# MOUNTAIN-PLAINS CONSORTIUM

**MPC 25-577** | P. Sherry and K. Ratner

# THE EFFECTS OF AUTONOMOUS VEHICLES ON SAFETY AND SAFETY CULTURE IN FREIGHT OPERATIONS


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16. Abstract

The present study examines the impact of autonomous vehicles (AV), driverless vehicles (DVs), and other on-board safety technology (OBST) on safety and safety culture in an operational environment. Data were gathered utilizing survey and interview methodologies to gather qualitative data from survey responses, focus groups, and interviews with employees and stakeholders from trucking companies, truck operators, and freight yard and dock workers. The research identified perceptions of the impact of technology as well as the relationship between utilization of autonomous and semi-autonomous vehicles, OBST, safety culture, and safety performance. An analysis of the relationship between perceptions of AV/DV and OBST and indicators of safety culture was performed. Results of analyses revealed a non-significant relationship between perceptions of technology and indicators of safety culture. Reports of safety violations, accidents, and numbers of traffic citations were not correlated with indicators of safety culture as measured by indices from the Safety Culture Survey (Sherry, 2018). Results show that a positive view of technology was also not significantly related to safe behaviors or overall indicators of safety culture. Drivers who perceived on-board technology (OBT) as positively contributing to improving safety were more likely to report concerns over eventual decreases in job availability. Additional findings regarding the perceived impact of AVs and DVs on the employment of commercial vehicle operators and resistance to automated technology were discussed and recommendations based on lessons learned were offered. Recommendations for the introduction and implementation of autonomous technologies into transportation operations are presented.

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# The Effects of Autonomous Vehicles on Safety and Safety Culture in Freight Operations

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## ABBREVIATIONS

| | |
|---|---|
| DV | Driverless Vehicle (DV) |
| AV | Autonomous Vehicle (AV) |
| LBCT | Long Beach Container Terminals |
| AI | Artificial Intelligence |
| CMTS | Committee on the Marine Transportation System |
| DOT | Department of Transportation |
| EPA | Environmental Protection Agency |
| FHWA | Federal Highway Administration |
| FLOW | Freight Logistics Optimization Works program |
| FMC | Federal Maritime Commission |
| INFRA | Infrastructure for Rebuilding America program |
| ILA | International Longshore Union |
| ILWU | International Longshore and Warehouse Union |
| ITS | Intelligent Transportation Systems |
| MARAD | Maritime Administration |
| MTDI | Maritime Transportation Data Initiative |
| OBT | On-board technology |
| OCR | Optical Character Recognition |
| PMA | Pacific Maritime Association |
| RAISE | Rebuilding American Infrastructure with Sustainability and Equity program |
| RFID | Radiofrequency identification |
| TEU | Twenty-foot equivalent unit |

# ABSTRACT

The present study examines the impact of autonomous vehicles (AV), driverless vehicles (DVs), and other on-board safety technology (OBST) on safety and safety culture in an operational environment. Data were gathered utilizing survey and interview methodologies to gather qualitative data from survey responses, focus groups, and interviews with employees and stakeholders from trucking companies, truck operators, and freight yard and dock workers. The research identified perceptions of the impact of technology as well as the relationship between utilization of autonomous and semi-autonomous vehicles, OBST, safety culture, and safety performance. An analysis of the relationship between perceptions of AV/DV and OBST and indicators of safety culture was performed. Results of analyses revealed a non-significant relationship between perceptions of technology and indicators of safety culture. Reports of safety violations, accidents, and numbers of traffic citations were not correlated with indicators of safety culture as measured by indices from the Safety Culture Survey (Sherry, 2018). Results show that a positive view of technology was also not significantly related to safe behaviors or overall indicators of safety culture. Drivers who perceived on-board technology (OBT) as positively contributing to improving safety were more likely to report concerns over eventual decreases in job availability. Additional findings regarding the perceived impact of AVs and DVs on the employment of commercial vehicle operators and resistance to automated technology were discussed and recommendations based on lessons learned were offered. Recommendations for the introduction and implementation of autonomous technologies into transportation operations are presented.

# 1. INTRODUCTION

Major manufacturers and developers are working hard to develop autonomous and self-driving vehicles. Companies like Rivian, Volvo, and Tesla are working to bring self-driving trucks to market.

Since truck drivers must do a number of managerial tasks with the freight they are transporting, they will need to focus on tasks that cannot be performed with current technology. "You're going to need that driver or whomever to physically check to make sure that the goods are not damaged in any way as they're being loaded," said Cathy Morrow Roberson, head analyst for consulting firm Logistics Trends and Insights (Sherman, 2024).

Abduljabbar (2019) noted that autonomous vehicles (AVs) have been under development since the late 1950s. However, it became a reality in 1968 when an "urbmobile," the first electric vehicle, was introduced by The Cornell Aeronautical Laboratory. Still, the technology at that time did not encourage its usage (Poczter & Jankovic, 2014). In recent years, the availability of sensors and cameras and more sophisticated software have increased their practical viability and underscored the need to develop more reliable and safer roads. While outside the scope of this study, autonomous technology is also in use in various transit systems around the world, such as the 500 km railway in the Pilbara region of Western Australia,

In addition to AVs on public roadways, self-driving tractor-trailers, cranes, and lifts are currently in use to stack containers and deliver them to waiting trucks and subsequently onto railcars. TraPac, a Long Beach container port facility, uses autonomous technology to move freight containers. TraPac's equipment reduces the time to load and unload ships further, enhancing productivity and profitability. In addition, the use of self-driving vehicles may also contribute to reduced emissions. The state of California has provided funds for the purchase of battery-powered tractor-trailers at a new automated facility in the Long Beach Container Terminal, which will use electric, self-driving cranes and carriers guided by transponders buried in the cement on the dock. The new equipment will double the volume of containers the terminal handles while cutting emissions in half, according to Art Wong, spokesperson for the Port of Long Beach (Lippert, 2016).

**Figure 1. Trapac headquarters Long Beach, California (Photo courtesy of author)**

At TraPac, only a few dozen people monitor operations from control rooms. On the wharf itself, TraPac uses workers only to run the cranes that unload ships and to drop containers the last few feet onto waiting trucks and trains. The question of how the use of AVs will affect the workforce remains an open question. There are many predictions that AVs will reduce the number of crashes and incidents on highways and roadways. However, more intense and concentrated operations may require additional training and monitoring to ensure that there is a safe environment (Lippert, 2016).

Sam Loesche, a Teamsters lobbyist, said, "We have not seen a situation where any responsible operator would agree that there is a role for this technology without an operator in the cab. Our view is [that] the best piece of safety technology is the driver." Joan Claybrook, former head of the National Highway Traffic Safety Administration, says it could take 10, 20, even 30 years of tinkering with and improving self-driving technology until it is truly safer than human drivers. The International Brotherhood of Teamsters asserts that “self-driving trucks will continue to need a driver to help out in case of emergencies, to handle paperwork, to assure the safety of the cargo, to pull a truck into a warehouse” (Greenhouse, 2017).

Technologically advanced automotive systems may enhance safety in comparison with human-only-operated vehicles. For self-driving vehicles to succeed at maximizing safety, they will need extensive testing and research. It is generally agreed that situational awareness, or the full understanding and appreciation of the surrounding environment, is critical for safety. However, collection and analysis of situational awareness data that influence the prevention of transportation related accidents is a significant hurdle for the automotive industry and at this point a barrier to developing vehicles that are reliable, safe, and operable. Partial autonomy may be the name of the game in the near future as operators are needed to augment the safety technology of experimental vehicles.

In the freight environment, the “longest continuous journey by a driverless and autonomous” vehicle was conducted on Oct 20, 2016, when a load of Budweiser beer was transported 132 miles from Fort Collins to Colorado Springs. While there was a worker in the vehicle monitoring the trip from the back seat and never taking the wheel, he did, however, drive it onto and off the interstate into the loading area (Chuang, 2017).

The “Self Drive Act” was unanimously approved by the House Energy and Commerce Committee in July 2017, before Congress adjourned for its August recess, and passed the full House on a voice vote. According to one estimate, self-driving cars could reduce traffic fatalities by up to 90%. However, recent experience has shown that technology remains a work in progress. For example, when Joshua Brown’s Tesla collided with a tractor-trailer in 2016 at more than 70 miles per hour, the fatality and crash became the world’s first known collision involving a partially autonomous vehicle. Results of the NTSB analysis of the available data indicated that prior to the collision, Brown was audibly warned six times and visually warned seven times to keep his hands on the steering wheel. The recorder data reviewed by the National Transportation Safety Board (NTSB) and Tesla indicated that Brown had his hands off the wheel for 90% of his final drive. Other data suggest that Brown had overridden the controls and set the cruise control for 74 mph (nine mph above the speed limit) less than two minutes before the crash (Neidig, 2017).

The state of Colorado has also taken steps to increase the receptivity to the use of driverless vehicles (DVs). In 2016, the Colorado General Assembly passed SB17-213, a bill that regulates automated driving systems. Subsequently, the Colorado Department of Transportation (CDOT) has begun using automated crash vehicles to increase road crew safety. Called an automated truck mounted attenuator truck, the vehicle is basically a “self-driving truck” in use since 2018 to protect CDOT striping crews. “All it does is follow the lead truck and there’s kind of like a little trail of electronic breadcrumbs that it just follows kind of like Pac-Man,” said CDOT spokesperson Timothy Hoover (Abeyta, 2018).

The Prius also has dynamic radar cruise control that maintains a specific speed on the highway but applies the brakes when it senses the car in front slowing down or stopping. However, the Prius owner’s manual warns, “There is a limit to the degree of recognition accuracy and control performance that this system can provide. Do not overly rely on this system. The driver is always responsible for paying attention to the vehicle’s surroundings and driving safely.” Thus, until fully autonomous vehicles are perfected, research needs to be conducted to inform manufacturers, policymakers, and drivers of the risks and countermeasures that will need to be managed and used to protect the human driver (Prius, 2017).

A recent report reviewed a number of studies from the NHTSA and aviation-related agencies to issues with attention and vigilance regarding in-vehicle safety technology. For example, research by Strayer et al. found interacting with voice-controlled navigation systems can be just as distracting as manually operated systems. Also, many psychological studies show people have trouble focusing their attention when there is little or nothing to attend to. In such situations, they tend to reduce their active involvement and simply obey the automation. There is already ample evidence that drivers disengage from the navigation task when the automation is programmed to lead the way. Several incidents reported in the popular media described drivers following GPS instructions that led them to drive off ramps and into a harbor in Hawaii (Good Morning America, 2023) and North Carolina (CNN, 2024). Casner and Schooler (2014) found that well-trained airline pilots report "mind wandering" when an advanced navigation system is active and the flight is routine and normal. Palmer et al. (1993) described many cases in which pilots missed an assigned altitude because the alerter failed to sound. Thus, it is easy for drivers to be distracted and less vigilant for prolonged periods when they rely on technology to alert them to trouble. Dufour showed relieving drivers of even one aspect of the driving task results in reports of increased driver drowsiness and reduced vigilance when driving on open stretches of road. But the effects do not stop there. Dufour also showed drivers take more time to respond to sudden events when they use cruise control.

The results clearly point to the conclusion that if you take drivers out of the role of active control, it is difficult to get them back when they are needed. The inference is that drivers and operators of semi-autonomous vehicles will be required to pay full attention to the driving situation, even if they are not required to do anything. Most critical is that they may need to take control of their vehicle in unexpected circumstances, usually fairly quickly. Experience with pilots suggests that this will not go smoothly for everyday drivers. Typical reaction times, where milliseconds might mean the difference between life and death, may not be sufficient. Drivers will likely expect their vehicles' safety systems to prevent crashes and will probably expect automated warnings to alert them when their attention or action is needed.

In the freight environment, a similar set of circumstances may arise where reliance on safety equipment and technology can lead to a lack of vigilance. Given that some of these settings may not be on the open road, the adoption of partially automated equipment may take place at a more rapid pace in ports, freight yards, and warehouses. Accordingly, the risk of safety lapses in such environments are greater than a non-automated or fully automated environment. Consequently, the present research seeks to address the issues of how the introduction and adoption of technology into an operating environment might affect safety attitudes, safety practices, and accidents and incidents in the immediate environment.

One of the key factors influencing the number of accidents that occur in the workplace, or in an autonomous or semi-autonomous work environment, is safety culture. As noted in our previous work, the FRA has expressed interest in studying safety culture in railroad operations. Recently, the FRA and BNSF engaged in a joint effort to review the BNSF safety culture (FRA, April 2015). FRA Administrator, Sarah Feinberg, noted when discussing a recent incident involving Metro-North that "safety culture, preventing accidents before they happen and increasing worker safety" was important. The FRA also stated, "Multiple studies have confirmed what many have intuitively known all along," that safety culture plays a key role in accident prevention. However, visible progress toward established goals is a more effective motivator than financial or personal recognition for the average worker in a world-class operation. Moving toward achievement metrics and away from failure metrics becomes increasingly vital (FRA, August 2011). Accordingly, the present research is designed to continue the development of a viable measure of safety culture by continuing the validation process with a large commuter rail transportation organization.

Recently, Sherry (2018) released a study that initiated the development of a tool to measure safety culture. The instrument was normed on a large sample of employees of a large public transportation agency. (N=1909) participants were obtained. A one-way between groups analysis of variance (ANOVA), and post hoc tests provided initial evidence of the validity and reliability of the safety culture scale (SCS) as a measure for the transportation industry in that the scale significantly differentiated ($p<.05$) between persons who had been involved in accidents and safety violations thus demonstrating the relationship between safety culture and accident rates (Figure 2). In addition, a follow-up study with a large regional rail transportation company demonstrated significant differences in safety culture and attitudes between key departments in the organization (Figure 3).

A normative instrument designed and validated on railroad properties is needed because of the vastly different environment and set of operating practices, corporate culture, historical traditions, and unique set of working conditions. Much of the published material on safety culture has to do with nursing, hospital practices, and oil and gas operations.

