-cars, contribute to rising obesity rates and non-communicable diseases (Crayton and Meier 2017; Rudolph et al. 2013). And while AVs may provide some health benefits, an "increase in automobile dependence could induce sedentary behavior, increasing incidence of obesity" and other NCDs (Biswas A et al. 2015; Acheampong 2018). Similar to those related to traffic collisions, the environmental and individual health impacts of AVs depend on such a range of factors that both analyses and approaches to analyses vary widely and are considered speculative (J. Anderson et al. 2016). And many if not all AV-related promises around land use and transportation networks (reduced need for parking lots, reduced travel time, increased mobility, reduced greenhouse gas emissions) have their caveats and limitations (Papa and Ferreira 2018).

For example, the question of whether AVs will reduce congestion on freeways relies on numerous vehicle design, individual behavior and technological advancement: will the cars be smaller and lighter

[7] Defined as 'the sum of influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals or populations' (Lake and Townshend 2006)

due to their increased safety record? Will the reduced cost of travel induce additional freeway traffic? What space savings will platooning achieve? There are many substantial studies on the effect of AVs on overall Vehicle Miles Traveled (VMT), an increase of which can represent more time spent in cars, less time being active, and more GHG emissions. Gucwa examined possible induced demand from AV's doubling of capacity on Bay Area freeways only increased VMTs by 1% per year, whereas changing users' cost of travel time increased VMT anywhere from 8% to 24% (Childress et al. 2015). In a thorough literature review, Milakis et al find that AVs could induce an increase in travel demand of between 3% and 27% due to changes in destination choice (i.e.longer trips), mode choice (i.e. modal shift from public transport and walking to car), and mobility (i.e. more trips, especially from people currently experiencing travel restrictions; e.g. elderly). Shared automated vehicles could result in additional VMT because of their need to move or relocate with no one in them to serve the next traveler. In general, VMT are expected to be lower for dynamic ride-sharing systems (Milakis, Arem, and Wee 2017).

Citing the role of light vehicles in contributing to climate change and air pollution deaths, Thomopoulos and Giovany find that if AVs are shared, pooled, and transit coordinated, VMT could be reduced by a quarter, greenhouse gas emissions (GHG) by a third, and travel costs by half (Thomopoulos and Givoni 2015). One study estimates VMT to approximately double and overall energy use increase threefold under some circumstances (Greenblatt and Shaheen 2015). Another indicated that if user costs per mile are very high in a shared automated vehicle based transportation system, VMT may actually be reduced (Childress et al. 2015). Childress also modeled four scenarios: 1. AVs increase network capacity; 2. Important trips are in AVs; 3. Everyone who owns a car owns an AV, and; 4. All autos are automated, with all costs of auto use passed onto the user. The first three scenarios increase VMTS by 3.6%, 5%, and 19.6% respectively. The fourth reduces VMT by 35.4%. Finally, a UC Davis study estimated the deployment of non-shared, non-electric AVs would increase GHG by 50% and vehicle use 15 to 20 percent by 2050. The alternative scenario, with pooled and electric cars, leads to vehicle use decrease of 60% and a GHG emissions reduction of 80 percent (Sperling, 2018).

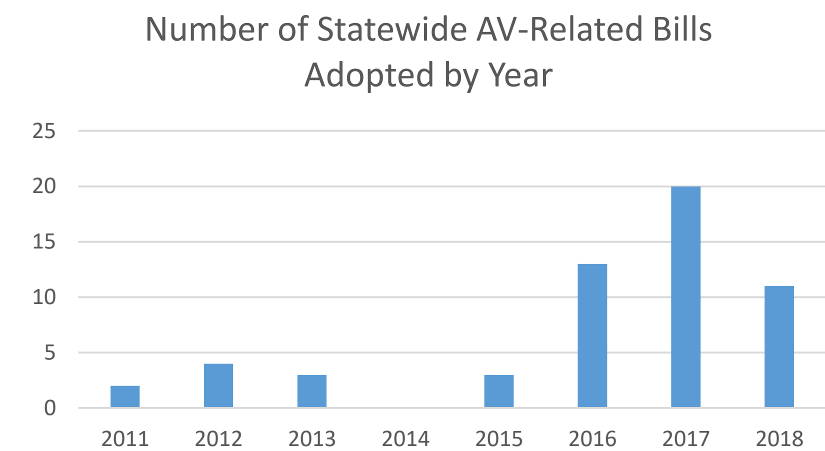
While a growing number of studies discuss the potential impact of AVs on land use, few go so far as to point out non-communicable diseases. And while other health-related topics such as personal safety inside of vehicles, cybersecurity, access to healthcare, mental health benefits, accessibility for people with disabilities or seniors, etc, are starting to garner interest, quantification of AV-related impacts remains under-researched.

