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The Effects of Truck Platooning on the Kansas Workforce

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16 Abstract

The objective of this project was to evaluate the expected impacts of truck automation and platooning on the Kansas workforce and formulate strategies to mitigate potential negative effects. The study was comprised of two phases: (1) a systematic literature review and (2) the compilation of insights from industry, workforce, and policymakers to create opportunities for platooning and automation. The literature review encompassed prior research, news articles, and reports to identify stakeholder concerns and potential solutions. The review also identified six potential scenarios of platooning based on previous literature. Based on these findings, a structured survey was developed for each stakeholder group, totaling 217 participants, with 89 professionals from the logistics industry, including managers and owners, and 128 workforce/drivers in long-haul and short-haul operations. The survey data analysis revealed potential impacts of platooning and automation, concerns of industry and workforce participants, and preferences of platooning scenarios. Additionally, the survey unveiled perceived solutions and anticipated responsibilities of stakeholders. Survey responses were further deliberated with six key officials from the freight advisory and automated vehicles-related committees within the Kansas Department of Transportation during a focus group discussion. Results showed the least workforce resistance for the first platooning scenario (i.e., human-human platooning with drivers in all leading and trailing vehicles), as well as stakeholder readiness to adopt this scenario for infrastructure, technology, and safety applications. The study also indicated a positive attitude towards future scenarios of automation-integrated platooning, while emphasizing the significant role of stakeholder collaborations to address challenges.

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PREFACE

The Kansas Department of Transportation's (KDOT) Kansas Transportation Research and New-Developments (K-TRAN) Research Program funded this research project. It is an ongoing, cooperative, and comprehensive research program addressing transportation needs of the state of Kansas utilizing academic and research resources from KDOT, Kansas State University and the University of Kansas. Transportation professionals in KDOT and the universities jointly develop the projects included in the research program.

NOTICE

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Abstract

The objective of this project was to evaluate the expected impacts of truck automation and platooning on the Kansas workforce and formulate strategies to mitigate potential negative effects. The study was comprised of two phases: (1) a systematic literature review and (2) the compilation of insights from industry, workforce, and policymakers to create opportunities for platooning and automation. The literature review encompassed prior research, news articles, and reports to identify stakeholder concerns and potential solutions. The review also identified six potential scenarios of platooning based on previous literature. Based on these findings, a structured survey was developed for each stakeholder group, totaling 217 participants, with 89 professionals from the logistics industry, including managers and owners, and 128 workforce/drivers in long-haul and short-haul operations. The survey data analysis revealed potential impacts of platooning and automation, concerns of industry and workforce participants, and preferences of platooning scenarios. Additionally, the survey unveiled perceived solutions and anticipated responsibilities of stakeholders. Survey responses were further deliberated with six key officials from the freight advisory and automated vehicles-related committees within the Kansas Department of Transportation during a focus group discussion. Results showed the least workforce resistance for the first platooning scenario (i.e., human-human platooning with drivers in all leading and trailing vehicles), as well as stakeholder readiness to adopt this scenario for infrastructure, technology, and safety applications. The study also indicated a positive attitude towards future scenarios of automation-integrated platooning, while emphasizing the significant role of stakeholder collaborations to address challenges.

Acknowledgments

The authors of this report thank the KDOT project monitor, Mitch Sothers, for his guidance and suggestions. The authors would also like to acknowledge the contribution of key officials from the KDOT freight advisory committee and research officials. The authors have used the large language model ChatGPT only to improvise grammar and vocabulary. However, the content strictly represents the opinions of authors derived from the conducted research.

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Chapter 1: Introduction

1.1 Background

The concept of automated freight transit began with platooning, which refers to one leading truck with a driver that controls two or three driverless, wirelessly connected trucks that follow at closely spaced gaps. The German national project KONVOI (2009) was the first to report driver resistance to platooning (Deutschle et al., 2010), but the drivers had not personally experienced the system. SARTRE (Safe Road Trains for the Environment) was the first European project (2010–2012) to demonstrate truck platooning on public roads (Robinson et al., 2010).

Road freight is a significant contributor to the U.S. economy, and almost 70% of freight in the United States depends on the trucking industry (Collingwood, 2018). However, the severe shortage of professional truck drivers and rising fuel costs are major challenges to freight management. The increased utilization of automated vehicles (AVs) has the potential for social and economic benefits totaling nearly $800 billion annually by 2050 (Bin-Nun et al., 2018). For example, the Society of Automotive Engineers (SAE) current level-2 truck platooning decreases driver workload by applying an automated system in which the truck with a driver automatically follows a leading truck, thereby reducing driver stress, enhancing safety, and potentially attracting more drivers to the profession. Automated platooning with reduced gap and accurate speed management also reduces congestion and produces a fuel savings of at least 20% (Bin-Nun et al., 2018).

Although these benefits make truck platooning an attractive solution to stakeholders and industries, Groshen et al. (2018) reported that rapid deployment of automation could displace 1.8 million trucking jobs by 2050. Viscelli (2018) suggested six potential scenarios for adopting automated trucks (ATs), with the most likely scenario replacing approximately 294,000 long-haul truck drivers. Modern technology often displaces current jobs and required skills over time, but the potential for the high displacement of professionals in the freight industry remains a significant societal concern. Moreover, the increased penetration of technology (or information technology industry) into freight vehicles and operations, which displaces the mechanical industry, is a potential concern to industry stakeholders (Sindi & Woodman, 2021). Previously, the launch of projects on adoption of AVs faced public resistance due to lack of awareness about the technology.

For example, the CityMobil2 project in Italy faced driver protests in Spain and adverse media campaigns that stirred social media discussions on the subject (Alessandrini et al., 2015). Therefore, increased understanding of how automation in the freight industry can affect various stakeholders, such as drivers, mechanics, managers, owners, and policymakers, is essential.

Non-scientific media articles have reported millions of job losses in the trucking industry, but their conclusions fail to consider the resulting economic growth and consequent increase in jobs (Balakrishnan, 2017; Rushe, 2017). Such impacts may be tied to very high levels of automation (e.g., SAE level-4 or above) or driverless trucks in the platoon, but the impacts are not attributed to partially automated and teleoperated trucks that remotely operate ATs or supervise self-driving trucks with no human driver on-site (Groshen et al., 2018; Bin-Nun et al., 2018). Self-driving trucks and e-commerce growth together are likely to create more jobs over time than the number of jobs that are anticipated to be lost to automation. However, the automation level, the automation adoption pace, and the geographical locations may also influence different stakeholders. These stakeholders can be identified as the workforce, logistic industry owners/consumers and policymakers. Without policy intervention, these new or displaced jobs may offer low wages and poor working conditions for drivers and no promising benefits for logistics industry stakeholders (Viscelli, 2018).

1.2 Objectives

The objectives of this research were to assess the expected impacts of truck automation and platooning on the Kansas workforce and formulate strategies to mitigate potential negative effects. This study was comprised of two phases: (1) a systematic literature review and (2) the compilation of insights from industry, workforce, and policymakers to understand and address workforce concerns.

Chapter 2: Systematic Literature Review

The literature review in this study was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page et al., 2021). The literature search was conducted using Google Scholar (including published articles through ResearchGate), PubMed, Elsevier, Taylor and Francis, SagePub, and the Transportation Research Information Database (TRID) to retrieve published articles on workforce concerns related to truck platooning. Additional project reports were extracted from Google, the Bureau of Labor statistics, and the U.S. Department of Transportation (DOT) websites. Key search terms were "truck platooning," "driver," "workforce," "driving jobs," and "employment," as well as domain-specific words such as "acceptance," "job market," "automated vehicles," "self-driving vehicles," and "platooning" to restrict the search results to the domain of trucks and vehicle automation. Because the first project to demonstrate platooning on public roads began in 2010, the current search was limited to records published between 2010 and 2023.

The following criteria were used to filter the literature for inclusion in this review:

- Studies should explore workforce-related concerns regarding the adoption of truck platooning. Studies examining driver behavior in platoons or responses to truck platooning, truck platooning performances, or the development and investigation of in-vehicle human-machine interfaces (HMIs) were excluded from the initial screening of literature.
- Studies focusing on platooning algorithms related to technical improvements in truck platooning, such as safety, vehicle-to-vehicle communications, gas emissions, fuel efficiency, sustainable transport, and planning were excluded during the primary literature search.
- Only published records, reports from authentic national/international or state level organizations, and peer-reviewed articles (journal articles, conference proceedings, etc.) with full text were retrieved from various databases. Only studies/records available in English were retrieved.

- Studies reporting impacts of truck platooning on employment or driving jobs, societal concerns, workforce acceptance of truck platooning, and user concerns regarding automation and platooning were included in the final set of reviewed studies.
- Studies with subsets regarding workforce concerns were also included in the review.

2.1 Literature Search Results

This study identified a total of 1,215 records from various search engines. The primary screening for keywords and titles resulted in 215 documents, including 24 reports from authentic national or state government agencies. After filtering the records using the described criteria, 58 records were retained and 11 additional records were identified from cross references. These 69 records were checked for duplicates and assessed to match the eligibility criteria via full text. Eventually, 17 studies (nine research articles, seven government reports, and one research brief) fulfilled the eligibility criteria (Table 2.1), and another 10 studies (including reports) had sub-sections related to the workforce or other stakeholders. Overall, 27 studies were included in the final review process in this study. In addition to these studies, existing laws related to platooning in the United States were also reviewed. The entire review process is summarized in Figure 2.1.

2.2 Study Methodology

The studies were reviewed for their aim or target stakeholders and methodology to explore concerns related to platooning and AT adoption. Only six research articles, based in Germany, the United States, and the United Kingdom (U.K.), were based on either expert interviews, surveys, or focus group discussions. The review of studies identified the stakeholders as policymakers including state and federal DOTs, truck operators and fleet owners in logistic industries. Most studies were conducted by state DOTs in collaboration with local educational or research institutions.

2.2.1 Study Methods

Eight studies were based on focus group interviews or semi-structured interviews with drivers; only two articles from one study included first-hand field exposure of drivers to automation (Castritius et al., 2020b), and three studies conducted interviews with experts from the logistics industry, government, labor economists, academia, and research. Six studies included truck operators, while seven studies obtained opinions from managers and logistics industry leaders. Consequently, the studies differed due to participants' prior knowledge and experience of automation or truck platooning. Iyer et al. (2019) surveyed four company stakeholders in Indiana and reported that the companies expected high investments in road technology, training programs, and infrastructure by the Indiana DOT (INDOT). However, none of the studies included relevant interviews with state DOTs on the opinions towards platooning and integration of automation in the trucking industry. Based on the feedback from company stakeholders, Iyer et al. (2019) determined that other departments, such as technology companies, the investment community, and the legislature, will be impacted more by automation in the trucking industry than the workforce.

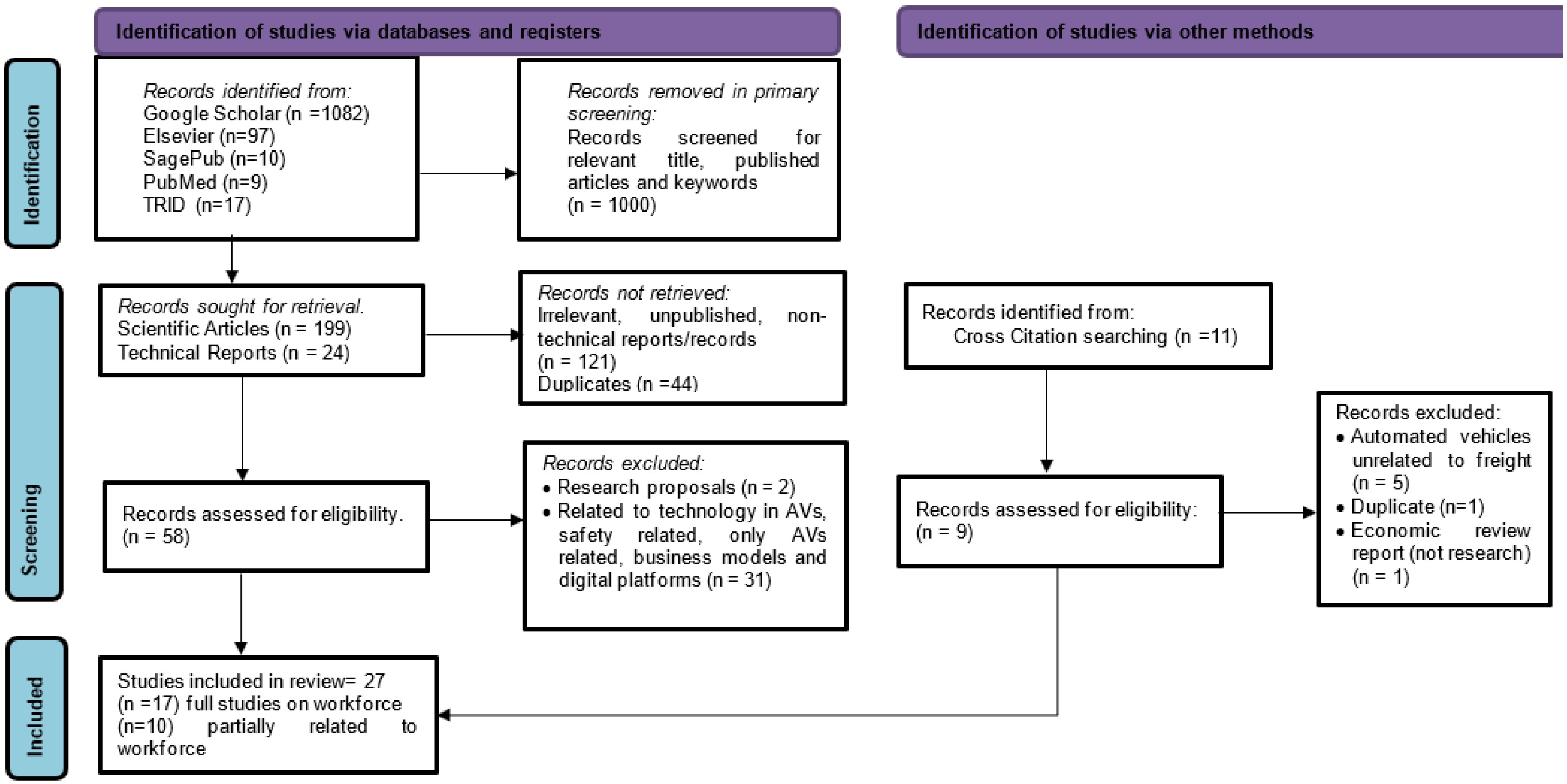


Figure 2.1: Identification and Selection Process Adopted for the Review per PRISMA (2020) Guidelines
Source: Page et al. (2021)

2.2.2 Characteristics of Reviewed Studies

As summarized in Table 2.1, seven studies utilized interviews with trucking professionals from various positions/roles, including academics, researchers, policymakers, and economists. The sample size varied from a minimum of four to a maximum of 76 respondents. However, only one study revealed demographics-related information of the participants. Castritius et al. (2020b) conducted focused discussions with 23 drivers aged 23–56 years and provided six months training of semi-automated truck platooning with L-1 and L-2 automation to 10 participants aged 32–54 years to collect post-platooning opinions from the drivers. In another study that used an online survey, Castritius et al. (2020a) compared the level of driver acceptance of platooning and factors affecting acceptance among drivers in California and Germany. In general, most studies utilized open-ended semi-structured interviews to obtain the opinions of selected participants (Table 2.1), except one study that included a set of Likert scales and a multiple-choice questionnaire survey with four logistics company stakeholders (Iyer et al., 2019). The targeted sample was higher than the actual sample size, but the response rate from the companies or market stakeholders was much lower. For example, Iyer et al. (2019) received responses from only four out of 50 companies approached for the survey questionnaire. Due to such a low sample size, their findings could not be generalized without further investigation.

