DOCK DOOR

# 2024 State of Supply Chain Gap Analysis Report:

## Review of Stakeholder Needs

## for Achieving Supply Chain Resiliency

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2024 State of Supply Chain Gap Analysis Report: Review of Stakeholder Needs

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DISTRIBUTION/AVAILABILITY STATEMENT

This document is available publicly on the VTTI website (vtti.vt.edu) and available to the D2D Coalition members through the member SharePoint site.

KEYWORDS

Artificial intelligence, automated vehicles, automated-connected-electrified technologies, coalition building, data sharing, freight decarbonization, freight optimization, alternative fuels, last mile delivery, logistics, socio-technical systems theory framework, STEM education, supply chain, supply chain resiliency, supply chain visibility

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# List of Acronyms

| | |
|---|---|
| ACE | automated, connected, and electrified |
| AI | artificial intelligence |
| AVIA | Autonomous Vehicle Industry Association |
| BVLOS | beyond-the-visual-line-of-sight |
| CAV | connected and automated vehicles |
| D2D | Dock to Door |
| DEIA | diversity, equity, inclusion, and accessibility |
| EV | electric vehicles |
| EVSE | electric vehicle supply equipment |
| FAA | Federal Aviation Administration |
| FCC | Federal Communications Commission |
| FHWA | Federal Highway Administration |
| FLOW | Freight Logistics Optimization Works |
| MHDV | medium- and heavy-duty vehicles |
| ML | machine learning |
| NEVI | National Electric Vehicle Infrastructure |
| NHTSA | National Highway Traffic Safety Administration |
| PACT | Powering America's Commercial Transportation |
| PAVE | Partners for Automated Vehicle Education |
| STEM | science, technology, engineering, and mathematics |
| STS | socio-technical systems |
| UAS | uncrewed aircraft systems |
| USDOT | United States Department of Transportation |
| V2X | vehicle-to-everything |
| ZE | zero-emissions |
| ZEF | zero emission freight |

# About the Dock to Door (D2D) Coalition

This gap analysis report was performed by Virginia Tech Transportation Institute researchers who are members of the Dock to Door (D2D) Coalition. Many of the member organizations participated in the research process through interviews and focus groups via their organizational representative to share their firsthand experiences with supply chain efforts. The D2D Coalition event in May 2024 marked an opportunity for members to engage with one another, learn more about the Coalition structure, and weigh in with their perspectives on supply chain challenges and opportunities. We at the Virginia Tech Transportation Institute framed the focus group portion of our D2D Coalition event around the gap analysis performed previously, with the event offering an opportunity to ground truth and refine the gap analysis. The output of the meeting was a summary of the challenges and potential solutions discussed during the roundtables and a broader understanding of the members' priorities in addressing each gap area.

**Who we are:** The D2D Coalition is a Virginia Tech-led partnership initiative of 85+ member organizations, and growing, who have come together to address today's most pressing supply chain challenges (Figure 1). The member organizations make up a diverse coalition of global companies, sole proprietors, and everything in between from industry, higher education, small businesses, non-profits, advocacy groups, and governments. The existing, loosely connected regional ecosystem of manufacturers, operators, research institutions, and tech suppliers is well positioned to grow into a national model for the efficient, resilient, equitable, and sustainable transport of goods from dock to door. Together, the D2D Coalition works towards supercharging this nascent ecosystem in one of the most economically challenged areas of the U.S., sparking equitable innovation in freight transportation, and providing high-quality jobs and access to emerging tech skills in communities long excluded from the tech economy.


**Figure 1: D2D Coalition members.**

**Our "Why?"** We envision a world where goods move seamlessly and reliably from dock to door through a fully connected, resilient, environmentally sustainable, and equitable transportation system. The term "dock" is meant to represent the originating destination once goods are in the United States. This can refer to maritime port facilities, inland ports, or the loading dock of a warehouse. "Door" refers to the destination of a product, whether warehouse, retail location, front porch, or elsewhere. Our mission is to develop an integrated approach for modern freight transport by galvanizing members to confront and resolve the critical and problematic supply chain issues.

**What are we doing?** Together, Coalition members are creating a model of freight transport to enhance efficiency, certainty, sustainability, and equity in the journey of a package from dock to door. Using a collaborative model of a sustainable partnership platform, Coalition members facilitate innovation and advancement towards solving critical supply chain challenges in a way that expands and creates product- and service-based industries to grow the region.

**How do we address supply chain issues?** As a first step, the D2D Coalition must overcome serious barriers to the reliable transport of goods.

Collectively, the D2D Coalition seeks to address the challenges coalition members and end users are facing by:

- building a data platform that can drive efficiencies in freight flow connectivity and increased visibility in the transport of goods;
- creating real-world ground and air test beds for development, testing, demonstration, and deployment of connected and automated vehicles for last-mile deliveries;

- advancing vehicle decarbonization along all aspects of the supply chain to decrease air emissions for improved sustainability and quality of life; and
- integrating workforce development with use-inspired research to keep pace with the digital economy.

These programs are integrated with workforce development, translation of innovation into practice, and coalition-building to grow a thriving, diverse, and self-sustaining innovation ecosystem that catalyzes regional economic development and creates a modern blueprint for supply chain resiliency.

**Where do we work?** The selection of the D2D Coalition anchor region (Figure 2) in which to develop member programs of service focuses on critical freight network corridors to address the challenges facing transportation of goods on a large scale. The anchor region, predominantly spanning rural areas with small cities from central Appalachia into North Carolina, Tennessee, and Virginia, is uniquely suited to become an ecosystem for supply chain innovation that could be scaled as a national implementation model. Large portions of the region are economically depressed due to a former reliance on now declining industries, and many marginalized residents lack equitable access to goods and services. While not enjoying the economic prosperity of tech-heavy metropolitan areas, the region's critical freight networks and port infrastructure position it to emerge as a hub of innovation in modern freight, as do its strengths in advanced vehicle manufacturing, education, freight logistics, and large-scale technology testing and development. While the regional program is well poised for innovation, a collective and purposeful effort is required to overcome key challenges (such as a lack of wireless connectivity, the need for data sharing, limited power availability at key strategic locations, and labor shortages). Such an effort is also necessary to advance product- and service-based innovations that will grow the region's nascent advanced mobility ecosystem, establish the regional workforce needed for the future of freight, and form a national implementation model for supply chain innovation.

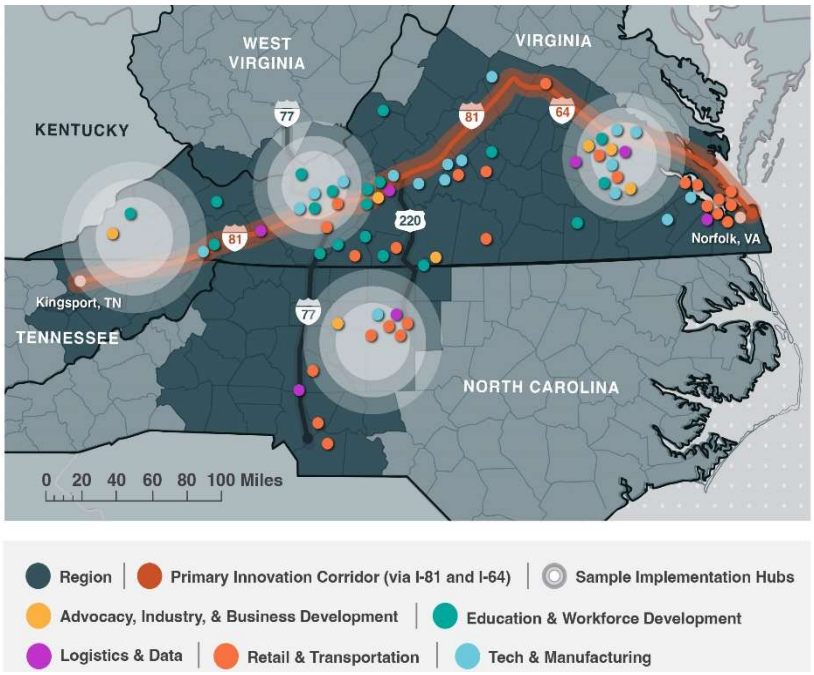


**Figure 2: D2D Coalition region showing the location of key members.**

**What is the relevance of the gap analysis report to the D2D Coalition?** The purpose of the D2D Coalition is to create an ecosystem of partners who work together to deliver a resilient,

efficient, environmentally sustainable, and equitable supply chain. Throughout this process, we have gathered information through a gap analysis to identify both strengths and opportunities for growth. The aim of this effort is to identify meaningful opportunities to improve the supply chain, build strategic partnerships, and establish a leadership role in regional supply chain program development that could ultimately be scaled to a national implementation model. This gap analysis provides the background for a variety of sources and frameworks that can inform solutions to today's supply chain challenges both for the D2D Coalition and for entities at a national scale.

# Executive Summary

## Introduction

As detailed in the 2023 Gap Analysis Report,[1] our nation's supply chain continues to recover and improve its fragility from the rippling effects of natural disasters, a global pandemic, and international conflicts in the last few years. Some of the lasting effects from these unexpected events remain and are evolving the state of the supply chain as a whole as new approaches and risk mitigation measures are taken to strengthen the chain's resilience. There is not a sole locus for these rippling effects—rather, our nation's supply chain is a complex web of interconnected actors and subsystems. In order to increase supply chain resiliency, this complex web of actors must address the disjointed logistics, worker shortages, and congested roads which threaten our environment, economic prosperity, equity, human health, and national security. The 2024 State of Logistics report provides a renewed look into trends occurring within industry and government regarding the transport of goods and current state of challenges to be solved, including stakeholder interests and concerns.

## Objective

A bold, comprehensive program is needed to improve weak links in the supply chain to move goods across all delivery points—rural or urban, near or far from a port or highway, easy or difficult to navigate, or in prosperous or economically challenged areas. As a first step towards developing programs with collaborative solutions, supply chain stakeholders must first have an informed understanding of the gaps that exist, know whether those gaps have changed, or if a former gap is no longer a relevant challenge. The objective of this annual iterative research is to assess and provide an informed understanding of the state of supply chain gaps and find potential solution pathways.

## Methods

Similar to the 2023 Gap Analysis exercise, this research was conducted using a combination of a literature scan (e.g., academic literature, current events, market projections, federal investments with a focus on updates since 2023) and gathering stakeholder feedback through focus groups.

To form a clearer research pathway towards collective solutioning, the 2024 analysis collapses several of the categories from the 2023 Gap Analysis with redundancies under four umbrella topic areas:

1. Data Sharing Platform

[1] Bedwell, K., Williams, G., & Blanco, M. (2023, November). *State of supply chain gap analysis report: Survey of stakeholder needs for achieving supply chain resiliency.* https://www.vtti.vt.edu/projects/supply-chain.html

2. Connected & Automated Vehicles
3. Sustainability & Decarbonization
4. Workforce Development & Community Engagement

Many of the suggested solutions towards improving the movement of goods are trending towards technologies such as data exchange, artificial intelligence, and automated, connected, and electrified vehicles. As such, this research analyzed the gaps from stakeholder feedback from a socio-technical systems (STS) theory framework, which frames how the introduction of technology affects multiple subsystems. This allows for stronger program development of solutions, whether these lie in environmental subsystems (e.g., policy change and advocacy needed), supply chain design and management subsystems (e.g., stronger ties or standardization of approach between actors), technological subsystems (e.g., research and development needed), or personnel (e.g., workforce development or talent pipeline needed). Using the STS theory framework, a qualitative analysis approach was used to synthesize and analyze the focus group data. More details can be found in the subsequent sections.

## Results

Compared to the 2023 Gap Analysis findings, technological barriers, in terms of more research and development, were viewed as the least common gap. Barriers to implementation in this analysis were more often related to lack of policy and infrastructure to enable technologies or decarbonization efforts, workforce shortages and lack of educational programs for projected industries, disjointed logistics, and lack of coordinated shared data between actors. A coordinated approach to solving these barriers will require both public and private partnerships within the supply chain.