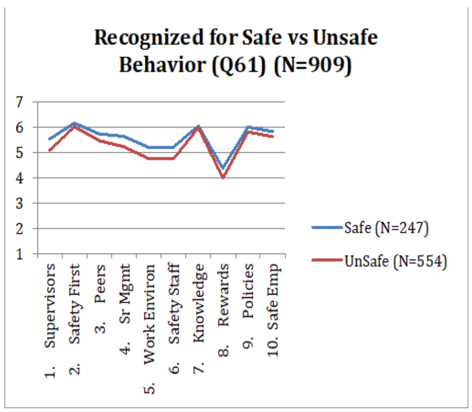



**Figure 2. Safety culture and unsafe behavior**

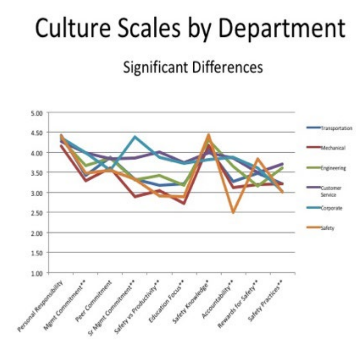



**Figure 3. Safety culture by department**

A Transportation Research Board review of the literature on safety culture in the trucking industry (Short et al., 2007) identified several key aspects of performance that were related to safety culture, including:

- **Inattention** to tasks and responsibilities
- **Lack of motivation** to perform well
- **Lack of awareness**

These factors might be especially affected by the introduction of autonomous or semi-autonomous vehicles into an operational environment. As such, the safety culture, which many companies go to great lengths to develop and maintain, could be negatively impacted and require additional efforts to address. The utilization of a standard measure of safety culture to assess the impact of the introduction and utilization of autonomous and semi-autonomous vehicles into an operational freight environment is needed. By assessing safety culture and accident rates, and comparing pre-post interventions as well as the normative comparison of organizations to each other, we can monitor and evaluate the impact of autonomous or semi-autonomous vehicles into an operational environment. Such measurements could also aid in the identification of areas within an organization, such as departments, relationships between management and labor, training programs, and other areas that need improvement relative to establishing a strong safety culture.

Thus, the proposed study will examine the relationship between the perception of autonomous or semi-autonomous vehicles on safety and safety culture in an operational environment.

# 2. METHODS

The project will primarily utilize survey and interview methodology to gather data from drivers and other key individuals.

## 2.1 Measures & Data Collection

**Questionnaire Data.** The data on safety culture will be obtained through the administration of an SCS (Sherry, 2018). The SCS was developed using a large sample of employees from a large public transportation agency (N=1909). A confirmatory factor analysis (CFA) compared the fit of likely models. One-way between-groups ANOVA and post hoc tests provided initial evidence of the validity and reliability of the SCS as a measure for the transportation industry in that the scale significantly differentiated ($p<.05$) between persons who had been involved in more accidents and safety violations, thus demonstrating the relationship between safety culture and accident rates. Implications of these findings are that the safety culture survey could be used to assess safety awareness and safety culture of trucking or transport companies, small communities, and other organizations involved in transport. Carefully monitoring scores on the SCS efforts could be done in various communities and organizations to improve attitudes toward safety and to reduce accidents and improve road safety.

**Focus Group Data.** The research team will conduct on-site focus groups and interviews with key personnel from the freight operation during a one-week period of observation. The inspectors will be looking for examples of safe and unsafe worker behavior. A checklist of questions will be prepared prior to the on-site visit.

# 3. RESULTS

## 3.1 Study # 01 – Perception of Autonomous Vehicles (AV) and On-Board Technology (OBT)

### Sample Characteristics

This study took place during COVID and intense union negotiations. The sample of freight truck drivers consisted of 123 drivers. Responses to various demographic items were characterized by missing data. Of those responding, 33% were Hispanic/Latino and 30% were white. Only 26% of respondents reported their age with the largest number (28%) being from 41–50 years of age. (See Table 1) A total of 59% reported being male, with 33% not responding. Most of those responding were married (41%) and only 23% identified as single. With respect to education, 39% had a college degree, and another 10% indicated a postgraduate degree.

**Table 1. Demographics**

| **Age** | **Count** | **Percent** | | **Marital Status** | **Count** | **Percent** |
|---|---|---|---|---|---|---|
| 21-30 | 7 | 22% | | Married | 34 | 41% |
| 31-40 | 5 | 16% | | widowed | 1 | 1% |
| 41-50 | 9 | 28% | | Divorced | 11 | 13% |
| 51-60 | 3 | 9% | | Separated | 8 | 10% |
| 61-70 | 5 | 16% | | Domestic partnership | 2 | 2% |
| 71-80 | 3 | 9% | | Single, cohabitating | 5 | 6% |
| Total | 32 | | | Single | 19 | 23% |
| Missing | 91 | | | Prefer not to answer | 2 | 2% |
| | | | | Total | 82 | |
| | | | | Missing | 41 | |
| **Race** | | | | **Education** | | |
| Asian | 5 | 6% | | No School | 1 | 3% |
| Black | 14 | 17% | | 5th grade | 1 | 3% |
| Hispanic/Latino | 25 | 30% | | 6th grade | 1 | 3% |
| Mid East | 1 | 1% | | 7th grade | 1 | 3% |
| Multi-Racial/Ethnic | 4 | 5% | | 11th grade | 1 | 3% |
| Native American | 1 | 1% | | HS Grad | 7 | 23% |
| Hawaiian | 1 | 1% | | 1 year of college | 3 | 10% |
| White | 28 | 33% | | 3 years of college | 1 | 3% |
| Another | 5 | 6% | | College Grad | 12 | 39% |
| Total | 84 | | | Post graduate degree | 3 | 10% |
| Missing | 39 | | | Total | 31 | |
| | | | | Missing | 92 | 100% |
| **Gender** | | | | | | |
| M | 73 | 89% | | | | |
| F | 7 | 9% | | | | |
| TG | 2 | 2% | | | | |
| Total | 82 | | | | | |
| Missing | 41 | | | | | |

Study participants were first asked about their perceptions of AV and DV technology and whether they believed that the technology was helpful to them. Histogram analysis of the respondents' perceptions of AV and OBT suggest that the majority of respondents believe that OBT will result in safer driving (Figure 4). The perception of the impact of OBT indicates that nearly 30% felt that OBT was an improvement to a very great degree and another 15% reported improvement to a considerable degree. Combined, more than 43% of respondents had a favorable view of AV and DV technology. Only 20% reported feeling that OBT improved to a little or no degree (Figure 5).

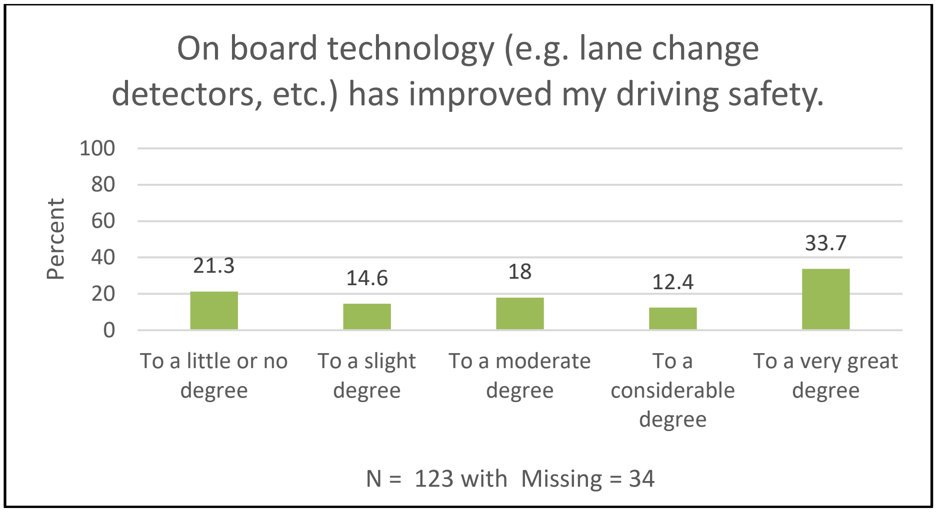



**Figure 4. Perceptions of AV and DV technology**

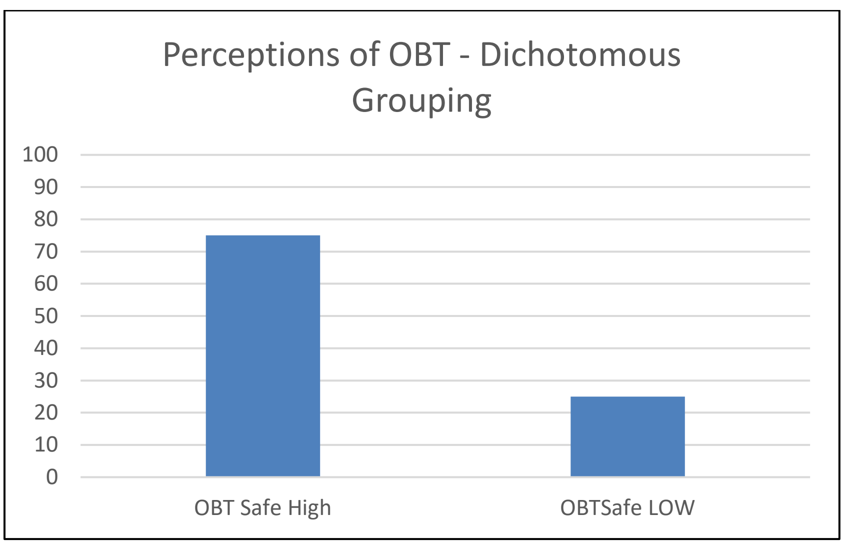



**Figure 5. Dichotomous grouping of OBT perceptions**

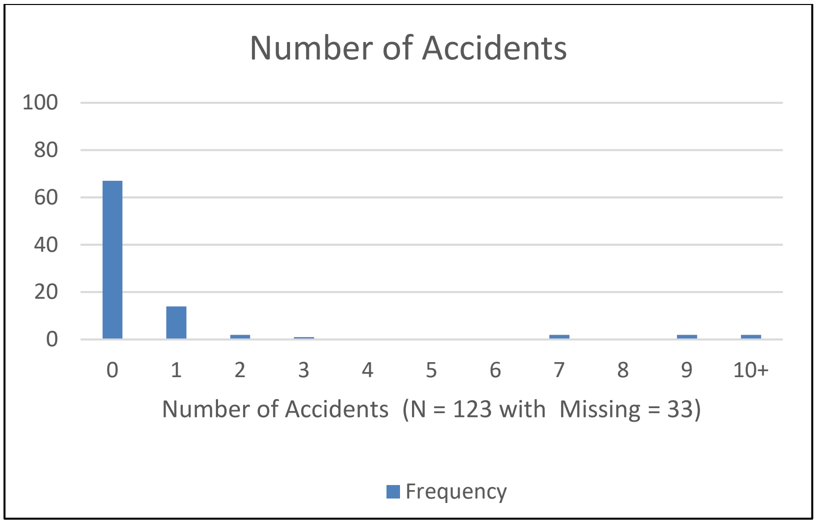



**Figure 6. Number of accidents**

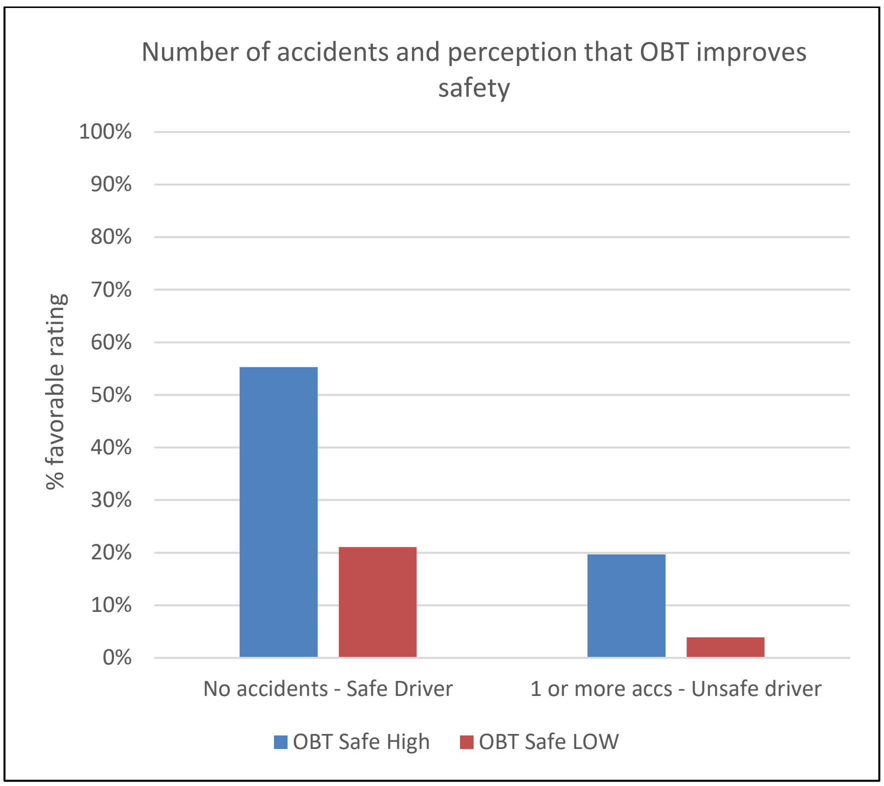



**Figure 7. Number of accidents and perception that OBT improves safety**

An analysis of the relationship between perceptions of OBT and accident rates was conducted. As seen from Figure 7, the perception of OBT value was only slightly related to the number of accidents. When drivers reported no accidents, the perception of OBT was essentially no different than when the driver reported one or more accidents, as shown in Figure 7.

Interestingly, the odds ratio (OR) for accident involvement among this sample was almost twice as large (1.9) for those who believed that the contribution of OBT to safety is high. While this is not a statistically significant result, it is noteworthy as a possible area for further investigation. In other words, it seems that people who have been involved in accidents have a stronger belief that OBT will be helpful in improving safety and making them better drivers.

**Safety and Perceptions of AV/OBT – Tickets**

Perceptions of the impact of AV/OBST and the number of traffic tickets or traffic violations was not strong. In general, the respondents were very safe drivers as the distribution of the number of tickets obtained shows in Table 3. While over half the sample did not answer this question, of those that did, most drivers did not get tickets 74.1% (Figure 8).

