Who Wants an Automated Vehicle?

Chapter · January 2019

DOI: 10.4018/978-1-5225-7949-6.ch008

2 authors, including:

Ben D Sawyer
University of Central Florida

Chapter 8
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David A. Thurlow
York University, Canada

Ben D. Sawyer
Massachusettes Institute of Technology, USA & University of Central Florida, USA

ABSTRACT

New advancements in vehicle automation, electrification, data connectivity, and digital methods of sharing—known collectively as New Mobility—are poised to revolutionize transportation as it is known today. Exactly what results this disruption will lead to, however, remains unknown, as indeed the technologies and their uses are still taking shape amidst myriad interests. The impacts of this shift to New Mobility could be enormous, shaping economies, cities, and the lives of people in them. It is therefore vitally important for public interests to play a strong role in the development and deployment of these technologies. With the current trajectory of these technologies warning of the potential for increased energy use, environmental costs, and social inequity, interests at the community level need to be included and influential as soon as possible.

INTRODUCTION

Driverless cars, it has been widely predicted, are on their way. With advancements in what planners call New Mobility, transportation as it is known today is on the verge of a revolution. While this term has lacked until now a precise industry meaning, it can be best defined as the combination of collective advancements

DOI: 10.4018/978-1-5225-7949-6.ch008

in vehicle automation, electrification, data connectivity, and digital methods of sharing. These advancements have the potential to change how people travel, how businesses operate, and even how cities are developed or reshaped (UITP, 2017). Urban, suburban, and rural communities alike could see their options for mobility improve in a variety of ways, from cost to connections to comfort. With automated vehicles (AVs), we are promised great benefits: an end to traffic gridlock, relaxing free time while traveling, and roads so safe as to render future generations amazed at the thought that humans were ever allowed to drive. At the same time, however, it has become clear that all visions of how such a transportation utopia should work are not necessarily aligned.

Competing versions of New Mobility's future abound. Will people own their own AVs and send them to park themselves, or will they buy rides in automated robotaxis? Will public transit start to offer door-to-door service with municipally-owned driverless vehicles, or will private companies or even co-ops of private AV owners assemble and manage such fleets? If vehicles are connected, what will they be connected to, and who will own the data that flows between them? The key to answering these questions lies in understanding that the results we get will be determined not only by engineering advances, but by the work of various social groups that hold interests in shaping the technologies' uses and outcomes. As this chapter will discuss, who these social groups are, the results they are advocating for, and the potential impacts of their efforts to shape the future of transportation suggest both appealing and alarming possibilities.

New Mobility represents a dramatic and important set of new risks and opportunities, with not only billions of dollars of commercial value at stake, but also the power to dramatically influence the future of jobs, land use, environmental impacts, and human interaction on a grand scale – as well as the safety of millions of human lives (Henaghan, 2018; Lipson and Kurman, 2016). Even if all the engineering challenges are overcome, positive outcomes are not guaranteed, nor is it known what unintended negative effects might result. The implications of new inventions generally require a considerable period of time to be understood (Wiener, 1954), but our experience since the arrival and proliferation of the automobile a century ago assures us that changes in transportation can have far-reaching impacts (Norton, 2011). With so much at stake, it cannot be overstated that transportation stands today at a critical crossroads – the likes of which has not been seen since the original introduction of the automobile.

Given the magnitude of this situation, the current trajectory of New Mobility technologies moving rapidly toward the goals of certain social groups invested in their development demands scrutiny. In this brief window of opportunity before the technologies become established, it is vitally important to carefully examine the imagined futures being presented, the potential broader impacts their realization could bring, and the need for the public to engage and put forth its own ideas for the New Mobility revolution at both the individual and community levels. In this way, without seeking to analyze the viability of vehicle automation or other new transportation technologies, this chapter will explore these issues of impact and engagement through the lens of sociological and scientific research, first by considering the role of social groups in shaping any new technology, then by looking at several examples of groups currently involved in shaping the technologies of New Mobility specifically. These examples will lead into an examination of how certain uses of New Mobility technologies could potentially impact communities. Finally, these concerns will be brought together as an argument for the importance of balancing individual and community perspectives, and for the role communities can and must play in setting their own goals for the future of transportation and advocating for their own interests.

HOW TECHNOLOGIES ARE SHAPED

Seeing the capabilities of mankind advance, many people assume technology is the natural result of human learning – in science, engineering, or math, for example – and that the forms it takes in technological artifacts are for the most part inevitable. From this point of view, technology is seen as always progressing, filling the needs of humans, and in the process shaping society with unstoppable and natural effects. Humans are seen to have little control over the path of technology, and must therefore adapt their lives when technological developments are introduced. Individuals "can't stop progress," it is assumed. In contrast to this perspective, a more nuanced study of such progress reveals how technologies can advance in ways that let them fall short of their potential.