### *Key Takeaways*

***Data Sharing Platform*** development priorities were as follows:

- Very few use-cases need the level of detail provided by real-time tracking. “Near-term” tracking may be more useful, as the end-user wants to know the probable time of arrival, and the real-time confidence of that probability as the delivery process progresses.
- Data should include some level of predictive modeling and be interpreted into actionable information. This will allow data to be used and analyzed to the fullest for other supply chain focus areas.
- Companies without dedicated IT infrastructure may face unique equity challenges. Users will need clear training/webinars on how to use the data as well as clear data sharing agreements on how the data is used and communicated.

***Connected & Automated Vehicle*** top three challenges were as follows:

- Public perception and acceptance of automated vehicle technology due to safety concerns or fear of job reductions/replacement.
- Shortages in qualified workforce/lack of workforce development regarding automated vehicles.
- Lack of a national framework for automated vehicle policy, regulations, beyond-the-visual-line-of-sight limitations, and Federal Communications Commission spectrum issues.

***Sustainability & Decarbonization in Freight*** top three challenges were as follows:

- Lack of trained workforce to service clean fuel transportation options.
- Overall cost of new, more efficient equipment.
- Insufficient infrastructure for electric vehicle (EV) charging needs.

***Community Engagement*** top three challenges were as follows:

- Public misperceptions about EV batteries and hydrogen fuel.
- Public misperceptions about climate change can be perceived as political (battery safety, climate change, automated vehicles, etc.).
- Community acceptance of new hubs, facilities, and other infrastructure.

***Workforce Development*** top two challenges were as follows:

- Training needs to evolve to meet the skills required for future technologies (mechanics, installers, automated vehicles, and infrastructure).
- Increased access is needed to training and job opportunities outside of the traditional K-12 to college trajectory (e.g., earn-while-you-learn programs, trade schools, second-chance employees).

# Introduction & Background

As a package moves from its arrival at the dock (inbound origin point), to its end destination of the door, a complex and connected sequence of logistic activities occurs in between. Oftentimes, this same package is processed between many actors, whether on the intermodal transfer to the long-haul journey from the port, during the sorting and processing stage in a warehouse, as part of a short-haul delivery to a retail store, or as part of the transfer or delivery to a customer's door. Though these actors operate within their own silos, any step that is disrupted internally or externally is felt at the next step by other actors. This is often referred to in the supply chain space as the "ripple" effect, where a breakdown at one node can trigger failures at other nodes. There is some social network theory research which suggests strengthening the ties between these nodes may enhance supply chain resiliency. Resiliency is the ability for these nodes to adapt to, or recover from, unexpected disruptions to resume operations. Research suggests that the strengthening of supply chain nodes relies on unification through tools of communication, cooperation, and integration of partners around a common goal.[2,3,4,5,6]

## Objective

The goal of this gap analysis is to provide a formal process by which to frame supply chain issues. This includes identifying relationships among supply chain stakeholders; stakeholder relationships to the movement of goods; and discovering stakeholder perceptions of gaps in research, infrastructure, capabilities, and policies to enable supply chain transportation innovation.

The 2023 Gap Analysis Report[7] made clear the fragility and state of our nation's supply chain considering recent international conflicts, natural disasters, and COVID-19. While the supply chain continues to recover and improve, there are still lasting effects at every level. It is

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[2] Johnson, N., Elliott, D., & Drake, P. (2013). Exploring the role of social capital in facilitating supply chain resilience. *Supply Chain Management: An International Journal, 18*(3), 324-336.
[3] Mandal, S., Sarathy, R., Korasiga, V. R., Bhattacharya, S., & Dastidar, S. G. (2016). Achieving supply chain resilience: The contribution of logistics and supply chain capabilities. *International Journal of Disaster Resilience in the Built Environment, 7*(5), 544-562. http://dx.doi.org/10.1108/IJDRBE-04-2016-0010
[4] Wei, H. L., & Wang, E. T. (2010). The strategic value of supply chain visibility: increasing the ability to reconfigure. *European Journal of Information Systems, 19*(2), 238-249.
[5] Wieland, A., & Wallenburg, C. M. (2013). The influence of relational competencies on supply chain resilience: A relational view. *International Journal of Physical Distribution & Logistics Management, 43*(4), 300-320.
[6] Linkov, I., Carluccio, S., Pritchard, O., Ní Bhreasail, Á., Galaitsi, S., Sarkis, J., & Keisler, J. M. (2020). The case for value chain resilience. *Management Research Review, 43*(12)
[7] Bedwell, K., Williams, G., & Blanco, M. (2023, November). *State of supply chain gap analysis report: Survey of stakeholder needs for achieving supply chain resiliency.* https://www.vtti.vt.edu/projects/supply-chain.html

important to address disjointed logistics, worker shortages, and congested roads, which threaten our environment, economic prosperity, equity, human health, and national security.

The 2024 State of Logistics report provides, on a global level, many examples of the fragmentation creating a domino effect on the cost of shipping and logistics complexities in the U.S. over the last year. The growing intensity of military conflicts have disrupted vital maritime corridors such as the Red Sea channel and have increased prices on the transport of goods as crude oil prices rise due to conflicts in the Middle East. In addition, the Panama Canal is experiencing historically low water levels due to drought from growing instabilities related to climate change.[8]

The decline in consumer demand since the pandemic has created an unpredictable supply and demand cycle for all modes of transport. Lowered demand combined with increasing operating costs has put a strain on the supply chain and the economy as whole. Retailers with excess inventories may be considering how to repurpose the workforce towards automated technologies to align with lower consumer trends. Third party logistics sectors face challenges of low freight rates and excess capacity and are turning towards different investment models in capabilities and technologies to stay afloat. E-commerce-related transport continues to grow compared to other modes of transport, but in the fourth quarter of 2023 experienced the lowest rate of any quarter seen since the 2008 Great Recession.[9]

There is not one source to pinpoint for these rippling effects, but rather there exists a complex web of interconnected actors and subsystems. Strengthening ties between the diverse links in the supply chain is a first step towards increasing resiliency and developing collaborative solutions. However, supply chain stakeholders must first have an informed understanding of the gaps that exist, whether they have evolved, or if a particular gap is no longer a relevant challenge. Challenges were viewed in terms of their relationship to the transport of goods, the viability of new technology solutions, and the resulting economic and social justice (diversity, equity, inclusion, and accessibility factors) impacts to communities.

Using a combination of a literature scan and stakeholder focus groups, the objective of this annual iterative research is to holistically analyze the supply chain from a socio-technical systems (STS) theory framework to assess the state of supply chain gaps and find solution pathways. This is especially useful in the movement of goods as technological solutions such as data exchange; artificial intelligence (AI); and automated, connected, and electrified (ACE) vehicles continue to increase in popularity.

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[8] Kearney. (2024). *CSCMP's 35th annual state of logistics report*. Council of Supply Chain Management Professionals & Penske Logistics.
[9] Kearney. (2023). *CSCMP's 34th annual state of logistics report*. Council of Supply Chain Management Professionals & Penske Logistics.

## Methods and Structure

The literature scan exercise is an annual exercise that uses a combination of academic literature, current events, market projections, federal investments, and stakeholder feedback to determine what supply chain gaps exist and what recommended approaches may be needed to establish a more resilient and secure supply chain.

Using the knowledge gleaned from the 2023 Gap Analysis Report, the research process was executed in two steps: a literature scan and stakeholder focus groups.

Based on the recommended focus areas from the 2023 Gap Analysis Report, the purpose of the literature scan was to identify the top supply chain challenge areas, current strategies of both government and private industry to address those areas, and trending suggestions of technological solutions. The literature scan used a combination of academic sources (with preference for the last year of 2023, with a few exceptions to include works from 2021–2022), current events, federal policy and investments, and market projections to inform this work.

The findings from the literature scan were then used to develop a validation priority ranking exercise and discussion questions for any new stakeholder focus groups challenges. Using the STS theory framework, a qualitative analysis approach was used to synthesize and analyze the data. More details can be found in the subsequent sections.

## 2024 Gap Analysis Scope

For consistency with the 2023 Gap Analysis report[10], the scope of this research in relation to the supply chain is limited to transactional operations at the transportation level, or the logistics within the movement of goods (rather than the sourcing, processing, or ordering of goods). This is otherwise referred to as the inbound-outbound logistics perspective.[11]

The following summary of stakeholder needs builds upon the data collected during the 2023 Gap Analysis report. As such, this year's exercise evolved from a scoping exercise into a validation exercise. The 2023 research casts a wide net to determine all possible topic areas within the scope of analysis. The 2023 focus groups were divided into the seven categories below:

1. Transportation Infrastructure
2. Logistics
3. Data Management

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[10] Bedwell, K., Williams, G., & Blanco, M. (2023, November). *State of supply chain gap analysis report: Survey of stakeholder needs for achieving supply chain resiliency.* https://www.vtti.vt.edu/projects/supply-chain.html

[11] Jenkins, A. (2020, December 13). *Guide to inbound and outbound logistics: Processes, differences and how to optimize*. Oracle NetSuite. https://www.netsuite.com/portal/resource/articles/inventory-management/inbound-outbound-logistics.shtml

4. Sustainability
5. Automated Vehicle Technology
6. Advocacy & Outreach; Policy & Regulations
7. Workforce Development; Economic Development

The 2024 Gap Analysis report shares the same purpose as the 2023 Gap Analysis exercise—it serves as research for a development tool to form future program areas. Program areas are intended to unite diverse supply chain actors around common goals to create collaborative ties and increase supply chain resiliency. The data from the 2023 Gap Analysis made it clear that the seven categories shared many of the same gaps, and the report suggested solutions and barriers to implementing those solutions. For example, the data management and logistics topic areas both fell under a collective solution of developing a data sharing platform. As another example, the transportation infrastructure and policy topics permeated both automated vehicle applications (connected vehicles) and charging infrastructure for decarbonization, and the latter topics were thus re-incorporated accordingly into the former. For a final example, a topic that transcended all seven focus groups was the need for community engagement to address public perception, public education, and community outreach; this came up more than economic development, which was absorbed into other topic areas. Diversity, equity, inclusion, and accessibility factors were embedded into all topic areas, with the challenges often related directly or indirectly to these factors. To form a clearer research pathway towards collective solutioning, the 2024 analysis collapses several of the categories with redundancies under four umbrella topic areas, which could potentially be transformed into program areas in the future:

1. Data Sharing Platform
2. Connected & Automated Vehicles (CAVs)
3. Sustainability & Decarbonization
4. Workforce Development & Community Engagement

## Socio-Technical Systems (STS) Theory Framework

An STS theory framework is commonly used within engineering practices to understand how different facets of an organizational system function interdependently. It is a useful framework specifically in the case of deploying new technologies to ensure joint optimization, efficiency, and resiliency between subsystems. In a supply chain setting, the STS framework is divided into

the four subsystems of (i) Environmental, (ii) Technological, (iii) Supply Chain Design and Management, and (iv) Personnel, all of which are interconnected.[12, 13, 14]

The "Environmental" subsystem is the external world in which the supply chain operates. Disruptions to this subsystem are largely unforeseen or uncontrollable events or disasters that happen due to factors from other systems that have a ripple effect. Examples of this may be pandemics causing global shutdowns, cybersecurity attacks, shortages or surges of inventories and customer demand, policy changes, or international conflicts.

The "Technological subsystem" of the supply chain ecosystem relates to factors that enable the deployment of new technologies or maintenance of pre-existing technologies. This could be factors that affect deployment ability or efficiencies such as sensors, information technologies, tools, techniques, performance or capital expenses.

The "Supply Chain Design and Management" subsystem is most concerned with the interaction of actors, their management models, and communication of information. How that information, or data, is standardized, the flow of processes, or how partners collaborate all have an effect on this subsystem. Challenges to any level of this process may create disruptions in actors' abilities to forecast, optimize, or function effectively, especially in response to unforeseen environmental subsystem disruptions.

