THE NEXT INDUSTRIAL REVOLUTION: AUTONOMOUS VEHICLES DISRUPT AMERICAN TRUCKERS

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By

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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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Despite the effort of Elon Musk's promise of fully autonomous vehicles by the end of the 2021, engineers are struggling to implement fully self-driving cars (Korosec, 2021, para. 1-2). To stratify different automation, the Society of Automotive Engineers (SAE) benchmarked progress on human interaction and the variety of situations. The following definitions are illustrated in Figure 1 below.

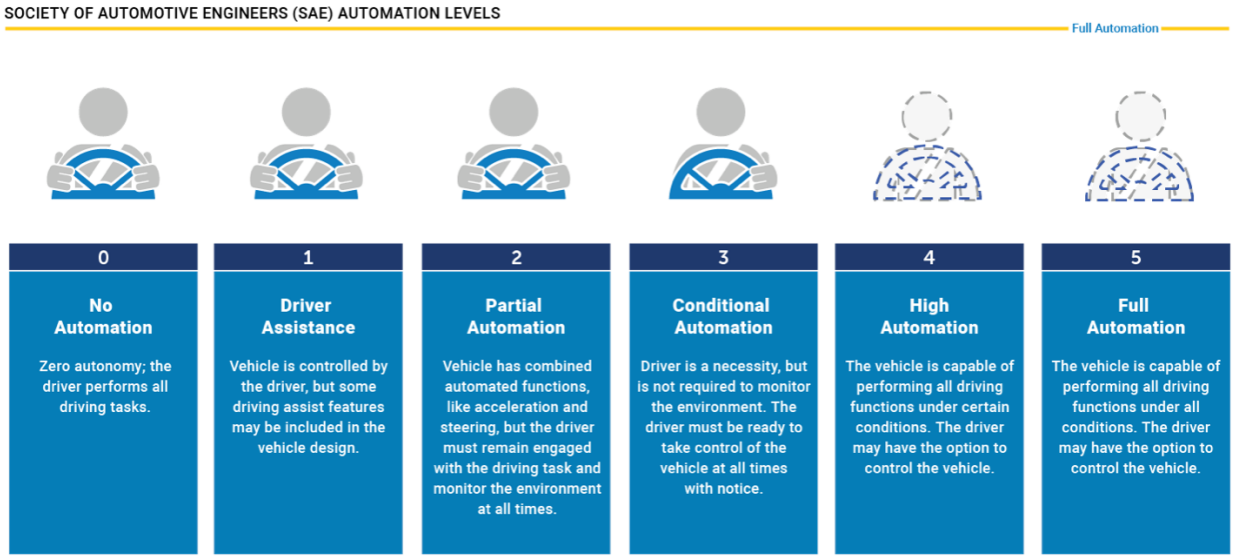

Figure 1: Level of Autonomy from SAE. Industry definition of autonomy from full human control, Level 0, to completely autonomy, Level 5. (NHTSA, n.d., The Road to Full Automation Section)

As shown in Figure 1, the levels of autonomy range from 0 to 5 with the following definitions: for Level 0, "the human driver does all the driving"; for Level 1, "an advanced driver assistance system on the vehicle can sometimes assist the human driver with either steering or braking/accelerating, but not both simultaneously"; for Level 2, "an advanced driver assistance system on the vehicle can itself actually control both steering and braking/accelerating simultaneously under some circumstances"; for Level 3, "an automated driving system on the vehicle can itself perform all aspects of the driving task under some circumstances"; for Level 4, "an automated driving system on the vehicle can itself perform all driving tasks and monitor the

driving environment – essentially, do all the driving – in certain circumstances"; for Level 5, "an automated driving system on the vehicle can do all the driving in all circumstances" (National Highway Traffic Safety Administration [NHTSA], n.d., Benefits section).