The field of Science and Technology Studies (STS) has shown how technologies take form through the interactions of multiple interests. Society can shape technologies, especially during their early development. Wiebe Bijker, Thomas Hughes, and Trevor Pinch (1987), in their work examining the social construction of technology, explain how social forces can determine the characteristics in technological artifacts. During the process of problem solving that happens during technological development, it is social groups – such as consumers, corporations, or communities – that define the problems to be solved and, in doing so, give meaning to the technology. These relevant social groups, for which a technological artifact represents a shared set of meanings, have different problems with the artifact, each with multiple possible solutions. These solutions represent possible variations for the artifact (Bijker et al., 1987; Kline & Pinch, 1996). Furthermore, when social groups take an interest in a technology, they not only see solutions to their specific problems, but they also form broader visions of desirable futures for the technology. Sheila Jasanoff (2015) identifies these as "sociotechnical imaginaries", which she describes as "collectively held, institutionally stabilized, and publicly performed" (p. 4). Together, these concepts from STS provide a toolkit with which the process of decision-making for the development and implementation of AVs can be better understood, discussed, and influenced.

MANY INTERESTS: GROUPS SHAPING AVs

Who are these social groups who are expressing interest in and visions of the future of automated and connected vehicle technologies? Several examples stand out. Note that, to different groups, such vehicles may represent a very different potential value, and that each group may wield very different means of influence. Understanding this landscape of interest and leverage is helpful for gaining a better view of the direction and scope of these new transportation technologies.

Automobile Manufacturers

While much innovation has in recent years come from new technology startups, major automobile manufacturers have been swift to catch up to, and at times even surpass, the early strides made by their younger competition (Navigant Research, 2018). Advancements in vehicle systems have opened new possibilities for the auto giants. Some, interested in taking a lead role, have taken steps to put forth their own sociotechnical imaginary for the future of vehicle use.

Swedish car maker Volvo is a representative example of the vision, interests, and leverage of an automotive manufacturer. Volvo has been among the leaders of the industry in its efforts to form early partnerships with AV tech and engineering startups, and has also been active in exploring imaginative design possibilities. In 2015 the company began a project dubbed the "Future of Driving" which included concepts for future vehicles that could operate autonomously (Volvo, 2015). One example described on their website, called "Concept 26"[1], visualizes a sleek interior for an imagined automobile that can be operated in three modes: "Drive", "Create", and "Relax". With a retracting steering wheel and reclining seats that operate at the touch of a single button, relief, it seems, may finally be coming to the bored and tired drivers burdened by their stressful task. Alternatively, options for entertainment or work are suggested with a large screen and control panel at hand for occupants. Though the occupant in Volvo's images is alone in his grey-toned, futuristic environment, the vehicle is clearly centered primarily on his comfort.

Figure 1. Design idea for Volvo's "concept 26". Copyright 2015 Volvo Car Corporation

After showing off their modern design, however, Volvo is quick to reassert their support of traditional driving and clarify what they wish to offer with AVs. "Cars have always been a symbol of freedom," a video at the head of the page begins. For Volvo, this means letting their customers drive when they want to, and delegate driving when they want to. By creating a car that allows drivers the "freedom" to choose how they want to use it, the company hopes time that was previously reluctantly spent in the vehicle can transform into a positive experience. "You might actually choose a route that allows you to have *more* time in the car," Volvo suggests.

At the heart of Volvo's vision for the future of driving remains a worldview that is central to the company's own sales model: private ownership. Volvo believes the future will include self-driving technologies, and it is proposing that car designs such as Concept 26 could perform a transitioning role to autonomous driving with which its customers could feel comfortable. In this way Volvo hopes to position itself as a leader in the sales of such cars when the time comes.

Technology Companies

Technology companies such as Google and Apple have expressed a unique vision, backed by specific interests, and unique leverage. Both have made significant investments into vehicle automation research. As might be expected from these iconic companies, their visions of the future are relatively bolder than many others. In 2014, Google (now Alphabet) put forth a prototype that Lipson and Kurman (2016) described as "a shot heard all the way to Detroit" (p. 45), in that it contained no steering wheel or brakes at all. Indeed, such a vehicle projects a very different sociotechnical imaginary from that of Volvo; one in which humans are not only not required, but in fact are *not permitted* to operate a vehicle. Google co-founder Sergey Brin indicated the reasoning behind this includes both the safety benefits of eliminating human drivers and the errors they are prone to making, and the improved accessibility such a design would represent to those who can't drive (Roberts, 2015).

Certainly such innovation does not appear out of line with the company's talents. But like some of the search engine's other endeavors into maps and mobile phones, there may be additional payoff for the company's investment that is perhaps not immediately obvious. One benefit the company would certainly enjoy in a driverless world would be that people, relieved of the burden of driving, could spend more time on their mobile devices using Google's profitable services. As noted by former Google design ethicist Tristan Harris, a top priority for Google and every other online service provider today is to maximise "time-on-site" (Harris, 2017, 18:00). Real life situations such as driving that prevent users from interacting with them are a direct impediment to that goal. *MIT Technology Review* editor Antonio Regalado (2013) likewise points out that freeing the attention of drivers could be worth billions to Google. In a highly competitive attention economy, companies like these which work tirelessly to engineer new ways to keep users attached to their connected devices could see the task of driving as a problem that is keeping vast numbers of potential customers out of reach.

Similarly, both Google and Apple, heavily invested in the collection and use of all kinds of data, could easily see the deployment of automated vehicles as attractive opportunities to expand such work. Also, with 95% of Alphabet's revenue drawn from advertising, the possibility of having direct access to a large captive audience of robotaxi users could be a strong additional reason to invest in promoting a vision and building a reality of shared AV use.