Lastly, the fourth "Personnel" subsystem in a supply chain setting focuses on the workers that enable the supply chain to function. Any type of worker, whether a logistics operator, a truck driver, or educator, plays a role as an actor within this subsystem. This subsystem may experience disruptions due to such factors as workforce availability, job satisfaction, or stumbling blocks along the pipeline development of new jobs needed for technology deployment within the supply chain.

A visual representation of each of these subsystems and their corresponding examples can be found below in Figure 3.

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[12] Baker, S., Bowman, D., Nakata, A., & Hanowski, R. J. (2008). *Focus groups in support of an operator drowsiness monitoring system* (Paper No. 08-1781). In Transportation Research Board 87th Annual Meeting, Compendium of Papers (DVD). Transportation Research Board.
[13] Hendrick, H., & Kleiner, B. (2001). *Macroergonomics: An introduction to work system design*. Human Factors and Ergonomics Society.
[14] Yurtseven, M. K., & Buchanan, W. W. (2013, March). *Socio-technical system design: A general systems theory perspective*. VIII International Conference on Engineering and Computer Education (COPEC), Luanda, Angola.

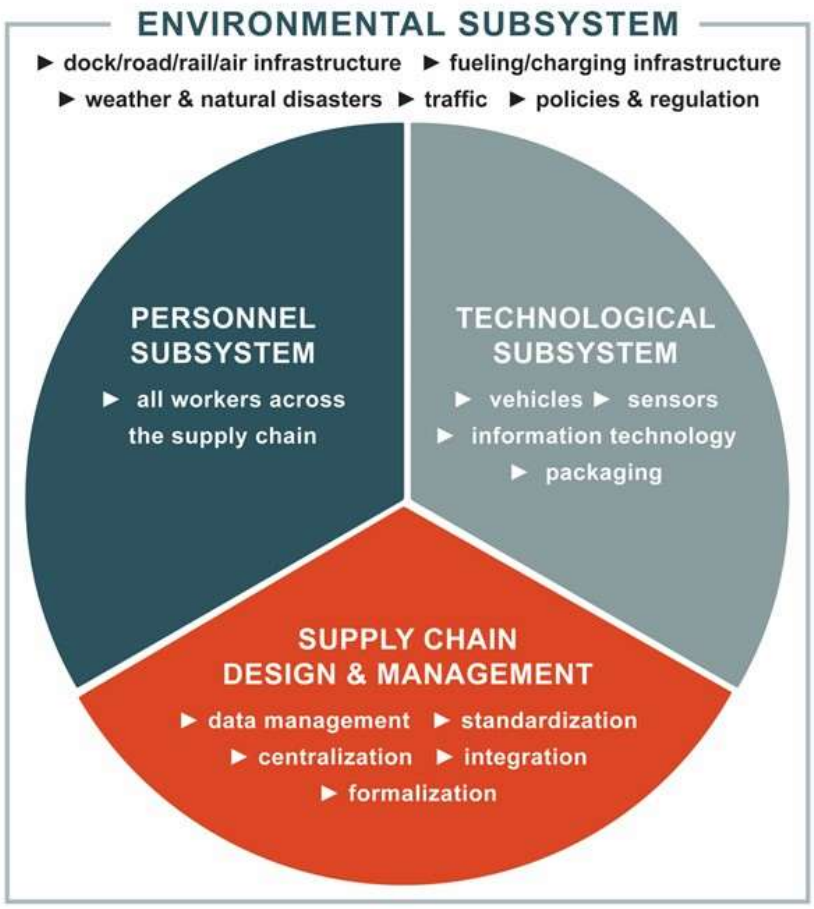


**Figure 3: Supply Chain Based Subsystems Using STS Theory Framework**

In sync with the 2023 Gap Analysis report, the STS framework is used as the foundation for the focus group data analysis research methods. Using the scope of the supply chain from an inbound-outbound logistics perspective, it's important to survey the challenges and needs of the transport of goods within the topic areas from a holistic perspective of all four subsystems.

## Literature Scan

As discussed in subsequent sections in more detail, the literature scan provides background information that projects the future of supply chain activities to revolve around deployment of new technologies. The literature scan findings used to validate the 2023 Gap Analysis report findings remained an issue and informed the structure and framework for the next step of the research process: stakeholder focus groups. As described in the Scope section above, the focus of this research was categorized into four main topic areas:

1. Data Sharing Platform,
2. Connected & Automated Vehicles,
3. Sustainability & Decarbonization, and

4. Workforce Development & Community Engagement.

The purpose of the literature scan was to identify the top supply chain challenge areas and present-day recommended strategies and/or suggested technological solutions. The literature scan used a combination of academic sources (generally limited to the last few years from 2021–2024); a current event scan (news media outlets and supply chain and logistics reports from 2022–2024); a scan of recent federal and state policy, investments, and strategy (supply chain related regulations, infrastructure and sector investments); and market projections (projected growth rates and impacts of ACE technologies for the next decade).

## Data Sharing Platform

Driven by issues exposed during the pandemic and further emphasized by the effects of the recent collapse of the Francis Scott Key Bridge in Baltimore, MD on port activity, historic federal investments in American port infrastructure and freight networks have the potential to transform our supply chain. However, realizing the full benefits of these investments will require new data standards for goods movement. This will provide the supply chain with the visibility and transparency needed to ensure that all organizations have information to optimize their operations. This includes basic standards such as defining what "arrived" means at each different step for different supply chain actors.

The current state of the regional flow of movement of goods suffers from fragmentation and lack of visibility into each node of the supply chain. Unfortunately, in the U.S., there is no national access point for data exchange and data formats and interfaces differ depending on the supply chain actor.

Private industry players Freightos and Flexport have attempted to address this gap through digital platforms by increasing connections between shippers, freight forwarders, and airlines for more seamless communication and logistics planning.[15]

The federal government has also tried to address this gap through initiatives such as Freight Logistics Optimization Works (FLOW), which collects data from partners for supply and demand management based on cargo assets. The approach is more of a macro-level analysis of retroactive data and does not involve "real time" or "near time" data to enable rapid decision-making in supply chain operations. The FLOW initiative also focuses on data from West Coast ports exclusively, and gaps may differ for the East Coast.[16] The FLOW initiative strategy has had success in its first 2 years and has since expanded in scope from container import volumes at the port to now capturing data on inland freight ports such as rail terminals and warehouse end-

[15] Kearney. (2024). *CSCMP's 35th annual state of logistics report*. Council of Supply Chain Management Professionals & Penske Logistics.

[16] The White House. (2021, November 9). *Fact Sheet: The Biden-Harris action plan for America's ports and waterways* [Statement/Release]. https://www.whitehouse.gov/briefing-room/statements-releases/2021/11/09/fact-sheet-the-biden-harris-action-plan-for-americas-ports-and-waterways/

destination data to provide a stronger end-to-end view of the supply chain activities.[17] The FLOW founding group that worked towards developing a proof-of-concept comprised 18 participants representing private businesses, warehousing and logistics, chassis, terminals, and port organizations.[18] By August 2022, the number of participants had doubled, and data sharing had begun.[19] As of June 2024, there were 76 members, demonstrating that the initiative is building at scale.[20]

Considerations for challenges around implementing a data-sharing platform, at least for e-commerce exchange, depends on the types of actors interfacing. The trends in the literature show collaborative engagement around information sharing for different purposes depending on the sector. For example, humanitarian organizations often use data exchange platforms as a tool to assist collaborative formations around a public good, such as distributing vaccines during an emergency. Industry exchanges information when it benefits the efficiency or competitive advantage of their operations, oftentimes using a for-profit exchange or subcontracted service.[21, 22] A B2B, or "business to business" e-commerce exchange benefits communication with manufacturers, wholesalers, distributors, and retailers for increased visibility into inventory levels, which helps businesses make stronger decisions during shortages. However, in order to be successful, the data platform itself needs to be supplemented by each party's own internal business management framework.[23]

"Business to Administration," or "B2A," are transactions between companies and government agencies or public administrations. These transactions may be more difficult to synchronize with the security restrictions commonly required for government data but are still valuable as they foster trust through transparency by allowing businesses to have greater accessibility to

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[17] LaRocco, L. A. (2024, March 20). *How Walmart, Target and the White House are tracking consumer demand and inflation in real time*. CNBC. https://www.cnbc.com/2024/03/20/biden-administration-is-expanding-its-real-time-supply-chain-tracker.html

[18] The White House. (2022, March 15). *Fact sheet: Biden-Harris administration announces new initiative to improve supply chain data flow* [Statement/Release]. https://www.whitehouse.gov/briefing-room/statements-releases/2022/03/15/fact-sheet-biden-harris-administration-announces-new-initiative-to-improve-supply-chain-data-flow/

[19] U.S. Department of Transportation. (2022). *DOT, Supply Chain Companies Collaborate to Speed Up Movement of Goods, Cut Costs for Consumers*. https://www.transportation.gov/briefing-room/dot-supply-chain-companies-collaborate-speed-movement-goods-cut-costs-consumers

[20] U.S. Department of Transportation (2024, September). *FLOW Members*. https://www.transportation.gov/freight-infrastructure-and-policy/flow-members

[21] Dubey, R., Bryde, D. J., Foropon, C., Graham, G., Giannakis, M., & Mishra, D. B. (2022). Agility in humanitarian supply chain: An organizational information processing perspective and relational view. *Annals of Operations Research, 319*(1), 559-579.

[22] Brandon-Jones, E., Squire, B., Autry, C. W., & Petersen, K. J. (2014). A Contingent Resource-Based Perspective of Supply Chain Resilience and Robustness. *The Journal of Supply Chain Management*, *50*(3), 55–73. https://doi.org/10.1111/jscm.12050

[23] Marketed Orienteering. (2024, February). *B2B, B2C, B2B2C... C2C, C2B... What do they mean?* https://orienteed.com/en/b2b-b2c-b2b2c-c2c-c2b/

information services. [24] As found in the 2023 Gap Analysis, these transactions could be useful towards informing administrative decisions around infrastructure, such as planning future charging stations, improving congestion reporting systems, or meeting other administrative and regulatory needs and serving a public good or goal.

In the context of goods transportation within the supply chain, data visibility could be a force multiplier of change to vehicle technologies. While supply chain data exists at an individual level, we have yet to see data sharing occur at a systemic level that includes users, businesses, policymakers, and government authorities. Following are some examples of the major challenges impeding this system-wide level of collaboration:[25]

- Lack of a coordinated approach
- Absence of standardization across systems
- Deficiency of clear instructions on how to use and structure data
- Inadequate public funding to source and use available data
- Monetizing vehicle data and analytics considerations
- Shifting landscape around privacy and security of data

This reemphasizes the potential for data-sharing platforms to be a valuable cross-sector collaborative opportunity that ignites diverse sectors to come together. It also shows the importance of a coordinated approach through data standardization processes involving the use of data dictionaries, metadata directories, identity providers, and clear and equitable data-sharing agreements.

## Connected & Automated Vehicles

CAVs are in the early stages of development, accelerated by AI. As they evolve into Level 5 full driving automation vehicles, CAVs will remove the need for, and replace the roles of, human drivers. Public perceptions on the development of CAVs rely significantly on general information gathered from the media. Therefore, society tends to misunderstand the stages of development and deployment being incrementally introduced. What is commonly perceived as a "vehicle with the highest levels of automation" creates unrealistic expectations of the industry.[26] Passenger vehicles tend to garner most of the public's attention, while advances across light-, medium-, and heavy-duty commercial vehicles, mass transit, and uncrewed aircraft systems

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[24] Marketed Orienteering. (2024, February). *B2B, B2C, B2B2C... C2C, C2B... What do they mean?* https://orienteed.com/en/b2b-b2c-b2b2c-c2c-c2b/

[25] Coalition for Reimagined Mobility. (2004). *Unlocking a 21st Century Mobility System How to Rethink the Future of Mobility and Restore Leadership in Transportation Innovation* https://reimaginedmobility.org/wp-content/uploads/2024/01/ReMo_Unlocking21stCenturyMobility.pdf

[26] Hamid, U.Z.A., Sandblom, F., Habibovic, A., and Li, B., Letter from the Special Issue Editors, *SAE International Journal of Connected and Automated Vehicles, 4(*1):3–5, 2021, doi:10.4271/12-04-01-0001.