Table 2.1: Study Records that Met Eligibility Criteria in the Review

Author, Year	Record type	Concern	Country/ Region	Method	Participants
Müller & Voigtländer, 2019	Conf Proc.	Adoption of platooning	Germany	Interviews	Logistic companies
Castritius et al., 2020b	Journal	Acceptance/concerns of platooning	Germany	Field and interviews	Drivers
Mohan & Vaishnav, 2022	Journal	Driver work hours	US	Interviews	Industry, drivers
Sindi & Woodman, 2021	Journal	Barriers & impacts	UK	Skype/Zoom interviews	Operators, industry
Marzano et al., 2022	Journal	Economic analysis	Italy	Research	-NA-
Collingwood, 2018	Journal	Policy	UK	Review	-NA-
Wang et al., 2023	Journal	Job alternatives	Michigan/US	Research	-NA-
Schulke & Nguyen, 2023	Report/Working Paper	Driver perceptions	Germany/EU	Survey	Drivers
Dougherty et al., 2017	Conf Proc.	Consumer perceptions	Georgia/US	Interviews	Industry, drivers
Groshen et al., 2018; Bin-Nun et al., 2018	Report	Policy	US	Expert interviews	Industry, government, academia, and research institutions
O'Brien et al., 2020	Report/White Paper	Policy	California (US)	Expert interviews	Industry leaders, renown labor economists, TRB 2020 - academic and industry stakeholders
Yankelevich et al., 2018	Report	Preparing workforce	Texas, California, & Michigan (US)	Expert interviews and focus groups	Industry and leaders
Iyer et al., 2019	Report	Policy	Indiana (US)	Questionnaire survey	Market stakeholders
Hendrickson et al., 2014	Report	Policy & workforce training	Pennsylvania (US)	Review	-NA-
Viscelli, 2018	Report	Policy	California (US)	Review	-NA-
Leonard et al., 2020	Research brief	Policy	US	Review	-NA-
*Castritius et al., 2020a	Journal	Acceptance of platooning	Germany and California	Online survey	Drivers
*Sohrabi et al., 2020	Review	Health impacts	US	Review	-NA-

Note: -NA- Participants not applicable for review studies; * Partially related to workforce concerns

2.3 Driver Shortage and Automation

The need for automation is prompted by a shortage of commercial drivers, targeted labor cost reduction, increased profit margins, automated warehouses, and increased efficiency for low-cost planning and operations (Müller & Voigtländer, 2019; Sindi & Woodman, 2021). The American Trucking Associations (ATA) predicts that nearly 1.1 million new truck drivers will be needed in the United States by 2030, with more than half (54%) of this need based on a retiring (aging) population of drivers and rapid industry growth of 25%, resulting in a need for more than 270,000 drivers. Truck driving jobs are currently classified as long-haul, high-wage jobs or local, low-wage delivery drivers (Viscelli, 2018; Yankelevich et al., 2018). Unsurprisingly, low wages for a stressful job make truck driving an unattractive option for young professionals. Long-haul drivers are generally more experienced and, therefore, older than the average U.S. worker, but a lack of motivation from trucking supervisors/managers and the inability of the aging workforce to keep up with the technological changes also contribute to skill gaps and driver shortages (Groshen et al., 2018; Yankelevich et al., 2018). Therefore, wages must increase or a new supply of drivers is required to meet driver demand (O'Brien et al., 2020; Viscelli, 2018).

Automation could create safer and more enjoyable jobs for the workforce (Müller & Voigtländer, 2019), and technology-based driving may attract younger workers (Wang et al., 2023). In addition, automation is likely to reduce insurance costs by 60%–80% by 2050 (Marzano et al., 2022) and driving hours (Dougherty et al., 2017). Stakeholders acknowledge that benefits such as decreased costs, more efficient trips, operability in all weather conditions, reduced regulations (e.g., levying tax, waiving liability, etc.), and enhanced safety are favorable for the adoption of automation (Mohan & Vaishnav, 2022; Schulke & Nguyen, 2023; Sindi & Woodman, 2021).

2.4 Automation Scenarios and Jobs

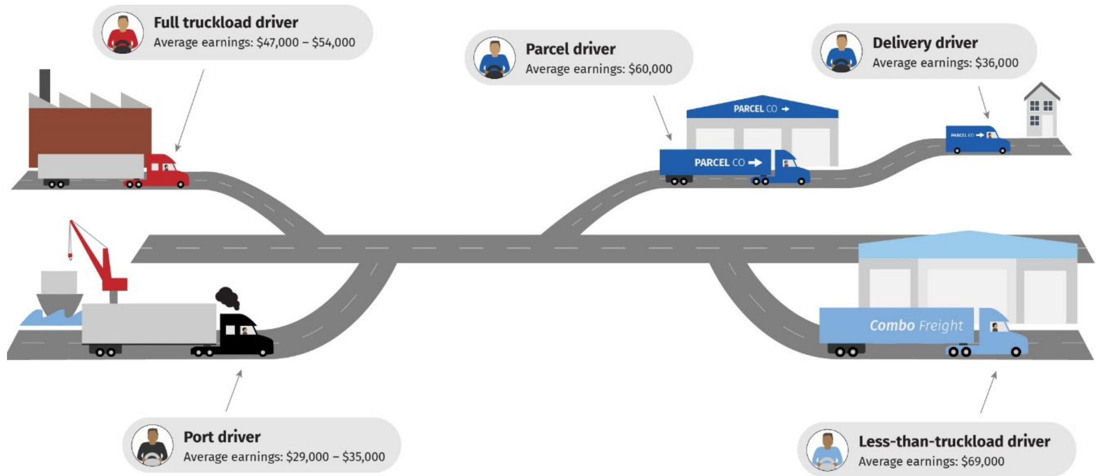
Müller and Voigtländer (2019) explored various cases of automation for freight transport operations to increase productivity, such as transport between depots and warehouses, transport locations outside city limits, transport suitable for automated warehouses, and warehouses on wheels. Platooning with human presence on site was shown to increase security, but completely driverless trucks (SAE L-4 and higher) have advantageous route planning and cost optimization with no limited operation periods due to rest restriction. Similarly, Viscelli (2018) suggested six potential scenarios of automation adoption for trucks with clear separation between human and automation roles (Table 2.2). Figures 2.2(a) and (b) show the transformation of the current configuration of truck driving jobs to automated highway driving, respectively.

Table 2.2: Potential Scenarios of Automation Adoption for Trucks

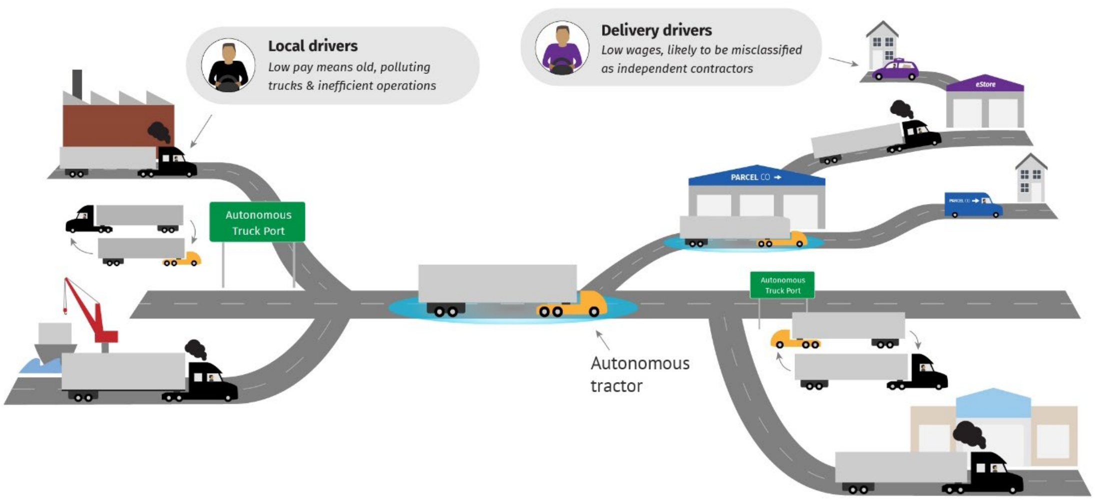
	Scenario	Description	Driver role	Automation role	Remarks
1	Human-human platooning (HHP)	Series of human-driven trucks	Lane maintenance Navigate local streets	Speed, gap and braking of trucks	No labor cuts
2	Human-drone platooning (HDP)*	Human-led series of automated trucks	Operation of lead truck Maintenance of platoon	Following human lead	Most feasible & labor cuts
3	Highway automation + drone operation	Remote human controls	Remote monitoring Remote local driving	Highways/ freeways driving	Labor cuts & outsourcing
4	Autopilot	On-site conditional human controls	Loading/unloading Local driving	Highways/ freeways driving	No labor cuts
5	Highway exit-to-exit (E2E) automation**	Swapping trailers between human and fully automated	Non-driving tasks Local driving	Highways/ freeways driving	Most economical
6	Facility-to-facility automation	Self-driving origin to destination on industrial roads	--	Fully automated	

*One legalized scenario in various U.S. states
**Most preferred scenario per the literature

Scenarios 1 and 2 are currently widely adopted with varying levels of automation and driver roles in Germany, the U.K., and various U.S. states. As described in Table 2.2, scenario 1 involves a human driver in each truck in the platoon, and automation controls speed and gaps while following the lead truck. Although scenario 1 does not reduce labor costs, it effectively decreases fuel costs due to platooning. Of all the scenarios, scenario 2 is the most feasible option because it offers the least technological challenges and highest savings in driver wages to justify the adoption of truck platooning (Marzano et al., 2022; Viscelli, 2018). However, scenario 2 depends on vehicle-to-infrastructure (V2I) communications and can only be implemented in selected routes/smart roads (Leonard et al., 2020; Marzano et al., 2022). Castritius et al. (2020b) reported no preference in either leading or following the drone trucks among drivers, but the drivers expected a minimum 25% increase in salary for the additional non-driving tasks and added responsibility of managing the platoon. As described in the table, scenario 3 involves hiring remote drivers to help ATs navigate dense urban areas and difficult work zones or remotely monitor multiple trucks simultaneously. These remote trucking jobs would improve the quality of life for truckers since drivers are responsible for multiple truck operations simultaneously providing more opportunities of earning higher wages without staying away from home for long periods for their jobs (Groshen et al., 2018; Bin-Nun et al., 2018). As an advantage for industry stakeholders, remote operators can significantly reduce labor costs and increase opportunities for international outsourcing (Goodall, 2020). However, the opinions of stakeholders regarding teleoperated trucks are not thoroughly explored in previous studies.



(a)



(b)

Figure 2.2: Change in Scenarios of Truck Driving Jobs: (a) Current Configuration, (b) Transformation of Human Truck Driving Jobs to Automated Trucks (Scenario 5)
Source: Viscelli (2018)

Scenario 5 is the most likely adoption scenario because it utilizes human drivers only near local neighborhoods and for non-driving tasks such as consumer deliveries and social interactions (Mohan & Vaishnav, 2022; Müller & Voigtländer, 2019; Viscelli, 2018). Currently, local delivery drivers, including port drivers and express deliveries, are employed by large scale logistic companies and classified as independent contractors who use their own vehicles. Such contractors require a large investment for owning a vehicle for logistic operations but earn low wages and have long working hours (including loading/unloading delays) (Viscelli, 2018). Without an adequate policy, this scenario is likely to replace high-paying long-haul highway driving jobs, including contractors between factories, for autonomous truck ports (ATPs) (Viscelli, 2018). However, the creation of truck ports will create new jobs, such as shifting trailers between human and automation, service providers for human operators, and maintenance and safety of AT equipment and sensors (Mohan & Vaishnav, 2022).

Both scenario 4 and scenario 6, which have no human role, require more research prior to deployment. Therefore, the gradual adoption of technology will allow time to retrain and prepare the workforce to adopt advanced platooning technologies.

2.4.1 Estimated Job Loss

Among the 47% of the total U.S. transportation and logistics occupations that could be replaced by automation, drivers and administrative support jobs are at the highest risk for replacement. Groshen et al. (2018) estimated a 60%–65% job loss rate for heavy truck and tractor-trailer driving jobs, while Gittleman and Monaco (2019) estimated a potential loss of 400,000 jobs based on the Vehicle Inventory and Use Survey (VIUS) of 2002 and Bureau of Transportation Statistics (BTS) data by the U.S. Department of Transportation. Viscelli (2018) estimated a loss of nearly 300,000 driving jobs due to high turnover and low wages. Waschik et al. (2021) estimated that nearly 550,000 long-haul driving jobs will be impacted by automation, and Mohan and Vaishnav (2022) predicted that 30,000 to more than 500,000 jobs will be impacted. However, the loss of driving jobs due to complex AVs may be gradual, including jobs such as driving, vehicle maintenance staff, employees at driving schools, insurance appraisers, postal service mail carriers, traffic surveillance staff, and even emergency room staff (Adler et al., 2019; Sohrabi et al., 2020). Automation may also eliminate the need for truck stops (scenario 5 in Table 2.2), thereby impacting 70,000 truck stop-based jobs (Mohan & Vaishnav, 2022). Geography/location may also affect the availability of employment alternatives and truck drivers' willingness to relocate for employment (Viscelli, 2018; Wang et al., 2023). The new technical jobs may prevail near Silicon Valley and other tech industry locations. For example, the platooning scenario 5 deploying ATs on highways will limit the driving jobs within city neighborhoods, the older drivers settled around rural areas may be reluctant to shift to urban areas for such low paying short haul jobs or for new technical non-driving jobs requiring retraining/upskilling (Viscelli, 2018). Prevailing low education and poor tech proficiency among drivers can also contribute to unemployment due to inability to adapt to the technological advancements and upskilling required for new jobs (Frey & Osborne, 2017; Wang et al., 2023). However, these job loss estimates are based on automation replacing the aggregate count of existing or projected workforce without considering the potential increase or displacement of jobs corresponding to automation scenarios and pace of adoption.

2.4.2 Alternative Occupations and Challenges

Although ATs are likely to replace jobs in the trucking industry, they are also expected to increase the logistics efficiency and demand for transportation and goods services, thereby creating new jobs (Groshen et al., 2018; Bin-Nun et al., 2018). Moreover, automation is likely to cause job displacement, not replacement, by shifting the roles or skills of the existing workforce in accordance with the adopted automation scenario (Table 2.2). For example, a remote operator may require additional computer technology skills to supervise multiple truck operations remotely, maintenance workers may require additional software handling skills, and on-site drivers may require additional administrative skills for customer service or port transitions (Yankelevich et al., 2018). These scenarios may require upgraded skills that potentially result in higher wages, thereby attracting more professionals to the workforce.

A report by Manyika et al. (2017) disaggregated occupations into 18 performance capabilities, including sensory perception and cognitive, social, emotional, or physical capabilities. Results showed that technical automation for each capability could replace 2,000 work activities and 800 occupations in the United States. In other studies, Wang et al. (2023) and Yankelevich et al. (2018) used the Occupational Employment and Wages Statistics (OEWS) 2020 data provided by the U.S. Bureau of Labor Statistics (BLS) to assess potential alternative occupations for truck drivers based on similarities in skills, knowledge, and required abilities. Results showed insufficient job alternatives if/when more than 50% of jobs are displaced by truck automation. Moreover, interviews with technology providers revealed that the existing skills and education of truck drivers may be insufficient for new jobs. With the penetration of technology providers into vehicle manufacturing and operations, the new jobs are highly likely to be created in the technology industry like Silicon Valley. A concerning finding of Wang et al. (2023) suggested that deindustrialized regions throughout mid-America, which host a large population of truckers may experience more automation-related job losses than regions near Silicon Valley where new jobs are likely to be concentrated due to the growth of technology hubs.

2.5 Pace of Automation Deployment

Without adequate policies, automation may cause short-term unemployment, but the delay of automation implementation may negatively impact the economy and road safety (Groshen et al., 2018; Bin-Nun et al., 2018). Reports based on interviews with industry experts, government policymakers, academics, and researchers have suggested three possible strategies or adoption paces, including rapid promotion of AV deployment or deliberate delay of AV deployment. However, according to the experts a prudent choice will be the rapid deployment of AVs, with the resulting financial benefits invested in workforce development jobs (Groshen et al., 2018; Bin-Nun et al., 2018). In addition, potential impacts to economic growth and subsequent changes in human roles and skills in the new job market should be noted via research and constant industry feedback during AV deployment, leading to the identification of new and alternative jobs for drivers, the likely duration of unemployment during the transition, wage changes, and actual productivity benefits derived from reduced driving time. Consequently, automation must be adopted in phases with gradual displacement of human roles, such as beginning with platooning. Although initial exposure to truck platooning may trigger stronger resistance to automation compared to individual self-driving trucks, increased exposure to automated systems can positively affect the workforce as they gradually ease into the idea of learning and practicing the new required skills (Dougherty et al., 2017). For example, Azienda Regionale Sarda Transporti (ARST), a regional transport company in Sardinia, reported that its personnel adapted to the Automated Road Transport Systems (ARTS) with only two weeks of training (Alessandrini et al., 2015).