Ride-Hailing Companies

The vision forwarded by ride-hailing companies combines new digital methods of sharing with vehicle automation to usher in a shift from vehicle ownership to ride-buying. Having successfully disrupted the urban taxi industry with new business models, ride-hailing tech companies such as Uber and Lyft have gone on to invest heavily in AV technology and partnerships, while at the same time actively promoting their own vision for the future. In a detailed article published to Medium in September of 2016, Lyft Co-Founder John Zimmer (2016) outlined what he saw as the coming

"Third Transportation Revolution". Most notably, Zimmer claimed in the article that a majority of Lyft rides would take place in AV fleets within five years, going on to predict that private car ownership would "all-but end" in major U.S. cities by the year 2025. The assumption behind this is that, when hiring an AV is cheaper than owning a car, most city-dwellers will opt out of personal vehicles. Citing decreasing percentages of young people who hold driver's licenses, Zimmer declared that for Millennials in particular, car ownership has become less a symbol of freedom and identity, and more like a ball and chain. For the young and the urban, he argued, car payments, parking, refuelling, and repairs are drawbacks that are increasingly seen as unattractive and unnecessary.

This position reflects ideas shared by others that a shift from owning cars to buying rides could profoundly change our physical environments, transforming our lives regardless of whether or not we ever set foot in an AV (SUMC, 2015; Henaghan, 2018). Specifically, many hope that a broad shift to ride-hailing services such as Lyft will bring with it the benefit of significantly reducing the need for parking, thereby freeing spaces currently allocated to parked vehicles to be repurposed in ways that improve cities, communities, and connections (and see Chase, 2016).

Along with such stated benefits, other incentives for ride-hailing champions Lyft and Uber to advocate for AVs are easy to imagine from an economic standpoint. To offer customers on-demand rides from their smartphone, Lyft and Uber have put their Silicon Valley expertise in computer networks to work optimizing connections between vehicles and riders. The human drivers in their systems simply play a functional role of moving the vehicles where they are told. But drivers are a thorn in the side of these companies – they need breaks, demand benefits, and require various incentives to coax them into working in certain areas or at certain times. Like many workers, they are both much less reliable and much more difficult to keep at the ready than a non-human substitute (Latour, 1988). Moreover, these drivers' salaries constitute a full fifty percent of the cost of each ride (Price, 2015). Switching to a business model of acquiring and operating fleets of automated, driverless vehicles – depending on the cost of such a venture – could theoretically enable ride-hailing companies to lower rates for increased ridership, as well as increase their own revenue from each fare. This would be very good news for Lyft and Uber (and their shareholders), neither of which have reportedly made a profit since their inception nearly a decade ago. The potential of vehicle automation to reduce driver costs perhaps explains why they are willing to invest so much into developing the technology.

Automobile manufacturers, although in many ways eager to have a hand in designing and building any such future robotic vehicle fleets, largely remain invested in individual ownership of automobiles as they bring to market new vehicles with advanced automation and connectivity for personal use. Additional comfort, improved safety, and the opportunity to reclaim time spent behind the wheel are commonly touted reasons consumers should want to own these vehicles. But while full automation on all roadways is likely to remain a distant goal in consumer vehicles for years to come, these companies are striving to be well-positioned for both futures: fully-automated ride-hailing for limited urban settings, and semi-automated individual ownership for more flexible uses or rural areas.

Land Developers

Aligning with the vision of ride providers, as well as the interests of auto manufacturers who would be happy to supply them with vehicles, yet another group has begun to see potential value in the increased sharing which New Mobility could enable. Some land developers interested in new urban construction are hoping that alternatives to vehicle ownership can help relieve the dents in their budgets caused by expensive parking. If city ordinances could allow parking minimums to be translated into car-share or ride-hailing accommodations, high-value spaces in dense areas could potentially be used in more valuable ways. Examples of such reasoning can be found far from the urban centers commonly described. Consider Bozeman, Montana, where a 2016 proposal for a new apartment building within the small town's historic downtown area offered to meet parking minimums by including four car-share parking spots, each counting for 5 of the standard spaces required in city codes. In an interview, the developer noted that the practice was already accepted in other communities, and asserted that car-sharing would be routine within five to 10 years. (Dietrich, 2016) This was apparently not a view of the future that all of Bozeman's residents were in agreement with, as the proposal sparked significant public controversy.

In contrast to such visions of densification, land developers with an interest in more expansive greenfield growth are also seeing opportunities in New Mobility. In Florida, the new planned communities of Babcock Ranch and The Villages have both taken steps to boost interest in their low-rise developments with pilot projects that offer access to automated shuttles or taxis to get around (Burns & Scarborough, 2013, and see Stocker & Shaheen, 2018). Although the planned communities do not appear to have eliminated any car infrastructure (the familiar wide roads, curbs, and garages in front of every house remain), the AV services will theoretically enable resident families to make do with only one vehicle instead of several. As the lots in these developments fill up with houses and as test programs of automated shuttles begin moving people slowly along fixed-routes between them, the ultimate impacts on car ownership and use remain to be seen. An alternative possibility is that the addition of automation to personal vehicles, such as Volvo's vision of the future describes, could mean living in low-density neighborhoods or remote city exurbs becomes more attractive to city-dwellers as the pain of long commutes and car-dependency is eased. With the increased demand for their work it might bring, this could be yet another potential sociotechnical imaginary that land developers have reason to support.