(UASs) are accelerating without as much public notice as infrastructure and government policy evolves.

The passenger car market of automated technologies (advanced driver assistance systems and automated driving systems) could be worth up to $400 billion in revenues by 2035. For connected and automated vehicles, the passenger vehicle market is leading in the number of vehicles and miles driven on public roads.[27]

According to the *Autonomous Truck Market Size 2022-2028 GM Share Report*, the automated truck market exceeded $900 million in 2021 and will exhibit a growth rate of over 17% between 2022 and 2028. The spike in demand and scarce capacity sparked significant investment from venture capital and trucking firms between 2019 and 2021, which has slowed in recent years as the supply and demand drastically countered in the other direction.[28]

The global commercial UAS services market was expected to reach a valuation of $5.8 billion in 2023. During the forecast period of 2023 through 2033, the market for commercial UAS services is expected to exhibit a compound annual growth rate of 14.8%, reaching $23 billion by the end of 2033.[29]

In their 2024 *Saving Lives with Connectivity: A Plan to Accelerate V2X Deployment*, the U.S. Department of Transportation (USDOT) promotes the use of vehicle-to-everything technology (V2X) as a tool for ratcheting annual roadway fatalities down to zero. Using both direct and network communications, V2X provides 360-degree awareness in situations that can challenge human drivers (e.g., around corners, in dense fog) and serves as a conduit for real-time traffic and road condition information.[30] Among other benefits, the report states that the utilization of V2X "…may improve safety, prevent crashes, optimize system performance, enhance traveler mobility and accessibility, improve the efficiency of good movement, mitigate negative environmental impacts, and address disparities in transportation equity."[31]

This initiative provides federal leadership and support for actions that can be taken by a variety of stakeholders to achieve common goals in the short term (2024–2028: Leading Deployers in Operation); medium term (2029–2031: V2X Deployer Community Growth); and long term

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[27] McKinsey & Company. (2023). *Autonomous driving's future: Convenient and connected.* https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/autonomous-drivings-future-convenient-and-connected

[28] Global Market Insights. (2023). *Autonomous truck market size and share: Industry report*. https://www.gminsights.com/industry-analysis/autonomous-truck-market#:~:text=The%20market%20size%20of%20autonomous,the%20transportation%20and%20logistics%20sectors

[29] FACT.MR. (2023). *Commercial drone services market is anticipated to reach US$23.0 billion by 2033: Fact.MR analysis.* https://www.globenewswire.com/news-release/2023/01/06/2584655/0/en/Commercial-Drone Services-Market-is-anticipated-to-reach-US-23-0-billion-by-2033-Fact-MR Analysis.html#:~:text=Drone%20as%20a%20Service%20Market,by%20the%20end%20of%202033

[30] USDOT. *Saving Lives with Connectivity: A Plan to Accelerate V2X Deployment.* August 2024. p. 3

[31] USDOT. *Saving Lives with Connectivity: A Plan to Accelerate V2X Deployment.* August 2024. p. 3

(2032–2036: Nationwide Secure, Interoperable V2X Deployed and Operational).[32] The need for open data formats is noted as a key factor for interoperability success. "V2X connectivity is envisioned as a cooperative system where technology operates as a single system despite various stakeholders, owners, operators, and equipment. Achieving interoperability requires close coordination across government and industry."[33]

Collaboration between various stakeholder groups, which include federal agencies, the automotive industry, the non-federal public sector (e.g., local governments, tribal communities), private entities, and professional organizations, will be important for successful deployment of this initiative.[34]

The National Highway Traffic Safety Administration (NHTSA), the Federal Motor Carrier Safety Administration, the Federal Highway Administration (FHWA), and the Federal Aviation Administration (FAA) are all working to design and implement standards to safely introduce CAVs into the traffic network. There are also advocacy groups making significant gains in steering public policy and public perception. The Autonomous Vehicle Industry Association (AVIA) has a mission to advocate for the safe and timely deployment of fully automated driving technology. Partners for Automated Vehicle Education (PAVE) is a coalition of industry, nonprofits, and academics with the goal of educating the public through conversation about automated vehicles so everyone can play a role in shaping our future.

For UASs, collaboration between industry, academia, nonprofits, and the government has enabled companies such as Walmart, Amazon, and their partners Wing, ZipLine and DroneUp to earn beyond-visual-line-of-sight exemptions from the FAA.[35]

For CAVs to scale in the U.S., positive public perception will drive favorable policy and regulation for stakeholders and growing businesses, ultimately growing the economy and creating jobs. Each of the developing technologies may succeed alone, but poorly deployed systems will ensure they lose together. The U.S. has a big stake in the success of CAVs on the global stage of technological progress, and it would appear we are behind in connected infrastructure. By 2020, China had at least 350K 5G sites compared to fewer than 30K in the U.S.[36] By the end of 2022, China was up to 2.3M 5G base stations, while the U.S. had only

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[32] USDOT. *Saving Lives with Connectivity: A Plan to Accelerate V2X Deployment.* August 2024. p. 7
[33] USDOT. *Saving Lives with Connectivity: A Plan to Accelerate V2X Deployment.* August 2024. p. 8
[34] USDOT. *Saving Lives with Connectivity: A Plan to Accelerate V2X Deployment.* August 2024. p. 16
[35] Daleo, J. (2024, June 10). *Walmart to introduce app-based drone delivery.* FreightWaves. https://www.freightwaves.com/news/walmart-to-introduce-app-based-drone-delivery
[36] Dan Littmann et al. (2018, March). 5G: The Chance to Lead for a Decade, Deloitte, 2018, at page 1; and Accenture Strategy and Accenture Network Practice, Impact of Federal Regulatory Reviews on Small Cell Deployment https://www2.deloitte.com/content/dam/Deloitte/us/Documents/technology-media-telecommunications/us-tmt-5g-deployment-imperative.pdf

100K.[37,38] The development of 5G will be a critical factor in a scaled deployment of CAVs across the country.

States and local municipalities are critical stewards of progress for CAVs. The Michigan DOT's partnership with Cavnue is one example of careful purpose-built integration of CAVs. Cavnue[39] is focused on integrating and developing technologies that will power the world's most technologically advanced roads. The company is partnered with Michigan's DOT for their first connected corridor, which will integrate vehicles with the road infrastructure and all things around it.[40] As another example of local involvement, the Jacksonville Transit Authority broke ground this year on an Autonomous Innovation Center for public transportation.[41] The Philadelphia Navy Yard, Mississippi State University, and Hawaii DOT at Daniel K Inouye International Airport have all launched pilot programs with fully automated public transportation shuttles.[42] The public's perception of CAVs will evolve as their exposure in everyday life increases and the benefits of CAV infrastructure illustrate improved safety, more jobs, and a growing economy.

## Sustainability and Decarbonization

The consensus is clear across all organizations with an environmental stewardship focus, both international and domestic: to prevent significant negative impacts on the human population and the environment, the production of greenhouse gases (GHGs) must be reduced significantly in the short term to ensure average global temperatures do not exceed 1.5°C above pre-industrial levels.[43] To achieve this, GHG emissions must peak by 2025 at the latest, decline to roughly 45% from 2010 levels by 2030, and achieve 100% net-zero emissions by 2050. By contrast, the United Nations is currently projecting an increase in GHG emissions of roughly 9% by 2030.[44] It is apparent that immediate and sweeping changes must occur to counteract current emissions projections.

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[37] GSM Association. (2023, March 26). *GSMA Mobile Economy China Report Forecasts China will be first market in the world to reach 1BN 5G Connections by 2025*.
[38] Mannion, T. (2022, October 25). *What is the impact of the U.S. lagging on 5G*? BDO Global
[39] www.canvue.com
[40] Larson, L. S. (2024, May 29). Testing of I-94 automated vehicle corridor project begins in Michigan. Mlive. https://www.mlive.com/news/ann-arbor/2024/05/testing-of-i-94-automated-vehicle-corridor-project-begins-in-michigan.html
[41] Wanek-Libman, M. (2024, May 30). Groundbreaking held for JTA's Autonomous Innovation Center. Mass Transit. https://www.masstransitmag.com/technology/facilities/article/55055005/groundbreaking-held-for-jtas-autonomous-innovation-center
[42] *Autonomous Vehicles*. (2024). Mass Transit. https://www.masstransitmag.com/alt-mobility/autonomous-vehicles
[43] Pathak, M., Slade, R., Pichs-Madruga, R., Ürge-Vorsatz, D., Shukla, R., & Skea, J. (2022). *Climate Change 2022 Mitigation of Climate Change: Technical Summary.* https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_FullReport.pdf.
[44] United Nations. (2023). *2023 NDC Synthesis Report.* Unfccc.int. https://unfccc.int/ndc-synthesis-report-2023

The transportation sector represents the largest source of CO2 emissions in the US. Medium and heavy-duty vehicles (MHDVs) play a crucial role in moving goods and supplies throughout the US supply chain. Dependability, fuel cost, high uptime, and quick turnaround time are critical to competitiveness and profitability for the MHDV industry. Even though MHDVs represent less than 4% of all vehicles on the road, they represent nearly half of vehicles miles traveled and approximately 25% of all US Transportation GHG emissions.[45] Within the Commonwealth of Virginia, nearly half of emissions originate from the transportation sector, causing detrimental impacts on climate, public health, and the economy.[46] Thus, there is increasing pressure on freight and other sectors of the supply chain to find methods to significantly reduce its carbon footprint and environmental impacts.

Numerous market forces (e.g., skyrocketing growth in e-commerce and global shipping) are driving unprecedented freight volumes. Within the Commonwealth, major freight corridors such as I-95 and I-85 are expected to experience a significant increase in freight tonnage.[47] Given the reliance on MHDVs to move over 72% of freight in the US, MHDVs represent the fastest growing source of vehicular contribution to emissions. Through demonstrations like the North American Council for Freight Efficiency's Run on Less – Electrification project, several use cases have demonstrated the technology readiness and feasibility of "return to base" (RTB) electric zero emissions (ZE) MHDVs[48]. Through this project, almost 300 electric trucks of various sizes were deployed to gather data to identify where electric trucks are already a viable solution, as well as where challenges remain. Results from their demonstration project indicate that 50% of heavy-duty vehicles and nearly 100% of medium-duty vehicles are electrifiable *immediately*. Their findings also cite market inhibitors for the overall regional trucking market, including factors such as operational integration, cost, and performance risk.

To put the nation on a path to advancing transportation and infrastructure solutions that are better for freight movement, communities, the environment, and the economy, the US has committed to actions that promote at least 30% ZE MHDV sales by 2030, with a goal of 100% by 2040. In March 2024, The Joint Office created the National Zero-Emission Freight (ZEF) Corridor Strategy to realize the ambitious goals set forth in the US National Blueprint for Transportation

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[45] US Environmental Protection Agency. (2021). *U.S. Transportation Sector Greenhouse Gas Emissions 1990–2019*. EPA. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P10127TU.pdf.

[46] U.S. Energy Information Administration. (2023). *State Carbon Dioxide Emissions Data - U.S. Energy Information Administration (EIA)*. https://www.eia.gov/environment/emissions/state/.

[47] *Technical Report. (n.d.)*Hampton Roads Transportation Planning Organization. https://www.hrtpo.org/336/Technical-Reports

[48] *Run on Less – Electric.* (n.d.). North American Council for Freight Efficiency. https://nacfe.org/research/run-on-less-electric/

Decarbonization.[49, 50] This strategy provides guidance on prioritizing investments, planning, and deployments for MHDV fueling infrastructure to advance ZE freight. Transitioning to ZE MHDVs provides an opportunity for the transportation sector to significantly decrease CO2 emissions and expedite the emission targets emphasized in the National Blueprint. However, to grow the market share of ZE MHDVs, numerous barriers remain. The functionality and benefits of ZE MHDVs must be clearly demonstrated to key stakeholders, including corporate fleets, owner/operators, and truck stop owners, to ensure seamless adoption of new vehicles and practices.