According to these definitions, Tesla's full self-driving package truly operates at a Level 2 autonomy (Korosec, 2021, para. 6). Autonomous vehicles benefit day-to-day life in four ways: road safety, increased profitability for companies, reduction in traffic, and assistance to people with disabilities (NHTSA, n.d., Benefits section). However, these benefits rely on the superior capabilities of computer perception and communication over their human counterpart. Therefore, the technology needs to Level 5, full autonomy, to reap all the rewards.

As a policy advocacy research paper, the STS research paper explores a potential future where fully autonomous vehicles exist. The trucking industry will be one of the first to adopt the technology. To frame the investigation of the American trucking industry, the STS research uses Hurtado-de-Mendoza (2015) et al.'s framework implemented in discussing medical technology (p. 330). This framework frames agency among key actors. Exploration of influential social relationships requires an additional framework—a social relationship framework. After examining agency and key social relationships, the STS research paper thoroughly analyzed the research question: how autonomous vehicles affect American workers. For the purposes of scope, the STS project is concentrated on the trucking industry. Using that information, this paper determines the potentially beneficial policy to minimize the harm to American truckers.

Closely coupled to the STS topic, the technical research contains two components: create an autonomous follower vehicle and create an autonomous leader vehicle to navigate the University of Virginia's campus. Both vehicles need to rely on environment perception from sensors, like cameras or LiDAR, to determine the automation. For distinction, the follower

vehicles can rely on another vehicle to determine appropriate motion. However, the leader vehicle must rely solely on detection of the environment to navigate around campus. Both vehicles will attempt to reach Level 3 autonomy without the use of GPS, which is a crucial intermediary step to reach Level 5 autonomy. Gregory Breza, Janani Chandler, Sara Khatouri, Zachary Kim, Harry Singh, and Charles Rushton compose the technical team. Professor Tomonari Furukawa leads the team, alongside one of his graduate students, William Smith.

THE RISE OF AUTOMATION

Previously used with medical technology, Hurtado-de-Mendoza et al. altered Actor-Network Theory (ANT) with a secondary Foucauldian view; this dual perspective analyzes the power dynamic from a technology within the proper scope (2015, p. 330; Latour, 2011). Figure 2 demonstrates the agency within the trucking industry from autonomous vehicles.