2.6 Impact on Stakeholders

Previous studies have highlighted various concerns of drivers, fleet owners and freight companies, and policymakers related to AV adoption scenarios and the pace of automation adoption in trucking (Figure 2.3).

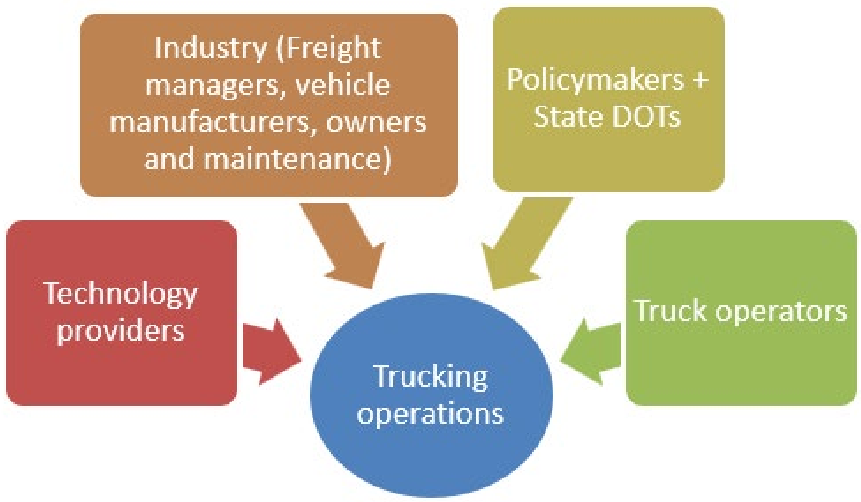


Figure 2.3: Trucking Industry Stakeholders Directly Influenced by Automation

The following subsections highlight concerns based on research and interviews in previous studies.

2.6.1 Concerns of Drivers

1. *Employment concerns:* Castritius et al. (2020b) reported that after platooning L-1 and L-2 ATs, drivers expected a minimum 25% pay raise due to their new roles as essential client contacts, dispatchers, and unloading personnel. Three potential scenarios were described: (1) platoon comprised of human-supervised trucks from multiple manufacturers, (2) highly automated driving (HAD) of L-4 or higher in which drivers in the trailing trucks can engage in other tasks and no supervision is required, or (3) human-driven lead truck with fully automated truck following. Only one of 10 drivers perceived automation as a threat to their job, whereas other drivers expected automation to reduce their workload. Despite acknowledging the benefits of automation, the discussions with truck drivers in some studies focused on negative impacts, such as concerns about layoffs, reduced union leverage, and the

need to have more consistent income stream (Dougherty et al., 2017; New America, 2017; Schulke & Nguyen, 2023). Other studies emphasized that automation may result in drivers taking over administrative jobs, including customer service and planning delivery schedules (Klumpp, 2018; Leonard et al., 2020; Yankelevich et al., 2018). The shift in driver roles would require upskilling and provide opportunities for higher wages (Leonard et al., 2020), but older drivers may be unwilling to relocate and retrain.

2. *Health concerns:* Automation is likely to remove long-haul driving's dormant periods that allow driver rest, thereby increasing trucking efficiency and demand. However, the consequent increase in demand may extend operators' working hours (Mohan & Vaishnav, 2022; Viscelli, 2018). Sohrabi et al. (2020) also identified that deployment of AVs will require constant connectivity and smart infrastructure, resulting in increased exposure to electromagnetic fields and a potential health risk. Sindi and Woodman (2021) found that AT design increases the space for the human operator to maneuver freely and relax or take naps in the truck during long journeys when automation is engaged.
3. *Added stress:* Leading a drone platoon may increase driver stress and responsibilities because they must safely monitor the vehicles and load in the platoon without knowing when they may be required to drive, rest, or complete other tasks in the ATs, manage challenges of sharing the road with conventional vehicles, handle customs clearance and container exchange, and provide loading-unloading or customer service (Castritius et al., 2020b; Klumpp, 2018; Leonard et al., 2020; Müller & Voigtländer, 2019; Sindi & Woodman, 2021). After experiencing platooning, the drivers did not express any interest towards additional non-driving tasks (Castritius et al., 2020b).
4. *Safety and reliability of automation*: Drivers expressed concerns about safety and reliability during critical situations, such as when operation must occur in inclement weather, when GPS is lost, or in locations without lane markings (Castritius et al., 2020b; Mohan & Vaishnav, 2022; Sindi & Woodman, 2021). In another study,

driver acceptance of platooning in California was higher than in Germany and was associated with ease of sharing the highway with other vehicles (Castritius et al., 2020a). Drivers expressed negative attitudes about adopting partial automation because it disengages and distracts the driver from the driving activity and environment (Sindi & Woodman, 2021).

5. *Occupational image or gender role:* Drivers expressed concern that the truck driving profession could be perceived as a tech-savvy profession only if automation or platooning can improve safety, improve fleet management operations, and reduce traffic congestion, consequently improving driving behavior and reducing stress while driving (Castritius et al., 2020b), thereby attracting young professionals. Collingwood's (2018) review found that driverless technology may negate the masculine perception of truck driving while decreasing gender bias in the trucking industry, making the truck driving profession increasingly open to women.
6. *Increased low-wage jobs:* Scenario 5 in Table 2.2 replaces long-haul jobs with short-haul jobs, but the scenario results in extended working hours. Short-haul jobs in urban areas may require 40% of long-haul drivers from rural areas to relocate to urban areas (Mohan & Vaishnav, 2022). Young drivers may want to relocate to urban areas, but elderly drivers may retire prematurely if they are unwilling to relocate and update their skills to new jobs.

2.6.2 Concerns of Policymakers

Legal, financial, or policy-related conditions required to deploy ATs revealed the following concerns:

1. *Road regulations for ATs:* Results from a study by Müller & Voigtländer (2019) showed that managers were concerned about lack of clarity regarding customs clearance with driverless ATs, liability for whom and for what actions (e.g., taking over at ramps, accommodating both conventional and ATs in the same infrastructure, etc.) (The Simon Law Firm, P.C., 2022). Another concern was related to untimely and frequent software updates that could interfere with truck operations

or completely disable outdated software. Therefore, adequate policies or guidelines are needed to avoid unreliable AT technology/software, especially for small-scale businesses.

2. *Licensing:* Hendrickson et al. (2014) found that updated licensing policies must include testing criteria for drivers to utilize new vehicle technologies (e.g., deactivate and activate features such as auto park, lane change, etc.) and the licensing criteria must be revisited if the driver has any medical disabilities that inhibit usage of the technologies in commercial or non-commercial vehicles. They also suggested a new class of licensing to distinguish manual or automated driving. HAD scenarios such as teleoperating or remote driving/supervision that do not require a human presence in the vehicle may make the required skill testing to obtain a license obsolete. Moreover, such scenarios may create more driving opportunities for physically challenged individuals. Results showed that simulators can be an effective tool for automation level training.
3. *Safety net programs:* Previous studies have explored safety net programs to support job transition within or outside the industry (a) by including work-sharing initiatives in which stakeholders develop a shared innovation agenda; (b) utilizing public research funding to implement shared innovation such as human-led platooning; and (c) supplemental unemployment insurance during job transitions and flexible retirement packages to accommodate drivers nearing retirement (Groshen et al., 2018; Viscelli, 2018).

Overall, employment policies should provide support for strengthening driver skills, improving labor standards, and creating better jobs with human-led platooning to balance the progress of automation and new jobs in the transportation sector.

2.6.3 Concerns of Fleet Owners and Company Stakeholders

Previous studies in the United States, Germany, and the U.K. have revealed the following concerns of owners or company stakeholders:

1. *Impact of technology:* Although drivers and other stakeholders acknowledge the benefits of technology for increasing safety and driver assistance, there is reluctance to share lanes with ATs and operate fully unmanned trucks (Dougherty et al., 2017; Schulke & Nguyen, 2023; Yankelevich et al., 2018). Stakeholders even expressed a willingness to pay an additional 25%–50% for hybrid driving due to the added complexity of maintaining advanced vehicles (Mohan & Vaishnav, 2022; Müller & Voigtländer, 2019; Sindi & Woodman, 2021). Therefore, safety and technological reliability are the most significant factors for fleet owner investment. Mohan and Vaishnav (2022) reported negative attitudes to partially-ATs because they do not decrease labor costs for stakeholders and can cause distraction and/or inactivity for drivers.
2. *Penetration of technology*: Company stakeholders such as manufacturers and service providers have expressed concern about the market inclination towards producers of computerized technology, which potentially reduces the competition of vehicle manufacturers and service providers in the vehicle manufacturing market, thereby reducing the market competition and increasing overall prices for logistics (Mohan & Vaishnav, 2022; Sindi & Woodman, 2021). Such a situation would also close the market for small companies, whereas large-scale companies could experience a decrease in their market name and value if they are associated with significant job losses (Iyer et al., 2019). Conversely, small-scale companies may be more likely to adopt higher levels of automation because of the significant reduction in anticipated labor costs (Talebian & Mishra, 2022). Additional concerns include frequent software updates that can result in inefficient operation of the trucks and potentially disable them completely (Sindi & Woodman, 2021).
3. *Data sharing for vehicle connectivity:* Because platooning with other companies would require data sharing, reliability and data protection are potential concerns of fleet owners. However, results of a study by Sindi and Woodman (2021) showed that stakeholders believe that data sharing and collaboration may reduce the number of freight vehicles that return empty, thereby optimizing fleet use,

decreasing the environmental impact, and providing potential tax relief. However, the feasibility or time frame for operating ATs with adequate regulations and infrastructure is a concern for investors.

4. Legal and associated challenges: Remote driving as suggested in scenario 3 (Table 2.2) is likely to reduce many driving jobs by nearly 25% since one driver can remotely operate more than one vehicle (Goodall, 2020). Moreover, without adequate policies, these jobs can be outsourced internationally, which would significantly decrease labor costs but eliminate many trucking jobs throughout the United States (Duff et al., 2011).

2.6.4 State and Federal DOT Responsibilities

The application of AV technology means DOTs must provide training programs to upskill the workforce and address user concerns related to sharing lanes with ATs. Previous studies emphasized the need to update workforce training, including on-board diagnostics and hybrid systems (Groshen et al., 2018; Hendrickson et al., 2014; Müller & Voigtländer, 2019; Bin-Nun et al., 2018). In addition, changes in courses related to land use and transit service planning would be required for traffic engineers and planners, and engineers of vehicle hardware, and lawyers/policymakers for handling legal issues must take courses related to human factors and ergonomics since ATs require complex and frequent decision-making processes. Automotive technicians also must have advanced knowledge of electronics, information technology, and computer science, resulting in collaboration with local and state educational institutes, the Institute of Transportation Engineers (ITE), and the US DOT (Hendrickson et al., 2014; Iyer et al., 2019). Finally, training programs for assistive-driving technology must be specific to driver demographics since most drivers who enter the trucking industry are over 30 years old (O'Brien et al., 2020). Previous studies have shown that drivers, at minimum, should understand the level of technology in the vehicle and its limitations to know when to intervene or call for assistance (Dougherty et al., 2017; Schulke & Nguyen, 2023; Yankelevich et al., 2018). However, despite the recognition of state and federal DOT responsibilities to prepare the workforce, none of the previous studies (Table 2.2) included concerns of DOT officials or perceived changes in their role related to the adoption of platooning and ATs.

2.7 Legal Status of Platooning in the US

According to the National Conference of State Legislatures (NCSL) (2023), 30 states in the United States allow ATs and four states allow pilot testing of vehicles without drivers (Goble, 2023). Existing legislature related to truck platooning based on the NCSL database (NCSL, 2023) is shown in Figure 2.4. Hawaii, Colorado, Maine, Vermont, and Washington have passed bills to form task forces to investigate the impacts of ATs on stakeholders and business models, including considering opinions from vehicle manufacturers and vehicle technology companies. California, New Hampshire, New York, and Vermont, allow testing of pilot ATs under the supervision of state police and required insurance, and New Hampshire is also developing a training curriculum for law enforcement and road safety.

Kansas Senate Bill 313 was enacted to establish the AV advisory committee to annually revisit the regulations and provide recommendations based on technological advancements (Kansas Legislative Research Department, 2022). The committee includes legislators, transportation agency officials or their designees, and other appointees of the governor and municipalities. The bill also requires a human driver with an adequate license to be physically present in every driverless-capable vehicle on Kansas roads. Furthermore, according to the bill, the owner must submit a law enforcement action plan to the Kansas Highway Patrol that includes vehicle information in case of emergency or hazardous situations. The bill also requires owners to obtain necessary insurance or other financial security before operating a driverless vehicle on the road.

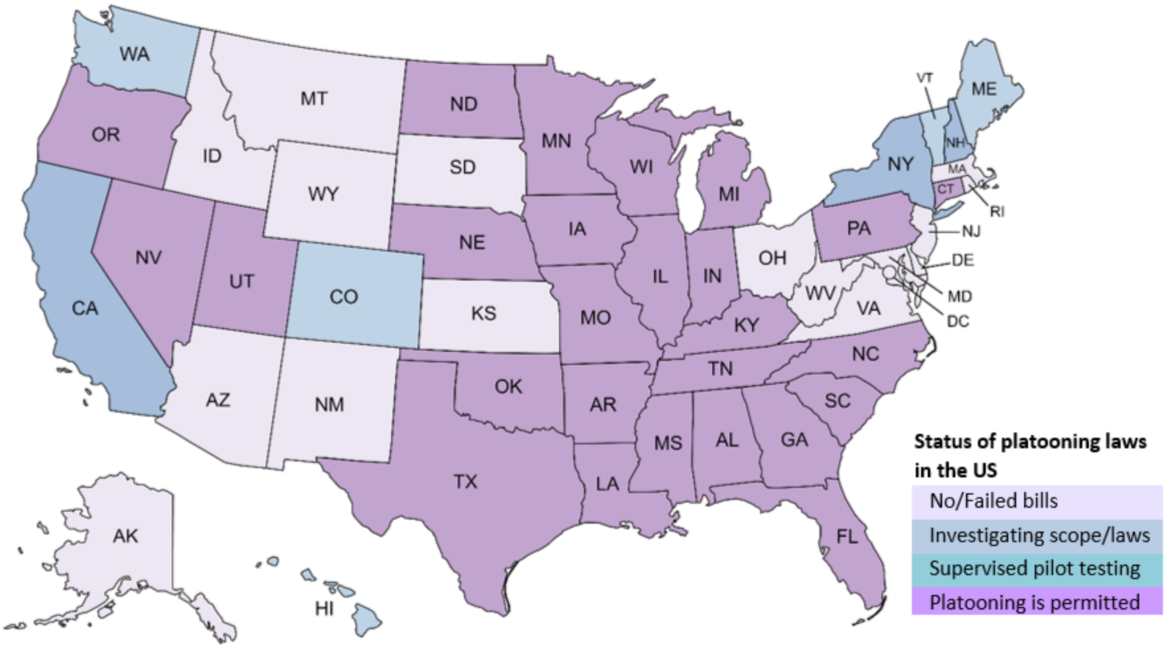


Figure 2.4: Platooning Legislation in the United States
Source: NCSL (2023)

Current U.S. state legislation (Table 2.3) related to platooning prohibits the trailing vehicles in a platoon from following too closely (NCSL, 2023; The Simon Law Firm, P.C., 2019). However, long platoons can inhibit the lane changing and weaving operations of other vehicles. Therefore, Iowa, Utah, Wisconsin, Texas, Oklahoma, Oregon, and Mississippi limit the platoon size to two vehicles, whereas Pennsylvania limits the platoon size to three vehicles.