The current state of electric vehicle (EV) sales is growing, with MHDVs currently lagging when compared to light duty vehicles. The light-duty EV passenger vehicle market is growing rapidly, thanks to major incentive investments and outreach and educational initiatives. Over 1.4 million light duty EVs were sold in the US in 2023, representing a 50% increase over the previous year.[51] When combined with hybrid vehicles, EV sales rose to 16.3% of the total new light-duty vehicle sales in 2023, an increase from 12.9% the previous year.[52] On an international level, ZE MHDV sales are on the rise but still represent a small amount of growth in the market. In 2022, EVs accounted for 4.5% of all bus sales and 1.2% of truck sales, most of which were produced and sold in China.[53] In the US, electric truck sales jumped threefold between 2022 and 2023; however, this still represents less than 0.1% of total truck sales during that time. From 2022 to 2023, ZE heavy duty truck registrations quadrupled from the previous year to 760, representing 0.28% of all new heavy-duty truck registrations. Medium-duty truck registrations stayed the same between 2022 and 2023, representing 0.1% of all new registrations.[54] The number of MHDV sales remains far behind the point where it would reach the emissions needed to achieve decarbonization goals.

To incentivize the transition to ZE MHDVs in the US, the number of private and public investments in these technologies and the supporting infrastructure is growing rapidly. The federal government is investing in EV charging an unprecedented rate. In May 2024, a $1.3 billion funding opportunity for EV charging and alternative fueling infrastructure (including

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[49] *National Zero-Emission Freight Corridor Strategy.* (2024). Joint Office of Energy and Transportation.https://driveelectric.gov/files/zef-corridor-strategy.pdf.

[50] Muratori, M., Kunz, T., Hula, A., & Freedberg, M. (2023). *US National Blueprint for Transportation Decarbonization: A Joint Strategy to Transform Transportation* (No. DOE/EE-2674). United States. Department of Energy. Office of Energy Efficiency and Renewable Energy. https://www.energy.gov/sites/default/files/2023-01/the-us-national-blueprint-for-transportation-decarbonization.pdf.

[51] Statement by U.S. Energy Secretary Jennifer M. Granholm on 2023 EV Sales. (2024, Jan 5). Department of Energy. https://www.energy.gov/articles/statement-us-energy-secretary-jennifer-m-granholm-2023-ev-sales

[52] U.S. Energy Information Administration. (2024, Jan). *Electric vehicles and hybrids surpass 16% of total 2023 U.S. light-duty vehicle sales*. https://www.eia.gov/todayinenergy/detail.php?id=61344.

[53] International Energy Agency. *Trends in electric heavy-duty vehicles, Global EV outlook 2023 Analysis.* https://www.iea.org/reports/global-ev-outlook-2023/trends-in-electric-heavy-duty-vehicles

[54] The International Council on Clean Transportation. (2024, June). *Zero-Emission bus and truck market in the United States: A 2022-2023 update*. https://theicct.org/publication/zero-emission-bus-and-truck-market-in-the-us-2022-2023-update-june24/

hydrogen) was released, the largest single funding opportunity for EV charging in the nation's history.[55] This grant program is in addition to the $5 billion National Electric Vehicle Infrastructure (NEVI) Formula Program and allows those entities that may not be eligible for funding under NEVI to now have access to crucial funding opportunities. Additionally, EPA's Clean Ports Program allocated $3 billion to fund zero-emission port equipment and infrastructure.[56] On a smaller scale, the federal government continues to offer consumers up to $7,500 as a tax credit for the purchase of qualifying clean vehicles, with fleets offered a similar credit for vehicles with a GVWR under 14,000 lbs. and up to $40,000 for all other vehicles. Consumers can receive a credit of up to $1,000 for installing EV charging equipment in their homes, while businesses, fleets, or tax-exempt entities can receive up to $100,000 for the installation of charging stations.[57]

Private industry has also taken measures towards regional collaboration for accelerating the infrastructure to support MHDVs. Powering America's Commercial Transportation, or PACT, was formed this year in January between Daimler Truck North America, Navistar, Inc., and Volvo Group North America. Their work includes collaboration with stakeholders such as infrastructure developers, policy makers, grid operators, electric utility companies, and commercial fleets. With regulators, for example, PACT works across agencies on accelerating the disbursement of ZE infrastructure funds from federal agencies. With stakeholders involved on the implementation side, they work to expedite and streamline permitting, zoning, and approval processes needed for infrastructure projects as well as pro-active grid build outs that allow utility companies to make grid updates now ahead of the anticipated demand.[58]

Within the Commonwealth of Virginia, many programs and opportunities are underway to improve and expand the state's charging and fueling infrastructure to prepare for the goal of net-zero emissions in the transportation sector. Already, the Virginia DOT has approved $11.3 million in funding for Phase 1-A through the NEVI program, to support the growth of EV charging stations along Alternative Fuel Corridors-designated interstates. An additional $33 million is allocated for Phase 1-B, currently open until July 2024, to support Alternative Fuel Corridors primary highway EV infrastructure and add more redundancies to interstates. As part of Phase 2 of this program, an additional $60 million is planned to be allocated in FY 2026

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[55] Joint Office of Energy and Transportation. (2024). *Biden-Harris Administration opens applications for $1.3 billion in funding to continue expanding National Electric Vehicle Charging Network*. https://driveelectric.gov/news/new-cfi-funding-released.

[56] United States Environmental Protection Agency. (2024). Clean Ports Program. https://www.epa.gov/ports-initiative/cleanports.

[57] Alternative Fuels Data Center. (2024). *Tax credits for Electric Vehicles and charging infrastructure.* US Department of Energy. https://afdc.energy.gov/laws/ev-tax-credits

[58] https://www.pactcoalition.org

through 2029 to create further redundancies along these corridors.[59] The Port of Virginia's ongoing Green Operator Program recently announced improved rebate incentives and eligibility requirements to allow more dray truck operators to qualify and receive more financial support.[60] In Round 7 of FHWA's Alternative Fuel Corridors Deployment Plan, efforts in Virginia expanded EV Pending Corridors and nominated many major interstates and highways as Hydrogen Pending.[61]

Many technological advancements and goals have been introduced to address the challenges of providing ubiquitous access to alternative fuels. Right now, concerns about the materials used and where the materials are sourced in the production of lithium-based batteries are limiting full support for converting to battery electrification.

Academic and NGO research confirms that the understanding of the organizational barriers to achieving carbon neutrality on a supply chain level remains limited. One study that researched supply chain organizations that were early adopters of carbon neutrality initiatives identified four common barriers: major upfront investment costs, lack of awareness, lack of expertise, and a resistance mind-set. However, most early-adopter organizations achieved positive economic performance associated with their carbon neutrality.[62] In other research, the main barriers to MHDV widespread electrification were identified as: costs to fleet transitions, logistics and operations, manufacturing challenges, infrastructure requirements, equity, and externalities.[63] In this Gap Analysis, we aim to validate the major challenges and barriers found in the literature towards achieving sustainability in freight.

## Workforce Development

Challenges currently facing the workforce in regard to the movement of goods in the supply chain primarily relate to ACE vehicles. The primary challenges can be broken into two primary areas: transitioning the current workforce and building the pipeline for the future. In terms of transitioning the current workforce, the industry is struggling to attract younger workers and

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[59] VDOT announces awards for electric vehicle charging infrastructure installation along the Commonwealth's alternative fuel corridors. (2024, March). VA Department of Transportation. https://www.vdot.virginia.gov/news-events/news/statewide/vdot-announces-awards-for-electric-vehicle-charging-infrastructure-installation-along-the-commonwealths-alternative-fuel-corridors.html

[60] Port of Virginia. (2023). *Green Operator Program*. https://www.greenoperator.org/.

[61] Federal Highway Administration. (2023). *Corridor-pending alternative fuel corridors* (round 7). https://www.fhwa.dot.gov/environment/alternative_fuel_corridors/pending/.

[62] Zhang, A., Alvi, M. F., Gong, Y., & Wang, J. X. (2022). Overcoming barriers to supply chain decarbonization: Case studies of first movers. *Resources, Conservation and Recycling, 186*, 106536. https://doi.org/10.1016/j.resconrec.2022.106536.

[63] B. Spiller, N. Lohawala, and E. DeAngeli. (2023). *Medium- and Heavy-Duty Vehicle Electrification: Challenges, Policy Solutions and Open Research Questions*. Report_23-03_v3.pdf (rff.org)

older drivers may show resistance to change and struggle to adapt to the new technologies.[64, 65, 66] Another challenge is that emerging technologies such as ACE vehicles are "beginning to outpace the skillsets of the current transportation workforce" and there is a "lack of resources available for the continuing technological education of the current workforce."[67] One of the challenges to building the future workforce pipeline for ACE vehicles includes understanding and addressing the educational gaps needed to develop the workforce for these new technologies.[68] In addition, there is a need to address a lack of diversity in the workforce. The National Science Foundation recently released a report that women, as well as Black, Hispanic, American Indian, Alaskan Native people, and people with disabilities, while making gains in STEM jobs over the past decade, "broadly remain underrepresented in science, technology, engineering, and mathematics when compared to their overall distribution in the U.S. population, reflecting the larger equity challenges our nation faces."[69]

In terms of recommended strategies for helping transition the current workforce, there should be collaboration across stakeholders (e.g., industry, academia, and government) to match education and training to workforce needs. As an example of such efforts, Hossain et al. (2024) describe how the Transportation Research Board Workforce Development and Organizational Excellence committee has the "goal of improving communication and collaboration among academic, private, and government transportation communities" and "aligning educational practices with workforce needs and fostering awareness of the transportation engineering profession." [70]

Investing in education, training, and experiences are ways to help the workforce transition. As an example, the USDOT has an ITS Professional Capacity Building Program that offers "training and resources to support workforce development and technical assistance for practitioners" and

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[64] Sugihara, C., Hardman, S., & Kurani, K. (2023). Social, technological, and economic barriers to heavy-duty truck electrification. Research in Transportation *Business & Management, 51*, 101064.

[65] Schuster, A. M., Agrawal, S., Britt, N., Sperry, D., Van Fossen, J. A., Wang, S., ... & Cotten, S. R. (2023). Will automated vehicles solve the truck driver shortages? Perspectives from the trucking industry. *Technology in Society, 74,* 102313. https://www.researchgate.net/profile/Shubham-Agrawal-7/publication/372128089_Will_automated_vehicles_solve_the_truck_driver_shortages_Perspectives_from_the_trucking_industry/links/64a65b6eb9ed6874a5fdc6fe/Will-automated-vehicles-solve-the-truck-driver-shortages-Perspectives-from-the-trucking-industry.pdf?origin=journalDetail&_tp=eyJwYWdlIjoiam91cm5hbERldGFpbCJ9

[66] Van Fossen, J. A., Schuster, A. M., Sperry, D., Cotten, S. R., & Chang, C. H. (2023). Concerns, career decisions, and role changes: A qualitative study of perceptions of autonomous vehicles in the trucking industry. *Work, Aging and Retirement, 9*(4), 399-406.