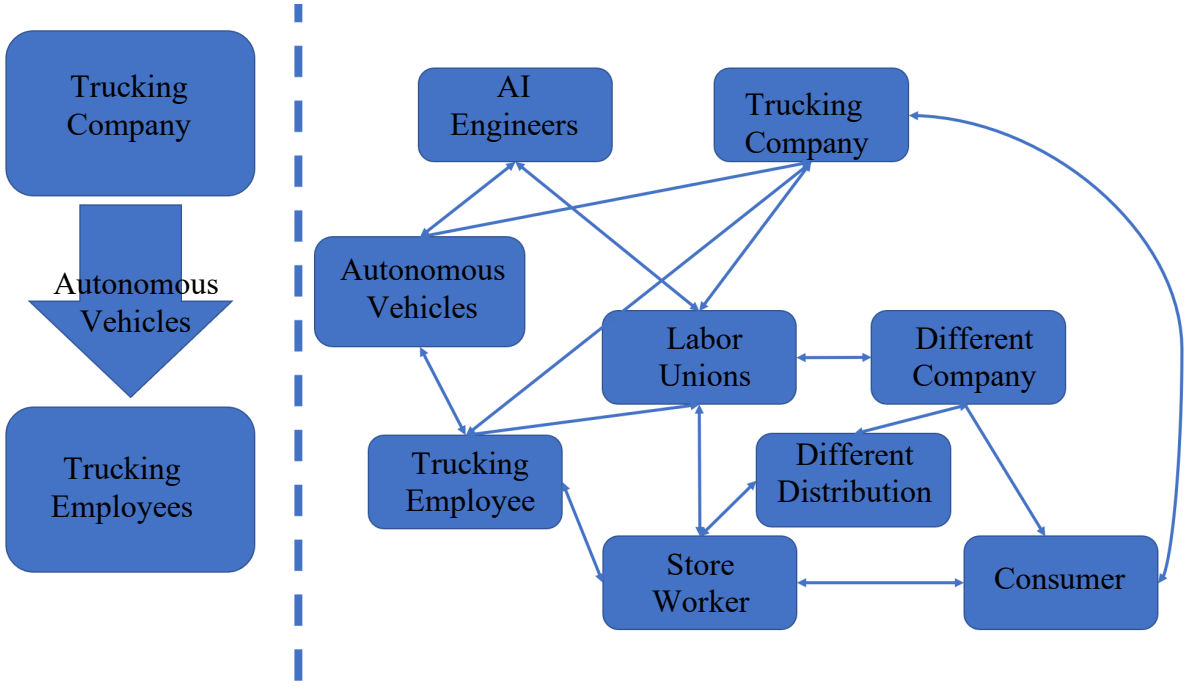

Figure 2: Adapted Technology and Social Relationship for Trucking. A sample truck driver's network of relationship that could be highly impacted by the introduction of autonomous vehicles. (Rushton, 2021)

Left of the dotted line portrays the purely Foucauldian view of the trucking companies using autonomous technologies to strip truckers of their agency. To some extent, this framework gives insight into the bartering agreement between employer and employee. The employer now has a direct substitute for human labor with self-driving trucks, giving the employer significant leverage when determining wages. However, this view fails answer the broad societal views. As shown in the right side of the dotted line, the ANT framework spans across more actors. The agency in this case is dispersed between multiple agents.

In addition to this framework, the scope of the network needs to be refined further to deliver meaningful results. Figure 3 below will show the four main relationships of truckers for this research: friends/family, bystanders, employer, and AI designers. The adoption of autonomous vehicles changes the dynamic most of these four relationships.

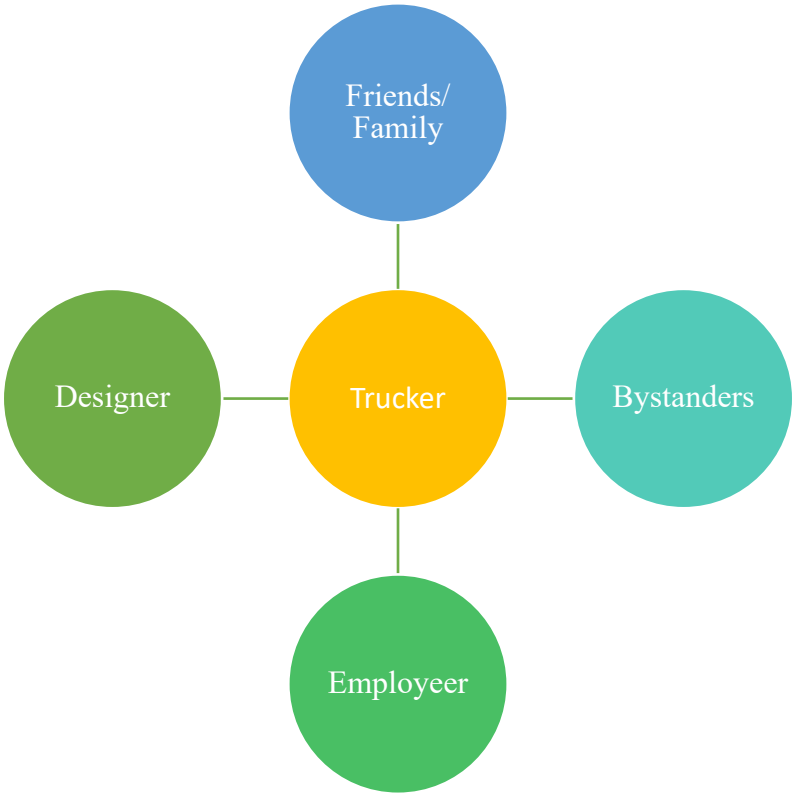

Figure 3: Potentially Affected Social Relationships for Trucker from Autonomous Vehicles. A sample truck driver's network of relationship that could be highly impacted by the introduction of autonomous vehicles. (Rushton, 2021)