How likely is it for one of these scenarios to come to fruition versus another? Just as with collisions, there are a myriad of factors affecting estimates. One study found that if customer demand drives technology development it is likely for AVs in the United States to evolve to be privately owned, with respondents preferring to own self-driving vehicles (59%) rather than just use them (41%) (Zmud and Sener 2017). And with proactive regulation, customer demand is likely to be influential for technological development. The NHTSA itself states, in its FAQ section (in response to "Will I be allowed to drive my own vehicle in the future if it is automated?"): "Companies may take different design approaches to fully "self-driving" vehicles that do or do not include controls allowing for a human driver. As is the case now, consumers will decide what types of vehicle designs best suit their needs" (National Highway Traffic Safety Administration 2018).

Review of adopted state legislation related to AVs

With the advent of AV technology, policymakers are being called upon to plan for transformative, multi-sectoral change. Guides, lists of principles and toolkits are being developed (J. Anderson et al. 2016; Angerholzen and Mahaffee 2017; ENO Center for Transportation 2017; Union of Concerned Scientists 2017; NACTO 2017) to help policymakers navigate this new field, and achieve a balancing act of fostering innovation while maximizing public benefit. This section reviews AV-related legislation adopted or considered by legislators across the United States.

The Federal Automated Vehicles Policy Statement released by the National Highway Transportation Safety Administration (NHTSA) in September 2016 differentiates the roles of state and federal government in regards to AV policy. Design and performance (including safety standards) is stated as the responsibility of the federal government, and licensing human drivers, insurance and liability, registering vehicles, enforcing traffic laws as the responsibility of state.



As of June 2018, 30 states have passed policies specific to AVs. In 2017, 20 such bills were passed throughout the United States. A number of other state legislatures have not explicitly acted in regards to AVs, however through executive decrees or simply through current legislative regulation allow for testing (Lewis, Rogers, and Turner 2017b; Walker Smith 2014). This does not mean testing is taking place in all of these states. As of June 2018, only 6 states (Arizona, Nevada, Texas, Philadelphia, Massachusetts) had active pilot testing programs (Metropolitan Transportation Commission 2018).

Adopted legislations are categorized in the following section based on their primary provisions; whether technical, related to funding and pricing, or related to mobility, land use and public health.

Technical provisions

The vast majority of adopted legislation focuses on what may be referred to as "technical policy", relating directly to defining AVs and enabling their testing and deployment by addressing liability, licensing, and operator requirements. For example:

- States are overall adopting the Society for Automotive Engineers (SAE) standards for defining different levels of automation in AVs.
- 17 states include a policy related to vehicle platoons (groups of vehicles traveling under electronic coordination at speeds and following distances that are faster and closer than would be reasonable and prudent without electronic coordination), making it the most common topic, often discussed in the context of commercial use. Typically, states legislate to exempt AVs from any "provisions that ban vehicles from "following too closely" in order to allow for platooning.

- Many states define parameters and requirements for pilot testing of AVs. For example, **Connecticut** and **New York** require a $5 million proof of insurance. **Georgia** and **North Carolina** do not require operators to have a driver's license, although require adult supervision when a passenger under the age of 12 is in a vehicle. Some states do not require a driver (**Michigan)**, whereas other require a human driver "prepared to take control of the autonomous vehicle at any moment" (**Washington DC**).