[67] Click, S. M., Mohebbi, M., Steiner, R., Sisopiku, V. P., Hadi, M., Michalaka, D., ... & Griffith, J. (2024). Framework for the Development of a Diverse Transportation Workforce in the Southeast Region. *Transportation Research Record, 03611981241242771.*

[68] Masoud, N., Tafreshian, A., Lim, J., Liu, H., Carrel, A., Bao, S., ... & Orosz, G. (2023). *Autonomy in Transportation Education.*

[69] National Science Foundation (2023, January 30). *NSF's NCSES releases report on diversity trends in STEM workforce and education.* [NSF News] https://new.nsf.gov/news/diversity-and-stem-2023#image-caption-credit-block

[70] Hossain, M. M., Zhou, H., & Turochy, R. (2024). Exploring Potential Critical Content of Connected and Autonomous Vehicles for Transportation Engineering Courses: A National Survey. *Transportation Research Record*, 03611981241248157

includes resources such as web-based training, webinars, and other resources (e.g., fact sheets) on topics such as Automated Vehicles and Cybersecurity. [71] In addition, experiencing new technologies may help address driver resistance and ease the transition to ACE vehicles. For example, experiences such as ride-and-drive events may help workers become familiar with the technology,[72] especially older workers who may find hands-on experience more in line with their learning preferences than online training. [73]

Building the future workforce pipeline will require a multi-faceted approach, including understanding educational gaps and developing needed curricula, building a talent pipeline from K-12 through college, providing appealing opportunities for the next-generation workforce, and promoting Diversity, Equity, Inclusion, and Accessibility (DEIA). An important initial step in building the future workforce pipeline will be efforts to explore educational gaps and the needed curriculum. For example, the Center for Connected and Automated Transportation's Autonomy in Transportation Education workshop, convened experts (e.g., industry, academia) in CAVs to explore gaps in transportation education and how to address those gaps through approaches such as hands-on learning. [74] An example of a hands-on learning approach identified in the literature was a cybersecurity summer camp for high school students that enabled "students to explore machine-learning (ML) through hands-on experiences such as collecting front-camera images and training an autonomous driving ML model" with the outcome of "boosting their confidence in computing and cybersecurity." [75]

A study by the Bureau of Labor Statistics found the demand for engineering skills will grow approximately 13% from 2023 to 2031. Despite the energy transition goals set forth by the ZEF Corridor strategy, the U.S. is stalling in competitive advantage, with a potential $450B in lost economic output due to the projected 186,000 job vacancies by 2031 in unfilled software, industrial, civil, and electrical engineering positions. These STEM areas are in high demand for the projected technologies of AI, ML, CAV manufacturers, developers, and operators, and alternative fueling maintenance technicians. This will affect federal initiatives such as the Build Back Better Act.

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[71] U.S. DOT Intelligent Transportation Systems Professional Capacity Building (n.d.) ITS Training and Resource Hub. https://www.its.dot.gov/pcb/ITSCourses/Default.aspx#training

[72] Sugihara, C., Hardman, S., & Kurani, K. (2023). Social, technological, and economic barriers to heavy-duty truck electrification. *Research in Transportation Business & Management, 51*, 101064.

[73] Click, S. M., Mohebbi, M., Steiner, R., Sisopiku, V. P., Hadi, M., Michalaka, D., ... & Griffith, J. (2024). Framework for the Development of a Diverse Transportation Workforce in the Southeast Region. *Transportation Research Record*, 03611981241242771.

[74] Masoud, N., Tafreshian, A., Lim, J., Liu, H., Carrel, A., Bao, S., ... & Orosz, G. (2023). *Autonomy in Transportation Education*.

[75] Won, M., Carrington, L. R., Espinoza, D. M., Ali, M. H., & Dasgupta, D. (2024, March). A Cybersecurity Summer Camp for High School Students Using Autonomous R/C Cars. In *Proceedings of the 55th ACM Technical Symposium on Computer Science Education V. 1* (pp. 1435-1441).

Doubling the number of women who pursue engineering degrees could contribute up to 40,000 more engineers annually and reduce the U.S. engineering gap by 30%, assuming a 100% conversion rate to engineering careers.[76]

The Boston Consulting Group and SAE Foundation are another example of two organizations working together to find creative ways to close the engineering workforce gap specifically. Coined the "40 by 30 initiative," these two organizations are working to increase the number of women in engineering roles from 20% to 40% by year 2030. Their efforts to increase women graduates will also open pathways for all individuals interested in professional development in current or new jobs across engineering disciplines.

Some other suggested solutions include strategic workforce planning by organizations in a proactive way to forecast how they might navigate the changing environment anticipated in the next decade. Reskilling the existing workforce is also a cost-effective way to increase employee retention while addressing the technology changes of the future. Another approach is to increase collaboration between education organizations and industry. This is to create a common taxonomy so these two entities are speaking the same language around hiring needs and skills of the future. Industry can present their exact needs and changing priorities to better match educational institutions' curriculum development, which can also potentially lead to a direct pipeline of graduates into a company, benefitting both parties.[77]

Another important step in building the workforce pipeline will be starting early in the education process and continuing throughout. Beginning to "recruit early in the educational pipeline (K-12)" could help address some of the "recruitment and labor challenges facing the industry." [78] The USDOT Strategic Plan FY 2022–2026 objective to "provide a variety of professional development opportunities for all grade levels through mentoring, coaching, and formal development programs" [79] also supports this concept of starting to develop the future workforce early and maintaining an ongoing presence in the education pipeline.

Developing appealing job opportunities and conducting outreach to promote transportation careers to the next generation to support ACE vehicles is also important. The FHWA has a flyer highlighting careers for the Next Gen Workforce. It suggests that DOTs can "overcome recruitment and retention barriers by offering the Next Gen Workforce unique opportunities,

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[76] Kodey, A., Bedard, J., Nipper, J., Post, N., Lovett, S., & Negreros, A. (2023, December 13). *The US needs more engineers. what's the solution?* BCG Global. https://www.bcg.com/publications/2023/addressing-the-engineering-talent-shortage

[77] Kodey, A., Bedard, J., Nipper, J., Post, N., Lovett, S., & Negreros, A. (2023, December 13). *The US needs more engineers. what's the solution?* BCG Global. https://www.bcg.com/publications/2023/addressing-the-engineering-talent-shortage

[78] Click, S. M., Mohebbi, M., Steiner, R., Sisopiku, V. P., Hadi, M., Michalaka, D., ... & Griffith, J. (2024). Framework for the Development of a Diverse Transportation Workforce in the Southeast Region. *Transportation Research Record*, 03611981241242771.

[79] USDOT. (n.d.) *Strategic Plan FY 2022-2026*. https://www.transportation.gov/sites/dot.gov/files/2022-04/US_DOT_FY2022-26_Strategic_Plan.pdf

incentives, benefits packages, mentors, and professional development to strengthen interest in DOT careers and ensure longevity in their career with the agency." [80] The FHWA suggests the creation of a strategic plan to engage the Next Gen Workforce through outreach to raise awareness of the transportation field, skills required, and opportunities.

A thread that should run through all these efforts to help workers transition and build the future workforce pipeline should be the promotion of DEIA. The 2022–2026 US DOT Strategic Plan has several objectives and strategies that address equity, including the need to "promote equity for transportation workers and support pathways to transportation careers for workers with diverse backgrounds." [81] The US National Blueprint for Transportation Decarbonization also highlights the importance of workforce training and educational opportunities "to support a transition to diverse and well-paying clean transportation sector careers" especially "for residents and businesses in disadvantaged communities." [82]

States and municipalities are presented with the opportunity to invest in advanced vehicle technologies for both CAVs and EVs as a surge of grants have become available throughout the country. For example, in January, the Biden Administration announced over $46 million to support 30 projects across the country that "enhance EV charging reliability and workforce development."[83] One of the grants was awarded in Philadelphia to pilot a program centered around training people to install EV chargers.[84] The initiative, being co-led with the International Brotherhood of Electrical Workers, will include an EV supply equipment (EVSE)-focused pre-apprenticeship program and will raise "awareness of high-paying professional opportunities in EVSE through outreach to disadvantaged communities." [85] Tennessee is also investing in its workforce by offering jobs based on electrification. The current Tennessee Department of Economic and Community Development figures indicate that, since 2017, EV projects have represented over $16.2 billion in capital investments, and that the industry employs more than 20,800 Tennesseans.[86] These are merely two examples of the many funding opportunities available to those groups harnessing ACE technologies. In terms of CAV vehicle technologies,

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[80] USDOT. (n.d.) *Engaging the Next Gen Workforce.* https://www.fhwa.dot.gov/innovativeprograms/centers/workforce_dev/pdfs/next_gen_workforce.pdf

[81] USDOT. (n.d.) *Strategic Plan FY 2022-2026.* https://www.transportation.gov/sites/dot.gov/files/2022-04/US_DOT_FY2022-26_Strategic_Plan.pdf

[82] Muratori, M., Kunz, T., Hula, A., & Freedberg, M. (2023). *US National Blueprint for Transportation Decarbonization: A Joint Strategy to Transform Transportation* (No. DOE/EE-2674). United States. Department of Energy. Office of Energy Efficiency and Renewable Energy.

[83] Biden-Harris Administration Announces Over $46 Million to Enhance EV Charging Reliability and Workforce Development. (2024, January). Energy.gov. https://www.energy.gov/articles/biden-harris-administration-announces-over-46-million-enhance-ev-charging-reliability-and#:~:text=%E2%80%94%20The%20Biden-Harris%20Administration%20today%20announced%20%2446.5%20million,transportation%20solutions%3B%20and%20grow%20the%20clean%20energy%20workforce.

[84] Schmidt, S. (2024, February 14). *Philly launches training program to grow and diversify EV workforce.* WHYY. https://whyy.org/articles/electric-vehicles-philadelphia-launches-new-job-training-program/

[85] Joint Office of Energy and Transportation FY23 Ride and Drive FOA (ride-and-drive-foa.pdf (driveelectric.gov))

the USDOT recently awarded $60 million in advanced vehicle technology grants to three states (Arizona, Texas, and Utah) as part of the Saving Lives with Connectivity: Accelerating V2X Deployment program.[87] Related to this funding, the USDOT released a National V2X Deployment Plan which notes that "to successfully accelerate this technology deployment to save lives and advance national goals, the U.S. needs to develop the workforce and skills critical to these growing systems."[88] The report goes on to describe how the DOT will coordinate resources, including professional capacity building (e.g., training), to support the deployment of V2X technologies by public agencies and tribal governments.

The workforce landscape for ACE vehicles is evolving and is tied to the advancement of specific vehicle technologies. While the CAV workforce is harder to predict, with longer projected deployment timelines to account for further technology development, the EV workforce projections show earlier progress as EV numbers rapidly grow. The electric vehicle market supports a steep increase in its workforce with a recent study estimating that "the growth of charging infrastructure could create more than 160,000 jobs by 2032."[81] A recent U.S. Department of Energy publication stated that, "the number of jobs in battery electric vehicles increased by 28,366 (+27%) from 2021 to 2022" and "the growth in battery electric vehicles was almost 17 times faster than the increase in gasoline and diesel vehicle employment."[82] EV technologies have made a strong initial impression on the market and are predicted to be in the forefront of being able to substantially increase jobs within the next decade. Alternatively, several market projections share the common theme that widespread adoption of CAVs is a decade or more away and the accompanying workforce requires additional resources to become robust. Alongside those predictions, there is still a call to action urging industry leaders and educational partners to tackle the workforce issues today to ensure workers are trained in time

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[87] USDOT Awards Nearly $60 Million in Advanced Vehicle Technology Grants to Arizona, Texas and Utah to Serve as National Models and Help Save Lives on Our Nation's Roadways [News Brief]. (2024, June). U.S. Department of Transportation. https://www.transportation.gov/briefing-room/usdot-awards-nearly-60-million-advanced-vehicle-technology-grants-arizona-texas-and

[88] Saving Lives with Connectivity: A Plan to Accelerate V2X Deployment. (2024, August). U.S. Department of Transportation, pg. 18. https://www.its.dot.gov/research_areas/emerging_tech/pdf/Accelerate_V2X_Deployment_final.pdf

[81] Bui, A., Pierce, L., Ragon, P.-L., Sen, A., Slowik, P., & Waites, T. (2024, January 23). *New Study estimates over 160,000 jobs to be created by U.S. Electric Vehicle Charging Infrastructure Buildout by 2032*. International Council on Clean Transportation. https://theicct.org/pr-new-study-estimates-over-160000-jobs-to-be-created-by-uss-ev-charging-infrastructure-buildout-jan24/#:~:text=The%20growth%20of%20charging%20infrastructure%20could%20create%20more%20than%20160,000