Acceleration of Autonomous Technology

During the coronavirus pandemic, over eight million workers left their jobs at an unprecedented rate, but companies continued similar levels of production (Lynch, 2021, para. 1). Electronic commerce (E-commerce), one of the major industries affected by the pandemic, coped with a loss of workers by innovating: "the e-commerce boom has fueled orders for…self-driving machines" (Lynch, 2021, para. 8). Whether these self-driving machines are forklifts, trucks, or other machinery, automation spells over eighty-five million lost jobs (Lynch, 2021, para. 26). Although The World Economic Forum forecasts a net gain of twelve million jobs from automation, the ninety-seven million new jobs could be in vastly different industries than lost jobs (Lynch, 2021, para. 26). This trend demonstrated an accelerated broad need for autonomous technology, and the trucking industry will likely follow the same trend.

Additionally, autonomous vehicles act more similarly to software rather than automobiles regarding innovation. Jack Ewing, an economics correspondent for The New York Times and winner of New York Times publisher's award in 2011, discussed the issues surrounding the accelerated pace of autonomous vehicles (The New York Times, n.d.). When innovating automobiles, car safety is of the upmost importance. From their inception, "automakers were lords of their realm, dictating terms to suppliers" (Ewing, 2022, para. 140). With this power, these manufacturers could control the speed of innovation, allowing for car safety within new models.

However, autonomous vehicles created an opening for software companies to enter the car manufacturing space. The automotive giants now need to integrate Big Tech into their cars. Since Big Tech expanded rapidly in the early twenty-first century, "Apple and Google command financial resources and software expertise that even auto giants cannot match" (Ewing, 2022,

para. 14). Being at the mercy of an external market, auto-manufacturers have attempted to alter their timelines to match the rapid innovation of technology. Usually, the research and development for a new vehicle consumed nearly four years (Ewing, para. 17). However, Ewing discuss the necessary integration of Apple's CarPlay and Google's Android Auto software into vehicles, but these companies release multiple updates annually (para. 19). This accelerated timeline causes "rocky transition to the digital age" for car manufacturers (Ewing, para. 6). During this time, Tesla became the largest auto-manufacturers; one reason for success is Tesla's ability "to send software updates to its cars over cellular connections, regularly adding features, even in cars that have been on the road for years" (Ewing, para. 28). Due to the increased pressure to innovate alongside Big Tech, automobile manufacturers innovate faster than before, causing an acceleration of autonomous car technology.

A Vulnerable Community

Having to travel long distances for extended periods of time, trucker become more susceptible to harm. Being far away from home can cause truckers to feel disconnected from their community. This disconnect removes a critical social support net, which helps truckers maintain a healthy lifestyle. Additionally, truckers may travel at night and sleep during the day. Working the night shift further limit human interaction, ostracizing truckers. All of this combined creates a vulnerable community. The vulnerability becomes a detriment in two main areas: physical health and drug abuse.

Truckers' physical health deteriorated due to the nature of their work. From 2005 to 2011, the morbidly obese rate more than doubled in the trucking industry (Thiese et al., 2017, p. 105). Furthermore, according to Apostolopoulos, Lemke, Sönmez, and Hege, "obesity rates (69%) of truckers compared to 34.9% of the general population", which leads to a "life

expectancy 16 years lower than that of the general population." (2016, p. 91). In the United States, the general population already struggles with overweight issues. Apostolopoulos et al. found that the discrepancy in obesity rate is that truck sites "provide insufficient resources to support physical activity or healthy eating but they either create significant barriers (i.e., pricing, availability) or encourages diets high in saturated fats and calories as well as other processed food" (p. 90). With inadequate support from truck stop infrastructure, truck drivers rely more heavily on personal agency and their trucking community for proper eating habit. A trucker's home community fail to assist truckers when traveling because of the geographic difference. Furthermore, without the infrastructure of physical exercise implemented at truck stops, truckers miss an integral part of maintaining a healthy lifestyle. Therefore, the truckers rely on the trucking community to support their physical health. A strong trucking community remains crucial to obstruct the worsening obesity rate.