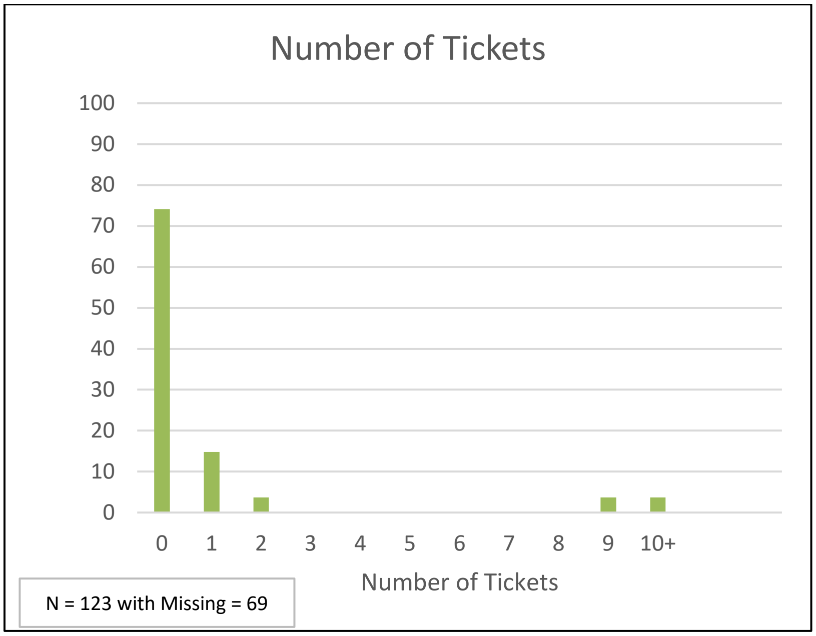



**Figure 8. Number of tickets**

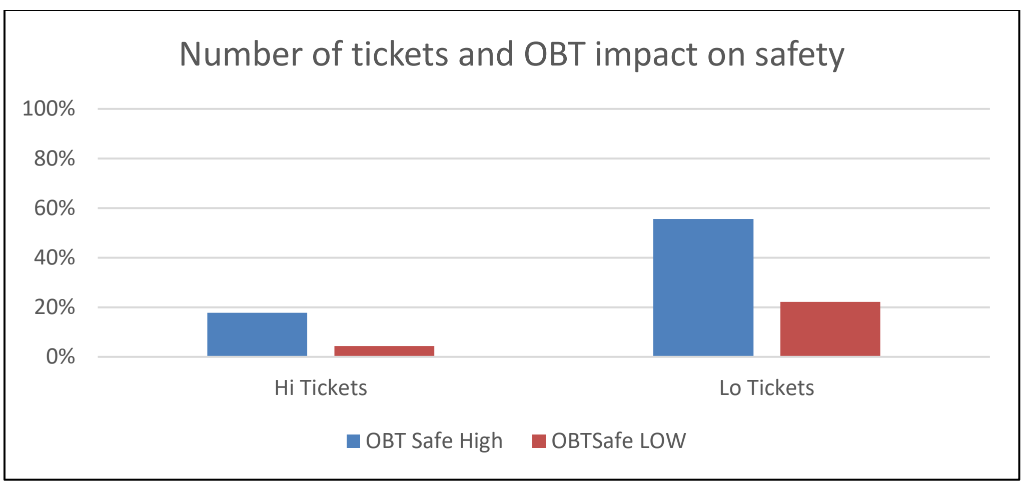



**Figure 9. Number of tickets and OBT impact on safety**

When examining the number of tickets associated with a strong belief in the positive impact of OBT, the results in Figure 9 show that for those who had a strong belief in the positive impact of OBT, the odds of having a high number of tickets was only 1.6 times that of getting no tickets. This suggests there was little relationship between perceptions of OBT and safe driving and safety culture ($X^2 = 2.92$, df=1, p<.589, ns).

**Technology and Employment Concerns**

A little over half of the respondents believe that driverless trucks will eliminate drivers' jobs, with only 58% having a little or slight degree of concern. The odds ratio of OR = 3.8 indicates that a person with a strong belief in OBT's safety contribution is 3.8 times more likely to feel that drivers may lose jobs due to AV or OBT tech (Figure 10). In other words, the odds are high that a person who sees OBT positively contributing to safety improvements will also more likely think that they will lose a job. This is a statistically significant association between the two ($X^2 = 5.22$, df=1, p<.022).

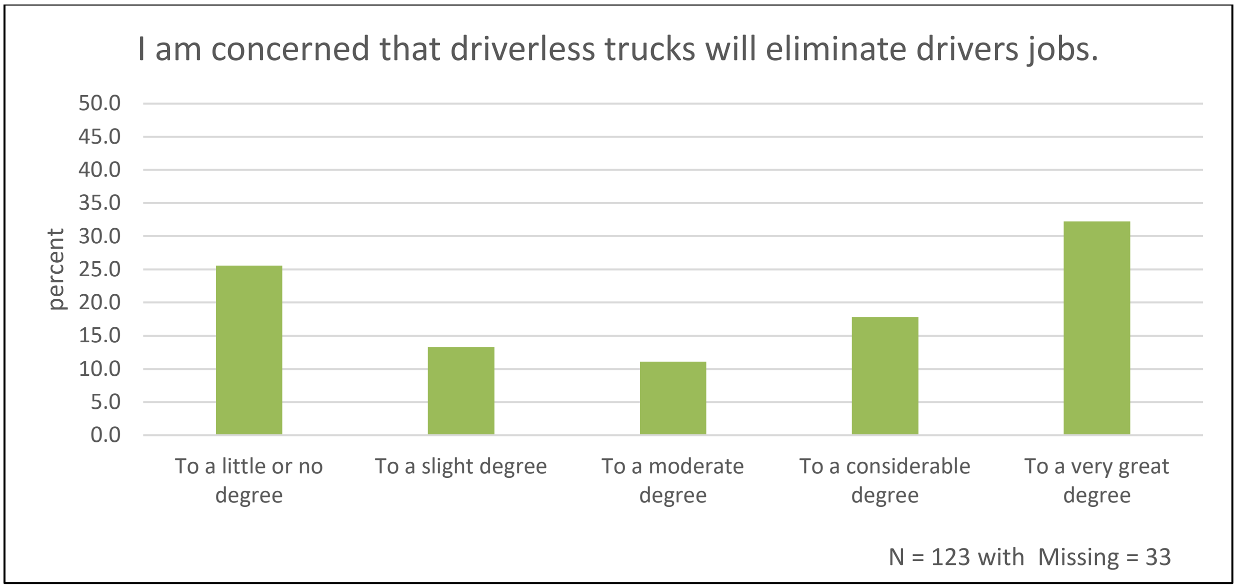



**Figure 10. AV Trucks will eliminate jobs**

**Safety Culture – Safety vs Productivity**

One main purpose of this study was to examine the relationship between perceptions of technology and the safety culture. Data from several sources were used to infer and determine this relationship.

One data source was the Safety Culture Survey (SCS) items administered to participants (Sherry, 2018). Given the emergency conditions imposed by COVID, the SCS was adapted and shortened considerably due to the circumstances, and results from responses to key items in the survey were obtained.

Responses to SCS item #10, "It is more important for me to drive safely, than to meet production quotas (e.g. delivery windows)," were examined. For the sample as a whole, nearly 64% of respondents indicated that safety "always" takes precedence over productivity (Figure 11) and production quotas when driving. Combining responses from three categories reveals that 78.9% indicated either "frequently" (7.8%) "very frequently" (7.8%) or "Always" (63.3%).

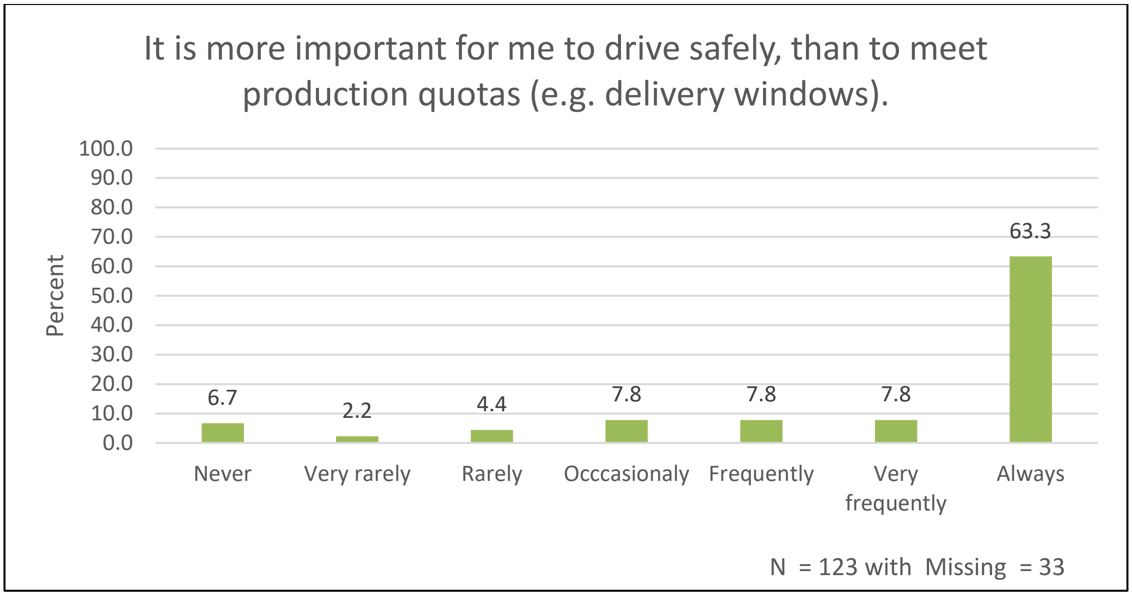



**Figure 11. Safety vs productivity**

Consistent with our previous analyses, we also looked at the relationship after dichotomizing responses by degree of comfort with technology. Figure 12 shows the two groups, one with a perception of technology and OBT enhanced compared with those of the group that had a less positive view of OBT and safety technology.

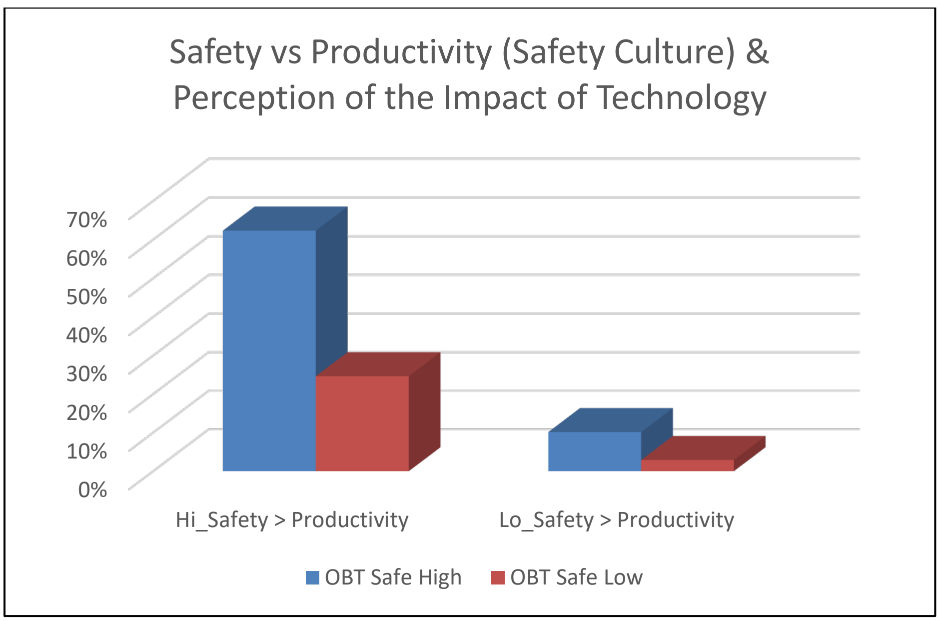



**Figure 12. Safety vs productivity and OBT improves safety**

These results suggest that *there is little relationship* between the perception of OBT's impact on attitudes toward safety and productivity, which is generally considered to be a major indicator of a positive safety culture. In fact, the majority of respondents (62%) had a positive view of whether OBT improved safety. They also viewed safety as more important than productivity compared with only 3% who felt that OBT had a negligible impact on safety and also that productivity was more important than safety (Figure 12).

A non-significant chi-square was obtained, *($X^2$ = 0.146, $p<0.702$, ns)*, suggesting little relationship between technology and safety culture. Predictions were not made, but some suggestions were noted, such as having a positive view of the impact of technology on driver operations would also lead to an overall improved safety culture. However, this was not the case.

**Safety Culture – Occasionally Violate Safety Rules**

Another key indicator of safety culture is the extent to which members of the organization believe that it is permissible to occasionally violate safety rules. As shown in Figure 13, 71.1% of respondents indicated that these violations are permissible to only a slight or little degree – indicating a strong adherence to the rules and, thus, a strong safety culture. A small percentage, only 13.3%, reported believing it permissible to a great degree to occasionally break driving rules.