[82] Keyser, D., Fiori, M., Jones, B., Ho, H., Jatkar , S., Gordon, K., Copland-Newfield, G., Frisch, C., & Veeder, C. (n.d.). *United States Energy & Employment Report 2023*. Energy.gov. https://www.energy.gov/sites/default/files/2023-06/2023 USEER EXEC SUMM-v2.pdf

[83] Lowery, L. (2023, September 25). S&P predicts AVs need at least 10 more years to hit widespread adoption. *Repairer Driven News*. https://www.repairerdrivennews.com/2023/09/26/sp-predicts-avs-need-at-least-10-more-years-to-hit-widespread-adoption/

[84] Chamber of Progress. (2024, April 8). *New study: Autonomous vehicle jobs to exceed 110K in U.S.* Chamber of Progress. https://progresschamber.org/new-study-autonomous-vehicle-jobs-to-exceed-110k-in-u-s/

for future developments. For example, Governor of California, Gavin Newsom, told his constituents that "he has the future of the state's workforce in mind pertaining to the impacts AVs could have" and has recommendations being developed to mitigate potential employment impacts in the realm of autonomous heavy-duty vehicles.[83] A reoccurring principle alongside these projections is that jobs will need to be created, though how many is uncertain. A publication from the Chamber of Progress forecasting the number and types of jobs that will be created as a result of AV deployment in the US reported that more than 114,000 workers—and up to 455,000 workers in an optimistic scenario—will be employed over the next 15 years to meet AV production, distribution, maintenance, upgrades, and repair needs.[84]

While the focus of the literature scan is on workforce development for ACE vehicles as a continuation of the 2023 gap analysis report, the research team decided, for the stakeholder focus groups, to expand the Workforce Development program area to include Community Engagement. Though it is not a part of this literature scan, future gap analysis reports will delve into community engagement and what recent literature reveals about topics and approaches to engaging communities around issues such as public perceptions of ACE vehicle technologies. As noted, particularly in the literature on CAVs, exploring public perceptions and raising awareness of the benefits of these technologies will be essential to shaping future program areas to address these gaps.

# Stakeholder Focus Group Methods

The second D2D Coalition Workshop was held in May 2024 to once again bring together supply chain leaders throughout the region to discuss the current gaps, challenges, and potential solutions towards realizing a more sustainable, equitable and inclusive supply chain. The Coalition membership comprises 87 diverse organizations, including global companies, industry, higher education, small businesses, nonprofits, advocacy groups, and government.

The D2D Coalition continues to solidify its focus in four main topic areas:

1. Data Sharing Platform for Freight Flow Connectivity and Visibility (Data Sharing Platform)
2. Decarbonization and Sustainability in Freight (Sustainability)
3. Workforce Development and Community Engagement (Workforce/Community)
4. Connected and Automated Vehicles throughout the supply chain (Connected & Automated Vehicles)

The focus of the 2024 Coalition Workshop was to continue to build participant understanding and awareness around the four main topic areas and gather updated data on gaps specific to those topic areas using focus groups. Each topic area was discussed in a separate focus group session attended by all participants. Participants were invited to randomly sit at one of five focus group tables during each topic area session, with a notetaker present to capture responses to the questions and prompts provided. Participants were encouraged to switch tables between focus groups to ensure they were in a diverse focus group with different participants each time. Forty-six participants attended, representing 29 Coalition member organizations, approximately one-third of the overall D2D Coalition membership.

The challenges identified in the 2023 Gap Analysis were used to initiate the discussion and data collection for the 2024 focus groups. Findings from the literature review aligned with many of the gaps and challenges from the 2023 workshop. As such, the gaps and challenges from the 2023 workshop that were closely related to the topic areas of Sustainability, Workforce/Community, and Connected & Automated Vehicles were included on the relevant focus group handouts. For more detail on the focus group session schedule, structure and handouts, please refer to the Dock to Door: Understanding Challenges and Opportunities Workshop Focus Group Session Guide, provided in Appendix A: Focus Group Guide. Note that the Data Sharing Platform focus group was conducted differently than the other three focus areas and is detailed in later sections.

## Research Priority Ranking Analysis

For the focus group sessions on the topic areas of Sustainability; Workforce/Community; and Connected & Automated Vehicles, a worksheet was presented to each participant listing the challenges identified the previous year. Participants were asked to prioritize the challenges most

important to their organization. They were also asked to cross out any challenges they felt were no longer an issue. Participants were provided with space on the worksheet in which to include any additional challenges and solutions relevant to the topic areas that may have emerged since the 2023 Coalition workshop.

All the data collected from the worksheets were placed into a spreadsheet for analysis of research priority ranking. The number of times each listed gap/challenge was crossed out or marked with an asterisk was recorded. To determine the top priority gaps/challenges from each topic area as whole, the number of times a challenge was crossed out was then subtracted from the number of times it was marked with an asterisk. The results of the analysis and ranking of the priority gaps for each topic area are included in the results section below.

### Qualitative Analysis

The focus group discussion was then spent elaborating on the participants' logic behind their selections, removals, or additions to this worksheet. The discussion data was digitized into short comments for qualitative analysis. The comments were analyzed by three researchers (blindly and independent of one another) and coded to the STS framework to compare the 2023 and 2024 data. An interrater reliability test was performed by a fourth researcher to indicate any areas of disagreement to ensure non-bias. Any areas of conflicting coding were discussed and resolved according to the definitions in the STS framework. The new challenges from this data were also pulled out and are summarized in the narrative summary section below. All four topic areas were analyzed using this qualitative analysis.

## Data Sharing Platform Methodology

The focus group methodology varied slightly from that of the other three focus groups. The goal here was to provide a potential proposed federated data architecture structure to participants and gather information specifically to inform the platform architecture development and future use-cases in which a future platform could be applied. The presentations of the architecture were followed by a discussion at each focus group table lead by subject matter experts, with notetakers capturing responses to the following questions:

We've found that the tracking element is most important to increasing visibility into the movement of goods.

- What is a greater priority for your organization: near time or real time tracking for predictive modeling?
- What kinds of data are needed to enable that?
- What would it take for you to be willing to share this in an encrypted peer-to-peer environment? Is your current system for storage of this data compatible with this type of environment?

The discussion data gathered from the Data Sharing Platform focus group was subject to the qualitative analysis methodology described above.

# Research Priority Ranking Results

Across the topic areas of Sustainability and Decarbonization, Connected & Automated Vehicles, and Workforce Development and Community Engagement, it was evident from the data that the participants had a tough time selecting only one priority challenge (noted with an asterisk). This was especially the case for the Decarbonization and Sustainability topic area, where the average number of asterisks marked per participant was nearly 3.5. For the other topic areas, the average ranged between 1.7 to 2.2. This indicated that many challenges from the 2023 workshop were still relevant.

## Connected and Automated Vehicles (CAVs) Throughout the Supply Chain

The CAV challenges are ranked in Table 1, with the top three priorities as follows:

1. Public perception and acceptance of automated vehicle technology due to safety concerns or fear of job reductions/replacement (n = 20)
2. Shortages in qualified workforce/lack of workforce development regarding automated vehicles (n=10)
3. Lack of a national framework for automated vehicle policy, regulations, beyond-the-visual-line-of-sight (BVLOS) limitations, and Federal Communications Commission (FCC) spectrum issues (n=8)

It is important to note that the number one ranked challenge was marked significantly more than the other priorities. It is fair to say that public misperception and acceptance of AV technology due to safety concerns and/or fear of job reductions/replacement is a priority issue for CAVs both in the supply chain and in society at large.

**TABLE 1: CAVS RANKING OF CHALLENGES**

| Connected and Automated Vehicle Challenges | Asterisk | Crossed off | Difference (n) |
|---|---|---|---|
| Public perception and acceptance of automated vehicle technology due to safety concerns or fear of job reductions/replacement | 20 | 0 | 20 |
| Shortages in qualified workforce/lack of workforce development regarding automated vehicles | 10 | 0 | 10 |
| Lack of a national framework for automated vehicle policy, regulations, beyond-the-visual-line-of-sight (BVLOS) limitations, and FCC spectrum issues | 8 | 0 | 8 |
| Lack of or weak infrastructure and communications to support widespread automated vehicle use for the long term, including in rural areas | 8 | 1 | 7 |
| Conveying the benefits of automated/connected vehicles to those with no access to public transportation or who have disabilities | 6 | 0 | 6 |
| Concerns about timeline for deployment of automated vehicles and the infrastructure needed for that | 6 | 0 | 6 |
| Costs incurred for obtaining automated/connected vehicles and the related insurance costs | 5 | 0 | 5 |
| Lack of shared language between OEMs and utility companies which is needed to match the technology to the infrastructure | 5 | 1 | 4 |
| Installation of fiber infrastructure and 5G communications (for vehicle-to-vehicle and vehicle-to-infrastructure) are difficult/costly to build and require roadway shutdowns in an already overburdened traffic situation | 2 | 1 | 1 |

## Sustainability and Decarbonization in Freight

The Sustainability & Decarbonization in Freight challenges are ranked in Table 2, with the top three priorities as follows:

1. Lack of trained workforce to service clean fuel transportation options (n=12)
2. Overall cost of new, more efficient equipment (n=11)
3. Insufficient infrastructure for EV charging needs (n=10)

It is interesting to note that if solely ranking the priority challenges based on those marked with an asterisk, the list would be similar with "Lack of a unified approach to coordinating infrastructure to support electrification of heavy-duty vehicles" replacing #3 above; however, both are infrastructure related and similar challenges.

**TABLE 2: SUSTAINABILITY AND DECARBONIZATION RANKING OF CHALLENGES**

| Sustainability and Decarbonization in Freight Challenges | Asterisk | Crossed out | Difference (n) |
|---|---|---|---|
| Lack of a trained workforce to service clean fuel transportation options | 12 | 0 | 12 |
| Overall cost for new, more efficient equipment | 14 | 3 | 11 |
| Insufficient infrastructure for EV charging needs | 11 | 1 | 10 |
| Lack of trained workforce to build and maintain the infrastructure needed to advance sustainability | 10 | 1 | 9 |
| Lack of a unified approach to coordinating infrastructure to support heavy duty vehicles | 12 | 4 | 8 |
| Concerns over high cost, future replacement, and recycling of batteries | 9 | 2 | 7 |
| Cost of new equipment too prohibitive for smaller fleets | 9 | 3 | 6 |
| Insufficient infrastructure for hydrogen fuel cell vehicles | 5 | 0 | 5 |
| Public misperception on EV batteries and hydrogen fuel | 7 | 2 | 5 |
| Identifying priority fuel types to build capabilities around and support at scale | 6 | 3 | 3 |
| Unrealistic deadlines for implementations such as decarbonization | 6 | 3 | 3 |
| Insufficient grid capacity for charging needs | 7 | 4 | 3 |
| More research is needed for hydrogen fuel cell vehicles | 6 | 3 | 3 |
| Concerns over battery life for long-haul freight transport | 6 | 3 | 3 |
| Public misperception on climate change and impacts and need for sustainability | 5 | 3 | 2 |
| Lack of carbon credits or similar incentives for fleet transitions | 4 | 5 | -1 |
| Long wait time to buy electric medium and heavy-duty vehicles | 3 | 5 | -2 |

## Workforce Development and Community Engagement

The Community Engagement challenges are ranked in Table 3, with the top ranked priorities as follows:

1. Public misperceptions on EV batteries and hydrogen fuel (n=11)
2. Public misperceptions on climate change can be perceived as political (n=10) AND Community acceptance of new hubs, facilities, and other infrastructure (n=10) AND Changing perceptions & misperceptions (battery safety, climate change, automated vehicles, etc.) (n=10)

Many community engagement challenges continue to persist, with minimal challenges present in 2023 being crossed off. Three of the four challenges centered around public misperceptions on topics. There is a need for community education on many of the topics related to sustainability, automation, technologies, and infrastructure.