A second problem in the trucking industry remains drug abuse. 30% of trucker drivers use amphetamines and 50% drank alcohol in 2021 due to the "due to the long hours and desolate nature of the job" (American Addiction Center, 2021, Truck Driver, Drug Use & Staying Awake Section). Trucking working conditions fail to support a healthy lifestyle, enabling significant drug use. Mayo Clinic (2017) cites environmental factors, "such as family's beliefs and attitudes and exposure to a peer group that encourages drug use", as one of the two main factors in drug abuse (Causes Section). An outstanding community acts as a deterrent for drug abuse. Given the ruthless environment of the trucking industry, a strong community can limit harm.

PAINFUL TRANSITION FOR USERS

With the autonomous technology rapidly innovating, implementation of vehicles could occur before analysis of their impact. Without forethought, autonomous vehicle could be

determinantal to the trucking community, especially given their vulnerability to poor eating habits, lack of exercise, and drug abuse. Additionally, autonomous vehicles change the social relations of the truck drivers. First, the autonomous vehicles transform the public's perception of the trucking industry at large. Secondly, autonomous vehicles change the liability surrounding an accident. Prior to autonomous trucks, if an accident occurs, the truck driver assumes responsibility. However, autonomous vehicles change this dynamic. All these aspects require further examination before the consideration of potential policy.

Effects of a Shrinking Community

Experts forecast that the United States trucking industry could implement autonomous trucks by 2027 (Baral, 2021, para. 4). Being the most common jobs in most states, 1.7 million out of the current 3.5 million truckers could lose their job to automation in the next decade (Baral, 2021, para. 6-7). For the remaining 1.8 million truckers, a shrinking community could threaten the lives of the drivers. A vibrant community creates intimate social connections, crafting important friendships and role models. A well-constructed community hold its members accountable. However, as that community falls apart, the accountability dwindles, leading to potential harm to the members.

With a smaller community, truckers may fail to communicate with a fellow trucker when they need support when choosing their diet. Whether late at night or midday, truckers are more likely to eat unhealthily if no fellow trucker supports them, which will occur more frequently if companies implement autonomous trucks. Therefore, a healthy lifestyle will likely continue to worsen. Another facet of eroding part of the social support system, drivers lose important role model truck drivers, drivers who demonstrated sobriety and industriousness. Without these role models, more truck drivers may abuse amphetamines or other hard drugs. As the community

shrinks to roughly half its size in a decade, the issue of health increases. With an already at-risk community, automation could cause an insurmountable toll on human life.

The increase of free time may also affect a truck driver's drug use. The utility of automation lies in the fact that computers complete tasks for humans. With computers taking more responsibility, users need to complete less, creating more time for drivers. However, this newly made time could become more work while the autonomous capabilities taking the wheel. Cohen (1987) shows that despite technological advancements in the home, housewives continued to work the same hours from 1960s through the 1980s (p. 58). These housewives continued to accept more responsibilities like using a car to "become her own door-to-door delivery service" (Cohen, 1987, p. 62). With the creation of free time, truck drivers may be asked to burden more responsibilities: make sales calls, take training courses, or participate in managerial meetings for example. However, with an increase of free time, there is a risk that truck drivers increase drug use. People need stimuli over long periods of time, whether that be television, work, reading, or more sinisterly drug use. Depending on the implementation of the autonomous vehicles, trucker may simply sit in the cab of a truck for hours without a proper task at hand. Without meaning in work, truck drivers may lose a sense of purpose and usefulness. That feeling of dread, compounded with extensive amount of boredom, creates a recipe for drug use. If this is the case, truckers may turn to increased drug use or start abusing drugs. Therefore, the implementation of autonomous vehicles creates an environment for increased drug use, whether from computers overtaking responsibilities or the erosion of the trucking community.

Shifting Public Perception

Autonomous vehicles change the view of a bystander on trucker drivers. The perspective of the bystander exists in two situations: instances involving accidents and general attitude

towards truck drivers. Bystanders may witness an accident firsthand or secondhand by reading or watching the news. For the general attitude, the situation addresses stigmas and societal views on trucker drivers. Each of these prominent situations transforms with autonomous technology.