Table 2.3: Truck Platooning Laws by State

State	Approved Legislation	Proposed/Pending Amendment
Indiana, Georgia	Platooning permitted with human driver (meeting state or federal qualifications) on a highway Exemption from FTC rule	-NA-
Kentucky	Exemption from the 2-seconds FTC rule Only lead vehicle is required to have human driver and trailing vehicle shall be fully engaged	Required insurance/self-insurance proof Requires submission of law enforcement plan
Mississippi	Exemption from 300ft FTC rule in multilane divided highways Platooning limited to two trucks Requires a pre-approved plan	Fully engaged trailing vehicles to be allowed on the state roadways without a human driver
Missouri	Exemption from 300ft rule Platooning is permitted	Allows ATs capable of V2V communication on state roads
Tennessee	Operator behind each truck in the platoon shall hold valid commercial driver's license (CDL)	Operator with valid CDL to be physically required only in the leading platoon truck
Alabama, Nebraska, Nevada	Allows teleoperated vehicles The remote driver is liable for traffic rules violations/crashes and should have a valid commercial motor vehicle (CMV) license AVs come under the sole and exclusive jurisdiction of the DOT	-NA-
Arkansas	Platooning is permitted for trucks equipped with "driver-assistive truck platooning systems" to allow coordinated acceleration and braking between two or more vehicles with driver in lead vehicle	-NA-
Connecticut	Requires physical presence of the driver anywhere in the vehicle Requires driver's insurance of at least $5M	-NA-
California, New Hampshire, New York, New Jersey	Permitted only for test pilot program and requires a report on the performance and safety implications of AV technology for commercial vehicles (specified by their gross vehicle weight)	Drivers required with adequate class of licensing for testing of AVs on public roads Required insurance proof Requires the automated driving system (considered as driver) of the vehicle (without human driver) to be fully engaged even when the automation fails in driving tasks
Florida	Exemption from 300ft FTC rule Permits teleoperated vehicles without human Prohibits additional fee, tax, or other requirements on AVs Invites funding for construction and operation of facilities to support AVs	-NA-
Iowa, Utah, Wisconsin, Texas, Oklahoma, Michigan	Exemption from FTC Limits platoon size to two vehicles Allows remote operation of trailing vehicles Limits operation within state highways	-NA-
Illinois	Platooning not permitted	Autonomous vehicles defined as vehicles capable of performing the entire driving task without any intervention/supervision by human drivers
Louisiana	Allows remote operations Requires valid license for remote driver and insurance of at least $2M Remote driver is liable for traffic rules violations/crashes	-NA-

State	Approved Legislation	Proposed/Pending Amendment
North Carolina, South Carolina	Allows platooning Exemption from the FTC rule	-NA-
Pennsylvania, Minnesota	Three or fewer vehicles in the platoon Permitted only on highways A driver in each vehicle with valid license A pre-approved operational plan at least 30 days prior to travel	-NA-
North Dakota, Oregon, South Dakota	Platooning is permitted, exemption from FTC DOT pre-approved operational plan required	-NA-

-NA-: Not Applicable

Except for the following distance rule, highly ATs in scenarios 5 or 6 (Table 2.2) may also require revised speed limit restrictions, centerline restrictions, and rules about vehicular interactions and use of electronic devices in the vehicle. State or federal DOTs and policymakers are responsible for addressing these concerns. There are additional concerns of the stakeholders that are related to existing platooning policies or laws. The first concern pertains to the permission of restricted platooning in which platooning is permitted only in flat highway corridors with no consideration of the complexity of urban driving with multiple road users, traffic signals, and gradients. For example, Pennsylvania restricts ATs to highways, with a required human driver for supervision or safety in some automation scenarios. In comparison, Kentucky, Mississippi, and Tennessee permit trailing ATs in the platoon to drive without an operator (scenario 2, Table 2.2), while Indiana, Georgia, Arkansas, and Pennsylvania permit platooning but require a human driver with appropriate licensing and qualifications in all ATs (scenario 1, Table 2.2). However, California permits platooning only for pilot testing and research.

The second policy concern is related to communication between vehicles. Adequate policies and research are required to ensure safe identification and communication between ATs and other vehicles, both within the ATs and while sharing the road with ATs. For example, Pennsylvania law requires that each vehicle in a platoon be marked with a visual identifier on the power unit. Connecticut requires driver insurance to exceed $5 million, while Louisiana requires insurance worth $2 million to drive an AT and remote driver liability for violations or penalties. Increased safety could attract drivers and stakeholders, potentially leading to a reframing of insurance regulations for the workforce and owners.

The final concern focuses on revisions to driving hours and licensing rules. With the shift in drivers' roles to AT supervisors or administrators, policies related to working hours and licensing and training of truck operators may require amendments. For example, Pennsylvania, North Dakota, and North Carolina require owners to submit an operational plan that must be approved by the state DOT. Such additional pre-planning and supervisory responsibilities for the drivers may limit the use of ATs to only long-haul operations which are possible only on the highways, and will always require in-vehicle drivers for supervision. Finally, the legal aspects associated with impacts of different platooning scenarios on employment such as programs for workforce retraining, assigning responsibility of retraining and financially supporting the workforce during transition to automation deployment, and restricting or allowing outsourcing of trucking jobs in scenarios involving remote operations, must be explored to safeguard the interests of workforce as well as industry stakeholders.

2.8 Conclusions

Previous studies have shown that driver opinions of automation with no direct experience of automated systems or adequate knowledge of new technologies are influenced by rumors, inhibition to technology, pre-conceived notions, or fear. Moreover, automation is likely to cause a shift in a driver's role from operator to supervisor/manager. Therefore, increased understanding is needed of the composition of tasks in trucking operations and the division of responsibility between automation and humans. In addition to infrastructure adaptation, some push policies may also be required to discourage the use of private or non-automated vehicles. For example, California has proposed that the public transit employer notify the workforce likely to be impacted by AV deployment before commencing the procurement process. This legislation proposal could be extended to the trucking industry.

Automation is typically deployed in phases, with phase 1 requiring a human driver, phase 2 requiring drivers only for subsets of the driving task on the route, and phase 3 requiring no driver for most rides or when following platoons. During the transition to automation, drivers can be trained for administrative roles or upskilled to operate ATs and provide low-level maintenance. New roles, such as AT supervisors and managers of the fleet route and schedules, could be created, and job displacement could be curbed by allowing the existing workforce to update their skills throughout the automation adoption process and offering updated training for the new trucking workforce. Adequate policies can mutually protect the workforce and industry stakeholders without delaying the adoption of automation.

Previous studies included detailed reviews, interviews, and discussions with experts, the workforce, managers, policymakers, and owners. Results of those studies revealed various workforce-related concerns, as summarized in Section 2.6. However, a critical review of the literature also suggests the following additional gaps in the previous research related to identifying various concerns related to the deployment of platooning:

- Previous investigations do not include DOT opinions on infrastructure, training programs, licensing, and other regulations or perceived changes in roles due to automation adoption.
- Safety-related concerns were revealed in previous interviews with drivers and owners, but no studies included consumer or insurance provider opinions on the likely impact on insurance costs and the role of insurance with improved safety.
- The job loss estimates were aggregate numbers without accounting for new automation jobs or jobs specific to the adoption scenarios. Additionally, the estimations of high job losses (1.8 million) by Groshen et al. (2018) and Bin-Nun et al. (2018) were based on overall automation deployment in the taxi and trucking industries.
- Research is required to identify alternative jobs suited for the existing trucking workforce and the required skills for those jobs. Moreover, previous studies also suggest to deeply analyze the potential economic benefits of deploying automation in the logistic industry to investigate if the transition is actually worth the benefits (Groshen et al., 2018; Wang et al., 2023).
- Although truck automation and platooning are permitted in various U.S. states, no clear policies or bills address workforce concerns or protect employee benefits to support the displacement of jobs corresponding to automation scenarios. For example, the truck driver population is primarily comprised of middle-aged or older drivers who are unwilling to relocate or learn new skills for new automation jobs (New America, 2017; Yankelevich et al., 2018). Moreover, the stereotypical attitude of hiring only younger population for new jobs or technical jobs in companies may also pose resistance to hiring older workers without any prior experience in the technical field (Yankelevich et al., 2018). Safety net programs may be required to support older drivers through the transition to automation or the

technology could be tailored to assist these drivers to mitigate driver shortages (Wang et al., 2023).

- Scenario 3 (teleoperations) is proposed as an economical scenario due to the potential to outsource the remote operations to low-wage countries. However, the legal and workforce concerns for stakeholders are yet to be explored.

Because the widespread utilization of ATs may alter the labor market in many aspects, multiple policies may be required to address the diverse range of impacts to stakeholders. Interviews with management revealed that, although AT deployment will address the current driver shortage, it will not reduce the total number of required employees since ATs require humans for supporting roles such as loading and unloading and to resolve any issues en route (Iyer et al., 2019; Sindi & Woodman, 2021; Viscelli, 2018). In addition, potential job displacement is specific to the automation scenario and may require upskilling, potentially resulting in higher paying jobs. Therefore, accurate investigation of concerns should correspond to the automation scenario and pace of adoption to provide sufficient time to allow such displacement of the existing trucking jobs to new jobs that will be created within or outside logistics industry with the deployment of platooning and automation.

Chapter 3: Methodology

This study sought to answer the following research questions using an online structured survey questionnaire for trucking industry stakeholders to understand concerns of the workforce (fleet operators, supervisors, etc.) and logistics industry owners and consumers.

- What are the potential impacts foreseen or expected by different stakeholders because of truck platooning and automation?
- Providing the knowledge of truck platooning and available scenarios of adoption, what are the likely scenarios of adoption, and why?
- What are the potential solutions and which entities are expected to resolve the concerns of stakeholders related to the adoption of platooning?

The survey was followed by a focused group discussion with policymakers, including experts and officials from the Kansas Freight Advisory Committee and KDOT. The adopted study protocol was approved by the Institute Review Board (IRB) at the University of Kansas (IRB ID: STUDY00150270).

3.1 Online Survey Participant Recruitment

Survey participants were selected if they identified in one of three stakeholder groups: (1) workforce (driver/operator, fleet manager), (2) industry (owner/provider/user), or (3) policymaker (freight advisory, state, or federal DOT). A pilot survey was conducted with 36 participants, and survey improvements were based on preliminary analysis. A total of 338 responses, including the pilot survey, were collected from eligible participants, but only 217 completed responses were included in the final analysis.

3.2 Questionnaire and Data Collection

Based on insights from previous studies, an online questionnaire was designed to explore stakeholders' opinions (Appendix A). A market research company was employed to collect responses from industry and workforce stakeholders. A total of 318 responses were collected, and incomplete or quick responses were eliminated. Overall, 217 responses were retained for the final analysis. The questionnaire included the following four sections:

- *Section 1 - Demographic and work details:* This section included information about participants' age, gender, education, role, and experience within the trucking industry, as well as type of goods (perishable, hazardous, etc.), range of logistic operations (long-haul, short-haul), and the likelihood of using any level of technology, which could indicate technology familiarity or a future willingness to use technology (Mahajan et al., 2021). Examples of vehicle technologies included navigation and in-vehicle infotainment systems (IVIS) and vehicle automation, such as advanced driver assistance systems (ADAS), lane keeping assist (LKA), automatic emergency braking (AEB), automatic cruise control (ACC), and crash warnings. Partially automated technologies that require driver intervention were included, as well as highly automated technologies with a conditional/optional driver or self-driving technologies, such as Waymo and Robotaxi.
- *Section 2 - Platooning information and assessment:* A 2-minute video by Ford Trucks International (https://youtu.be/sirzW3AiPhU; Appendix A) was shown to drivers to demonstrate truck platooning on highways. The video showed scenario 1 of platooning with human drivers in both leading and trailing trucks. The video also included generic capabilities such as fuel savings, allowing other cars to safely cut in, enhanced safety technology, and electrical coordination between trucks. Following this video, drivers were asked to rate the potential effects of platooning on 11 relevant factors (identified in the literature) using a 5-point Neg2Pos scale of *-2 = significantly decreasing* to *2 = significantly increasing* and *0 = neutral/no change*. These factors included potential impacts on employment rate; social image of truckers; workforce wages; driver shortages in the trucking sector; logistic operating costs such as fuel, maintenance, and insurance costs; additional non-driving responsibilities, including non-driving tasks such as loading, unloading, handling customers; working hours; overall stress due to driving; road safety; required skills/qualifications; and related effects on job satisfaction and overall quality of life.

The participants were then shown another 2-minute narrated presentation of six potential platooning scenarios proposed by Viscelli (2018), entailing the role of driver and technology in each scenario. The videos were embedded in the questionnaire such that participants could not proceed to the next question if they did not spend the stipulated time at each video. Additionally, a few redundant questions were asked from each video to ensure that each participant watched the videos. A list of 11 benefits of automation or platooning was prepared, and the participants were asked to choose the top two preferred scenarios that they associated with the given benefit. Participants were also asked to share their top concerns about AT adoption and platooning. Additionally, a generic list of five challenges was provided, and all participants shared their opinions about which stakeholder is expected to resolve these challenges. Participants were also asked to state their preferred choice of scenario among the provided options (neglecting any safety-related concerns): automated truck platooning (ATP), non-automated truck platooning (NATP), may be in future, or complete resistance to truck platooning and automation. The stated preference of scenario was used as the dependent variable in this study.

- *Section 3 - Potential solutions and stakeholder responsibilities:* A list of 10 potential solutions relevant to industry stakeholders was prepared based on the literature. Stakeholders, including logistic industry users, owners, and policymakers (excluding the workforce), identified whether automation developers/technology providers, logistic industry users/owners, policymakers, or state/federal DOTs should be responsible for implementing each potential solution.
- *Section 4 - Subjective opinions:* Participants were allowed to share any other relevant potential concerns, solutions, or expectations of policies, incentives, engineering requirements, etc. regarding automation of the trucking industry. They were also asked their willingness to invest in automation that allows human intervention at higher costs, their willingness to prepare for automation, or expected new jobs and subsequent required skills due to technological innovations.

3.3 Focus Group Discussion

Results from the workforce and industry survey were compiled to form the agenda of a 60-minute online focus group discussion to determine the opinions of policymakers. Ten KDOT experts involved in freight operations management, road safety, and AV committees were invited to the online discussion; six experts participated. Following introductions, the discussion was structured to collect opinions on five topics: (1) effects of platooning, (2) preference of the six platooning scenarios, (3) expectations, (4) personal concerns about platooning, and (5) perceived readiness for an era of truck automation. Participants were shown the survey results related to each topic as prompts to initiate open-ended discussion. The platooning videos and potential platooning scenarios were also presented to the group during the discussion. No time restrictions or interruptions were allowed, and the discussions lasted 10–12 minutes for each topic.

3.4 Analysis

An in-depth analysis was conducted to answer the defined research questions. Because the preliminary analysis revealed many response similarities of the two stakeholder groups (workforce and industry), t-tests were used to determine if the two groups were statistically different. All variables collected through the questionnaire were compared, and the t-tests showed no significant difference between the two groups (*p-value >0.1)* for all variables. Therefore, survey responses were combined for both groups in the rest of the analysis.

To understand the impacts of platooning as perceived by the participants, a correlation analysis was conducted between the initial 11 potential platooning impacts. Initial correlation analysis revealed significant correlations (Pearson's R >0.3, *p-value <0.001)* among 10 items, excluding the factor E6 - impact on driver responsibilities including various non-driving tasks (NDTs) (Pearson's R <0.3, *p-value <0.001* with all other variables). Principal component analysis (PCA) was conducted using the responses for the 10 correlated factors, which allowed the factors to be grouped together to identify potential perceived impacts from the responses.

Detailed survey responses regarding stakeholder concerns, potential solutions, and stakeholder roles in addressing or implementing the suggested solutions were also analyzed. The discussion based on results from the initial survey with key KDOT officials was analyzed qualitatively, and the discussion was electronically transcribed and then thematically analyzed to summarize the narrative of expert opinions (Schuster et al., 2023). After thoroughly reading the transcripts, excerpts with similar underlying narratives or excerpts that indicated a pattern were coded together. Based on insights from the in-depth literature review and research questions, the codes were reread to identify the emphasized themes.

Chapter 4: Results and Discussion

4.1 Descriptive Statistics

Individual and stakeholder group characteristics of the online survey participants are summarized in Table 4.1.