Regulatory Groups

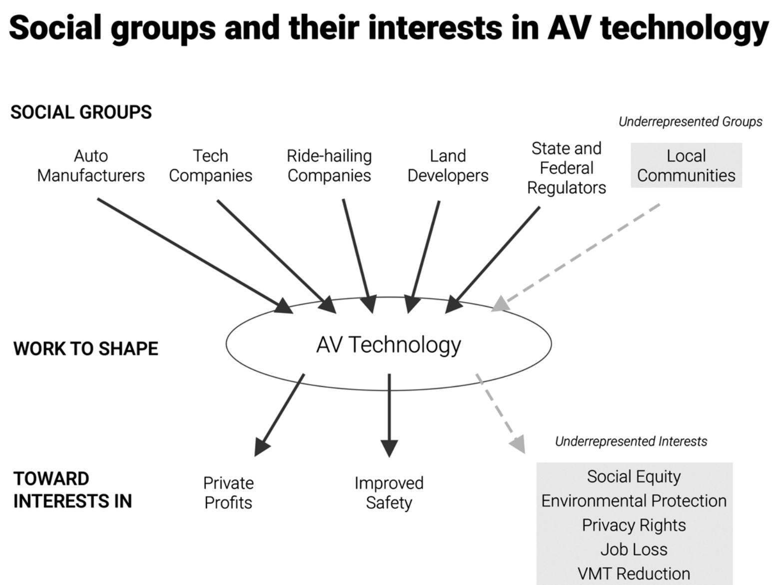
At the same time as these commercial interests are charging ahead, various government entities and public interest groups are seeing potential in vehicle automation, electrification, connectivity, and sharing platforms to help them reach their own goals. It is important to note that, while each may be tasked with serving the public good, their specific missions and priorities may differ. At a national level, for example, the United States' federal Department of Transportation (DOT) is tasked with ensuring that the US overall continues to have safe, efficient, modern transportation, and as such the addition of various new transportation technologies supporting improved safety, efficiency, and economic benefits has broadly been made a priority by the organization (DOT, 2018). But these interests can diverge slightly within the DOT's various administrations. The National Highway Traffic Safety Administration (NHTSA), for example, with its focus on safety and security, may not hold the same priorities as the Federal Highway Administration (FHWA), which works to maintain infrastructure, optimize mobility, and encourage innovation. In some ways, FHWA acts as an accelerator toward the deployment of New Mobility technologies through its investments in national highway research (FHWA). NHTSA, in contrast, at times acts more as a force of caution, though most recently quite gently so through its suggestions for voluntary safety approaches (NHTSA, 2017). As a whole, the DOT has been very supportive of the development of new transportation technologies, by both funding research and working to clear the way for private companies to test their products without interference. Of course, this is only one department of one country. Many more federal officials in nations around the globe are also working to clarify their own goals for New Mobility.

At the state and local levels, an even greater number of government branches, public agencies, and special interest groups have likewise taken an interest in the possibilities of New Mobility technologies. Planners seeking to make streets safer, reduce traffic congestion, or decrease vehicle emissions see opportunities to lower accident numbers and improve efficiency and the use of cleaner energies (Henaghan, 2018). Groups focused on social equity are looking to new vehicle technologies to fill gaps that leave those who cannot or do not wish to drive at a disadvantage (and see SUMC, 2016). Indeed, although they may have more limited resources or funding than federal, state, or commercial entities, at the municipal level there is considerable interest growing amongst a wide array of diverse social groups as advocates for the environment, public transit, housing, land use, and many others seek to influence how new transportation technologies are deployed in their communities. As will be discussed next, this can be especially important as the potential impacts of such changes become apparent.

THE IMPACT OF AVs UPON SOCIETY

Many of the possibilities for transportation's future which these and other social groups are calling for appear quite beneficial for companies or consumers. But they can also be seen as problematic, particularly if public interest is defined not just at the level of the individual but at that of communities. While consumers of automated vehicles or rides may see individual benefits through lower prices, better services, or increased amenities, the collective negative impacts of these technologies can add up when costs or downsides are externalized. To better understand how introducing new technologies into transportation could affect society, we will look at four examples of potential areas of impact: vehicle miles traveled, jobs, social equity and privacy, and safety.

Figure 2. Examples of social groups with an interest in shaping the development and use of automated vehicles. The motivation of each group can include multiple and sometimes overlapping interests of differing priorities. When groups at the community level are not involved, however, common community interests risk being underrepresented.



Vehicle Miles Traveled

One key risk of new transportation technologies is that of changing people's vehicle use in ways that could increase the total number of vehicle miles traveled (VMT). This can happen when the number of vehicles goes up, the number of trips increases, or when trips become longer. The increased use of any vehicles correlates to higher energy demands, added road congestion, and a greater footprint for vehicle fleets overall (Puentes & Tomer, 2008), including vehicle construction, maintenance, storage, and ultimately recycling or disposal requirements. Added VMT also brings additional new demand on vehicle infrastructure, which in most of North America today remains publicly funded and free of road pricing (tolls). For most car-centered contemporary cities, improving quality of life for residents involves reducing VMT (Jacobs, 1961). AVs could result in the reverse.