If an autonomous truck creates an accident, bystanders may blame the truck driver. Elish calls this phenomenon the moral crumple zone: "how responsibility for an action may be misattributed to a human actor who had limited control over the behavior of an automated or autonomous system" (2019, p. 41). Autonomous vehicles fit into the moral crumple zone. With the experimentation around self-driving cars, accidents occur for two reasons: the computer perception and computer processing. Computer perception deals with sensory input from the surroundings; however, sensors have limitations. For example, a camera lacks the capabilities to detect images miles away. When a vehicle is traveling at high speeds, precise imaging is required to make accurate stops. Additionally, the computer processing can fail. If the sensors correctly visualize the environment, a computer may incorrectly assess the situation. In the 2018 crash of an Uber autonomous vehicle, the car "detected [the bystander] about six seconds before the crash—first identifying her as an unknown object, then as a vehicle, and then as a bicycle, each time adjusting its expectations for her path of travel" (Marshall & Davies, 2018, para. 3). Because of the car's failure to properly assess the situation, the car collides with the bystander, resulting in the loss of her life (Marshall & Davies, para. 1). Because of these aspects, autonomous vehicles can create moral crumple zones. In the situation above, the public could incorrectly assign fault to driver of the Uber autonomous car. Elish (2019) reiterates this point: "intelligent and autonomous systems in every form have the possibility to generate moral crumple zones because they distribute control, often in obfuscated ways, among multiple actors across space and time" (p. 54). As more autonomous vehicles become adopted, accidents will

occur with vehicles on the roads. Between 2019 to 2022, “there have been 187 accidents…in California alone involving autonomous car testing” (Brown, 2022, para. 11). Responsibility remains a huge component of the relationship between truckers and other agents. Therefore, the moral crumple zone greatly affects the public perspective of truckers in autonomous trucks.

Furthermore, automation will affect truckers on the job. One aspect of trucking is long hours on the job. Unlike most professions, truckers must always observe their surroundings. If they fail, then innocent civilians could be injured. A study from 2005 found that “thirty-five percent of drivers reported dozing at the wheel in the month prior to the interview and many had fallen asleep multiple times.” (Monaco et al., 2005, p. 623). With the adoption of autonomous technology, the need for drivers to be at high alert constantly is reduced. However, when moments come where drivers need to be alert, they may fail to complete the required action because of the complacency due to infrequency of instances requiring attention. With a computer taking control of some of the work, drivers will sleep more during the long grueling hours of the drive. Tying into the moral crumple zones, a dozy driver creates the portrayal that the driver created an accident despite if the computer causes said accident. Autonomous vehicles affect the public perception of truckers two-fold: a change in observed trucker behavior and a formation of a moral crumple zone.

Outside of liability, the public’s perspective of the trucking industry changes with the adoption of autonomous vehicles. Collingwood (2018) argues that “automation in the trucking industry…will ultimately bring with it a revised identity which, though arguably welcome, is out of keeping with historical and cultural perceptions” (p. 265). Specifically, the cultural perspective is preserving “the last bastion of machismo” in the trucking industry (Collingwood, 2018, p. 260). As the trucking loses its masculine stigma, women can enter the field with less

stigma attached. Every person should feel as if they may enter a field without social scrutiny. Women entering the industry have both internal and external affects in respect to companies.

Externally, with a loss of stigma, more women feel as if they may enter the industry. With this, companies can hire from a broader, more diverse hiring pool. This shift gives companies more power over existing workers since more people would be willing to work a trucking job. The existing truckers become more replaceable. With a surplus of women in the industry, policy need to consider them in its creation. If only consider male components, policy may fail to embrace a new sector of the trucking industry. Internally, if trucking loses its stigma, the fraternal bond between truckers also diminishes. As highlighted earlier, social fabric prevents significant consequences in the trucking industry. Without machismo, the truckers could face increased percentages drug use or obesity. Additionally, with women replacing men in industry, animosity towards women could grow. Men could see women as the reason their friends lost their job. Therefore, policy need to ensure a smooth integration of women into the industry, while also supporting current workers.