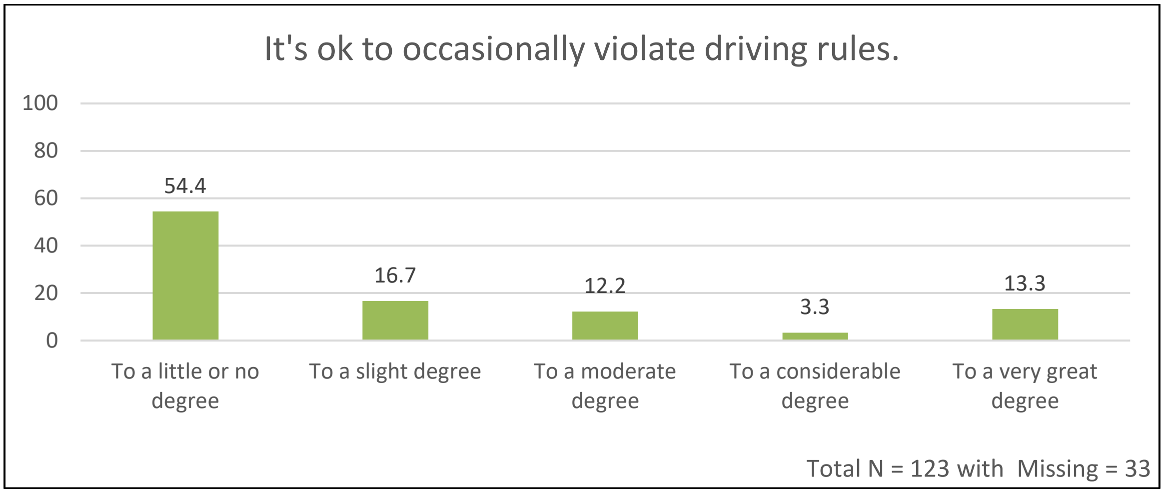



**Figure 13. Violate safety rules**

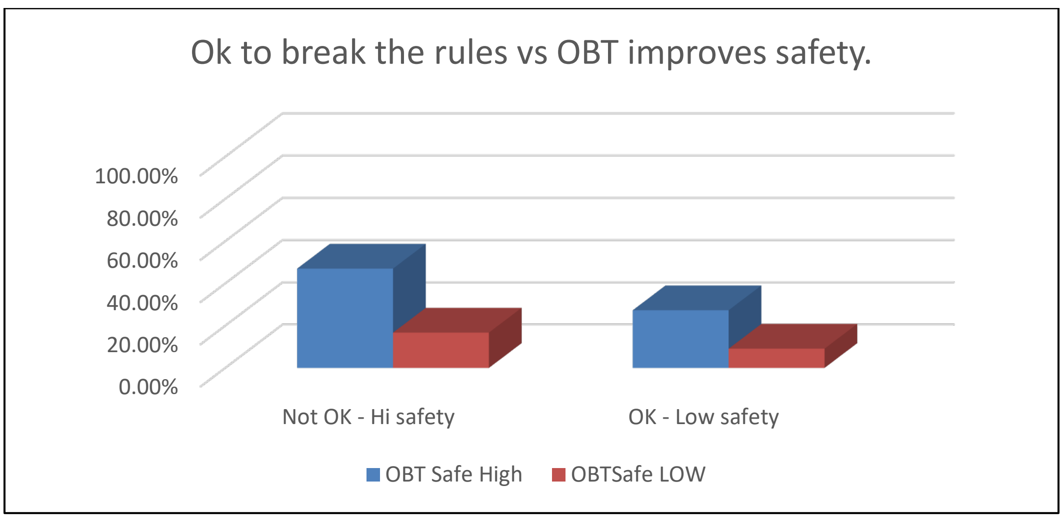



**Figure 14. Violate safety rules and OBT improves safety**

Participant's responses were dichotomized to assess the perception of OBT and the indicator of safety culture—occasionally breaking the rules (Figure 14). A 2x2 matrix compares attitudes toward whether OBT improves safety and the attitude toward permissibility of occasionally breaking rules. Results shown in Figure 14 indicate there is little relationship between the two attitudes as 47% of all respondents believed it is not okay to violate rules and also held the opinion that OBT improved safety ($X^2 = .011$, df=1, $p<.915$, ns). Thus, a non-significant relationship between perceptions of technology and indicators of safety culture was found.

**Safety Culture – Taking Shortcuts**

Safety professionals note that taking shortcuts is another important indicator of the safety culture. The SCS survey includes an item that indicates the extent to which organization members perceive taking shortcuts. The results of the present study show that by combining responses to the "little or no degree" and the "slight degree" choices, 77.8% indicated that taking shortcuts was not acceptable, indicating a strong safety culture. A small percentage, only 3.3%, reported believing it was permissible to take shortcuts.

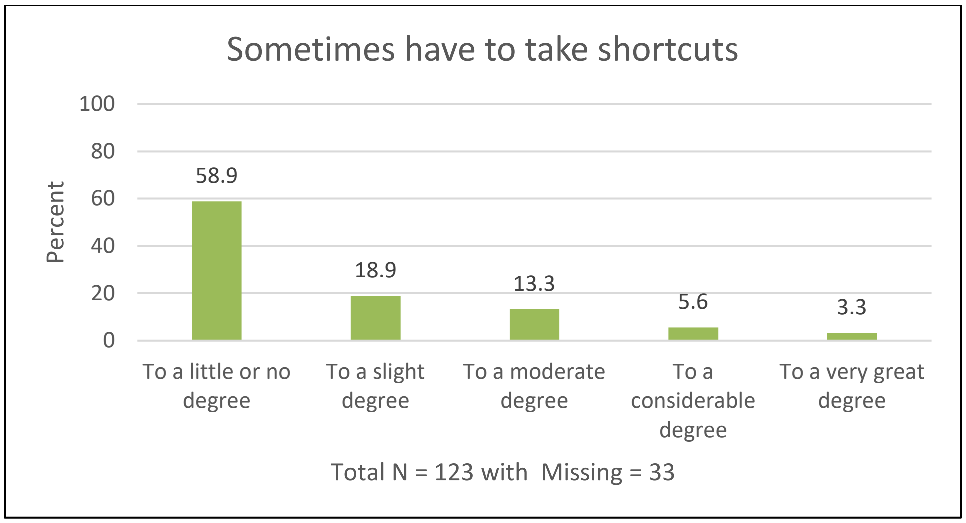



**Figure 15. Sometimes have to take shortcuts**

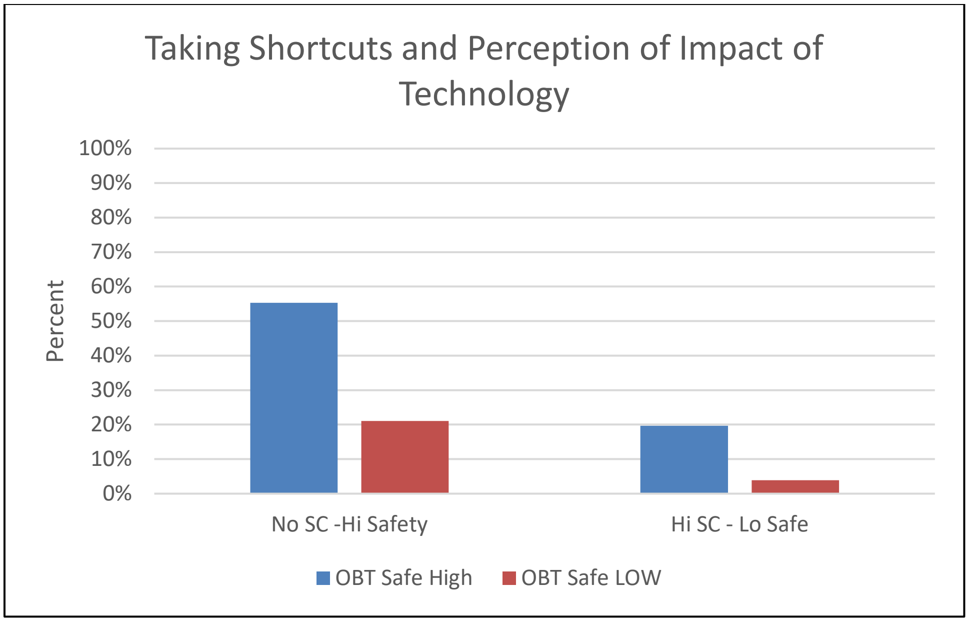



**Figure 16. Taking shortcuts and the perception of impact of technology**

Note: ($X^2$ = .525, df=1, p<.350, ns).

Responses were dichotomized to assess the perception toward OBT and the indicator of safety culture—taking shortcuts. A 2x2 matrix comparing attitudes toward whether OBT improves safety and the attitude toward acceptability of taking shortcuts was constructed. Results shown in Figure 16 indicate there is little relationship between the two attitudes, as 55% of the total number of respondents believed it is not acceptable to take shortcuts and also believed that OBT improved safety ($X^2$ = .525, df=1, p<.350, ns). Thus, a non-significant relationship between perceptions of technology and a key indicator of safety culture was found.

## Summary

These results show a consistent pattern of a limited or small relationship between attitudes toward onboard technology and driverless vehicles and several key indicators of safety culture. Taken together, it appears there is very little or no relationship between the two constructs.

## 3.2 Study #2 – Perceptions of Driverless Vehicles

A second study of DV perceptions was also conducted. The first was undertaken in 2019, just before COVID. A convenience sampling of people is also being studied for a larger scale study of perceptions of general transportation issues. Several questions are relevant here.

### Sample Characteristics

**Table 2. Sample Characteristics Study 2**

| **Race** | Frequency | Valid Percent |
|---|---|---|
| White | 58 | 96.7 |
| Asian | 1 | 1.7 |
| Am Indian | 1 | 1.7 |
| Total | 60 | 100 |
| | | |
| **Age** | Frequency | Valid Percent |
| 18-24 | 4 | 6.7 |
| 25-34 | 36 | 60.0 |
| 35-44 | 15 | 25.0 |
| 45-54 | 4 | 6.7 |
| 65+ | 1 | 1.7 |
| Total | 60 | 100.0 |
| | | |
| **Education** | Frequency | Valid Percent |
| High School | 7 | 11.7 |
| Some College | 3 | 5.0 |
| College | 3 | 5.0 |
| Graduate Degree | 37 | 61.7 |
| Postgraduate | 10 | 16.7 |
| Total | 60 | 100.0 |
| | | |
| **State** | Frequency | Valid Percent |
| Missing | 1 | 1.7 |
| AK | 17 | 28.3 |
| AL | 1 | 1.7 |
| CA | 5 | 8.3 |
| IN | 9 | 15.0 |
| LA | 1 | 1.7 |
| MI | 1 | 1.7 |
| MO | 1 | 1.7 |
| NM | 3 | 5.0 |
| NY | 1 | 1.7 |
| OR | 1 | 1.7 |
| SC | 1 | 1.7 |
| TX | 14 | 23.3 |
| UT | 1 | 1.7 |
| VA | 2 | 3.3 |
| WI | 1 | 1.7 |
| Total | 60 | 100 |

**Use of Driverless Vehicles**

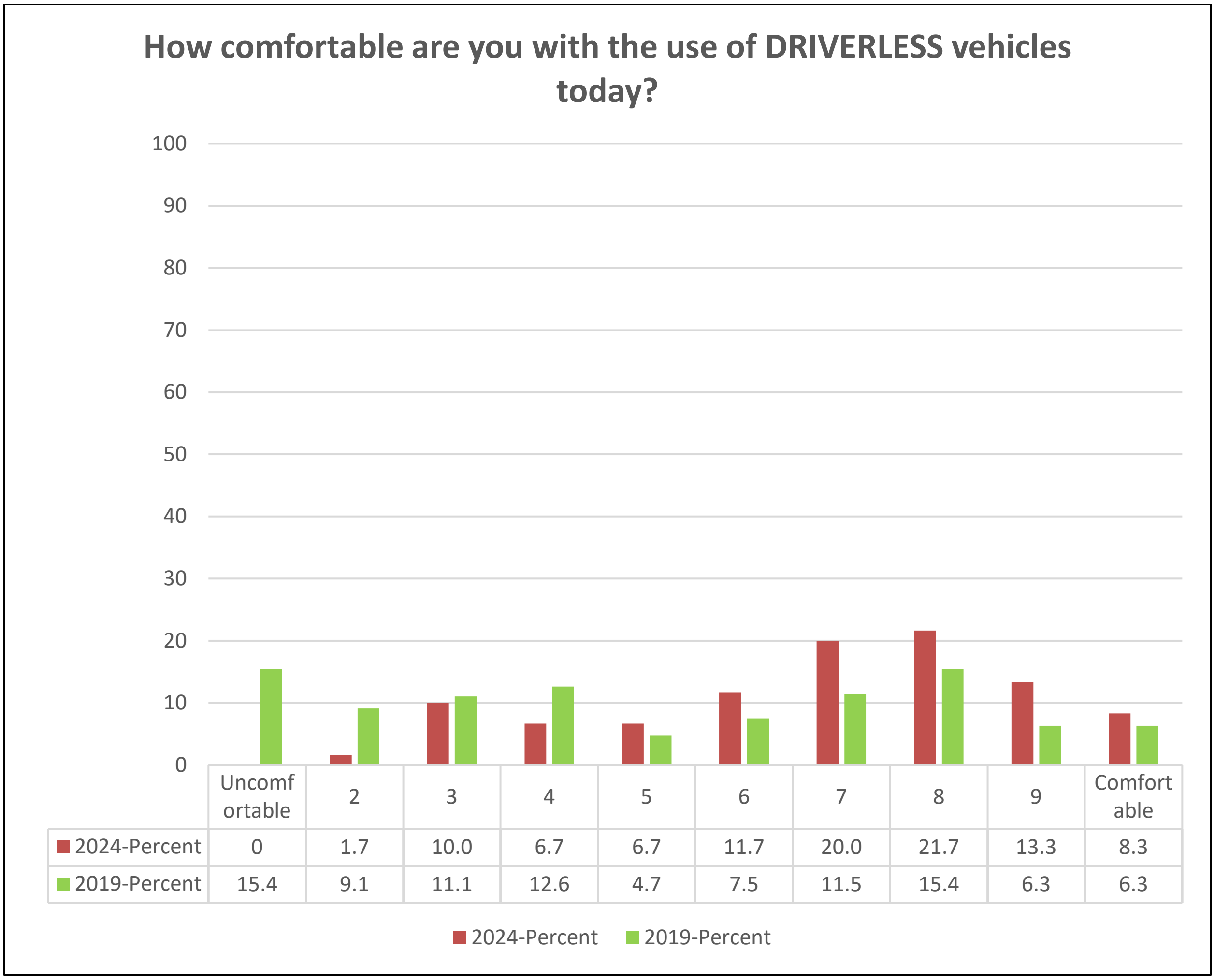



**Figure 17. How comfortable with DVs today?**

Note: (2019 = 239, 2024 = 60)

Results from 2024 show that more than half (63.3%) had a positive view of using generic driverless vehicles, compared with only 39.5% in 2019, a 60% increase in favorability ratings of DVs (Figure 17). Interestingly, none of the 2024 sample indicated an “uncomfortable” rating for using DVs, while 15.4% of the 2019 sample were extremely uncomfortable with DVs.

