Social Factors Affecting Autonomous Public Transit Adoption

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

Thanks to the drastic improvements in autonomous vehicle technology in recent years, several companies are closer than ever to unleashing fleets of driverless shuttles into dense urban environments. Driverless shuttles have the potential to improve road safety by eliminating human driver error. They are also designed to reduce traffic by communicating with other vehicles to optimize routes. Because less time is spent idling, the shuttles are projected to reduce energy consumption and pollution. No matter how safe the technology is by engineering standards, stakeholders will ultimately decide whether these shuttles have a place on city streets. Rare accidents during testing have shaped negative public opinion and lack of trust in autonomous vehicles (AVs). The idea of replacing human drivers has drawn the ire and opposition of the public transit labor unions representing cab, bus, and ride-hailing drivers. Engineers also continue to face obstacles from local and federal governments, significantly delaying real-world testing and progress. This STS research paper will examine the relationships between driverless shuttle technology and its main stakeholders using the Social Construction of Technology framework, including a forecast of possible solutions to the problems presented.

Social Construction of Technology

The Social Construction of Technology (SCOT) framework was introduced by Wiebe Bijker and Trevor Pinch in 1984. It stems from a criticism of technological determinism, in which technology determines societal development. In contrast, SCOT proposes that new technology is given meaning by the societal context in which it is introduced. Human behavior shapes technological development, and criteria for adoption are decided by affected social groups instead of technical benchmarks. Four main tenets laid out in the SCOT framework are used to analyze the adoption of various technologies. *Interpretive flexibility* means that any given technological artifact has different meaning for different groups of people. *Relevant social groups* are distinguished based upon shared or diverging interpretations of the artifact. Any differing interpretations can cause *problems and conflicts* between design criteria. *Design flexibility* means that there is no one way to solve a specific problem or conflict among social groups. The numerous problems presented by social groups, each addressed by several different solutions, presents a multi-directional model "in contrast with the linear models used explicitly in many innovation studies" (Pinch and Bijker, 1984). SCOT theorists identify closure and stabilization of a technology in two ways. *Rhetorical closure* occurs when social groups decide individually that the important problems are solved, and no new design is needed. If this does not happen, *redefinition of the problem* allows the design to be repurposed to solve a different problem with fewer incidental conflicts.

Undoubtedly, safety is a priority in the development of driverless shuttles. But the technology would never stabilize if engineers ignored the problems of relevant social groups. Customers must feel comfortable riding in driverless shuttles, and state of the art is not the only concern. Engineers need hundreds of thousands of accident-free miles to prove that driverless cars are even just 10% safer than human drivers (Kaufman, 2020). The customer interprets the technology as a means of traveling from place to place safely, and accidents stand in the way of willingness to ride. Additionally, certain labor unions fear that driverless shuttles will replace the jobs of taxi and bus drivers, though the impact of this technology on the labor market is currently unknown.

Background Information

To fully understand the public perception of autonomous vehicles, it is necessary to examine their history of technological development. The idea of driverless cars stoked public imagination during demonstrations of a remote-controlled vehicle between 1931 and 1949. Dubbed the "phantom auto," the retrofitted Pontiac's brakes, steering wheel, and horn "could be operated from as far as five miles away" with a telegraph key (LaFrance, 2016). The first semi-autonomous car was developed in 1977 by the Tsukuba Mechanical Engineering Laboratory, using a computer. It was able to drive on specially marked streets up to 20 miles per hour (Weber, 2014). German pioneer Ernst Dickmanns equipped a Mercedes sedan with cameras and microprocessors in 1987, which was then able to detect obstacles and other vehicles on the road. In 1995, the CMU NavLab 5 completed the first autonomous coast-to-coast drive. A design for a national automated highway system was demonstrated in 1997, but the project lacked clear direction and funding. Waymo began testing vehicles without a safety driver in 2017, commercializing an autonomous taxi service in Phoenix a year later. By 2020, the service was opened to the public.