Table 4.1: Descriptive Statistics of the Sample by Stakeholder Group

Variable	Categories	Workforce (W)		Industry (I)		Total	
		N = 128	%	N = 89	%	N = 217	%
Age (in years)	< 25	10	7.80%	5	5.6%	15	6.9%
	25–34	46	35.9%	27	30.3%	73	33.6%
	35–44	29	22.7%	24	27.0%	53	24.4%
	45–54	32	25.0%	16	18.0%	48	22.1%
	55+	11	8.6%	17	19.1%	28	12.9%
Gender	Male	100	78.1%	42	47.2%	142	65.4%
	Female	28	21.9%	47	52.8%	75	34.6%
Education	School	0	0.0%	1	1.1%	1	0.5%
	High school	51	39.8%	37	41.6%	88	40.6%
	Graduation or higher	60	46.9%	44	49.4%	104	47.9%
	Any vocational course	17	13.3%	7	7.9%	24	11.1%
Experience in trucking industry (in years)	0–1	5	3.9%	16	18.0%	21	9.7%
	1–5	44	34.4%	31	34.8%	75	34.6%
	5–10	26	20.3%	23	25.8%	49	22.6%
	10+	53	41.4%	19	21.3%	72	33.2%
Type of logistic operations	Primarily short haul/ parcels/delivery	34	26.6%	16	18.0%	50	23.0%
	Primarily long-haul	25	19.5%	27	30.3%	52	24.0%
	Both	67	52.3%	41	46.1%	108	49.8%
	Other	2	1.6%	5	5.6%	7	3.2%
Type of goods transported	Perishable	40	31.3%	18	20.2%	58	26.7%
	Non-perishable	64	50.0%	55	61.8%	119	54.8%
	Hazardous	7	5.5%	4	4.5%	11	5.1%
	Both perishable & non-perishable	1	0.8%	2	2.2%	3	1.4%
	Others	16	12.5%	10	11.2%	26	12.0%
Understanding of platooning (post-video)	Yes	46	35.9%	27	30.3%	73	33.6%
	Yes, but concerned about cutting in vehicles	82	64.1%	62	69.7%	144	66.4%
Used or willing to use automated vehicles	No	65	50.8%	52	58.4%	117	53.9%
	Partial automation (L3)	38	29.7%	26	29.2%	64	29.5%
	Highly automated driving (HAD)	5	3.9%	3	3.4%	8	3.7%
	Self-driving	20	15.6%	8	9.0%	28	12.9%

Participant distribution by age was similar in both the industry and the workforce groups, with most participants being 25–44 years old, except the industry group had more than twice the proportion of participants over 55 years of age. Overall, 35% of the 218 respondents were females, but the proportion of females in the industry group exceeded the proportion of females in the workforce group. Most participants were at least high school graduates, and more than 50% of the participants in both groups had more than 5 years of experience working in the trucking industry. Approximately half the participants in both groups had experience managing short-haul and long-haul operations, with at least 50% of the participants involved in transporting non-perishable goods. Only 5% of the participants in both groups were involved in the transportation of hazardous goods.

Individual responses were collected to determine participant willingness to adopt various vehicle technologies and automation in personal vehicles. The responses are summarized in Figure 4.1. Most drivers (>60%) were neither familiar with using AVs nor interested in using them in future.

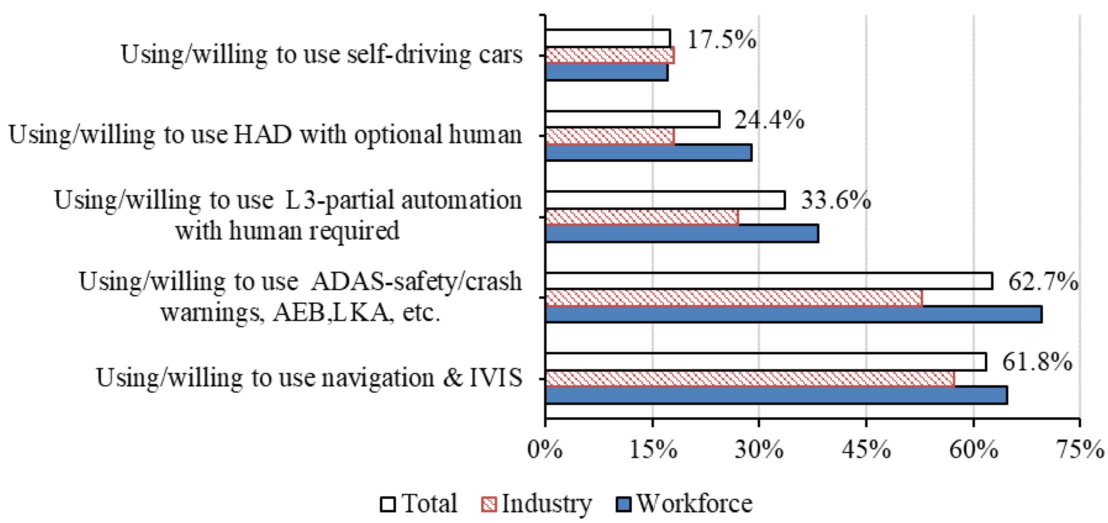


Figure 4.1: Stakeholder Familiarity With or Willingness to Use Vehicle Technologies

However, the minority in favor of automation levels 3 or higher declined as the level of automation increased to conditional driver or driverless vehicles. Notably, most participants in both groups (>60%) use in-vehicle technologies, such as navigation or IVIS, or are willing to use them in the future, especially ADAS features such as crash warnings, AEB, LKA, and ACC.

4.2 Platooning Impact Assessment

In the responses to questions about platooning following the 2-minute platooning video, all participants indicated a correct understanding of how platooning works and its advantages. However, although the video effectively demonstrated vehicles merging into and departing from the platoon, more than 60% of participants expressed concerns about merging vehicles.

Initial PCA with oblimin rotation of an initial 10 items yielded three components, two of which were significantly correlated (r >0.3). Negligible factor loadings (<0.1) were suppressed in the results. Most items clearly loaded on first two components, and only factor E1 (impact on employment rate) loaded significantly (>0.4) on the third component. Similar loading distribution was recorded in the pattern and structure matrix, suggesting that the adoption of a two-factor solution may be more appropriate compared to the three-factors (Pallant, 2016). Another PCA with oblimin rotation was conducted with a desired two-factor solution, resulting in two uncorrelated components (component correlation = 0.122), leading to a cumulative variance of 50.35% in the responses. PCA results from the pattern matrix after rotation are summarized in Table 4.2. Cronbach's α = 0.705 indicated internal consistency of factors and reliability of factors used to identify potential platooning impacts. The scree plots also supported the retention of two components, with a clear break after the first two components with eigenvalues >1. The goodness of PCA was indicated by the significance of Bartlett's test of sphericity (p <0.001) and Kaiser-Meyer-Olkin (KMO) index of 0.70 (minimum required for sampling adequacy >0.6) (Pallant, 2016). Factors E2, E4, E5, E7, and E8 significantly loaded on component 1, and the remaining factors, including E1, loaded on component 2.

Table 4.2: PCA of Potential Impacts of Platooning

Factor Description	Valid responses %					Component	
	Significantly decrease	Slightly decrease	No change	Slightly increase	Significantly increase	1	2
E1: Employment rate	4.1	26.7	21.7	26.7	20.7	0.10	0.67
E2: Reckless driving image	13.4	39.2	27.2	10.1	10.1	0.56	0.18
E3: Workforce wages	5.1	15.2	32.3	31.3	16.1	0.09	0.81
E4: Driver shortage	10.1	34.1	21.7	24.0	10.1	0.70	-0.03
E5: Operating costs	10.6	32.3	11.5	30.0	15.7	0.78	-0.15
E6: Driver responsibilities (including NDTs)	0.9	9.7	31.8	41.9	15.7	NA	NA
E7: Working hours	8.3	34.1	30.0	18.4	9.2	0.58	0.30
E8: Overall stress	20.3	36.4	18.4	14.7	10.1	0.85	-0.16
E9: Road safety	3.7	6.5	18.9	38.2	32.7	-0.15	0.60
E10: Required skills/ qualifications	1.8	15.7	25.8	40.6	16.1	0.16	0.49
E11: Overall quality of life	4.6	5.1	21.7	45.6	23.0	-0.18	0.79
Eigenvalues (after rotation)						2.805	2.229
% Variance explained						28.05	50.35

*NA: not included in the final PCA reported

The results suggest that platooning may decrease factors loading on component 1, such as reckless driver's image of truckers, driver shortages, operation costs (e.g., fuel, maintenance, and insurance), working hours, and overall job stress. Overall, component 1 represented a likely decline in challenges within the freight sector, so component 1 was labeled "challenges in trucking operations" (CTO). The remaining factors loading on component 2 increased due to platooning, including employment rate (E1), workforce wages (E3), road safety (E9), required skills or qualifications of the workforce (E10), and overall quality of life and job-satisfaction (E11). Component 2 cumulatively enhanced the benefits of trucking operations due to platooning; therefore, component 2 was labeled "benefits of truck platooning" (BTP).

In general, the participants expected a bidirectional split of platooning impacts. Platooning was perceived as a promising solution to critical challenges in the trucking industry, such as driver shortages, operating cost-efficiency, and an enhanced social image of the workforce, and platooning was expected to enhance safety and spur economic growth, potentially resulting in higher wages and an overall increase in employment opportunities. However, survey participants expressed uncertainty regarding potential shifts in their roles and responsibilities because assistive automation may add responsibilities of managing goods and other trailing trucks, which would require increased compensation. Conversely, an equivalent proportion of participants indicated that automation may not substantially alter their roles. A majority of participants expressed a positive attitude towards adopting platooning technology, suggesting that they do not expect to be replaced by platooning technology. Notably, these responses occurred after participants viewed the video demonstrating scenario 1 of platooning with human drivers in all trucks. Opinions regarding driver roles, wages, and employment prospects may evolve as higher levels of automation become integrated with platooning.

4.2.1 Scenarios vs. Benefits

Figure 4.2 summarizes the top two scenarios chosen by survey participants for each platooning benefit (denoted as ScnX, where X signifies the scenario number). In contrast to the literature review that suggested scenario 2 and scenario 5 were the most likely scenarios of adoption, the figure shows that scenario 1 and scenario 4 were primarily preferred by the workforce and industry stakeholders. Scenario 1 was the top-rated choice for most benefits except for reducing the labor costs and working hours of drivers. The second most preferred scenario was scenario 4, where drivers are present for supervision but the trucks are self-driving. Although the participants did not prefer automated scenarios, the responses show that drivers acknowledged the benefits of automation, such as aiding and sharing driver workload and enhanced safety and efficiency due to automation. The lack of support for other automated platooning scenarios suggests that participants perceive a threat to their existing jobs due to these automation scenarios.

Scenario 2 (human-drone platooning, HDP) was associated with limited benefits, such as improved efficiency, improved social reputation, and potential increase in wages due to increased driver responsibilities. Moreover, stakeholders perceived this scenario to be least effective at reducing insurance or labor costs. Scenario 5 was preferred among the scenarios for benefits such as reduced working hours of drivers and decreased fuel, maintenance, insurance, and labor costs. However, scenario 5 was the least preferred for improving the social image of truckers, improving the efficiency of freight and subsequent increase in employment, improved job satisfaction, and increased road safety and workforce wages. Despite the cost benefits, the workforce and industry stakeholders associated the automated scenarios with a threat to existing jobs and poor safety. Participant responses clearly indicated the perception that safety would improve only with platooning scenarios that involve the presence of a human driver in each truck.

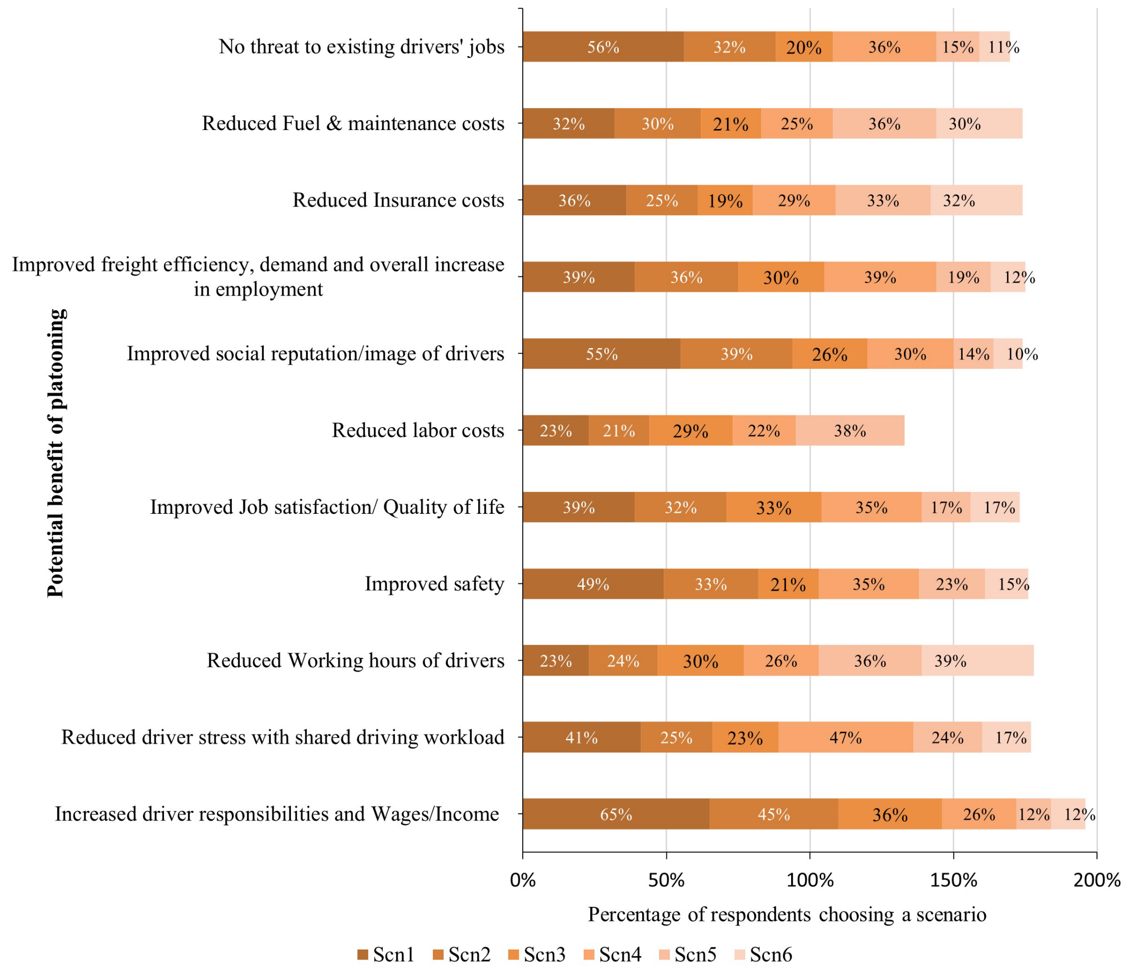


Figure 4.2: Platooning Scenario Preferences with Benefits

4.2.2 Platooning Concerns

The platooning scenarios aligned with participant concerns about platooning and truck automation, as depicted in Figure 4.3. Almost 70% of the workforce exhibited significant apprehension about potential job losses, while more than 60% of industry stakeholders were primarily focused on addressing legal issues and ambiguities in operation policies. A prevailing concern among more than 60% of participants in both groups was a lack of trust in technology's capacity to safely operate on the road and a general lack of acceptance of technological advancements. Furthermore, a deeper exploration of industry concerns revealed unpreparedness for platooning adoption, including insufficient infrastructure, data security strategies, implementation costs, workforce training, and readiness for potential job displacement. The responses also revealed technology aversion and workforce reluctance to train to facilitate platooning adoption. These factors may contribute to workforce resistance to truck platooning and automation.