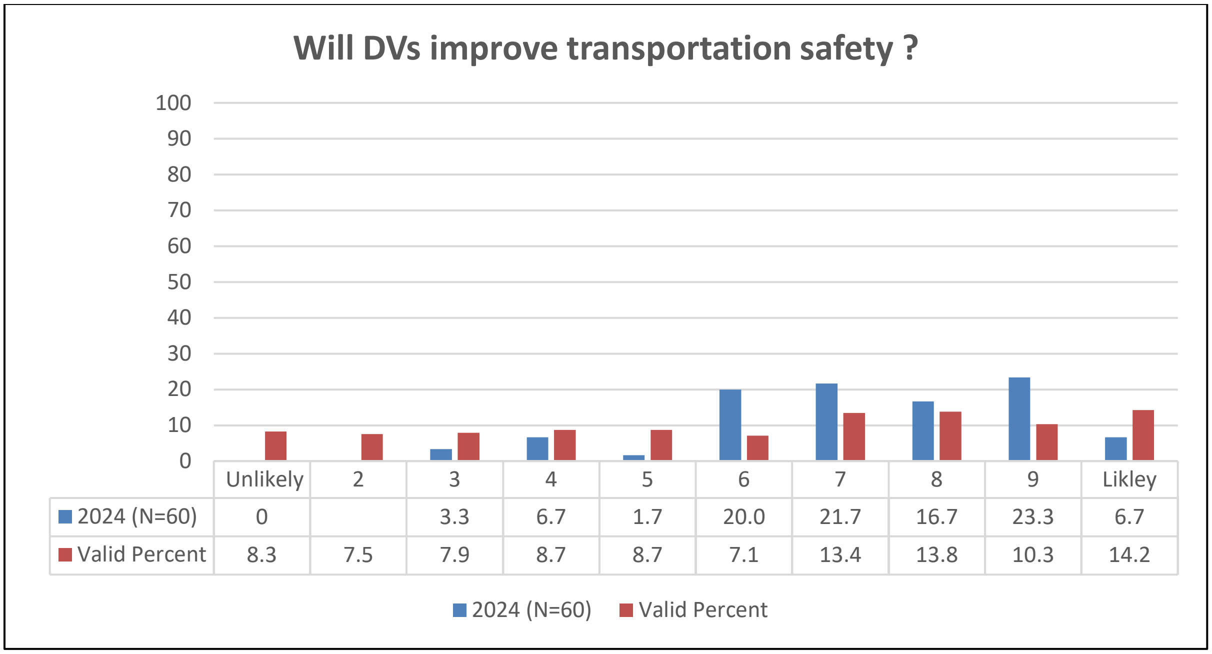
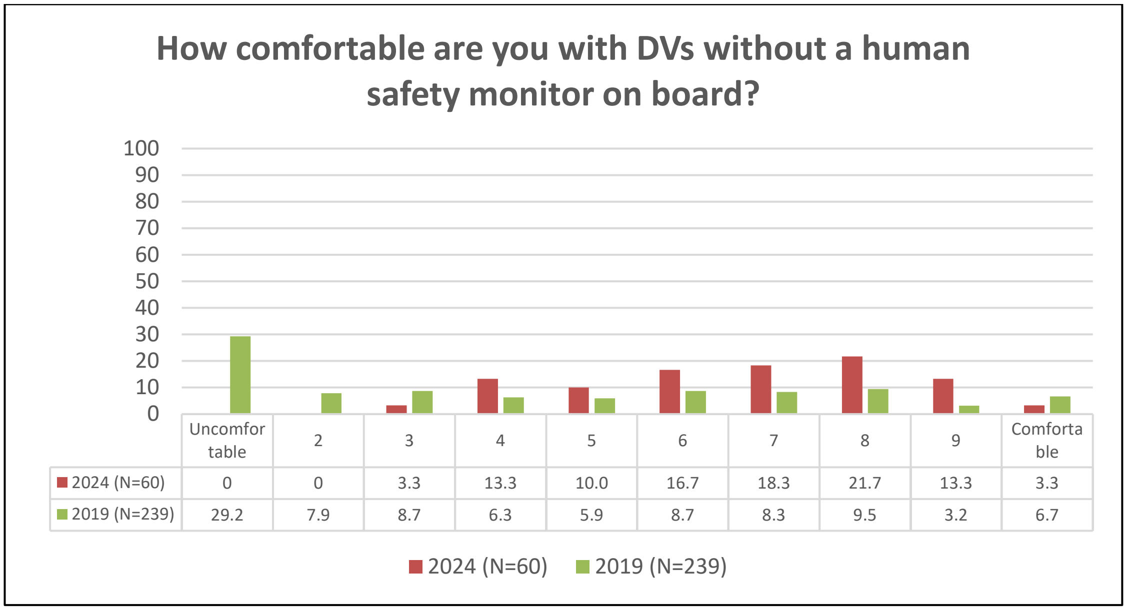



**Figure 18. Will DVs improve transportation safety?**

Similarly, in 2019, pre-pandemic, only 51.8% of respondents felt that AVs would improve general transportation safety and reduce injuries compared with over 68.3% in 2024 who felt that AVs would reduce “accidents injuries and crashes,” a 32% increase in favorability rating (Figure 18). Again, in 2019, 8.3% indicated that improving safety was extremely unlikely as compared with 0% in 2024.

**Driverless Trucks**

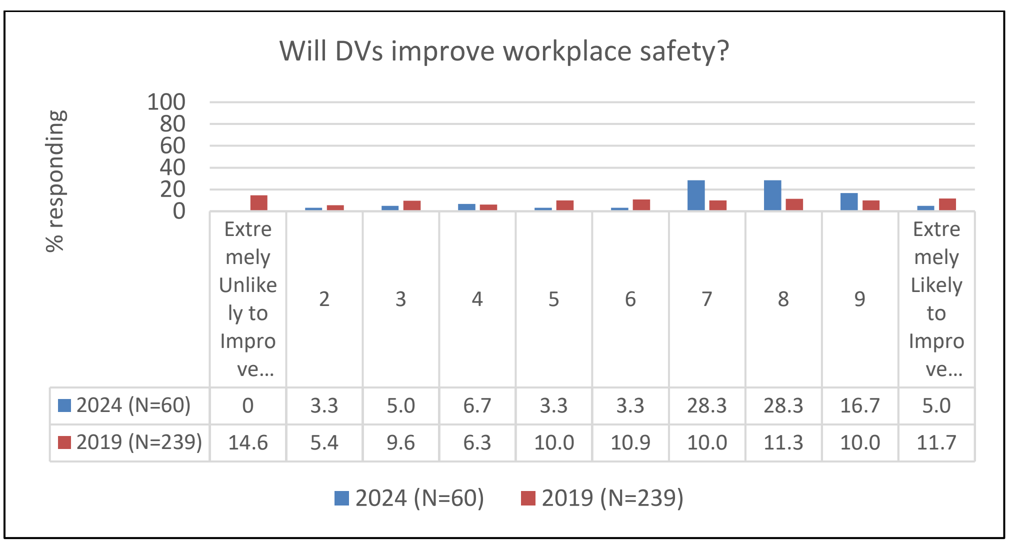



| | Uncomfortable | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Comfortable |
|---|---|---|---|---|---|---|---|---|---|---|
| 2024 (N=60) | 0 | 0 | 3.3 | 13.3 | 10.0 | 16.7 | 18.3 | 21.7 | 13.3 | 3.3 |
| 2019 (N=239) | 29.2 | 7.9 | 8.7 | 6.3 | 5.9 | 8.7 | 8.3 | 9.5 | 3.2 | 6.7 |

**Figure 19. How comfortable are you with DV trucks?**

Results of questions regarding driverless trucks, shown in Figure 19, operating without human safety monitors on board, changed somewhat between 2019 and 2024. Perceptions toward the DVs became more favorable, with 56.7% finding a comfortable rating in 2024 as compared with 29.3% in 2019, a change in the more favorable direction of over 60%. Again, no ratings of "extremely uncomfortable" were obtained in 2024 as compared with 31% in 2019.

**Safety of Driverless Trucks**




| | Extremely Unlikely to Improve... | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Extremely Likely to Improve... |
|---|---|---|---|---|---|---|---|---|---|---|
| 2024 (N=60) | 0 | 3.3 | 5.0 | 6.7 | 3.3 | 3.3 | 28.3 | 28.3 | 16.7 | 5.0 |
| 2019 (N=239) | 14.6 | 5.4 | 9.6 | 6.3 | 10.0 | 10.9 | 10.0 | 11.3 | 10.0 | 11.7 |

**Figure 20. Will DVs improve safety?**

Comparatively, results show that 78.3% in 2024 and 43.1% in 2019 thought DVs were likely to improve workplace safety, an increase in improvement rating of 82% (Figure 20). Similarly, 0% in 2024 rated improvement as extremely unlikely as compared with 14.6% in 2019.

**Employment Prospects**

Questions were added to the 2024 survey about the potential impact of DVs on various conditions. Figure 21 shows there was concern among workers that there could be a loss of jobs if DVs are permitted to operate. Data gathered in our most recent survey (2024, N=60) provide some insight into this question.

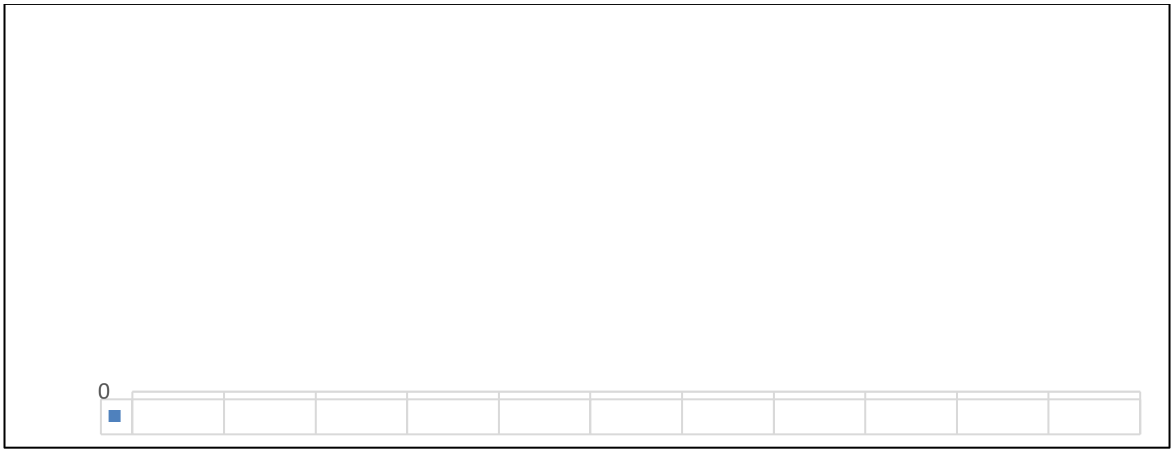



**Figure 21. Will DVs affect the number of jobs?**

Summing the responses by category revealed that 71.7% believed there was some likelihood of job loss for CMV drivers. Only 20% perceived a very high likelihood of job loss. Interestingly, 0% indicated it was unlikely that DVs would affect the number of CMV jobs (Figure 21).

**General Contributions**

DV's will make a positive contribution to improving the

100.0

percent

| | to a little or no degree | to some degree | to a moderate degree | to a great degree |
|---|---|---|---|---|
| 2024-Road safety | 5.4 | 13.5 | 24.3 | 51.4 |
| 2024-Road congestion | 8.1 | 18.9 | 32.4 | 35.1 |
| 2024-Economy | 10.8 | 18.9 | 32.4 | 37.8 |
| 2024-Environment | 2.7 | 24.3 | 27.0 | 27.0 |

Note: 2024, N=60.

**Figure 22. Will DVs make a positive contribution?**

In addition, several questions assessed perceptions of DVs' effect on improving the economy, road congestion, and road safety (Figure 22). Results of the assessment obtained by summing the responses to the categories chosen revealed that, for the most part, the respondents believed DVs would make a positive contribution in the areas of safety (75.7%), reduced road congestion (67.6%), and improvements to the economy (70.3%) and the environment (54.1%). Taken together, almost three-fourths of the total sample reported a favorable view of DVs' impact on safety, the economy, congestion, and the environment. The perception of the impact on the environment was the lowest. The impact of DVs on CMV jobs, however, was seen as having the most negative effect with fewer jobs being available.

### Summary

The results of the supplemental survey of respondents from the transportation trucking industry indicate that 78.3% in 2024 and 43.1% in 2019 thought DVs were likely to improve workplace safety, an 81.6% increase in positive perception; 70.3% of respondents had a favorable view of DVs' impact on the economy. Finally, road safety and road congestion were also seen as improving by 75.7% and 67.6%, respectively.

## 3.5 Study #3 – Autonomous Vehicles and Freight Operations at Ports

### Sample Characteristics

Personnel at the ports of Tacoma, Washington, Oakland, California, Long Beach, California, and Los Angeles, California, were interviewed for perceptions and opinions regarding the use of AVs in port operations and land transport involving freight transport on docks, over the road, and to railheads. Due to the sensitive nature of the topic, considering contract negotiations and COVID concerns, identifying information and demographic characteristics of interviewees were anonymous and remained anonymous.

**The Port of Long Beach**

The Port of Long Beach (POLB) and the Port of Los Angeles (POLA) (Figure 23) eclipse all other U.S. port volumes. The POLB is primarily located on Terminal Island. Not long after its establishment, the island began to expand with fill from new channels that were dug to provide better ship access. In 1911, after several years of negotiations, the state of California split the San Pedro tidelands between Long Beach and Los Angeles.[1]

[1] https://polb.com/port-info/history#port-history-timeline

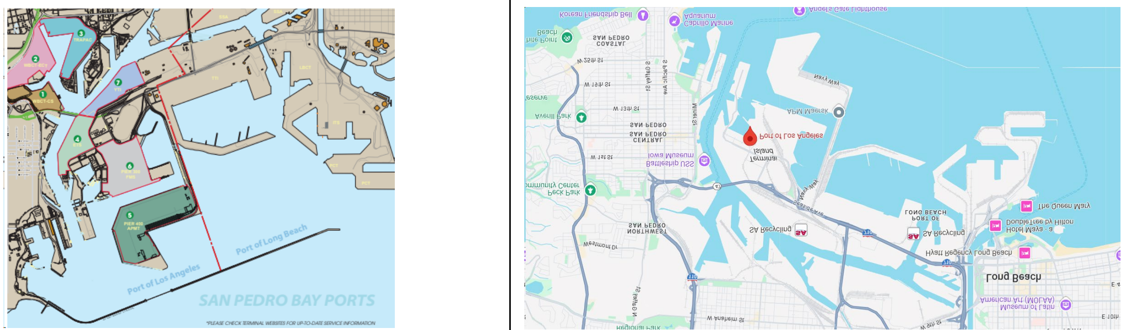



**Figure 23. Map of Ports of Los Angeles and Long Beach**

**Figure 24. Port of Long Beach**

**Figure 25. Intermodal facility Port of Long Beach**

(Photos courtesy of the Port of Long Beach)

The POLB (Figure 24), administered by the City of Long beach, is a container port adjacent to the POLA. The POLB is a major destination and U.S. entryway for Asia Pacific trade. It is 3,200 acres of land with 25 miles of waterfront in the city of Long Beach, California. The POLB is two miles southwest of Long Beach and 25 miles south of downtown Los Angeles. The port employs more than 316,000 people in southern California. The POLB is a major intermodal terminal (Figure 25) adjacent to the POLA.