Research on induced travel demand shows that as costs (including monetary expenditures, risk, and discomfort) decrease, vehicle travel increases (Weis & Axhausen, 2009). If the increased comfort and amenities of Volvo's Concept 26 vehicle encourages motorists to spend more time in their vehicles and take more and longer journeys, the result would be increased VMT, congestion, and energy use (not to mention emissions, in all likelihood). Likewise, people who otherwise would have opted for another form of transportation might decide that they would prefer to take their driverless car. Use of mass transportation, cycling, and even walking could be reduced; just as was seen with the introduction of cars a century ago. The occupants in Concept 26, though entertained by screens, would be sitting in worse traffic and pollution than before.

Increased use of ride-hailing services, while potentially reducing parking needs or even improving vehicle occupancy averages, comes with an increased demand for the use of limited public curb space (ITF, 2018). Currently, in dense urban areas, taxis and ride-hailing services frequently pick up and drop off passengers by stopping temporarily at the side of the roadway, frequently blocking a lane of travel (or bike lane) in the process. As this practice increases, traffic flow in popular areas could become worse and worse, with the result resembling the gridlock of a busy airport drop off area.

Also, as above, any shift to vehicle ridesharing by those who would otherwise have used public transit, active transportation, or not have traveled at all constitutes an additional increase in VMT. Some studies have confirmed this pattern (Gehrke, Felix, & Reardon, 2018; NYC DOT, 2018; Schaller, 2018), and indeed that ride-hailing services have already added significantly to VMT in some cities (Schaller, 2017b). Such alternatives to vehicle transportation are likely positioned to be the biggest losers in many of these proposed futures (see UITP, 2017). The fact that they are, in most cases, the more effective way to solve urban transportation problems is unfortunately not enough to ensure they will prevail.

Beyond the additional VMT that could stem from increased use of vehicles by people, both privately-owned AVs and robotaxi fleets have the potential to generate another very significant source of additional VMT: zero-occupancy travel. While an automated taxi is repositioning itself to pick up its next passenger – a practice known as "deadheading" – it is adding to VMT without creating any immediate value. Research has shown that, in a city such as New York, approximately 45 percent of overall miles driven by taxis and ride-hailing vehicles today are unoccupied by passengers (Schaller, 2017a). While opportunities exist to improve this metric, any such gains are likely to pale in comparison to the added deadhead VMT caused by an expansion of ride-hailing services through vehicle automation. Similarly, if privately-owned AVs are able to park themselves after dropping off passengers, or be sent empty to pick up a family member or even cargo, such travel also adds to VMT and contributes to energy use, congestion, and vehicle footprint.

Jobs

Clearly the introduction of fully-automated vehicles would also not be good news for the large number of people currently employed as drivers. In August of 2016, Uber acquired self-driving truck company OTTO with the goal of automating the highway freight transportation industry (Woodall, 2016). Truck driving is one of the most common jobs in North America (Lipson & Kurman, 2016). In the US alone, in addition to 200,000 taxi drivers, there are approximately 1.5 million truck drivers whose jobs could be eliminated if automation efforts are successful (Bureau of Labor Statistics, 2015, 2017).

This is not to say that such a transition would necessarily be instant, nor entirely painful for the groups involved. Overall the trucking industry has faced an ongoing driver shortage for years, and a significant portion of those who do drive trucks today are nearing retirement (Tett, 2018). Some research estimates peak effects of vehicle automation on unemployment at 0.06 - 0.13 percentage points in the U.S., with an average displacement of 350,000-750,000 workers per decade (SAFE, 2018). This is significantly less than the 1.7 million jobs lost per decade in U.S. manufacturing (Groshen, Helper, MacDuffie, & Carson, 2018).

Beyond driving, however, there are still a variety of other positions that could be made expendable in a driverless world. Valets and parking lot attendants, traffic and parking enforcement officers, and driving instructors could all see demand for their services dwindle. Furthermore, with smoother computerized driving there is the potential to minimize wear and tear on roadways, reducing the need for work by road maintenance crews. But perhaps most dramatically, if AV proponents get their wish of eliminating vehicle collisions, entire economic sectors would be impacted. Today's automobile accident industry involves a vast network of ambulances, fire services, hospitals, police, tow-trucks, cleaning crews, forensic photographers, mechanics, auto body repair, insurance assessors, and accident attorneys (Graham, 2007; Lipson & Kurman, 2016). A world with no automobile crashes might ultimately be desirable by everyone, but a transition to that state would likely be difficult for a significant portion of the economy.

Equality and Privacy

In the case of privately-owned automated vehicles, the major benefits implied by many proposed future uses appear likely to remain limited to those who can afford them. It is therefore not difficult to imagine that in such a future there would remain strong divisions between the haves and the have-nots. In this case, any potential for automated vehicles to solve social equity problems for those who are unable to drive themselves would be restricted to only benefit users over a certain economic threshold.

AVs used for ride services could potentially offer more affordable mobility, but that doesn't necessarily mean they would bring a solution to socioeconomic inequity. Those needing to rely on the least expensive option for transportation might find in exchange for a cheap ride, a relatively undesirable robotaxi experience awaits them. In addition to ride-pooling with strangers heading in the same general direction (an option some ride-hailing companies offer today), a rider might find him or herself in a utilitarian, hard-surfaced interior with litter, graffiti, or gum on the seats (Lipson & Kurman, 2016). The car might recognize you when you enter, know your online browsing history, and interrupt you with suggestions for shopping stops along your route. Clearly, in such a scenario there are certain social groups who benefit, and certain groups who give something up.