These legislative efforts are in line with the "Model Automated Driving Laws" drafted by Bryant Walker Smith, in which keywords such as safety, operation and registration occur dozens of times but tax, fund, health, mobility, land use, equity, and even collision or accident, are not mentioned at all (Walker Smith 2017).

Funding or taxing provisions

Although one of the most important policy lever to mitigate against AV deployment leading to accelerating sprawl and environmental damage is pricing (M. Anderson and Larco 2017), no states have adopted legislation with funding or tax provisions that would specifically encourage shared, pooled or electric vehicles.

- **Nevada** imposes an excise tax on passenger service equivalent to 3% of the total fare charged, with the potential effect of discouraging shared ownership which is essential if we are to land AVs in a way that benefits the public interest
- **Michigan**, **Nebraska** and **Nevada** explicitly prohibit certain fees, taxes or regulations on automated vehicles
- **Tennessee and Massachusetts** have attempted and failed to pass per-mile fee charge systems

Land use, mobility and public health provisions

Although several states have commissioned studies or created advisory commissions, few states have considered policies that impact technology development beyond security, operational and safety issues.

- **California** explicitly requires projects funded by a newly created Road Maintenance and Rehabilitation Program to consider automated technologies during project planning and selection.
- **Alabama, Connecticut, Maine, North Dakota, North Carolina, Oregon, Vermont** and **Washington** require the study, review or reporting on autonomous vehicle impacts and policy by either a legislative body, the Department of Transportation or the creation of a task force or commission. Some require or encourage some aspect of land use, mobility or public health to be considered within their study process although mostly cursorily. Vermont's, for example, calls for a one-time meeting to discuss amongst other things of the "social, economic, and environmental consequences of the rollout of AVs"(M. Anderson and Larco 2017).

Overall, not much appears to have changed since 2015 when Lari wrote that beyond legal, liability, definition, testing, operational safety, "environmental regulations, transportation planning, and zoning" should probably be addressed within the context of AVs (Lari, Douma, and Onyiah 2015). The type of legislation passed to date is reflective of a drive to support the development of the technology, to create a legal and liability framework for AVs, and to attract autonomous vehicle manufacturers and startups to respective states.

Executive Orders

As of July 2018, ten executive orders had been signed by nine US Governors (**Massachusetts**, **Arizona**, **Wisconsin**, **Delaware**, **Washington**, **Ohio**, **Hawaii**, **Idaho** and **Minnesota**). Seven of these executive orders establish working groups, steering committees, or advisory councils to assist states in studying, assessing and preparing for AV deployment. Only **Massachusetts's** executive order specifically calls for an evaluation of health, sustainability and environmental risks. **Massachusetts** is also the only state that explicitly appoints a commission member from an environmental agency, and Minnesota is the only state to explicitly appoint a councilmember from a health agency.

The majority of Executive Orders refer solely to the potential benefits of AVs:

- **Minnesota's** assures "the widespread adoption of connected and automated vehicles will positively impact public health by reducing injuries, traffic congestion and air pollution". **Arizona's** states that "the State believes that the implementation of fully autonomous vehicles will provide a dramatic increase in pedestrian and passenger safety, reduce traffic and congestion, and improve the movement of residents and commerce across the state"
- Many of them include in their introduction that human error is a contributing factor in 94% of serious and fatal collisions (Minnesota, Ohio, Arizona and Washington).
- Executive Orders from **Massachusetts** are the most cautious in unconditionally embracing AVs, with an overt contrasting of the dream and nightmare scenario; "WHEREAS, in the absence of appropriate policy and regulation, the eventual widespread deployment of highly automated driving technologies could instead increase safety risks for drivers and other users, including pedestrians and cyclists, increasing traffic congestion and resulting vehicle miles travelled, and increased emissions of harmful greenhouse gases and exacerbating other social harms".
- Most of the Orders are plain in their intent to establish the state as a leader in the field of testing and developing of AV technology. The 2017 Executive Order from Hawaii for example states in its introduction: "acknowledging that, today there is something akin to a space race to see who will develop driverless vehicles" and that Hawaii "has stepped out ahead—extending open arms to motor vehicle manufacturers and technology companies from around the world, signaling that the Aloha State is open for business for testing and deploying the new driverless vehicle technology"