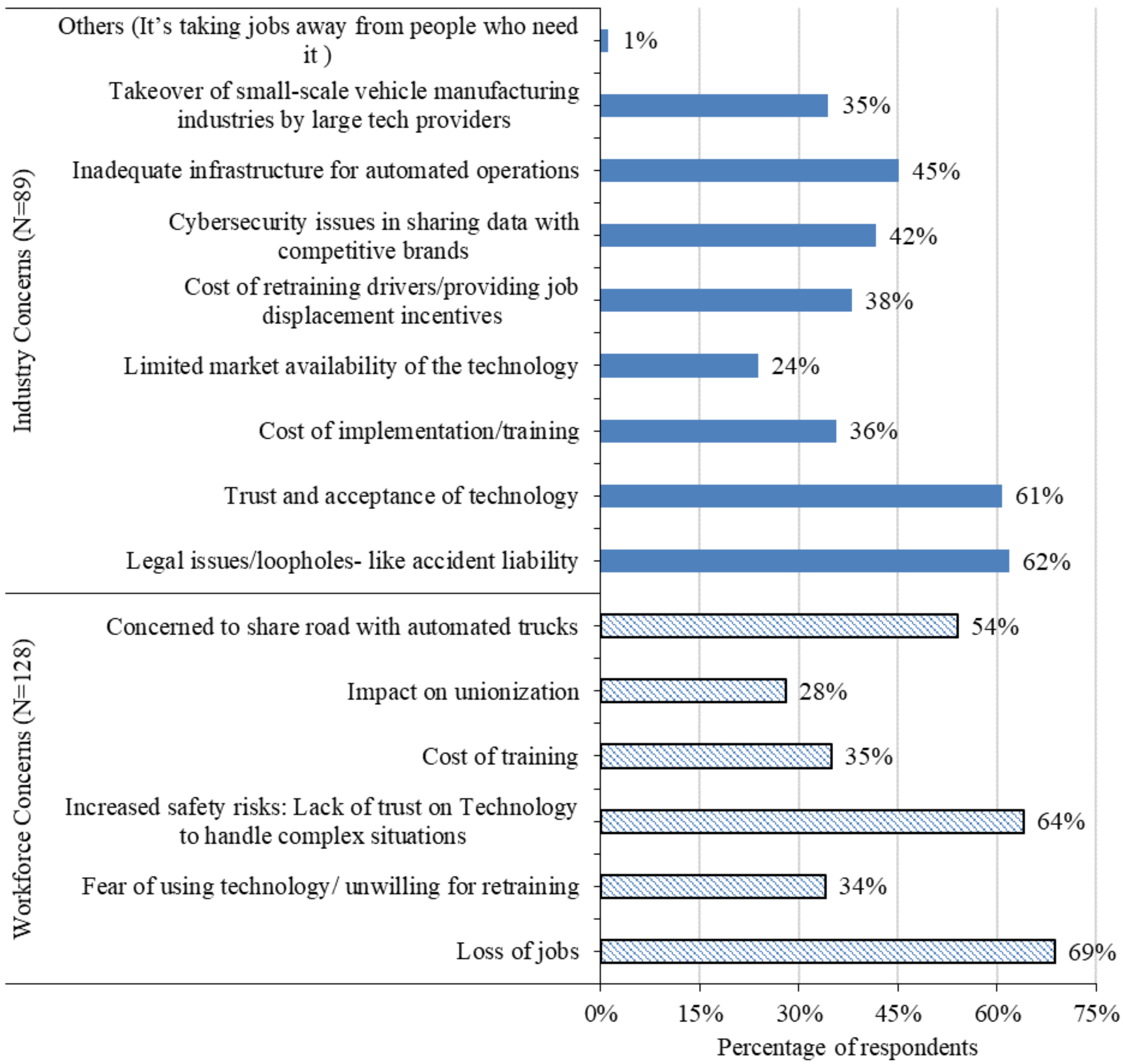
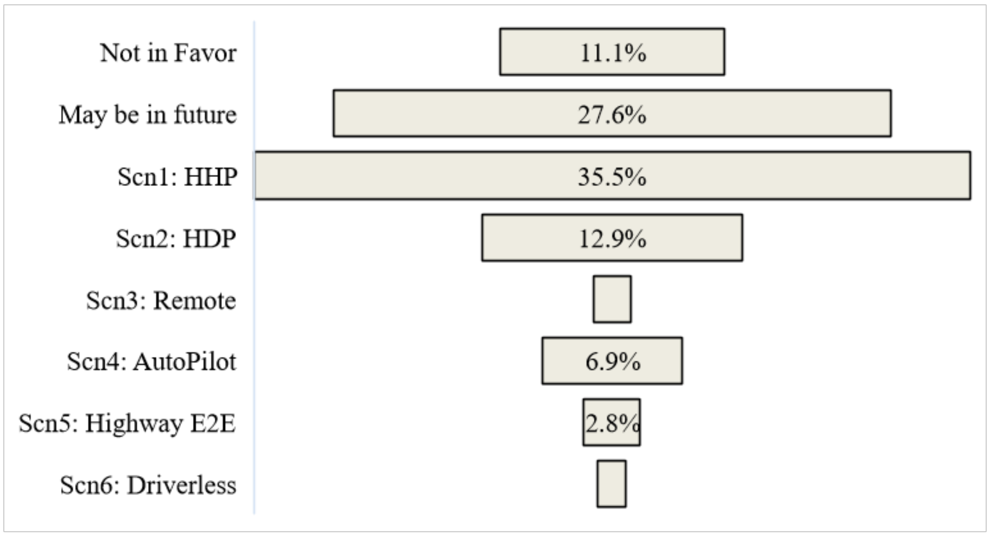


Figure 4.3: Industry and Workforce Platooning Concerns

4.2.3 Preferred Scenarios

Preferred platooning scenarios are depicted in Figures 4.4 and 4.5. Figure 4.4, presented as a funnel diagram, illustrates specific platooning scenario preferences. In descending order of preference, both groups favored scenario 1, followed by scenario 2 and scenario 4, while other scenarios received less than 3% of the votes.



(blank data labels represent <3%)

Figure 4.4: Preferences of Platooning Scenarios

Due to the limited responses for scenarios with high levels of automation and driver absence in trucks or trailers, these scenarios were collectively categorized as ATP scenarios in Figure 4.5. As shown, most participants preferred Scn1: HHP, with human drivers present in all electronically coordinated leading and trailing trucks within a platoon.

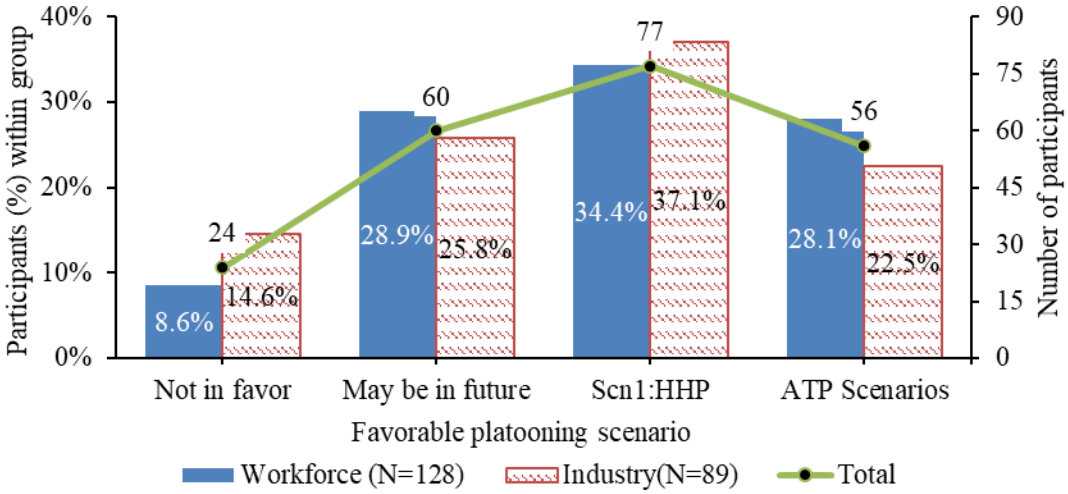


Figure 4.5: Preferences of Platooning Scenarios by Stakeholder Group

Notably, responses from both groups indicated a positive attitude towards platooning adoption or an interest in other ATP scenarios. Only 11% of participants negatively perceived truck platooning, and the resistance was lower among the workforce group (8.6%) than the industry group (14.6%).

In the comprehensive analysis of scenario preferences, scenario 1, featuring human drivers in electronically-connected trucks equipped with driver assistance systems, was the most preferred choice among survey participants. This choice aligns with findings from Section 4.1, which revealed a willingness and familiarity among participants regarding the use of driver assistance systems in their personal vehicles (Table 4.2 and Figure 4.1). Although the overall scenario preferences, as presented in Figures 4.4 and 4.5, were gathered without factoring in paramount safety concerns, future research should include a deeper analysis of the benefits associated with each scenario, as well as the concerns related to potential job displacement and the need for well-defined policies. These aspects should be the focus of future research on platooning and automation integration within the trucking sector.

4.3 Potential Solutions and Stakeholder Responsibilities

Figures 4.6 and 4.7 show the solutions envisioned by the workforce and the logistics industry, respectively, highlighting the respective roles and responsibilities of each stakeholder and subsequent actions to prepare for platooning and ATs.

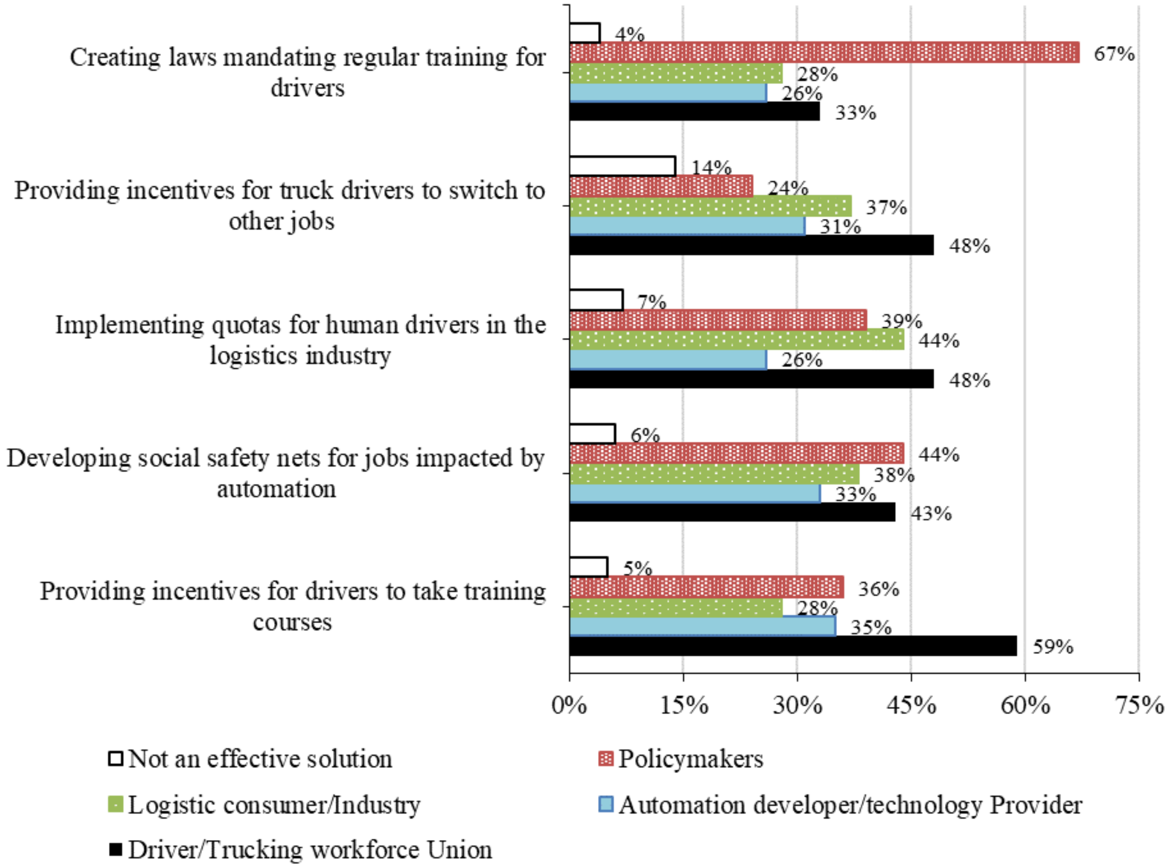


Figure 4.6: Workforce (N = 128) Opinions about Potential Solutions

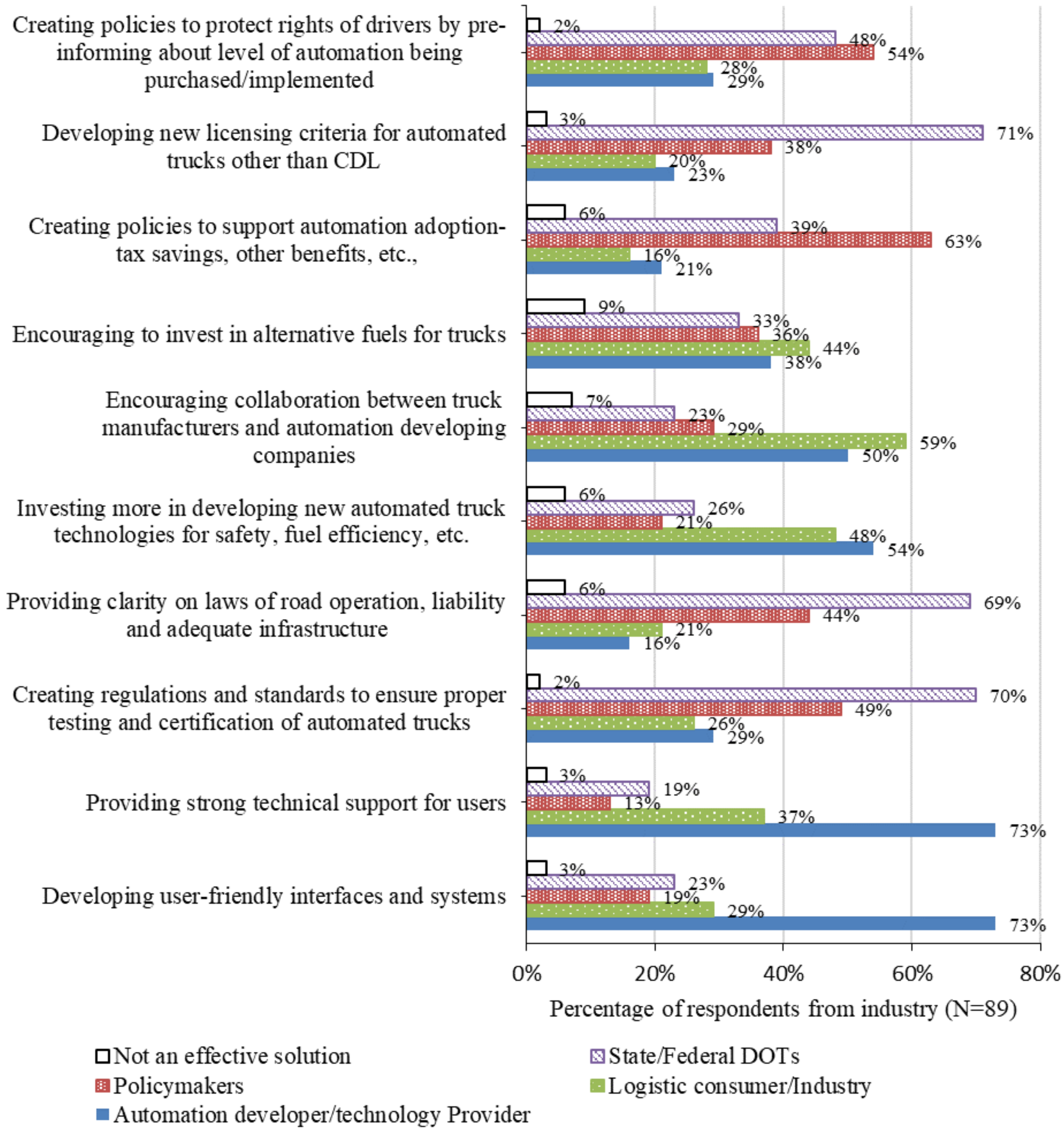


Figure 4.7: Industry Opinions about Potential Solutions and Stakeholder Roles

4.3.1 Role of Drivers and Workforce Union

As shown in Figure 4.6, most of the workforce view the proposed solutions for resolving workforce concerns to be effective. They strongly believe that the workforce union and individual drivers hold significant roles in the implementation of these solutions. Respondents agreed that the workforce union should assume a leading responsibility for providing incentives for retraining and addressing job displacement concerns, enforcing quotas for human drivers within the logistics sector, and establishing social safety nets for workers whose employment may be affected by platooning and automation. Furthermore, the workforce union should formulate regulations that facilitate a smooth workforce transition through mandatory retraining. These viewpoints underscore the crucial role of the workforce union in discussions concerning strategies to support job transitions for automation and platooning. Along with other stakeholders, the workforce unions are seen as advocates for workforce interests and job security.

4.3.2 Role of Logistics Industry and Automation Developers

The perspectives of the workforce and the industry (Figures 4.6 and 4.7) highlight the need for collaboration between automation developers or technology companies and their logistics partners to address workforce and trucking industry concerns. The workforce responses highlight technology and automation providers as integral components of the logistics industry. Based on the workforce perspectives (Figure 4.6), industry stakeholders should proactively alleviate workforce-related concerns, including implementing quotas for human drivers and providing incentives for drivers to transition to new roles within or outside the industry. These suggestions underscore the responsibility of the industry and automation developers to create new employment opportunities or support workforce transitions via safety net programs when automation replaces traditional human roles.