**Port of Los Angeles**

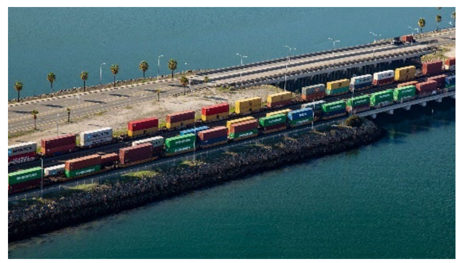


**Figure 26. Port of Los Angeles**

(Photos courtesy of the Port of Los Angeles)

The federal government had required the POLA (Figure 26) to conduct only war-time efforts, which included ship building and staging military efforts in the Pacific. The Pacific Naval Fleet was headquartered next door at the POLB.[2]

[2] https://www.portoflosangeles.org/about/history

**Port of Tacoma**

The Port of Tacoma historically was heavily involved in building military ships during World War II. It ranks fifth in the U.S. for container volumes. The port is located on Commencement Bay in south Puget Sound and is one of the largest U.S. container ports (Figure 27). It is also a major gateway to Asia and Alaska. The port owns nearly 2,500 acres of property, and its marine cargo operations are among the largest in the United States and supports over 42,000 jobs. More than 70% of its international cargo emanates from or is delivered to the central and eastern parts of the U.S. The port also manages about 80% of the marine cargo between Alaska and the Lower 48 states.[3]


**Figure 27. Map of Tacoma and Seattle**

**Figure 28. Port of Tacoma**

Photos courtesy of the Port of Seattle Tacoma

**Port of Oakland**

The Oakland Seaport ranks eighth in U.S. container volumes and comprises approximately 1,300 acres of maritime-related facilities, including approximately 780 acres of marine terminals (Figure 29). The seaport is one of the 10 busiest container ports in the U.S. and one of four major gateways for containerized shipments on the West Coast. It serves as the principal ocean gateway for international containerized cargo shipments to and from Northern California, California's agricultural Central Valley, and Western Nevada. The seaport is also a key gateway for the Intermountain States, including western Colorado and Utah. In 2023, approximately 2.07 million twenty-foot equivalent units (TEUs) moved through the seaport.

Approximately 92% of this activity was associated with international trade, while the remaining 8% represented domestic trade within the U.S.[4]

[3] https://www.portoftacoma.com/
[4] https://www.oaklandseaport.com/resources/about-the-oakland-seaport/

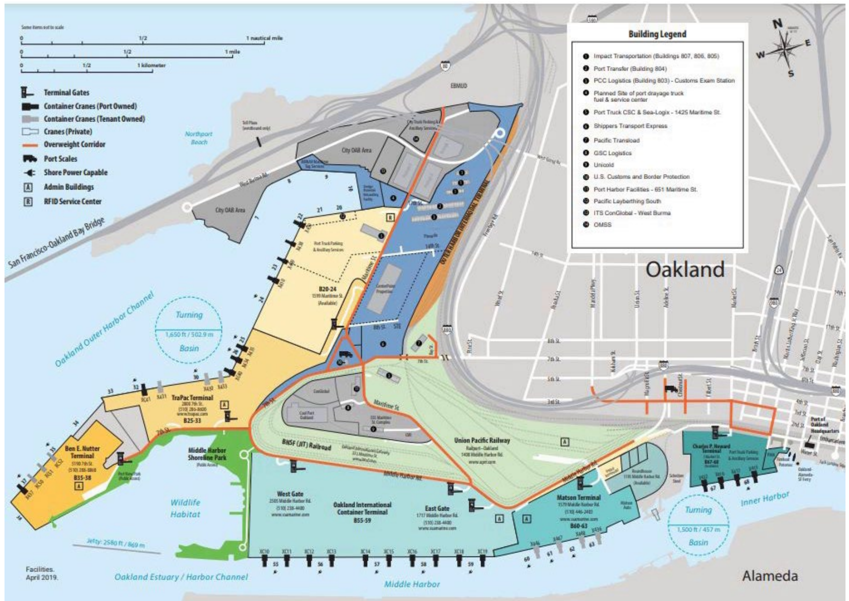



**Figure 29. Map of Port of Oakland**

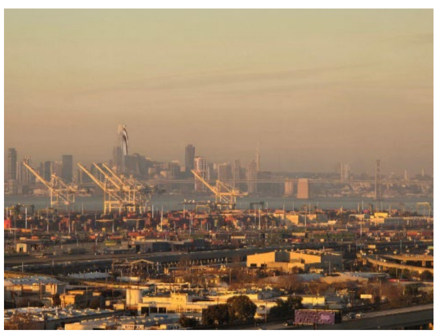


**Figure 30. Port of Oakland**

(Photos courtesy of the author and Port of Oakland)

## Focus Group Interviews

Port personnel and officials and other employees were interviewed regarding port operations and their perceptions and opinions of its operations and activities as well as providing background information about the port. Due to the sensitive state of affairs with the pandemic as well as ongoing contract negotiations, interviewees preferred to remain anonymous. Consequently, no demographic information was obtained.

In addition to surveys of people involved with overland freight transport, additional information was gathered on surface transportation work being done at seaports. Seaport operations are similar to over-the-road transportation in that they use similar equipment such as trucks and cranes to lift and haul containers. Interviews were conducted and observations made at three West Coast ports to determine perceptions of and attitudes toward AVs.

## Port Automation

Automation of operations at ports on the U.S. West Coast has been and continues to be a controversial issue that began in the 1970s. The Pacific Maritime Association (PMA) position has been that there are significant improvements to efficiency and the environment with automation and also positive impacts on the workforce. According to a PMA report, "Automated container terminals at the Ports of Long Beach and Los Angeles have generated more work hours and higher pay for longshore workers" (2022 PMA Report: Michael Nacht and Larry Henry).

On the other hand, the International Longshore and Warehouse Union (ILWU) disagreed with the benefits claimed by the ports and feared the loss of often very high-paying jobs. "Automation at the Long Beach Container Terminal and the Port of Los Angeles has eliminated 535,848 hours and $41.8 million in wages annually for dockworkers" (Donna Littlejohn, Los Angeles Daily News, 6/30/22).

These opinions reflect the unrest and tension between management and organized labor associated with ongoing efforts to introduce automation. Historically, labor and management have been in conflict over the issue of technology since the 1950s, when increased mechanization allowed bulk cargo such as wheat and corn to be loaded directly out of storage silos rather than by hand. In the early 1960s, a landmark agreement on mechanization and modernization was signed that helped pave the way for a long period without disputes.

On July 1, 1971, ILWU members walked off the job in all 56 West Coast ports, including those in Canada. The union's stated goal was to address employment, wages, and additional benefits thought to be threatened by increased mechanization, loss of jobs, and the slowing economic climate of the early 1970s. Negotiations with the PMA were conducted and lasted for 134 days. One of the most contentious issues was the automation of truck manifests and some cargo tracking. At that time, it became apparent that the government might support the integration of new technology resulting in "the union…concluding that new methods and machines would be introduced no matter how great the effort by the membership to resist change." On October 4, 1971, then-President Nixon invoked the Taft-Hartley Act, forcing the end to the strike and creating an 80-day period for resolution to occur. After negotiations were completed, automation was adopted as well as job security and wage increases for the union workers (Lindsey, 2011).

In 2002, the port authorities wanted to implement more automation but the ILWU was against it. According to NBC News, "The central issue in the negotiations is management's desire to make use of new technology, including computerized information systems to track cargo. Dock workers, … want to ensure that any new technology-related jobs are unionized. The two sides also are at odds over pensions, but technology is the major sticking point" (NBC, 2002). The ports locked out dock workers for 11 days. On October 9, 2002, President Bush ended the 11-day strike of 29 West Coast ports, stating that the port operations are "vital to our economy and to our military" (Sanger, 2002). Negotiators said the agreement provided "substantial improvement in wages and benefits for the union's members." Also, "Necessary technology and dispute resolution improvements needed to ensure that America's West Coast ports continue to modernize and increase in both efficiency and productivity" (Cleeland, 2002).

The most noticeable impact on the work has been the improvement in productivity. As noted earlier, port productivity has been thought to have had increased speed of movement of goods and containers. However, another aspect of the impact on productivity is likely to be likely to be fear—fear of income loss or job loss. Fear of job losses has been the recurring theme on the West Coast for some time. For example, according to the Wall Street Journal, "The cycle of disruption goes back years. In 2008, the ILWU and the Pacific Maritime Association began negotiations early but still missed the deadline for reaching a contract. The 2002 negotiations were even more disruptive and eventually involved then-President George W. Bush. After 29 West Coast ports were closed for 11 days when longshoremen refused to work at all, Mr. Bush chose to invoke his powers under the Taft-Hartley Act to get the ports open and ordered the longshoreman back to work. The same sort of disruptive tactics played out in 1999 and in negotiations dating to the 1970s" (Holtz, 2014).

Prolonged negotiations and slowdowns were also observed in 2008 and again in 2015 when an agreement was reached allowing for more automated cargo tracking, but also increasing union salaries and guaranteeing all currently employed clerks can keep their jobs until they retire. In 2016, there was continued implementation of huge dock cranes, which the industry suggests boost terminal productivity and reliability in performance at lower costs and are critical to the ability of ports to cope with surging trade volumes. Industry estimates suggest that technology can reduce the amount of time ships spend in port and improve productivity by as much as 30% (Phillips, 2016).

In 2020, the POLA opened the fully automated Trapac Intermodal Container Transfer Facility (Figure 31) in Wilmington. The TraPac On-Dock Rail Yard occupies a 209-acre container terminal and is the most technologically sophisticated on-dock rail facility at the POLA. The facility was built in stages beginning in 2012 with the first four automated stacking cranes. This was followed between 2014 and 2018 by eleven more cranes and an increase in the number of automated straddle carrier or "autostrad" cranes that straddle the containers. The Autostrad vehicles move containers between locations on the dock area. They navigate based on virtual routes with a high degree (two centimeters) of accuracy (Allyon, 2022). The automated stacking cranes, which can stack containers up to five high and lift loads up to 41 tons, have enabled TraPac to stack containers more densely, freeing up space for the intermodal rail system, which also was brought online during this period (Figure 32). It is the only fully automated, emissions-free on-dock U.S. rail yard. Using an integrated network of lasers, GPS, and magnetic technologies, rail-mounted gantry cranes are able to transfer containers to and from rail cars. (Trapac, 2025).

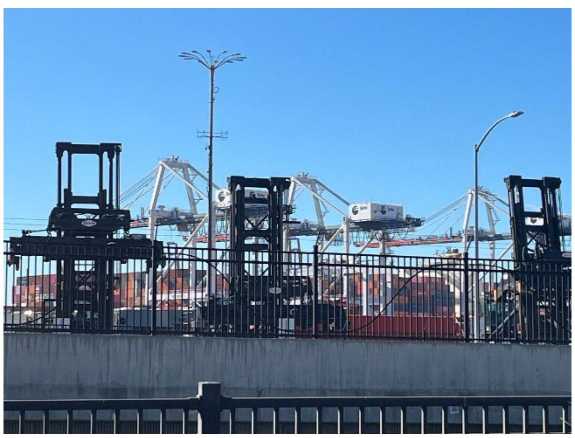


**Figure 31. Trapac autonomous at vehicles Long Beach container facility (Photo courtesy of author)**

In 2022, automation was again center stage in contract negotiations between dockworkers and the shipping lines at U.S. West Coast seaports. Ocean carriers and terminal operators argued for increased use of robotic equipment to alleviate backlogs and bottlenecks due to high volumes of cargo in U.S. supply chains. Dockworkers made concessions over time about the utilization of automation but were against any further use of automated cranes, self-driving vehicles or other advances which could replace jobs. "The bottom line is that automation has killed jobs at the ports," said Frank Ponce De Leon, a senior ILWU official (Berger, 2022).

According to a recent report "Automation at the Long Beach Container Terminal and the Port of Los Angeles," the TraPac terminal has eliminated 535,848 hours and $41.8 million in wages annually for dockworkers, even as production at ports that are automated is typically lower than at those that are not, according to a new study (Littlejohn, 2022).

**Figure 32. Trapac automated straddle carrier ("autostrad") at LA Long Beach**

A survey by McKinsey in 2017 estimated that port operating expenses fall by about 20% with the utilization of automation. However, productivity was predicted to decline by about 7%. McKinsey reported that at fully automated terminals, the average number of gross moves per hour for cranes—a key indicator of productivity—would be in the low 20s. While at many conventional terminals, it is estimated to be in the high 30s (Chu et al., 2018). For example, at the Port of Seattle Terminal, 18 reportedly averaged 30 crane moves per hour, moving 5,500 containers on and off a single vessel (NWSPA, 2018).

The West Coast labor talks have significant hurdles to overcome once the two sides resolve their regional disagreements, according to shipping industry officials. The ILWU has concerns about the use of fully automated machinery, which has already been introduced at some ports because of prior contract agreements. Shipping industry officials say the talks covering Gulf Coast and East Coast ports face fewer obstacles. The International Longshore Union (ILA) has fiercely opposed the use of fully automated equipment at ports covered by its contract (WSJ, 2023). In late August 2023, the ILWU ratified a new, six-year contract covering dockworkers at West Coast ports with more than 75% of its members voting in favor of the contract. The contract purportedly included a included a 32% pay increase through 2028 and a one-time "hero bonus" for dockworkers who worked through the pandemic (Berger, 2023).

According to a recent GAO study, 10 of the largest U.S. container ports have installed automation technology to some degree. "All ten of the largest U.S. container ports are using some form of automation technology to process and handle cargo. At least one terminal at each port uses it to track and communicate container movements. Four also use automated cargo handling equipment to load, unload, and move containers" (Von Ah, 2024). In addition, some ports are adopting process automation technologies rather than automated cargo handling equipment. That includes the Port of Long Beach, which Von Ah said is the "gold standard in terms of automation in the U.S.," with cranes that are almost fully automated at the West Coast port's container terminal.

The GAO report concluded that "U.S. and international port stakeholders agreed that automation technologies can improve worker safety by separating humans from machines and can reduce emissions by improving efficiency. However, they reported mixed effects on the workforce, security, and performance. For example, a few terminal operators said automated equipment could stack containers more densely than conventional equipment, increasing capacity; others said this equipment moved containers more slowly than conventional equipment, reducing performance. Similarly, a few stakeholders said automation can reduce jobs; others said automation can create more comfortable work environments and new, higher-skilled positions" (Von Ah, 2024).