AVs could indeed become one more source contributing to growing concerns regarding data use. Privacy concerns with AVs could be unique, as not only would their networks see who is riding where and when, but also the cameras they use to see the world would potentially be watching, recording, and transmitting to their networks the activities of everyone they pass. With artificial intelligence that can recognize faces and compile vast amounts of data from multiple sources, it is possible that such a network of moving cameras could comprise a surveillance system on a scale that has never been seen before (Lipson & Kurman, 2016). Such data on people's activities would certainly be of value to many business or government interests, but it would come at the cost of people's privacy (see Rakower, 2011).

Furthermore, such an escalation of data gathering and use brings with it significant new risks. Since the very introduction of computer networks it has been clear that any software, digital network, or data channel can be vulnerable to malicious hacks. Networks can be breached, and software can be tricked into functioning incorrectly (Lipson & Kurman, 2016). Many of the computerized systems required to make AVs function and operate effectively could open them up to new security risks, and data and control that users willingly give up to the machines could end up in the hands of someone else (see NHTSA, 2017).

Because the processes of competition involved in shaping new technologies can lead to certain groups benefiting over others, the results can be both less positive for society overall, and especially detrimental to interests that become marginalized. In many areas of our modern consumer culture, it is clear that externalized costs and consequences can build over time into collective problems such as pollution, resource depletion, and systemic inequality.

Safety

Another set of impacts, perhaps for many the most significant, relate to safety concerns. With non-automated vehicles today, 93% of all traffic accidents are attributed to human error (NHTSA, 2008). Many people see the introduction of AVs as a potential solution to this problem, which globally takes the lives of millions each year and impacts many more. However, it is important to realize that improvements to safety are not actually related directly to the introduction of automated vehicles. Instead, such impacts would only come when we *stop driving today's cars*, which is a very different proposition. AV penetration into the vehicle fleet will be slow; estimates based on adoption of advanced driver assistance systems (ADAS) suggest that under optimal scenarios safety advantages from AVs might arrive between 2040 and 2050 (Litman, 2017; and see Grush & Niles, 2018). The most utopian goals such as the "Vision Zero" of getting to zero automobile accident deaths or injuries, or doing away with traffic signs and signals, will not be possible until all human-driven vehicles are taken off the roads. Such benefits are unlikely to be realized within the lifespan of those who are alive today, if ever. It is therefore important to set expectations regarding the ongoing impacts and limitations of mixed AV and non-AV traffic. New Mobility is a revolution today's population will likely witness, but not see to conclusion.

Amid this intermediate, mixed-vehicle transition, safety could take on the guise of trade-offs. In collision-imminent situations, autonomous systems will make decisions that once fell to humans. Automotive manufacturers, cognizant of the self-preservation instincts of their customers, will need to expressly address this new reality. Each reader should ask themselves, would you buy the vehicle which promises to attempt to save your life at all costs, or the one that will consider the balance of your life against others? Such questions have been explicitly asked in a research setting (Bonnefon, 2016), and results show that while users are in favor of vehicles which make ethically correct choices, they would not like to ride in one themselves. This finding indicates that certain advanced safety systems could face an uphill battle in winning over consumers. If successful, however, ethically programmed vehicles could shift the balance of safety from what it is today, perhaps even to favor specific social groups such as pedestrians, cyclists, small children, or any other group the algorithms chose to prioritize.

Safety further plays into many of the previous concerns. For example, as traveling by car is currently among the riskiest activities in which the general population routinely engages, increases in VMT are generally accompanied by increases in property damage, injury, and fatality. In order to avoid such effects of an increase in VMT due to AVs, it will be necessary for this risk to be offset by the safety gains of New Mobility. However, such changes are likely to be complex and difficult to track. At present, Tesla claims their autopilot technology to be twice as as safe as the average driver (Tesla, 2018, but see Sparrow and Howard, 2017), despite criticism that the technology may be problematic from both a conceptual and design standpoint (Endsley, 2017). Noting that this does not help the above-average driver, one can assume that this product and similar products to come will be most attractive to below-average drivers. In a future where these drivers flock to AV technology, the "average driver" remaining would be significantly better. This confusing scenario is nonetheless a best case scenario. The Dunning Kruger effect (Dunning, 2012) shows that individuals least qualified to perform a task often assume they have superior skills, and so suggests that the individuals that will turn to safer AV technology may in fact be the above-average drivers. Such a future, in which the least qualified remain behind the wheel, is part of what interests insurance companies, safety advocates, and regulatory bodies. This example is only one in a broad array of potential unintended consequences which could accompany the utopian futures automated vehicle proponents suggest (and see Hancock & Parasuraman 1992; Hancock, 2015).