As stated above, autonomous vehicles impact the four main relationships: friends/family, bystanders, employer, and AI designers. Autonomous vehicles cut the size of the trucking industry in half, impacting individual truckers' friendships. These vehicles create moral crumple zones, which alter the bystander's perceptive of the trucker's fault in accidents. Additionally, the moral crumple zone affects the AI designer's considerations of software. The AI engineer must ensure that both the legal system and public correctly assigns blame. Autonomous vehicles remove bystander's perception of trucking's male stigma. In turn, the employer possesses a direct substitute for the current driver: an underutilized women hiring pool and fully autonomous vehicles.

FRAMING THE INQUIRY

With these complications, unforeseen consequences could outweigh the technological benefit of automation. The ultimate question is: how does autonomous vehicles affect American truckers? With the pain points are identified, then the secondary question of how to limit these negative experiences for the driver. One method to prevent unnecessary harm to driver is public policy. Public policy can minimize the harm to drivers while maximizing the use of autonomous technology.

QUALITY GOVERNMENTAL POLICY

With the rapid speed of innovation of the autonomous technology, organizations should turn to policy as quickly as possible. The major organizations for this policy would consist of government actors and automobile companies. Both entities can create influential policy, and the STS research examines both parties.

Governmental policy must be iterative, so that the policy adapts with the technology. With government actors, an integral step of any policy requires convincing the public of the utility. Cohen et al. examined the potential government interaction for autonomous vehicles in the United Kingdom. Cohen et al. discovered that "a laissez-faire approach to governance was strongly rejected by almost all of the stakeholders to whom we spoke" (2018, p.269). These authors argue for "at an early stage, coherent visions of desirable future transport and put [autonomous vehicles] in their place. Disruptive and utopian claims should be met with [organized], incremental policies" (Cohen et. al, p. 271). With this information, governments recognize that the people want policy around autonomous vehicles. With most innovation, technology usually outpaces the policy. However, the people fear autonomous vehicles becoming too unregulated, so they want to policy to match the pace of innovation.

Having established that nature of the policy, the government must decide on the specific components of the policy. A major component of the policy will consist of liability. A moral argument exists for manufacturers being potentially liable. If autonomous vehicles prove to benefit society, Hevelke & Nida-Rümelin argue that there is a "moral obligation for…the legal responsibility for crashes of autonomous cars in a way which helps the development and improvement of autonomous cars" (2014, p. 621). However, the moral obligation hinges on the assumptions that autonomous vehicles benefit society. One of the fundamental assumptions is that "autonomous vehicles…cause fewer and less severe accidents than cars steered by the average driver" (Hevelke & Nida-Rümelin, 2014, p. 620). These vehicles would limit vehicular deaths in aggregate, but the technology could harm a bystander group rather than the drivers. For example, an autonomous vehicle may choose to kill a pedestrian rather than a driver. Hevelke & Nida-Rümelin wisely recognize that the moral obligation only occurs if no "group of people whose risks of injury are bound to be raised by the introduction of autonomous cars" (p. 623). Therefore, manufacturers holding liability could incentivize better technology if no harm is placed on an innocent group.

On the other hand, the users of the autonomous vehicles could become liable. If the drivers became accountable, they would constantly alert of the road. However, an alert driver causes "autonomous vehicles…[to] lose much of their utility" (Hevelke & Nida-Rümelin, 2014, p. 624). Additionally, since the vehicle computes the surroundings significantly more efficiently than the driver, the driver averting an accident becomes nearly impossible; placing the blame on a driver unable to prevent an accident becomes preposterous (Hevelke & Nida-Rümelin, p. 625). Despite the irrationality of assessing fault to the driver, the driver decided to enter the autonomous vehicle, which causes the driver to assume some level of risk. Instead of looking at users

individually, the collective group of drivers could reasonably assume liability because the morality exists in the aggregate benefit of the technology. Therefore, Hevelke & Nida-Rümelin recommend a "system in which the cost of any accident caused by a … autonomous vehicle is shared by all the owners/users of such vehicles. A scheme like that might work like a tax or a mandatory insurance" (p. 627).