**Figure 33. International Longshoremen Workers Union (Photo courtesy of author)**

The GOA report indicates that the question of whether automation improves productivity or reduces jobs is not a simple thumbs-up or thumbs-down proposition.  Several issues affect the outcome. For example, different regulations, labor agreements, and management's lack of familiarity with equipment all come into play with respect to the impact. In many cases, productivity is slower because of equipment limitations.

The ILA port strike of 2024 ended, but negotiations continue at the time of this writing over the role of automation. The ILWA union president "is determined to prevent what happened to cashiers and toll booth attendants from happening to his 47,000 dockworkers. Fresh from a big win in a three-day port strike, which ended with his members getting a 62 percent raise over six years, the union chief will now turn his focus to a tougher foe: The march of progress" (Eavis, 2025).

Negotiators representing ocean carriers, terminal operators, and dockworkers (ILA), based in Long Beach (Figure 33), announced an agreement on January 8, 2025, covering 25,000 workers that will allow automation technology at container ports on the Eastern Seaboard and Gulf of Mexico while guaranteeing more ILA positions to help operate that equipment (Chrils, 2025).

Labor and management have developed agreements regarding automation and jobs. "The Port of Virginia is thriving with automation," said Ram Ganeshan, professor of operations and supply chain at William & Mary in Williamsburg, Va. "They're not mutually exclusive." Labor experts identified a model for compromise: The union could agree to more automation, and the employers would offer solid job guarantees. For example, the ILWU agreed to a contract over a decade ago that "recognized that the introduction of new technologies, including fully mechanized and robotic-operated marine terminals, necessarily displaces traditional longshore work and workers." The union got guarantees that its members would maintain and repair the machinery at the terminals (Eavis, 2025).

## Summary

The ports have seen a considerable amount of turmoil and conflict as a result of the introduction of automation. These developments have had a profound effect on the work, as well as the organizational and safety culture. The situation with respect to automation at port facilities is complex and evolving but has had a profound impact on productivity, the culture, and the workforce.

The most important aspect of the automation initiatives, from the point of view of the workforce, is that jobs are eliminated and the number of employees is reduced. Job loss does not occur immediately, however, but takes place over time as the technology is put in place. Some jobs may be added to maintain the automated equipment, but for the most part it is estimated that the end result is fewer employees, fewer jobs, lower wages and fewer hours worked. Consequently, automation is typically met with fear and trepidation, resistance by labor, and, as we have documented, in some cases work slowdowns and strikes as workers anticipate layoffs and unemployment. The impact on the culture then becomes one of mistrust and disengagement with respect to management and the organization as a whole. Two published reports draw somewhat different conclusions. It appears, however, that after the automation of LBCT and TraPac terminals, dockworkers spent less time working compared with the other non-automated terminals at the same ports—the most glaring decrease in dockside-to-shipside hours at LBCT (Schmidt, 2022).

A second area of impact regarding automation is on the productivity of the organization. Improvements in the overall gross productivity, at least in the port area, are not as pronounced as one would have thought. Again, several reports have been published which indicate the comparative productivity of the U.S. versus other ports worldwide. Of great interest is the fact that U.S. West Coast ports typically report an average of 35 container moves per hour as compared with a much higher number in Asian and Southeast Asian ports. Interestingly, a record for U.S. port moves was set in 2018 by two human operators working the containership Gudrun Maersk at Total Terminals International's Pier T terminal. They moved 564 containers using a single crane over just an eight-hour period, averaging 70 container moves per hour. The U.S. West Coast average is 25 container moves per hour (Captain, 2018).

Another report suggests that increased automation and robotics have increased productivity. A study sponsored by the PMA reported that the West Coast's two automated port terminals, TraPac and LBCT, had a 31.5% increase in hours worked by dock workers, and that the speed of container movements had doubled over previous years (Asia News Monitor, 2022). However, Patrick Burns, a senior researcher at the Los Angeles-based nonprofit Economics Roundtable and co-author of *Someone Else's Ocean*, supported in part by a grant from the ILWU, argued that automation reduced employment from 37% to 52% at LBCT, and from 34% to 37% at TraPac. Specifically, the authors concluded that nearly 580 jobs were eliminated at the ports between 2020 and 2021, which they characterized as a "staggering amount of job loss" (Flaming & Burns, 2022).

Most reports indicate that safety is improved. The GAO report found that for one port operator, before automation, their terminal had two or three injuries per month, and that some past injuries had been fatal. In the months since adopting automated gantry cranes, the operators reported that the terminal has had no injuries (Von Ah, 2024, pg. 14). The separation of humans from the risk of coming into contact with machinery clearly was an improvement. In another example, a check-in clerk had contact with over 1,000 vehicles a day; after automation, no physical presence was needed.

# 4. DISCUSSION

The results of these studies suggest that perceptions of the on-board safety technology and the potential inclusion of autonomous or driverless vehicles in the freight industry has a minimal impact on safety cultures at present. However, there are several areas that may be likely to have an impact going forward.

## 4.1 Perceptions of Automation Including OBT and AV

Results of the analysis indicated that the perception, in general, was that safety would be improved as the result of the use of automated onboard technology. Taken together, 43% of respondents had a favorable view of OBT, AV, and DV technology. Only 21% reported feeling that OBT would result in improvements to a little or no degree. For people who already had some type of OBT installed, results indicated that 64% had a positive view of the impact of OBT on their safety.

Interestingly, when the respondents were grouped into those with a favorable versus unfavorable view of OBT, those with a positive perception of OBT, 55% reported no accidents and only 20% reported one or more accidents. Similarly, for those who did not have a positive view of OBT, only 20% reported having no accidents, but about 2% reported having one or more accidents. The inverse association of the number of accidents with the view of the impact of the technology is clear: fewer accidents and a positive view of the technology is evident.

Looking also at the relationship between perception of OBT and the number of tickets received, an indicator of safe driving capability, the results did not reveal any significant pattern. There was no relationship between the number of tickets received and the perception of OBT's safety impact. This is not surprising since OBT is more likely to prevent collisions than the type of operational errors that result in violations.

As noted earlier, a little over half of the respondents believed that technology in the form of driverless vehicles would eliminate driver jobs with only about a third of respondents having just a little or a slight degree of concern. The longshoremen's union claims about the threat of automation may remind history buffs of the Luddite movement in 19th-century England, where workers rioted against the automated textile machines that were replacing them (Eaton, 2024).

It was also interesting that the odds of a person with a strong belief in OBT's safety contribution is almost four times more likely to feel that drivers may lose jobs due to AVs or OBT. In other words, the odds are high that a person who sees OBT positively contributing to improved safety is also more likely to think that jobs will be lost. Apparently, believing that technology will improve safety is associated with the belief that jobs will be lost.

This also makes sense in that if drivers believed OBT had no impact then there would be nothing to fear. The fact that OBT is viewed as having a positive impact on safety seems to suggest that there is a perceived threat. Moreover, if history is any indication, there may be something to fear in the form of job loss.

## 4.2 Resistance to Automation

Historically, the introduction of automation has met with resistance. In 1960, as ports on the West Coast introduced machinery to move cargo once moved by hand, the union representing dock workers negotiated protections for workers, including assurances that the current workforce would not be laid off, according to the International Longshore & Warehouse Union. Harry Bridges, who led the union at the time, negotiated pay increases and job security arrangements for some of the workers, according to Adam Seth Litwin, associate professor of industrial and labor relations at Cornell University. "He saw that this was going to become potentially a real problem if he didn't try to get ahead of it," Litwin said. "Essentially what he was saying was, 'I recognize the reality of what's happening here, and the way to best represent my members is to make sure that they are protected.'"


**Figure 34. Longshoremen Dispatch Hall, Long Beach, California** (Photo courtesy of author)

Harold Daggett, the ILA leader based in Long Beach (Figure 34), has demanded "absolute airtight language that there will be no automation or semi-automation" over the next six years. "I've been fighting automation for years," he noted in a recent video. He threatened that he is ready to take the fight across the globe. "We are all together in solidarity around the world. We will fight against automation of the maritime industry," Daggett said (ILA, 2024). However, other experts disagree. "What the dock workers are doing now is not winnable. You can't just say no to technology," noted Daron Acemoglu, a Nobel Prize-winning economist at MIT who has studied long and hard the impact of automation on the workforce (Porter, 2024). "What unions must do is settle on a plan that allows technology but offers a win-win situation that also benefits workers." The ILA, however, threatened another strike on January 15 unless any additional automation — e.g., automated cranes loading and unloading containers — is banned. The strike would have caused major disruptions to the nation's economy before Trump took office in early 2025 and imposes his promised tariffs (Porter, 2024). However, the strike was avoided and a six-year contract was signed that included significant wage increases and a framework for addression terminla automatoin and automation. (Evis, Jan 8, 2025b)

A study by David Autor, an economist from MIT, found that wages of college-educated workers rose sharply between 1979 and 2017 but that wages for non-college-educated workers declined. "Changes in work—many of which are technological in origin—have been more disruptive and less beneficial for non-college than college workers. Almost all occupational change among non-college workers reflects a movement from the middle toward the bottom of the occupational distribution" (Autor, 2019, pg. 9). In addition, Autor argues that "not only has technology change been transformational, it has been broadly deskilling," which means that it has reduced the number of jobs in which non-college workers performed work that was traditionally compensated at higher pay levels (Autor, 2019, pg. 9). Thus, the decline of middle-skill occupations has meant a profound reallocation of non-college workers in urban and metro areas from middle-skill production and work to low-skill services, transportation, and laborer occupations (pg. 17).

Resistance to automation seen in other sectors was not observed in the present study. Several reasons may account for this finding. Most likely, the immediate threat of job loss was not perceived as imminent at the time of data collection. In fact, according to the American Trucking Association (2024), "In December 2024, the trucking industry is expected to face a driver shortage of around 82,000 drivers" (ATRI, 2024). The ATRI report lists driver shortages as the third highest concern among owner operators. These findings suggest that the immediate threat of unemployment is not as salient. Whereas in other sectors, like ports or docks, the use of automated cranes and tractors is more imminent.

## 4.3 Artificial Intelligence and Transportation

Related to the specific issue of autonomous or driverless vehicles and onboard safety technology affecting transportation is also the overriding construct of artificial intelligence, or AI.

Abduljabbar et al. (2019) identified several challenges related to applying AI to transportation. Specifically, AI has been used to transform road-based traffic sensors into a smart agent that detects accidents automatically and predicts future traffic conditions. It has been considered for road planning, public transport traffic incident detection, and predicting traffic conditions to predict future mobility demand in Switzerland.

A recent report by the Eno Center for Transportation suggested that while there is much talk about the role of AI and the potential of AI in transportation little has actually been done. "There are few resources available that offer a plain language explanation of how it can be applied in transportation, particularly to lay out the practical considerations that transportation professionals and policymakers need to be aware of" (ENO Center for Transportation (ENO), 2023).

A study 2023 by Deloitte, based on a survey of 210 business leaders in transportation and logistics, found that 54% of respondents had at least one AI implementation project underway, and another 21% were beginning pilots. Only one in five companies had a broad implementation project underway in their supply chain operations. The supply chain was seen to have the most activity. Further, most of the activity related to implementation appears to have been in route optimization, asset management, and warehouse operations. No respondents reported applying AI to frontline "workforce productivity" efforts. About two-thirds of respondents indicated that AI has assisted in generating insights into inventory management.

The U.S. Department of Transportation (USDOT) recently published a report that highlighted several key issues related to the adoption and implementation of automated technology and its applications.

- USDOT should model principles for the trustworthy development and deployment of AI by openly and proactively showing its work.
- Initiate the development of a multi-agency task force on the impact of AI on the transportation workforce and develop a comprehensive gap analysis of evolving workforce needs, scenario planning and corresponding training and programs to support the transportation workforce.
- Consider how AI-enabled technologies will affect the nature of work in ways that could change, eliminate, or create jobs—in some cases quickly and dramatically. AI could help improve workplace safety and productivity, and changes will demand adaptations across the transportation system.

These considerations should be fully examined going forward.


**Figure 35. Waymo self-driving truck** (Photo courtesy of author)

In 2024, several trucking companies began to deploy driverless trucks, albeit with human safety monitors on board; however, the introduction and implementation of automation in trucks is not expected to be a single point in time event. Rather, it will develop gradually over the next decade or two. “I think people still have this notion of AV or not,” said Dr. Stefan Heck, CEO of Nauto, an AI and data platform for driver coaching, safety, and AV development. “And I think that is the wrong notion. There will not be a date of March 5, 2027, and boom, AVs are on the road. It will be gradual” (Fleet, 2024). While Waymo (Figure 35) has pulled back from its self-driving truck experiment in Texas, Kodiak, an independent trucking company, presented its driverless-ready Class 8 truck and opened an AV truckport with Ryder in Houston. Kodiak also demonstrated an autonomous test Ford F-150 for the U.S. Department of Defense, with whom Kodiak currently has a contract for two off-road-capable vehicles for reconnaissance. At the same time, Kodiak and supply chain solution business Martin-Brower Company unveiled autonomous refrigerated deliveries, which take place eight times per week for restaurants between Dallas and Oklahoma City. Kodiak trucks still use safety drivers, but the company plans to launch its first driverless operations from Dallas to Houston this year (Keenan, 2024). Other companies are also introducing driverless trucking operations: Aurora and Continental are currently finalizing the design and architecture of Aurora’s Level 4 autonomous platform; Torc, a subsidiary of Daimler Truck, plans to roll out an AV Freightliner Cascadia by 2027; Navistar is planning to launch an autonomous SuperDrive technology with the Traton Group; Gatik AI plans to continue operations in Dallas, Texas. Volvo l begin moving freight within Texas before the end of 2024, and DHL in 2025 (Fisher, 2025).

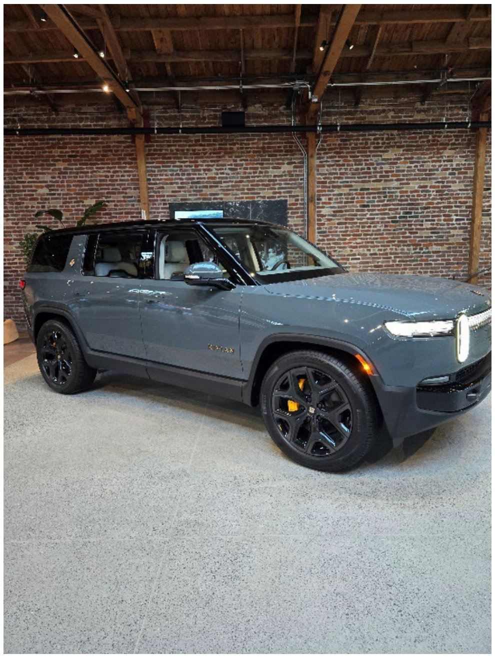


**Figure 36. Rivian electric vehicle with self-driving capability.**

Rivian CEO R. J. Scaringe recently noted that it is also developing AI self-driving technology for its trucks (Figure 36). “We believe it’s really about the incremental features – whether it’s safety or comfort – that you can progressively add to the vehicle,” Scaringe said (Lee, 2024). Overall, there is a gradual but steady increase in the deployment of driverless options.