To better research these added safety concerns, new approaches for simulation and experimentation (see Sawyer & Hancock, 2012; Sawyer, Calvo, Finomore, & Hancock, 2015) are being employed to allow industrial and civil engineers, as well as engineering psychologists, to make better predictions of where future pitfalls might lie. With safety, however, as with each of the above concerns, transformative decisions are not determined by the evidence of science, nor the recommendations of engineers, but instead by the amalgamated viewpoints of a variety of influencers (see Wetmore, 2009). Safety in AV systems, whether at the level of the interface in the vehicle, the vehicle on the road, the road network, or the laws that govern it, is not an immutable piece of some inevitable technological advancement. Rather, individuals and social groups will contribute decisions which influence the state of safety, the state of jobs, the number of VMT, and the questions of equality and privacy. Myriad futures are available, but collectively we will only get to realize one.

COMMUNITIES VS. INDIVIDUALS: THE IMPORTANCE OF COMMUNITY INTERESTS

Many of these potential issues for the future of transportation can be seen as various versions of the Tragedy of the Commons, wherein benefit-seeking at the individual level leads to detrimental outcomes for all (Hardin, 1968). This highlights what can be the biggest challenge in involving the voice of the public in the decision-making process, namely that the public itself holds multiple, sometimes conflicting, interests and concerns. As people play multiple roles in their lives, they may belong to multiple relevant social groups. As consumers we may want the cheapest or most convenient form of travel. As parents we may want the safest, or a world of healthy sustainability we can pass on to our children. As taxpayers we may want the most fiscally responsible use of tax dollars, but as employees or business owners we may want whatever boosts our incomes. As drivers we may wish streets to stay clear for our use, but when we park our cars and become pedestrians we may wish streets to be available to us and free of cars. Conflicting viewpoints therefore exist not only between social groups, but between incongruent interests within each person. Focusing on those interests which stem from the community as a whole, therefore, can be a difficult but important challenge.

In this way, the solution to any Tragedy of the Commons is not merely to include the interests of the public, but to include interests at the community level that are often left out or overshadowed by interests at the individual level. For transportation, this might include the safety and enjoyment of shared walkable streets, reducing air pollution, or ensuring equitable mobility for all residents (see UITP, 2017). Each of these can be criteria upon which to evaluate the options for how new transportation technologies are introduced. Any proposed visions for how these technologies can be used in society might therefore be best examined through the lens of community impact by those interested in attaining the most desirable collective results.

This can mean looking beyond short-term interests to long-term benefits and consequences. Where multiple goals conflict, it means taking into consideration the long-term effects of prioritizing one over the other; for example, between goals of a healthy economy on one hand, and a healthy planet on the other. One may be desirable in the short term, the other, in the long term.

As transportation technologies compose a vital layer in the fabric of our actions and interactions within our environment – establishing the parameters of our economic, social, and physical worlds – any consideration of what communities want from them in the long term must also involve thinking about the deeper goals those communities wish to achieve with transportation as a society. It must not only ask how communities wish to move their people and goods, but where, when, and why they are moved at all. Looking at the growing problems of car-oriented society around him in the 1950s, Lewis Mumford (1958) challenged us to consider what transportation is for (suggesting it is not perhaps something that highway engineers ever ask themselves). "To increase the number of cars," he writes, "to enable motorists to go longer distances, to more places, at higher speeds, has become an end in itself" (p. 241). Mumford was frustrated not by a lack of planning, but by a system of planning that had failed to orient itself around human values.

To avoid repeating the same pattern with automated vehicles, those interested in putting AVs to their best use from a community perspective might begin their planning with deeper questions. What kind of world do we want to live in? And what might that world's environment look like? The process of considering these questions must happen early, when sociotechnical imaginaries are being formed.

In this way, bringing forward a true transportation revolution might require shifting to a new mindset, or as Thomas Kuhn described, new paradigms (1962). Instead of focusing on energy use, for example, we might think in terms of sustainability. Although it may be deeply embedded, the current model of unconstrained use of energy and materials could be replaced (Dennis and Urry, 2009). This might mean building an interest in better aligning the cyclic demands on systems, such as by adjusting work schedules to reduce rush hour congestion. Or it could mean, instead of seeking to increase individual travel as a metric for mobility, seeking to reduce unnecessary travel.

Mumford (1958) claimed, in response to his own question, that the purpose of transportation is to move people and things to where they are needed, and to concentrate both in ways that increase choices without the need to travel. In his words, "a good transportation system minimizes unnecessary transportation" (p. 236). This wasn't just about reducing traffic or moving people more efficiently, but providing them with more meaningful movement and better use of their time. "Human purpose", Mumford argued, should govern the choice of a means of transportation (p. 237). Not just faster connections, but better relationships.

Importantly, community-level interests do not necessarily need to compete with interests that benefit individual groups. Making decisions over how new technologies are used is not necessarily a zero-sum game, and therefore including support for community-level interests does not negate the potential for mutually beneficial outcomes. A number of recent collaborations between ride-hailing companies and municipalities provide examples of this, as commercial ride providers have been tasked with supporting connections to transit hubs or even filling in for public transportation services in places that lack them (Schwieterman, Livingston, & Van Der Slot, 2018). The results in many cases have proven to be win-win, as municipalities save money, ride-hailing companies increase their business, and travelers see improved alternatives to private-car use. Clearly, desirable results at the community level may still require compromise. But they do not necessarily require that other interests be excluded.