Currently, the Society of Automotive Engineers (SAE) ranks a vehicle's level of automation on a scale from 0 to 5 (Automated Vehicles for Safety, 2020). A car with level 0 automation requires full-time performance by a human driver. Most older cars on the road fall into this category. Level 1 vehicles are readily available today, providing either steering or acceleration/deceleration assistance in certain driving environments. Some cars automatically follow another at a safe distance on the highway, and others assist with maintaining a steady lane position. Level 2, or partial automation, includes both types of assistance. Though Tesla's vehicles are advertised with "full self-driving autopilot," it is generally considered to be a level 2 system. The driver must hold the steering wheel and maintain awareness of surrounding conditions. Level 3 systems handle all aspects of the driving task, with the expectation for a human driver to respond when prompted. These systems require no human attention to traffic. Level 4 systems take this a step further by requiring no human driver at all, but they are geofenced into specific areas and limited in speed. Level 5 vehicles can drive with no restrictions on any road alongside regular traffic. Some Tesla drivers who mistake the autopilot system for one of this level have gotten in fatal accidents. Self-driving taxis like Waymo's shuttles are of interest because they are projected to result in a 60% decrease in the number of cars on city streets with an 80% reduction in tailpipe emissions. 94% of crashes are caused by human error, which could be prevented by autonomous vehicles. In 2010, vehicle crashes cost $242 billion in economic activity and $594 billion from loss of life and serious injury. These costs could be significantly reduced if autonomous vehicles are widely adopted.

Public Testing Initiatives

City officials were largely unprepared when ride hailing services such as Uber and Lyft ballooned in popularity about 10 years ago. As a result, public transit ridership dropped in 88 percent of major metropolitan areas in 2017 (Bliss 2019). Now, autonomous shuttle startups such as EasyMile are offering test vehicles to cities and transit agencies, who believe that "AVs could attract new riders to transit and reduce costs, positioning agencies for long-term success" (Zipper, 2020). Shuttles could serve as the crucial "last mile" solution between public transit stations and residential areas. Cities that have already planned for AV testing include Houston, Jacksonville, Florida; Las Vegas, Nevada; Providence, Rhode Island; and Frisco, Texas. Two types of vehicles were already tested in Columbus, Ohio, both of which encountered inconvenient technical problems. The first test, using vehicles supplied by May Mobility, ran on a 1.4-mile loop and exposed a major weak spot for AV technology – left-hand turns in traffic. The vehicles could not safely decide when to make the turn and a safety driver was always required. In a second instance of testing, vehicles from EasyMile were used to carry riders between a housing development and a nearby transit station. One vehicle made an emergency stop while travelling at 7.1 miles per hour, throwing a passenger from her seat (Marshall, 2020). The passenger experienced minor injuries and expressed publicly that she would never ride in an autonomous vehicle again. Incidents such as these are partially responsible for the public opinion of autonomous vehicles. A study of transit riders in Michigan found that about half of riders were "hesitant about riding in autonomous buses citing concerns over safety, no human, and distrust in technology" (Kassens-Noor, 2020).

Still, city officials believe that they can win over the public with continued testing. An autonomous shuttle called Relay is being tested in Northern Virginia, carrying up to a dozen passengers between the Dunn Loring Metro station and the communities in Merrifield (Augenstein, 2020). The proposed route is only 1 mile long and includes a traffic light on U.S. Route 29 that communicates its timing with the vehicle. Testing has received support from Fairfax County, Dominion Energy, the Commonwealth of Virginia, and real estate developer EDENS. Dominion Energy is particularly concerned with transitioning most vehicles on the road from gasoline to electricity. Autonomous vehicles also have the potential to increase certain property values. Currently, properties close to office buildings and public transit stations are highly valued for their short commute times. Driverless shuttles would make longer commutes feasible for workers who do not own cars, potentially making more distant residential areas more attractive. This added value would certainly be of interest to EDENS and explains why they have invested in driverless shuttle public testing and adoption.

Automation and Jobs

If the goal of autonomous shuttles is to remove the human driver, then adoption of driverless shuttles would certainly have an impact on the public transit labor market. It remains to be seen how many jobs will actually be displaced, and whether or not those jobs will be reallocated. Labor unions representing transit workers have not hesitated to display their resistance to automation. John Samuelsen of the Transport Workers Union (TWU) personally led a protest against the driverless shuttle tests in Columbus, Ohio. Samuelsen believes that vehicle attendants and backup drivers would never earn the wages that bus drivers do (Ahmed, 2018). In addition to the safety concerns shared with riders, he sees a possible "dehumanization" of transit if vehicle attendants are not needed. The bus driver who normally assists handicapped riders would be obsolete, potentially reducing the accessibility of public transit.