Although not the primary focus of this study, the Federal Railroad Administration recently approved a pilot test program to examine autonomous railcars. Parallel Systems will evaluate an autonomous self-propelled flatcar system on a pair of Genesee & Wyoming short lines in Georgia. The experimental prototype flatcar can carry one intermodal container 500 miles on a single battery charge, which powers the car’s traction motors. The vehicle uses cameras, sensors, and software to operate the car, and electronic brakes can stop the car in one-tenth the distance of conventional equipment with air brakes. The prototype battery powered electric cars are able to operate alone or as an autonomous platoon of up to 50 cars. The vehicles can reach speeds of up to 25 mph and traverse grades as steep as 3%. The first phase of the pilot program will involve only a two-mile section of track in Georgia that is free of grade crossings. The hope is that, if successful, the railroads are close to the Port of Savannah, which is experiencing increased truck traffic. Ultimately, as East Coast ports grow, the equipment will take trucks off the road in short-haul markets where the existing railroads have difficulty competing (Trains, 2025).

## 4.4 Workforce Implications

Results suggest that as changes in technology emerge there will be a need to upgrade workforce skills. There are ways both employers and unions can protect workers. Some unions have negotiated that employees must receive guaranteed employment protection if companies bring in technologies that could make their jobs obsolete. Others have bargained for employers to provide tuition reimbursement or retraining programs so workers can shift into other roles when machines come in. “The trick is to make it over time, not to do it haphazardly,” said Yossi Sheffi, director of the MIT Center for Transportation & Logistics. In its current contract, the ILA has a provision that requires the union’s agreement if the ports add any automation, essentially giving the ILA veto power. But ILA President Harold Daggett has said the union wants a stronger ban (Bussewitz, 2024).

When health care giant Kaiser Permanente switched from paper to digital medical records a decade ago, dozens of unions bargained together to ensure workers would not lose jobs or face wage reductions as a result of the technology deployment. Drivers who moved boxes of medical records to warehouses and librarians who retrieved paper files were trained and reassigned to roles such as medical librarians or coders. “They ultimately all got pay increases because they ended up being in jobs that ended up being more highly skilled,” Litwin said.[5]

[5] U.S. News and World Report. (2024, October 2). “Dockworkers join other unions in trying to fend off automation, or minimize the impact.” https://www.usnews.com/news/best-states/new-york/articles/2024-10-02/dockworkers-join-other-unions-in-trying-to-fend-off-automation-or-minimize-the-impact

Labor organizations continue to monitor the impact of technology on their workforce. Recently, video game workers reached an agreement after striking with 80 games that provided protections around exploitative uses of AI. In 2023, Hollywood screenwriters concerned that scripts would soon be written by AI won protections against the use of AI after a five-month strike.[6]

David Autor (WP, Oct 2024) wrote, "How do we make a technology that complements workers? I think there is an answer to that question, and the answer is a technology that complements workers is one that allows people without elite levels of education to do more valuable work. So if we see technologies that allow workers without a four-year college degree, again, who are the majority of working adults in America, do more valuable health services, do more software development, do more legal services, do more valuable repair and contract and design, if we see a reversal of the growing power of elites and an increasing reward or demand for people with good formal skills who don't have elite degrees, that would be a valuable use of technology. That is a benchmark we can measure."[7]

The following recommendations for implementing changes to work involving automation are offered:

1. The most important thing is for management to put forth a gradual plan for introducing technology and automation into the workflow. This plan hopefully can be agreed to by workers and labor.
2. The plan should be future oriented, gradual, and offer the transition from manual to automated work.
3. As part of the plan, retraining and reassignment of workers to new jobs should be undertaken. The issue is reducing uncertainty and anxiety.
4. Incentives for participating in retraining should also be offered.
5. Reassignment to new jobs should be compensated for at equal pay with the opportunity for salary to increase over time.
6. Ensure that new tech comes with commitments to maintain jobs and retrain workers.
7. Implement rigorous safety protocols to ensure that new technology meets all safety specifications and provides sufficient safeguards to protect employees from harm.

## 4.5 Automation and Safety Culture

With respect to the impact of automation and technology and the use of AV and DV on safety culture, the results of our study suggest there is little impact at this point. Survey results revealed that the majority of respondents (62%) had a positive view of whether OBT improved safety. The respondents also viewed safety as more important than productivity, compared with only 3% who felt that productivity was more important than safety, indicating that OBT had little impact on safety. (Figure 5). Regarding rule violations, another strong indicator of safety culture, results shown in Figure 10 indicate that there is little relationship between the two attitudes as 47% of the respondents believed it is not acceptable to violate rules and felt that OBT improved safety ($X^2$ = .011, df=1, p<.915, ns).

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[6] Bussewitz, C. (2024, October 3). "Dockworkers join other unions in trying to fend off automation or minimize the impact." *AP News*. https://apnews.com/article/longshoremen-dockworkers-strike-union-automation-4707b764692f6061cd5948d3c73b3c53

[7] Autor, D. (2019). "Work of the past, work of the future."
https://www.nber.org/system/files/working_papers/w25588/w25588.pdf
DOI 10.3386/w25588

However, the overall impact on safety culture from the introduction of technology—especially autonomous technology—appears to be negligible for the respondents in this study. A quick survey of the internet indicates many non-empirically based opinions that technology drives safety. Little mention of safety culture was found. In order to improve and enhance safety culture it must be noted that while the overall safety of the workplace may be improved the safety culture may also need to be augmented by continuing to engage the workforce in the kinds of preventative activities known to enhance safety. The most important activity will be to engage the attention and motivation of workforce members in considering and thinking about likely and possible scenarios that could lead to injury, crashes, and fatalities.

Research from our own studies suggest that supervisors and senior executives focus on and commit to safety efforts that contribute significantly to the development and maintenance of a strong safety culture. In other words, strong role models and immediate focus on safety in the workplace enables and supports awareness and behaviors that create a strong safety culture. To the extent that senior leadership prioritizes technology over human factors, then there will be likely be a decline in the importance of safety culture. Maintaining and increasing personal and situation awareness, reinforcing effective safety behaviors, and other initiatives will continue to lead to a productive safety culture. The introduction of technology will likely augment the overall safety culture if the leaders continue to espouse, support, and enforce a strong emphasis on safety.

While the results show there is little impact of AVs or DVs and OBT on perceived safety culture of driver operators at this time, there are lessons to be learned. The lower impact of AVs and OBT on safety culture is not heightened. However, little or no perceived threat to employment or displacement is likely being experienced at this time.

## Summary of Findings

1. Transportation workers in port and dock operations have experienced tension and even strikes because of the perceived threat of automation to income and job loss.
2. Current findings suggest that the introduction of automation in the form of AVs and OBT will likely increase safety and contribute to an improved safety culture.
3. Current findings suggest that the introduction of automation such as AVs and OBT is likely to improve economic conditions.
4. Current findings suggest that the use of AVs and DVs does not entail the displacement of drivers that this time.
5. The use of OBT does not necessarily disengage driver operators from the process of vehicle operation at this time.
6. The use of AVs and OBT do not at this time point to either an increase or a decrease in economic performance. At least in the short run, the use of human operators is likely to be the more cost-effective approach.
7. The business case, according to the sources studied, is not likely to result in enhanced profits in the near term of three to five years.
8. The need for driver retraining and/or skill development is not an issue at this time.
9. Some indications are that in port operations there can be a decline in safety with the introduction of new technology as adjustments and calibrations occur.

## 4.7 Recommendations for Automation and Safety Culture

Based on the current study, the following recommendations seem warranted for the introduction of AVs and OBT regarding the maintenance of a strong and positive safety culture:

### Recommendations for the Introduction of Autonomous Technology

1. Management should convey the message that automation is not a substitute for human driven safety efforts. We cannot automate ourselves into safety.
2. Make a compelling case for the safety and operational benefits of AVs and OBT to drivers and other stakeholders.
3. Ensure that economic hardships (e.g., job loss or displacement of human workers) do not befall the existing workforce as a result of implementing automation into operations in order to ensure continued buy-in, support, and decreased resistance.
4. Ensure that senior leaders maintain a strong commitment to operational safety.
5. Ensure that immediate supervisors also continue to emphasize the importance of operational safety.
6. Ensure that supervisors continue to ensure that operational excellence is desired, and that shortcuts or operations failures result in negative consequences.
7. Ensure that the leaders of the organization maintain a commitment to a just culture, including accountability of both operational and technical aspects of the organization such as technology, automation, and human factors.
8. Ensure that the culture continues to advance and improve through continued learning and inquiry to further enhance the safety of the organization.

## 4.8 Future Directions

Taken together, these results suggest that with the introduction and adoption of new automated technology, safety culture will remain an important area of focus for managers and safety professionals in the transport industry. While there are several articles that point to the role of technology in safety improvements, they generally refer to the introduction and use of data to monitor and observe indicators that could lead to accidents, crashes, and fatalities from various operational sources, as opposed to autonomous functions operating independently of driver or operational actions. In our view, this suggests that using technology as a monitoring process, which still requires a human operator to observe, react, and decide what to do with workplace data, will likely not have an effect on the overall safety culture or attitudes of humans who do not engage or interact with the technology. Examples include oil pressure or tire pressure readings or other indicators that signal the driver. In those cases, the driver/operator will need to make a decision and operate the vehicle. If, on the other hand, the technology operates without the operator's participation, then it is likely that this reduced engagement will lead to a reduction in the safety culture, thus an overall lack of contribution to the safety culture. The resulting consequence is that safety is no longer one's own responsibility, rather it is the responsibility of the technology and others, or outside of any one person's control.

Autonomous vehicles and driverless trucks will not be implemented all at once; there will be a gradual easing into the use of technology. Over the next 10 years, the industry will expand, major manufacturers will continue to expand their offerings, and major freight carriers will gradually begin to adopt the technology. Eventually, a fully functioning system will necessitate that all vehicles are interconnected and communicating electronically so as to ensure the optimal functioning of the system. Regulations that establish the rules and limits of operating requirements will also begin to emerge. The workforce, labor organizations, and educators will need to stay one step ahead to ensure that those whose livelihoods are tied to the industry are sufficiently engaged and prepared to take advantage of the needed skills and competencies required to direct, implement, operate, and maintain the emerging technologies. The impact of AV technology on workplace safety and safety culture will continue to depend on management's commitment to ensure that people are engaged in the work, work processes. . Maintaining awareness and vigilance when interacting with technology will be necessary to contribute to a positive safety culture (Figure 37).

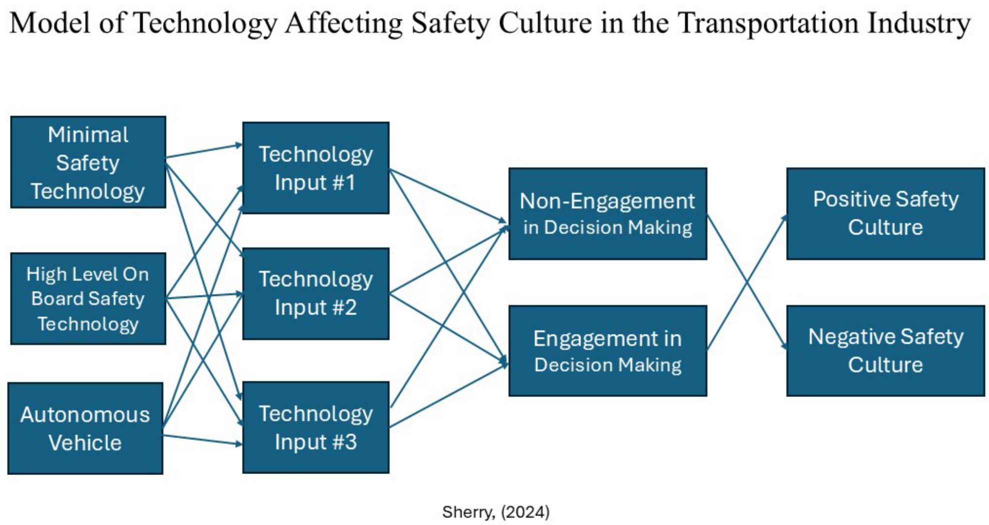


**Figure 37. Hypothetical model of AV effects on safety culture**

Consequently, the use of AVs, OBT, and other independent processes could lead to a decrease in human operator vigilance, attentiveness, and engagement in the overall process of safety.

Data from the present study did not reveal a strong relationship between a perceived relationship of technology and safety attitudes indicative of safety culture at this time. No significant correlations were obtained, suggesting little or no relationship between the perception of technology's impact or contribution to the related perceived indicators of culture. No relationship, however, does not mean nothing is happening and that there has been no impact. Perhaps the measures we employed are not sensitive to the possible changes that may take place in the culture. While most responses in the current study believed that the introduction of autonomous and other safety monitoring technology may contribute to the overall safety of the operation, a relationship to the culture was not detected.

Clearly, the introduction of autonomous and other forms of technology into the workplace have an impact on the culture and the workforce. As previously noted, the morale and indeed the livelihoods of organization members were found to be significantly affected by technological changes. As a result, several suggestions for managers to consider when introducing technology into the workforce were identified. The main theme of these suggestions is to involve the workforce in decision making regarding the timing and introduction of the technology and ultimately to offer training and alternatives to offset the displacement of human workers by the technology.

In summary, these observations and speculations can be presented as a hypothetical Model of Technology Affecting Safety Culture in the Transportation Industry (Figure 34), which could be studied further and subject to empirical validation. The present study's findings suggest that most respondents consider the introduction of AVs and other technologies will likely have a positive benefit on the actual safety of the workplace. AV and other technologies were also thought to have a generally positive impact on the economic viability of the organizations. However, some perceptions suggest that the threat to employment and the eventual displacement of human workers was also a possibility and needed to be addressed and considered. Suggestions for addressing the impact of AVs and OBT on the workplace safety culture were offered. Ultimately, preparations, including engaging and training the workforce to anticipate the impact of technology while preventing worker displacement and worker replacement, are in order.

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