CHOICES FOR COMMUNITIES: THE NEED FOR COMMUNITY PARTICIPATION

Going a step further, as each social group works to present their own sociotechnical imaginary, it is clear that communities have the power as well to put forth, and advocate for, their own proposed visions of how vehicle automation and connectivity should be used. Understanding that technology can be shaped is ultimately only helpful if followed up with active participation in the efforts that influence what that technology becomes. Engaging in this process requires not only making decisions about desired outcomes, but also actively pushing for the realization of those outcomes. Thus it is necessary to both understand how that process works, and to identify areas where it can be influenced.

Social groups perform a kind of "world-making" when they try to get others to take on their same perspective. They attempt to spread their ideas about which actors and roles are important, as well as what the final sociotechnical imaginary should look like. Michel Callon (1986), well-known for his contributions to STS in Actor-Network Theory, provides us with examples of how this can be done. One is when social groups put forth a spokesman who attributes to an actor an identity, interests, a role to play, or a course of action to follow. Actors of course may resist these roles, but the attribution is necessary to begin an endeavor that may later be achieved. This act of "translation", though not in itself an imperative, can shift the mindsets of other social groups in a way that starts making the paths of the network easier to form.

We see this performed when Volvo puts out videos of models relaxing behind the steering wheel, when Google tells us they are working on problems of safety and accessibility, or when Lyft publishes blog articles about the possibilities of needing fewer parking lots. Although these actions themselves do not make any outcomes a reality, the groups behind them are counting on consumers, lawmakers, and others to support their sociotechnical imaginaries.

In another example, during the early automobile days, certain social groups were relatively successful in convincing others that city streets should be socially reconstructed as motor thoroughfares where cars should take priority, instead of gathering places for residents (Norton, 2011). This idea eventually spread to the politicians and engineers who paved the roads, the pedestrians who stayed out of them, and the police who watched over them. But achieving this was not simply a matter of one social group conveying their interests to the others; it involved a hard fight. As traffic accidents and congestion were originally perceived to be the fault of cars, supporters of the automobile organized together to push the message that these problems were to be seen as issues of regulating human behavior and perfecting road engineering (Norton, 2011).

Ultimately, collaboration and compromise between many voices will be the path toward agreeable and optimal integration of New Mobility technologies. What is good for communities and good for individual social groups can be different, and again, even conflict. At the individual level, the best choice for transport might be a private car, but when everyone takes a private car it increases traffic and creates congestion that negatively impacts the entire community. Potential uses of vehicle automation, electrification, data-connectivity, and digital ride-hailing services could involve many such paradoxes. At a community level, systems of local organization and regional government, working in both private and public forums, must play a leading role in bringing interests together. Such cooperative decision-making enables resources and facilities to be put to use to benefit both suburb and metropolis on a larger scale (Mumford, 1958).

At an individual level, this can occasionally mean concession. "Good public policy favours necessities over luxuries," writes Todd Litman (2009), "and so should favour basic mobility (transport activity considered socially valuable) over less important activity" (p. 213). This might prove challenging to the expectations of today's drivers, who have long benefited from a focus upon individualized and flexible movement (Dennis & Urry, 2009). But although a more libertarian perspective might still be appropriate for many uses of AVs, when it comes to the potential shared consequences and missed opportunities involved, some amount of collaborative planning could bring benefits that prove to be well worth certain sacrifices.

CONCLUSION

Transportation technology is not just another area of consumption. The systems society builds to move people and things affect much more, from the shapes of cities to the social interactions of those within them. Therefore, anyone with an interest in maximizing the benefits and minimizing the negative consequences of a new transportation technology such as vehicle automation must not only pay attention to how that technology could function, but also think in terms of the unintended consequences or deeper long-term impacts it could have. This involves considering the effects of building, operating, and disposing of the technological artifacts involved, as well as thinking a step further to the secondary impacts of integrating them into the social fabric of people's lives.

Given the magnitude of what's at stake, it is simply vital that emerging transportation technologies be steered toward uses which offer the most shared benefits. In shaping vehicle automation, connectivity, electrification, and sharing, we must reconcile our roles as individuals with our roles as community members. If we fail to do so, our transportation systems are in danger of sliding us closer to a dystopia where automation increases vehicle use and congestion, decimates public transit ridership, and only the few see any benefit. Conversely, we now face an incredible opportunity to reduce traffic deaths, make better use of our resources, and improve the mobility options of all people. If communities push toward the future they collectively want with shared interests in mind, they may find that moving toward their goals is only a matter of choice. Communities that wait too long, however, may find that someone else has made these choices for them.

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KEY TERMS AND DEFINITIONS

Automated Vehicle (AV): A road vehicle with the ability to complete all driving tasks for some or all portions of a journey without human assistance.

New Mobility: A shift in transportation systems made possible by the emergence and confluence of multiple new transportation technologies, including vehicle automation, electrification, data connectivity, and digital methods of sharing.

Ride-Hailing: A service with which a person can request transportation as it is needed (on-demand), commonly via smartphone app, website, or by telephone.

Social Groups: A set of people for whom a technological artifact represents a shared value or problem.

Sociotechnical Imaginary: A vision for how a technology could be manifested and put into use by social groups, potentially including particular outcomes for these or other social groups.

Tragedy of the Commons: A situation in which the pursuit of individual gain leads to overall collective loss.

Zero-Occupancy: Road travel of an automated vehicle with no persons on board.

ENDNOTE

1 Available at https://www.futureofdriving.com/concept26.html