Uber CEO Travis Kalanick and vice president Anthony Levandowski released a statement predicting the effects that automation could have on the economy. As one example of job displacement, "self-driving Ubers will be on the road 24 hours a day, which means they will need a lot more human maintenance" (Wiseman, 2016). Waymo has also responded to concerns about job loss by describing four roles that will need to be filled if autonomous fleets are implemented. In addition to the technicians inspecting vehicles and performing the tasks of a conventional mechanic, dispatchers are needed to ensure that enough vehicles are on the road to meet varying demand. A fleet response team will serve as a backup for when vehicles encounter uncertain conditions. For example, if a vehicle encounters a blocked road unexpectedly, "it may come to a stop and request confirmation" remotely from the fleet response team (Lee, 2018).

Riders can also connect with a Waymo representative at any time while inside the vehicle, which will bring some elements of a human driver back into the experience. Cars will need to be cleaned regularly due to a phenomenon that ridesharing drivers are already familiar with, known as the "vomit problem" (Welch, 2017). Waymo plans to partner with rental car company Avis, who will share maintenance and cleaning tasks.

One promising example of automation creating more jobs than it replaces can be seen in the adoption of automatic teller machines. As they became more available throughout the 1990s, automation alarmists expected that ATMs would completely replace human bank tellers. The average number of tellers needed to operate a bank branch did decrease from 21 to 13, but as a result, it became cheaper to operate branches and the number of offices increased "enough to offset the labor-saving losses of jobs that would have otherwise occurred" (Pethokoukis, 2016). This appears to be a general pattern with automation throughout history. For instance, automation in the 19^{th} century textile industry decreased the price of cotton cloth, resulting in a decades-long increase in the number of weaving jobs. Driverless shuttles could have a similar effect on the taxi market, which only accounts for a small percentage of traffic in the United States. If these shuttles are cheaper, safer, and more convenient than taxis, it is possible that an increase in related jobs would offset the loss of taxi driver jobs.

Government Approval and Closure

In November of 2020, the California Public Utilities Commission finally approved programs allowing some companies to charge for driverless shuttle rides. The approval came after months of lobbying by the likes of Waymo and Uber, but still imposes bureaucracy that "could delay deployments by more than two years" (Korosec, 2020). Companies will need to obtain permits from both the CPUC and the DMV. Participants must submit Passenger Safety Plans that outline how they intend to provide service to disadvantaged communities and reduce pollution. To this end, the CPUC will also require quarterly reports with detailed pickup and drop-off location data. Companies have taken issue with the Tier 3 process for obtaining deployment permits, which is typically reserved for regulated utilities. In a statement issued to the CPUC, driverless shuttle company Cruise suggests that the procedures for Tier 3 approval are a poor fit for the AV industry, which is "competitive, flexible, and receptive to passenger feedback" unlike the utility companies for which the procedures are designed (Plotkin, 2020). The slow approval process could cause significant delays in rollout should competing companies or opposing communities voice their concerns. Cruise proposed submission of annual reports instead of quarterly, in addition to removal of the Tier 3 application.

If autonomous vehicles are not adopted in cities soon, whether due to delayed government endorsement or consumer hesitance, it is likely that autonomous driving technology will be redefined for use on highways first. Though high speeds pose additional safety risks, ground freight follows "a very predictable route, every day, all the time" with no pedestrians and would be much easier for an autonomous vehicle to navigate (McGee, 2020). The sensors required for such autonomous trucks have decreased in price dramatically from $75,000 apiece in 2014 to $1,000 in 2020. The loss of jobs is not as great of a concern as with driverless shuttles because the trucks will still need backup drivers due to their size and speed. However, this application introduces its own set of relevant stakeholders with different considerations.

Conclusion

Driverless shuttles are a promising solution to many of the challenges of urban transportation. City streets would likely be cleaner, safer, and less congested with shuttles intended to replace human-operated taxis and individually owned cars. The obstacles facing driverless shuttle adoption are readily apparent through the analysis of relevant social groups and their attitudes using the SCOT framework. Closure depends largely on customer willingness to ride in autonomous vehicles, which itself is contingent on a history of safe driving and personal experience with public testing initiatives. Transit drivers and the labor unions that represent them have strongly protested driverless shuttles, even though they may eventually create more jobs than they replace. Vehicles will need maintenance, sanitation, and a large network of remote labor to dynamically scale the supply of vehicles. Companies such as Waymo, Uber, and Cruise are still navigating and negotiating the processes for obtaining government approval, which has the potential to delay deployment for years if not executed correctly. Rhetorical closure cannot be achieved until these social groups decide that their concerns have been addressed adequately, and closure by redefinition may come in the form of autonomous freight trucks supervised by a human operator. In either case, we can expect to see the commercialization of autonomous vehicle technology within the next decade.

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