Conversely, industry opinions (Figure 4.7) indicate that the logistics industry must also prioritize investments in sustainable alternative fuels and continually develop and test new technologies to enhance freight safety and efficiency in collaboration with automation developers. Automation developers must spearhead collaborations with logistics partners to promote the seamless acceptance of technology, including investing in safe, fuel-efficient trucking technology and user-friendly interfaces and systems, as well as providing robust technical support for users. Furthermore, industry stakeholders can contribute valuable feedback to identify policy requirements, shape laws (including revisions to licensing criteria), and offer legal support or incentives to facilitate automation and platooning testing standards and implementation. In addition, feedback from the technology industry will help establish technical standards for technology and platooning integration, and technology providers and the logistics industry should collaborate, with both parties facilitating a smooth transition toward automation and platooning. This collective effort will enhance efficiency and safety in the logistics and trucking sectors.

4.3.3 Role of Policymakers and DOTs

Both workforce and industry survey responses emphasized the pivotal role of policymakers, including freight advisory members from state and federal DOTs, in crafting effective policies to facilitate job transitions and implement platooning technology. The workforce expects policymakers to safeguard their job opportunities by mandating human driver quotas within the logistics industry and offering safety net options for those affected by automation-induced job displacement. They also seek policymaker support in promoting job transitions via mandatory driver training and incentives. These initiatives require active participation from industry stakeholders, including logistics and automation developers. Policymakers are critical for protecting workforce rights by enacting legislation to keep the workforce informed about technology acquisition or implementation efforts, thereby ensuring that the workforce is adequately prepared for job transitions or motivated to engage in training in alternative skills.

The industry responses also indicate that policymakers should incentivize platooning and automation adoption in freight operations by offering tax savings or other benefits to motivate industry partners to invest in testing and platooning technology. DOTs are also urged to lead collaboration with policymakers to facilitate the seamless operation of platooning technology, including amending commercial driver's license (CDL) requirements to incorporate safe and efficient technology in platooning, providing legal clarity on platooning operation, implementing predefined protocols for automated truck usage, and assigning liability in safety-critical incidents. The involvement of DOTs and policymakers is crucial for ensuring adequate infrastructure to support safe and efficient platooning integration with automation. Furthermore, they lead the development of technical standards for integrating automation and platooning for secure and efficient freight operations, and their engagement encourages industry-led investments in fuel-efficient technology and the sustainable integration of automation within the logistics industry without adversely impacting the logistics market, especially small-scale owners or fleet operators.

4.4 Focus Group Thematic Analysis Results

Transcription of the focus group discussion highlighted repetitive keywords. Figure 4.8 presents a word cloud of keywords based on their frequency of appearance in the excerpts (Appendix B).

Figure 4.8: Keywords from Excerpts Based on Frequency of Repetition

These keywords were then used to identify four themes with similar underlying narrative: (1) concerns, (2) benefits, (3) potential solutions/future actions, and (4) readiness to adopt platooning scenarios. The themes are summarized in Figure 4.9, and example excerpts are presented in Appendix B.

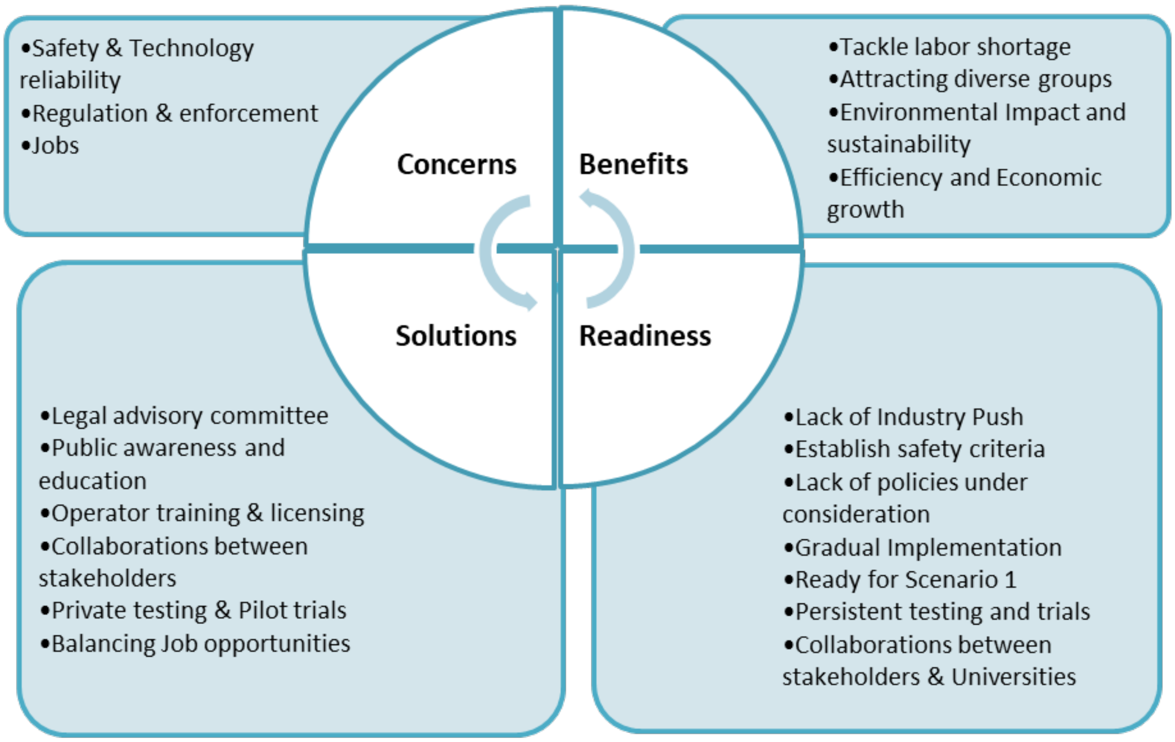


Figure 4.9: Outcomes of the Focus Group Discussion Thematic Analysis

4.4.1 Concerns

Safety was one of the primary concerns revealed throughout the focus group discussion. Nine of the extracted excerpts from the discussion contained the keywords “safe” or “safety.” Participants emphasized the need for reliable technology to ensure safety for the traveling public. The discussion included concerns about the capability of technology to adequately respond to safety critical situations or unforeseen situations, such as a truck stalling out, a safety incident at site, or other vehicles or emergency response vehicles stopped at the roadside. The participants shared that KDOT’s priority is to ensure safety of the traveling public and roadway maintenance when automation technology is applied. The discussion revealed concerns related to platooning practices on two-lane highways, such as merging with, passing, or driving around ATs. Ensuring safe driving practices on two-lane highways is a key challenge. The need for appropriate regulations and law enforcement was identified as vital for maintaining high safety levels.

Job displacement was also acknowledged as a significant concern. Driver fear of being replaced by technology can lead to resistance to AT adoption among the workforce. Additionally, the discussion highlighted the need to increase public awareness and understanding of technology and related developments. The discussion on legalized framework emphasized the need for advisory committees and clear plans.

4.4.2 Benefits

Potential improvements in efficiency and positive environmental impacts were noted as significant benefits of automation adoption. The focus group experts argued that automation technology may actually alleviate the labor/driver shortage in the trucking industry rather than create job losses because this technology will create new job opportunities. One of the experts mentioned that *"change in the job itself with this technology could, attract different groups… we've seen historically for this type of work force… So I think it could create an opportunity for growth in this part of the country."* The discussion suggested that the use of technology may also increase recruitment by attracting younger drivers, as evidenced from the history of impacts of technology such as deployment of computerization in the previous century. Moreover, results of the focus group discussion disproved the perception that new technology-based jobs would be confined to areas with booming tech industry. In fact, economic growth due to ATs is expected to create new opportunities throughout the United States. For example, previous studies found that the increase in hospitality services around newly created transfer hubs and overall economic growth due to efficient freight also generates employment in the manufacturing and distribution sectors (Mohan & Vaishnav, 2022).

4.4.3 Potential Solutions

The focus group discussion recommended the establishment of an advisory committee to address issues related to technology adoption, specifically existing and required regulations and enforcement tied to safety concerns. Second, the discussion emphasized the need for testing and pilot trials in privately owned logistics parks or hubs. Testing for short runs and between distribution centers was approved in the legislation. The industry could conduct controlled trials at private properties and with smaller vehicles or trucks prior to full-scale implementation on public roads. Third, these efforts should be accompanied by increasing public awareness and timely, adequate education about safely driving around ATs. The discussion suggested that collaboration between various stakeholders, including industry, policymakers, and law enforcement, is crucial for the successful implementation of ATs or platooning.

Participants acknowledged that technology could be more of a solution than a problem for job displacement. Various options were suggested to prepare the workforce for job displacement either within or outside the trucking industry, such as the gradual introduction of technology, timely training for new jobs, operator training to handle technology, or exploring future possibilities, such as remote driving. Adequate training of operators is also essential, but the willingness of the labor workforce to embrace these changes will determine the effectiveness of these suggestions. Future vehicles with additional technology inside the vehicle may have more licensing requirements than current CDLs. The KDOT officials mentioned that safety net programs are not currently being considered for the workforce, nor are any supporting policies related to tax or environment-based incentives being proposed for the industry to promote technology adoption, although they are open to these ideas and discussions. Therefore, the workforce must present their opinions or needs, and the industry needs to demonstrate quantified benefits after successful controlled testing and initial trials.

4.4.4 Readiness to Adopt Platooning Scenarios

Analysis of the discussion excerpts revealed unanimous favoring of scenario 1 (HHP) due to the current readiness of technology for deployment and the mandatory presence of human drivers in all trucks. Scenario 1 was also preferred for Kansas because of the restriction of conventional human drivers in current CDL requirements. Current Kansas policies also do not favor the adoption of driverless trucks or trailers in a platoon, and although the discussion acknowledged the need for adequate policies, the role of law enforcement authorities was identified as crucial to ensure a smooth incorporation of technology. Despite recent advances in platooning and technology, the KDOT experts acknowledged a lack of enthusiasm in the logistics industry for policy decisions or plans and that technology adoption will be slow. Pilot testing or the adoption of scenario 1 is likely the first step in towards the deployment of platooning because it allows sufficient time for the workforce and the public to accept the technology and for the technology to establish reliability.

Overall, these excerpts highlight the multifaceted considerations of automated truck technology adoption, including safety, regulation, public awareness, education, workforce impact, and potential implementation scenarios. The discussion emphasized the need for safe and reliable technology through collaborations and planning.

Chapter 5: Conclusions and Recommendations

The objective of this project was to evaluate the anticipated impacts of truck automation and platooning on the workforce of Kansas and formulate strategies to mitigate potential negative effects. This study included two phases: a systematic literature review and a compilation of insights from industry, workforce, and KDOT policymakers. The systematic literature review encompassed prior research, news articles, and reports to identify stakeholder concerns and potential solutions. Based on these findings, a structured survey was crafted for each stakeholder group, totaling 217 participants, including 89 professionals from the logistics industry (i.e., managers and owners) and 128 workforce/drivers involved in long-haul and short-haul operations. Survey data analysis revealed the potential impacts of platooning and automation, concerns of industry and workforce participants, and preferences for various platooning scenarios. The survey also revealed perceived solutions and anticipated responsibilities of stakeholders to facilitate a smooth transition to platooning and automation integration within the trucking sector. These responses were further deliberated with six key officials from the freight advisory board and AV-related committees within KDOT during a focus group discussion that emphasized the readiness of the government's infrastructure, technology, educational campaigns, and policies for platooning adoption.

5.1 Conclusions

Previous studies included detailed reviews, interviews, and discussions with experts, the workforce, managers, policymakers, and owners, as summarized in Chapter 2. The review revealed limitations in previous research. First, previous studies showed that driver opinions of automation without direct experience of automated systems is influenced by rumors, technology inhibitions, pre-conceived notions, or fear of new technologies. Some studies assumed a prior understanding of platooning among study participants. Second, despite the significant role of DOTs in research and freight operations in every state, no studies have gathered DOT opinions to gauge government readiness, infrastructure, policies, and technology for platooning adoption. Finally, although the literature suggests strategies to mitigate platooning adoption challenges, stakeholders must accept certain responsibilities related to platooning and truck automation. Therefore, the current study was designed and conducted to address these limitations. The following key findings were gathered from this study:

1. *Primary stakeholders:* The study identified three main trucking industry stakeholders impacted by platooning and automation: the logistics industry (technology providers), the workforce (truck drivers), and policymakers (DOTs).
2. *Positive impacts of platooning:* The impact assessment of platooning showed that both industry and workforce acknowledge the overall positive impacts of platooning. According to PCA results, these positive impacts can enhance the benefits of freight and decrease the challenges associated with freight operations.
3. *Challenges addressed*: Platooning is likely to help mitigate driver shortages, improve the social image of truckers, reduce operating costs (fuel, maintenance, insurance) and working hours, and decrease workforce job stress. Platooning is also likely to increase the general employment rate, workforce wages, road safety, and the overall quality of life and job satisfaction of the workforce. However, stakeholders agree that platooning may require additional skills or qualifications for the workforce.
4. *Safety and trust:* The surveys and the focus group discussion revealed that safety, trust, and acceptance of technology is critical for all stakeholders. The workforce shared their apprehensions about job losses, which result in resistance to technology adoption, while industry experts asserted the need for clarity in operational policies. Policymakers/DOTs emphasized the need for timely driver education and awareness campaigns to safely navigate with and around ATs, especially on two-lane highways.
5. *Preferred scenario*: Scenario 1 (HHP) was the favored platooning scenario due to technology readiness (in terms of vehicles, infrastructure, safe and optimal logistic operations) complying with the current legal requirement of the presence of licensed human drivers in trucks. The scenario utilizes industry readiness to invest in driver assistance technology, familiarity of the level of technology, and

workforce willingness to use driver assistance systems, as well as the presence of a licensed CDL driver in the trucks for platooning.

6. *Future scenarios:* Other platooning scenarios that integrate automation are likely to be adopted in the future, such as scenario 4, because it requires constant human supervision and presence in the vehicle. Scenarios 3 and 6 were less preferred by survey participants, and current policies in Kansas and many other US states do not support driverless trucks or trailers in platoons. Technology adoption is expected to be slow-paced, starting with scenario 1.
7. *Key solutions:* Significant solutions to the identified concerns of stakeholders include driver education and awareness, pilot testing, and phased deployment of technology, starting with scenario 1, which does not displace human roles in platooning.
8. *Slow-phase adoption*: The DOTs highlighted the lack of enthusiasm and feedback from logistics industries responsible for lagging policy decisions or plans. This indicates a slow pace of technology adoption, which allows time to build technology readiness and public receptivity.
9. *Collaborations:* Findings from the survey responses and focus group discussion emphasized collaborative efforts from all stakeholders as key to addressing platooning challenges.

The current findings agree with previous economic and social analyses suggesting that automation is likely to be deployed in phases, initially requiring drivers and then gradually shifting to driverless operations. During the transition, drivers can be trained for administrative roles, upskilled to operate ATs, and provide low-level maintenance. New roles can be created, such as supervising ATs and optimizing the fleet route and schedules. Job displacement can be managed by allowing the existing workforce to update their skills while moderating the adoption pace and automation level via adequate policies and simultaneously updating the education and training for the new trucking workforce. Such policies can mutually protect the interests of the workforce and industry stakeholders without delaying the adoption of automation.

5.2 Recommendations and Future Work

Future steps should be taken to address the challenges of platooning and automation in trucking. First, workforce union initiatives must be established. The workforce union, which represents truck drivers, should preemptively advocate for workforce interests and job security, and initiatives should include incentives for training, the implementation of human driver quotas, safety net programs, and regulations to inform and prepare drivers. Second, policymakers must mandate safety nets and training incentives, which requires collaboration with other stakeholders to provide job security for displaced workers. Similarly, the logistics industry should collaborate with technology providers to create new jobs within the trucking sector or retrain drivers for roles outside the industry. Workforce training and transition is another recommendation to address platooning challenges. Workforce preparation for job displacement could involve gradual technology introduction, training for new roles, operator training, and the exploration of remote driving possibilities. Recommendations for licensing requirements include changing requirements as technology integration advances. In addition, policymakers, industry, and universities should identify and develop driver education programs to support platooning and automation, while the industry could incentivize workforce participation to enhance safety and technology acceptance. As another recommended step for platooning challenges, the logistics industry and automation developers should collaborate to address safety concerns and promote technology acceptance, including pilot testing on private properties prior to public route implementation. Both the industry and workforce should also seek legislation to ensure job security and incentives for platooning adoption. Policymakers require industry enthusiasm and feedback to drive initiatives for incentivizing platooning and automation. Finally, policymakers, including key DOT officials, play a crucial role in crafting effective policies. Industry and workforce feedback should help shape policies and standards, and the industry's pilot testing, including cost-benefit analysis, should be shared with policymakers to inform decision-making.