Hevelke and Nida-Rümelin evaluate the potential liability of autonomous vehicles between the manufacturer and the user. A mandatory insurance for all users appears to be the most ethical solution. However, the authors failed to consider incentives. If the state implements a mandatory insurance, the manufacturer lacks the incentive to make safer vehicles outside of market's competition. To continue the innovation of these vehicles, the state should reward companies with safer vehicles with a portion of revenue generated from the insurance policy.

Combining the two ideas, the public policy requires heavy emphasis on iterative process. Therefore, the best solutions implement a tax on every vehicle and on every ride of the vehicles through a gas or energy tax. The government will hold most of the money generated through the taxation to help innocent bystanders hurt in an accident. With this policy, the trucking company stays in business despite a single case of faulty autonomous technology. Additionally, the government will highlight the goals for the next generation of autonomous vehicles. For example, the goals could highlight a new safety feature or reduction in accidents per mile. If a company can create vehicles that met the qualifications, then a portion of the tax money is gifted to that company. This policy allows for an iterative process with the government always have a good pulse of autonomous vehicles.

Separate from the policy above, another policy needs to address drug use. As mentioned earlier, truckers use drugs more frequently than the average American. With autonomous

technology implemented into their jobs, more truckers will be at risk of using drugs and becoming addicted. Brown discusses the stigma around people with substance use disorder (SUD). Brown says, "people with SUD are not categorically different from us, and addiction is not a disease of the weak or immoral. Rather, people with SUD have underlying genetic and environmental vulnerabilities, and these risks are present to a different degree in each of us." (2021, p. 75). Using this view, the stigma around drug use is reduced. Instead, drug use can be seen as a medical issue rather than a criminal one. Treating those with SUD as a medical issue ensures that more citizens can get the help necessary to overcome their addiction. Brown poses a solution: "by funding local public health campaigns that emphasize that (1) addiction risk is neurogenetic and exists on a continuum; (2) once addiction takes hold, voluntary choices related to drug use are constrained; and (3) treatment can be quite effective, and those in treatment can lead meaningful lives; we can start telling a different, and more hopeful, story about recovery" (p. 77). Using this idea, the trucking companies themselves should implement such policy. The companies need to care for their employees and ensure that they get the proper resources to live their lives. The companies should have a health insurance plan that covers visits to doctors about drug abuse. Furthermore, the companies should allow open dialogue for the employees to discuss if they are having a hard time given the weakening of their employees' community.

The corporate policy also needs to extend socially for truck drivers. The dwindling trucking community increases the risk factors for obesity and drug use. Additionally, the trucking industry will see an influx of women drivers, which changes the dynamics within companies and the industry at large. Therefore, corporate policy should strengthen the existing relationships, while welcoming women into the industry. To accomplish both tasks, trucking companies should hold regularly scheduled events. For example, these events can include a

Fourth of July barbeque, a Christmas party, a dinner celebration for a profitable quarter, and many more. These events allow for truckers to see one another more frequently and break up the monotony of work. Moreover, these events allow for women to integrate into the workforce. Women can interact with existing truckers, reducing the possibility of misogyny within the industry. The regularly held events reduce the negative consequences of autonomous trucks.

With both the governmental and company policy, American companies can implement autonomous technology while reducing the risk to American truckers. This dual policy further distributes agency away from the corporation to the other agents identified in the ANT in Figure 2. The policy allocated the government more agency to protect the people. Furthermore, the policy incentivized the AI designer to rapidly innovate and fulfill their duty as an engineer. Finally, the corporate policy assists the truck drivers in making responsible decisions. Being sober and healthy, the trucker can satisfy their social responsibilities to friends, family, and employer. The future with autonomous vehicles remains hazy, but the value proposition of these policy helps alleviate the fears of American truckers.

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