Policies at the Local Level

Although the topic of many transportation futurism discussions over the last decade, AVs are only recently starting to be included in adopted regional or local planning documents. In 2016, only one of the twenty-five largest metropolitan transportation organizations even mentioned driverless car technologies in its most recent long range transportation plan (Guerra 2016). This trend has begun to change as planning for AV deployment shifts from a long-term possibility to an imminent reality. Some cities have begun articulating principles for equitable adopting policies specific to AVs beyond the technical provisions.

- Seattle Department of Transportation, WA: Calls for intentional, outcome-driven and anticipatory approach to AV policy. States the imperative acknowledgement of the far-reaching social, economic and environmental impacts of a new mobility era and calls for AVs to be safe, shared, connected and electric (Seattle Department of Transportation 2017).

- Portland Bureau of Transportation, OR: Adopted set of policies to ensure AVs are deployed as fleet/shared ownership, fully automated, electric and, for passenger vehicles, shared by multiple passengers. Policies reflect public health, land use, data gathering, equity, and sustainability concerns. Transportation System Plan, May 2018: Connected and Automated Vehicles Policies (Portland Bureau of Transportation 2018)
- City of Boston, MA: Aims for zero deaths, zero injuries, zero disparities, zero emissions and zero stress. Envisions a graduated process to deploying new technology that focuses first on operational safety and testing before exploring various business models and urban infrastructure that improve safety, access, and sustainability (Boston Transportation Department 2017).
- Los Angeles Department of Transportation, CA: LA was one of the first cities to specifically address autonomous vehicle policy. The 2018 Strategic Implementation Plan aims to implement the earlier Urban Mobility for a Digital Age and Blueprint for Autonomous Urbanism documents. It emphasizes the need to "actively manage" AVs that are shared and electric, and the public sector's failure to understand and anticipate major technological shifts in the past. A non-exhaustive list of potential strategies to improve the city's overall transportation infrastructure and access to mobility includes for example curb pricing, autonomous transit, and an application to take varying pricing data from the city and use it to optimize requested routes by autonomous vehicles (LADOT 2018).
- San Francisco County Transportation Authority, CA: The SFCTA drafted a list of ten guiding principles to shape the evaluation, regulation and implementation of new transportation services or technologies (San Francisco County Transportation Authority 2018).
- City of Austin, TX: The City's Smart Mobility Roadmap calls for incentivizing the development and operation shared, electric AVs. Recommended actions include establishing "mobility as a service" options that reduce single-occupancy vehicle trips, increasing on-street EV charging, managing curb access and creating multi-modal transportation hubs. The Roadmap does not commit specific budgets or metrics but will be incorporated into the future Austin Strategic Mobility Plan (City of Austin 2017).
- City of Palo Alto, CA: Adopted in November 2017 an AV-specific policy in the most recent General Plan update (City of Palo Alto 2017)

Policy T-1.5 Support the introduction of autonomous, shared, clean motor vehicles with the goals of improving roadway safety (especially for vulnerable road users), improving traffic operations, supporting core mass transit routes, reducing air pollution and GHG emissions, enhancing transportation opportunities for the disadvantaged and reclaiming valuable land dedicated to motor vehicle transportation and parking.

- City of Chandler, AZ: While many cities are removing parking minimums or adding flexibility to parking requirements, Chandler may be the first city in the US to adjust zoning code based on specifically the potential deployment of AVs as shared use vehicles (Maryniak 2018)

Hurdles to Legislation

Lessons from the past tell us that rushing to embrace disruptive, transformative or revolutionary transportation innovation may lead to unforeseen negative consequences (Crayton and Meier 2017). Yet there is still significant reticence or slowness in regulating new technology. Legislating this evolving domain appears a herculean task, with many potential reasons for the discrepancy between recommendations and adopted policies: whether fear of overregulation, (J. Anderson et al. 2016; Angerholzen and Mahaffee 2017), fear of creating of a statewide patchwork of regulation (Lewis, Rogers, and Turner 2017b), the result of industry influence[8], or simply the result of the normal technical and political challenges of regulatory work (Guerra 2016). Alternatively, there may simply be a preference for policies that do not specifically target AVs. Many of the solutions for reducing AV-related VMT and maximizing public benefits are the same solutions that are at hand today to deal with traditional sprawl or human caused collisions (Litman 2017; M. Anderson and Larco 2017).