These recommendations aim to address the challenges associated with platooning and automation in the trucking sector and promote a smooth transition to ATP while safeguarding the interests of the workforce and the industry. Collaboration among stakeholders is essential for the success of these initiatives.

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Appendix A: Survey Questionnaire

Age
- 24 years or less
- 25-34 years
- 35- 44 years
- 45-54 years
- 55+

Gender
- Male
- Female

Education level completed
- School
- High-School
- **Graduation** or above
- any vocational training

Occupational Experience within trucking industry
- less than 1 year
- 1-5 years
- 5-10 years
- 10+ years

Type of logistics operations involved within your employment role
- Majorly Short haul/ within urban neighborhoods/ parcels/delivery
- Majorly Long Haul/ including highways
- Both
- Other (key in)

What level of automation and in-vehicle technology are you *familiar with or willing to use* in your personal vehicles?
- Navigation and infotainment systems only
- Assistive driving (lane keep assist, cruise control-automatic speed adjustment, emergency braking, crash warnings, etc.)
- Partially automated with human intervention required sometimes
- Highly automated driving where the human driver is allowed but not necessarily required to intervene
- Fully automated or self-driving like Google Waymo,

Based on your current involvement in road freight sector, in which occupation group do you identify yourself?
- Driver/Truck operator
- Manager/ Fleet supervisor
- Logistics owner/provider
- Logistics user
- Policymaker/Freight Advisory
- Federal/ State DOT

What type of freight industry are you associated with, based on the type of products transported?

- o Perishable goods
- o Non-perishable goods
- o Hazardous goods
- o Other (key in)

Truck platooning is already on the US roads to address driver shortage.
Please see this 2-minute video (https://youtu.be/sirzW3AiPhU) to understand truck platooning, then choose the correct statement:

(time restriction = length of video)

"It improves freight efficiency, and significantly reduces fuel costs and congestion on highways"

- o True and it also allows other cars to safely cut in
- o True
- o False*
- o I did not see the video*

(* Disqualifying answers)

How do you expect the following factors to change in the trucking industry due to truck automation?

	Significantly Increase	Slightly increase	No Change	Slightly decrease	Significantly decrease
Employment rate					
Opinions about truck driving as a reckless/masculine job					
Wages/Income of the workforce					
Driver shortage in trucking industry					
Overall costs- Insurance, fuel & maintenance					
Non-driving responsibilities of drivers e.g., loading, unloading, interaction with clients, supervision of drone-trucks, etc.					
Working hours of drivers					
Overall Stress					
Safety on the road					

	Significantly Increase	Slightly increase	No Change	Slightly decrease	Significantly decrease
Required skills/qualifications of the existing workforce					
Job satisfaction/ Quality of life of the trucking workforce					

Please see this 2-minute video on available choices of automation scenarios for platooning with the varying role of human drivers. (https://youtu.be/2knpEpzkFic)
Choose the correct statement based on the video. (time restriction = length of video)

- There are 6 scenarios of truck platooning
- I did not see the video*
- Driver is never required, if any form of platooning is supported by the trucks*

*Disqualifying answers

Which scenario of truck automation is most suitable or preferable for the given benefits? (Please limit your selections to the top two choices)

Scenario--	**1**	**2**	**3**	**4**	**5**	**6**
Increased driver responsibilities and Wages/Income						
Reduced driver stress with shared driving workload						
Reduced Working hours of drivers						
Improved safety						
Improved Job satisfaction/ Quality of life						
Reduced labor costs						
Improved social reputation/image of drivers						
Improved freight efficiency, demand, and overall increase in employment						
Reduced Insurance costs						
Reduced Fuel & maintenance costs						
No threat to existing drivers' jobs						

1. Platooning with human drivers (assistive technology
2. Human leading a platoon of drone trucks
3. Drivers remotely monitoring multiple drone trucks
4. Auto-Pilot: Driver in the truck, is backup for technology
5. Self-driving trucks only on highways without drivers (exit-to-exit)
6. Fully automated/ self-driving trucks- no manual driving

Who should be responsible for implementing the following solutions to address driver concerns about adopting automated trucks?

	A	**B**	**C**	**D**	**NE**
Providing incentives for drivers to take training courses					
Developing social safety nets for jobs impacted by automation					

	A	B	C	D	NE
Implementing quotas for human drivers in the logistics industry					
Providing incentives for truck drivers to switch to other jobs					
Creating laws mandating regular training for drivers					

A. Driver/Trucking workforce Union
B. Automation developers
C. Consumer/Logistic Industry
D. Policymakers/State DOTs
NE: Not an effective solution

What are the top concern(s) do you have as drivers about adopting automated trucks? (Select all that apply)

- Loss of jobs
- Fear of using technology/ unwilling for retraining
- Increased safety risks: Lack of trust on Technology to handle complex situations
- Cost of training
- Impact on unionization
- Concerned to share road with automated trucks
- Other (key in)

What are the top concern(s) you have as a consumer of automated trucks about adopting automated trucks? (Select all that apply)

- Legal issues/loopholes- like accident liability
- Trust and acceptance of technology
- Cost of implementation/training
- Limited market availability of the technology
- Cost of retraining drivers/providing job displacement incentives
- Cybersecurity issues in sharing data with competitive brands
- Inadequate infrastructure for automated operations
- Takeover of small-scale vehicle manufacturing industries by large tech providers
- Other (key in)

What are the top concerns of lawmakers about adopting automated trucks? (Select all that apply)

- Regulation enforcement
- Safety of the technology
- Impact on employment
- Economic impact
- Cybersecurity issues
- Adequate laws governing operation of automated trucks- licensing, accident liability coverage & responsibility, etc.
- Environmental impact/ Sustainability
- Other (key in)

What do you think are potential solutions to encourage the adoption of automated trucks and who should be responsible for developing/implementing them? (not applicable to drivers)

A. Automation developer/technology Provider
B. Logistic consumer/Industry
C. Policymakers
D. State/Federal DOTs
E. Not an effective solution

	A	B	C	D	NE
Developing user-friendly interfaces and systems					
Providing strong technical support for users					
Creating regulations and standards to ensure proper testing and certification of automated trucks					
Providing clarity on laws of road operation, liability, and adequate infrastructure					
Investing more in developing new automated truck technologies for safety, fuel efficiency, etc.					
Encouraging collaboration between truck manufacturers and automation developing companies					
Encouraging to invest in alternative fuels for trucks					
Creating policies to support automation adoption- tax savings, other benefits, etc.,					
Developing new licensing criteria for automated trucks other than CDL					
Creating policies to protect rights of drivers by pre-informing about level of automation being purchased/implemented					

Are there any other expectations/ potential solutions to encourage the adoption of automation and who should be responsible for that (in terms of policies, incentives, investment benefits, etc.)?

What are the different steps you are taking or willing to take in the future to prepare the workforce for an era of truck automation?

What are the different steps you are taking or willing to take in the future to prepare the workforce for an era of truck automation?

- o Not interested or not my responsibility
- o partnering with universities for developing training programs
- o guiding logistics users on required new skills
- o investing in driver retraining or education
- o analyzing or researching new roles to retain the existing workforce
- o Other (key in)

What new jobs will be created as a result of technological innovations and what skills will be required for these jobs?

What new jobs will be created as a result of technological innovations and what skills will be required for these jobs?

- o Short-haul driving jobs with increased efficiency and demand for freight
- o Instead of driving, jobs related to supervision of technology, loads and dealing with clients
- o Remote driving jobs with software/technical knowledge
- o Vehicle mechanics with additional software skills required to handle such vehicles
- o Supervision/Managing new ports created to transfer trailers between drivers and automation
- o More hospitality related jobs with increased trailer transfer ports
- o Driving instructors with basic vehicle software/systems knowledge
- o Other (key in)

Would you be willing to invest in technology (probably for higher costs) that allows human intervention at any time during extended driving operations?

- o Yes
- o No
- o May be in future

Could the hourly rate of drivers be reduced if they are not active drivers? (The driver is inactive on highways or mid-mile and drives only in local streets)

- o Yes
- o No
- o May be in future

Would trucks carrying dangerous goods/materials be allowed to travel closely together?

- o Yes
- o No
- o May be in future

Please provide any other information (concerns/suggestions) you feel would be relevant to the implementation of autonomous road haulage for example your expectation in terms of policies, incentives, engineering etc.

Assuming promising road safety technology, which scenario of platooning do you prefer the most, if any?

- o I oppose the idea of platooning & vehicle automation
- o May be in future

- Human-Human Platooning, drivers in all trucks
- Human in lead and (1-2) drone trucks following
- Remote operation of single/multiple trucks
- Auto-pilot like flights, driver in truck as supervisor
- Self-driving trucks without driver only for highway operations
- Completely self driving without any drivers

Appendix B: Thematic Analysis

Table B.1: Excerpts from the Focus Group Discussion Coded into Four Themes

Concerns	Benefit	Solutions/ Action plan	Readiness for scenarios
safety of the technology comes to the forefront and having it proven technology that produces a safe outcome is something that would be of main concern.	if we are experiencing a shortage of truck drivers,	regulation enforcement ties into the safety piece, it may not be KDOT, it may be law enforcement, more so on regulation enforcement, but that's a needed tool for to help maintain the high safety levels	If an instance were to happen where there was a truck stalled out, had a crash, it had something else was stopped on the side of the road for other reasons. Any number of things similar to what you would typically see for a human license and then setting that criteria for the ongoing training.
the efficiency of such vehicles	environmental impact	adequate laws that kind of goes into the regulation enforcement side of things	first scenarios the one that's gonna happen the most readily without as much resistance because you've still got people in the cab of the truck actually driving or helping doing the driving.
from our standpoint for as a transportation agency, an owner operator of the roadways, essentially I think our main concern again is xxx had mentioned it, it is the safety of the traveling public on that roadway and the maintenance of that roadway. How do we do that?	not a job loss situation, but a fulfillment of jobs that they can't fill right now.	education as to how to work in drive around platooning vehicles, merging with them, passing them on, umm, two-lane highways…It's an education.	working with industry and really understanding how we can make an impact and what everybody's role is would be the next key step
I think that's where my concern is these two-lane highways that we have in the state of Kansas and making sure that people drive safely with platooning	an opportunity to assist with the current issue	technology, it's more of a this could be a solution to a current problem	you can't necessarily say one job opportunity is better than the other …. a delicate balance to find and I think it's not necessarily again

			alright within the departments.
I know there's that flip side to this conversation where there are a lot of drivers out there that are gonna be resistant because they feel they're going to be replaced with a computer or technology and therefore would be put out of a job.	Recruitment for truck drivers by or for younger truck drivers by the use of technology and it being more attractive to the younger generation to actually drive in the truck if they're able to use technology.	looking for other opportunities, to train workforce that is currently doing that, looking into how you might do it in the future or drive or operate vehicles in the future by way of remote driving.	the partnering and just further analysis and that with not just universities, but also just with all the stakeholders to make sure that we've got the best path forward for uh safe piloting operations and potential future just operations after a pilot are probably the most important steps that I see.
that is the labor workforce as to how they would be receptive of those options. A lot of people maybe would just prefer to continue driving the vehicle itself.	opportunities to fill uh jobs that you can't fill right now.	lot of that has to be vetted with the group that you know primarily affecting and that is the labor workforce as to how they would be receptive of those options.	DMV, they would be a critical piece to this as far as setting up licensing criteria and so there would be a need to have that discussion amongst the different stakeholders for what is required
back to the safety aspect and how if that technology, it can be considered as reliable as having a human driver	environmental impact, quality of jobs	change in the job itself with this technology could, umm, attract different groups… we've seen historically for this type of work force. So I think it could create an opportunity for growth in this part of the country	I think they (laws/ bills) anticipate, you know, as more technology gets placed in these vehicles, there could be additional requirements to obtain a license to operate them.
operators that are being trained for this type of automated truck operation have the proper training to know what to do in an instant.	Technology can help in achieving fulfillment of jobs rather than creating job problems	I think a lot of this is gonna be tied more to the industry as well as just the commercial motor vehicle operators themselves, as technology evolves.	I might say that it's kind of us taking the crawl, walk, run sort of scenario you gotta learn slowly how to do this before year's ear off and doing it. Kind of without guardrails but you're not without guardrails. You're you're gradually

			expanding out the guardrails and the safety aspect to make sure that it's there so that you know it feels safe to the best of the technology and the human drivers' abilities.
a combination of the two where you CDL license driver needs to know how to operate a larger, heavier load vehicle. Know the capacity or the abilities of that vehicle to be able to start and stop turning maneuvers, rules of the road.	we've already got legislation that was enacted.	yeah, there would be further types of training or criteria that would be needed for an operator to know how to operate a commercial motor vehicle. That's automated, that that you're not actually in the cab of.	But we are not currently considering anything at the moment from a policy adoption perspective or looking to create any policies on the
safety aspect going back to the safety aspect, you need to know that this operator, whether they're in the cab or whether they're in an office driving that vehicle		the language in the existing bill says the conventional human driver must possess a valid driver's license for the type of vehicle used.	If you've got driver A, B or C out on the road and they see a commercial motor vehicle without a driver in the cab, there's definitely a bit of a shock factor
Again, the legislation that just was introduced and passed here a couple of years ago, I don't know that I'm aware of any other policies currently that the agency is really considering tied to the supportive audit adoption, umm, tied to tax savings or benefits or other items,		not that we wouldn't be uh open to having that dialogue or discussion if there were ideas that wanted to be there that someone wanted to bring up.	Uh on the on the highways, I think some of those things are potential barriers or hurdles that will have to be overcome while moving forward.
it has to be registered as a driver's, you know, driverless, capable vehicle… I don't see anything about identification on the vehicle for other drivers		there's gonna need to be a continued partnership and an ongoing dialogue with several different stakeholders	we're still studying it ourselves and industry will drive a lot of this … I do see it as a future outcome

I think that that legislation doesn't set forth maybe necessarily policies, but does talk about. ..For a pilot operation would have to have some sort of messaging associated with it potentially to help the public understanding it,		I mean this legislation, a big part of it is creating that autonomous Vehicle Advisory Committee to deal with some of these issues	Gets to the point where people feel comfortable with the use of it.
there is that idea that that the general driving public does need to have some level of awareness of what's happening because you know there is definitely a concern.		the idea of designing and initiating campaigns for public awareness about the technology needs to be evaluated and discussed	I think there's going to be a slow path forward in some cases here on this.
likely resistance from drivers to accept change, or fear job replacement. Acknowledgment for the need of appropriate laws by policymakers. However, more emphasis is required on law enforcement authorities than policymakers to ensure a smooth adaptation of technology.		education to the public and we are still working on educating the public on how to work with regular size or tractor trailers that are driven by humans and so that education as to how to work in drive around platooning vehicles,	I think for Kansas, it's most likely the first scenario is gonna be the one that's most likely going to be adopted or or put to to test first
I think it was two years ago, we have yet to see any real push from industry or companies that wanted to do this that introduced this legislation to move forward to say hey, we wanna try something, where's the IT is there an advisory committee established we'd like we have this proposal plan to go forward that just that has not happened yet.		the plan for the Advisory Committee or anybody to consider, they could very well test this on their own private property. So, and I think that was something that was being considered by some companies where they have logistics parks that could be all private, privately owned where they're moving freight from one side of the park to the other.	it would probably be scenario one to start with.

		one thing when this legislation was proposed was distribution center to distribution center short runs that they have a specific route... but it would be on public roads… shorter distance and possibly even smaller vehicles or trucks.	
		KDOT participation on that legislative committee	

Table B.2: Frequency of Keywords Repeated During the Focus Group Discussion (in Word Cloud)

Keyword	Frequency
Fear	1
Resistance	2
Legislation	7
Driver Education/awareness	6
Trust & Reliability	2
Future technology	3
Safety	9
Jobs	8
KDOT roles	3
Platooning & automation	3
Policy	3
Pilot Testing	4
Licensing	5
Opportunities	2
Industry collaborations	6
Awareness	2
Scenario 1	4
Law enforcement	2
Concerns	5

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