Whether or not AV-specific, performance based, gradual, light-handed, etc, it is important to not let out of sight the regulatory imperative articulated by so many. “The future is likely to be far more positive if government interevenes and guides the invisible hand of the marketplace to avoid the excesses of self-interested behavior,” and the benefits of AVs depend critically on the merging of electrification, pooling and automation” (Sperling). And many stress the time crunch we are under: There is likely to be a narrow window in which governments have a real opportunity to influence outcomes before path dependence makes it increasingly difficult to change (Lewis, Rogers, and Turner 2017a; Docherty, Marsden, and Anable 2017). As Avs are evaluated and tested, “it is imperative to develop adaptive regulations that are designed from the outset to evolve with the technology so that society can better harness the benefits and manage the risks of these rapidly evolving and potentially transformative technologies” (Nidhi Kalra and Susan M. Paddock 2016).

Conclusion

At the current rate of dialogue and debate, this work will likely be out of date within 6 months. It is clear that the complexity of AV deployment matches that of its impacts. The evaluation of AVs’ impact on public health issues is still speculative, difficult to isolate and immensely dependent on the business and ownership models of AVs as well as local planning regulations. However, that does not mean we are unaware of the consequences of the nightmare scenario described by Sperling. Moreover, while the breadth of research on topics related to both is substantial, currently the scope of the majority of adopted policies is quite narrow. The current legislative landscape focuses primarily on enabling and legalizing the testing of AVs on public streets and highways with long term goals of economic development and safety gains.

However, AVs need to be understood as part of a larger solution to multiple, layered contemporary environmental, health and socio-economic challenges. Earlier this year Mary Nichols, Chair of the California Air Resources Board stated in regards to VMT reduction and GHG reduction goals that “technology, like zero-emission vehicles, will carry us far, but it will not be enough to get us where we

[8] AVs are a business opportunity with considerable profits at stake, and commercially driven goals can often wield more lobbying proactive lobbying funds than humanitarian goals (Papa and Ferreira 2018). Leading AV companies Ford, Waymo, Lyft, Uber, and Volvo formed the “Self-Driving Coalition for Safer Streets” led by former NHTSA administrator David Strickland. The coalition’s goals are to lobby for “policies that advance technological innovations related to self-driving vehicles in order to realize their full potential and safety” and work “with non-commercial stakeholders to realize the broader societal potential of self-driving vehicles and accelerate their adoption” (“Self Driving Coalition for Safer Streets: Policy” 2018). MADD (Mothers Against Drunk Driving), a member of the coalition, has advocated for the federal government to disallow states from regulating the safety of AVs “because they do not have the technical expertise to do so and their involvement could hinder the technological progress in the deployment of this life-saving technology”(Mothers Against Drunk Driving 2017).

need to go" (J. E. Smith 2018). Not only will the public be disappointed if AVs are perceived as a silver bullet solution to stem traffic fatalities, but an opportunity to meet a myriad of goals will be missed.

Those who have written about long and short-term health impacts of AVs also write of an imperative to act with intentionality. This imperative is often expressed with urgency, referring to current and past failures to effectively prevent environmental and social costs of transportation innovation. Preventing the death of tens of thousands of people on our streets every year is possible and even with reach, as is reducing the prevalence of obesogenic environments and building healthier, happier, and more connected communities. But AVs are not the answer alone, and need to be perceived as a tool to be shaped to best fit the needs of society: "Autonomous vehicles will not displace the need for walking, cycling, and public transit; on the contrary, efficiency and equity require public policies (…). My main conclusion: autonomous vehicles will not reduce the importance of good planning"(Litman 2017).

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