**TABLE 3: COMMUNITY ENGAGEMENT RANKING OF CHALLENGES**

| Community Engagement Challenges | Asterisk | Crossed off | Difference (n) |
|---|---|---|---|
| Public misperceptions on EV batteries and hydrogen fuel. | 11 | 0 | 11 |
| Public misperceptions on climate change can be perceived as political. | 11 | 1 | 10 |
| Community acceptance of new hubs, facilities, and other infrastructure (“not in my backyard”). | 10 | 0 | 10 |
| Changing perceptions & misperceptions (battery safety, climate change, automated vehicles, etc.). | 10 | 0 | 10 |
| Community acceptance of automated vehicle technology is a significant barrier; members of the public have concerns about safety and fewer jobs. | 8 | 0 | 8 |
| Lack of acceptance of new facilities and infrastructure changes by some communities | 4 | 0 | 4 |

The Workforce Development challenges are ranked in Table 4 below, with the top two priorities as follows:

1. Training needs to evolve to meet the skills needed of future technologies (mechanics, installers, automated vehicles, and infrastructure) (n=22).
2. Access to training and job opportunities outside of the traditional K-12 to college trajectory (e.g., earn-while-you-learn programs, trade schools, second-chance employees) (n=15)

There was a significant gap between the prioritization of the first and second ranked challenges, indicating that developing training to match the needs of emerging technologies is of utmost importance. Additionally, none of the Workforce Development challenges were crossed off, potentially indicating that program participants felt little has been done to address these persistent challenges since 2023.

**TABLE 4: WORKFORCE DEVELOPMENT RANKING OF CHALLENGES**

| Workforce Development Challenges | Asterisk | Crossed off | Difference (n) |
|---|---|---|---|
| Training needs to evolve to meet the skills needed of future technologies (mechanics, installers, automated vehicles, and infrastructure). | 22 | 0 | 22 |
| Access to training and job opportunities outside of the traditional k-12 to college trajectory (e.g., earn-while-you-learn programs, trade schools, second-chance employees). | 15 | 0 | 15 |
| Aging workforce. | 10 | 0 | 10 |
| Employee satisfaction and retention in many supply chain careers (i.e., trucking, warehouse) is low. | 10 | 0 | 10 |
| Workforce development impacts every aspect of the supply chain. | 7 | 0 | 7 |
| Higher demand for educators than there are people to fill these positions | 7 | 0 | 7 |

# Qualitative Analysis Results

## STS Data Coding Results

### Across All Focus Groups

The discussion responses from the focus group discussion across all four sessions were coded and assigned one of four STS categories:

1. Environmental
2. Personnel
3. Technological
4. Supply Chain Design and Management

When looking at the aggregated data across all four groups, the frequencies of the focus group coded responses (329 in total) were as follows: environmental factors were considered the most common barrier (n=113, 34% of responses), followed by supply chain design and management (n=100, 31%), personnel barriers (n=76, 23%), and technological limitations (n=40, 12%); see Figure 4 below.

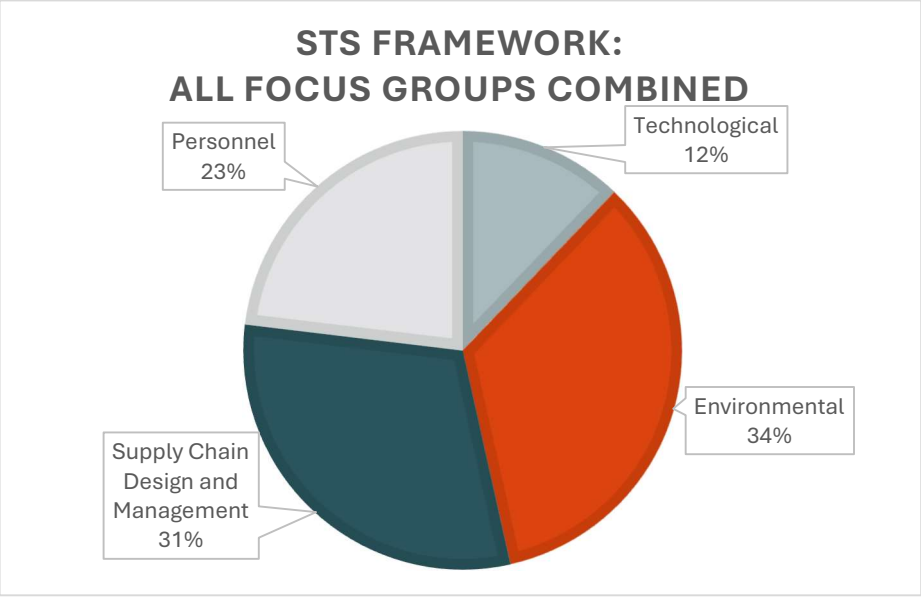


**FIGURE 4: STS FRAMEWORK RESPONSE CATEGORIZATION ACROSS ALL FOUR FOCUS AREAS (329 RESPONSES).**

### Sustainability and Decarbonization

For the Sustainability and Decarbonization focus group, the frequencies of the focus group coded responses (69 in total) were as follows: environmental factors were considered the most common

barrier (36, 52% of responses), followed by supply chain design and management (16, 23%), technological limitations (9, 13%), and personnel barriers (8, 12%); see Figure 5 below.

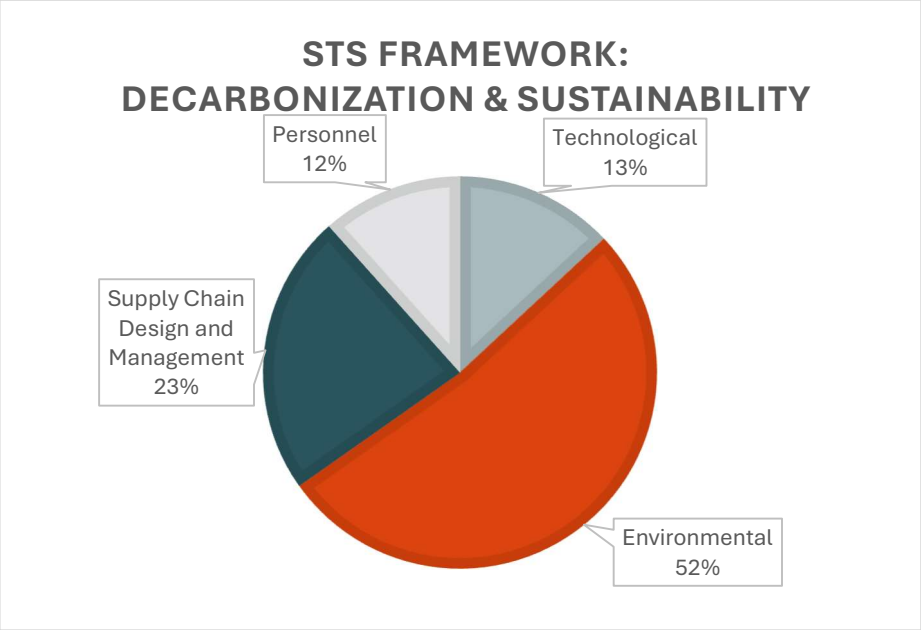


**FIGURE 5: STS FRAMEWORK RESPONSE CATEGORIZATION FOR THE DECARBONIZATION AND SUSTAINABILITY FOCUS AREA (69 RESPONSES).**

## Workforce and Community Development

For the Workforce and Community Development focus group, the frequencies of the focus group coded responses (87 in total) were as follows: Personnel and workforce barriers were considered the most common barrier (50, 58%), followed by environmental factors (29, 33% of responses), supply chain design and management barriers (6, 7%), and technological limitations (2, 2%); see Figure 6 below.

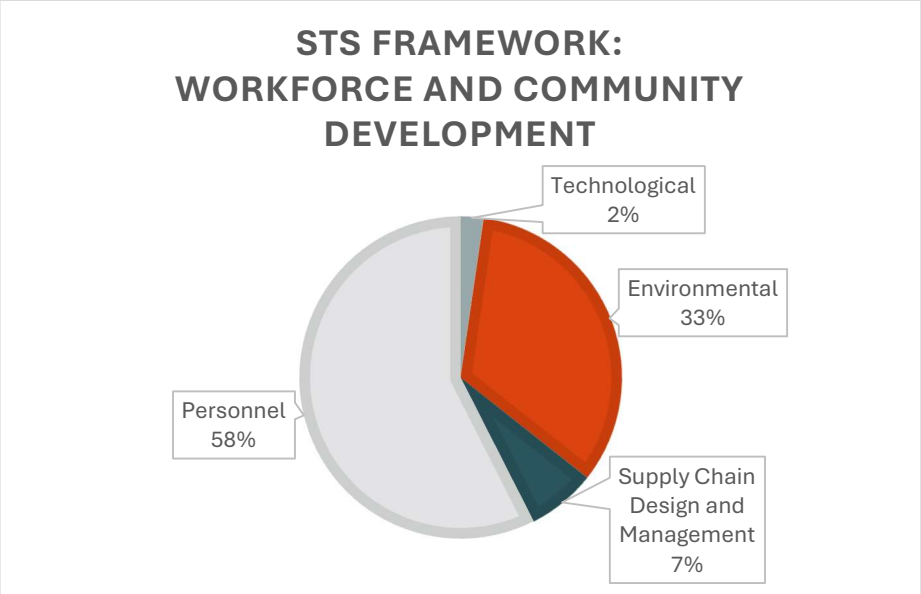


**FIGURE 6: STS FRAMEWORK RESPONSE CATEGORIZATION FOR THE WORKFORCE AND COMMUNITY DEVELOPMENT FOCUS AREA (87 RESPONSES).**

## Connected and Automated Vehicles

For the Connected and Automated Vehicles focus group, the frequencies of the focus group coded responses (62 in total) were as follows: environmental factors were considered the most common barrier (24, 39% of responses), followed by supply chain design and management (19, 30%), personnel barriers (13, 21%), and technological limitations (6, 10%); see Figure 7 below.

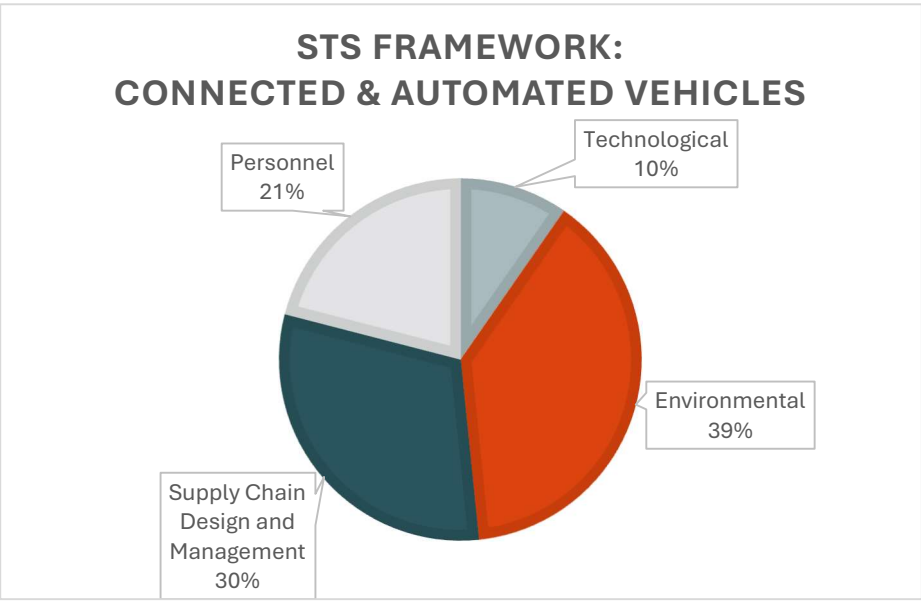


**FIGURE 7: STS FRAMEWORK RESPONSE CATEGORIZATION FOR THE CAVS FOCUS AREA (62 RESPONSES).**

## Data Sharing Platform

For the Data Sharing Platform focus group, the frequencies of the focus group coded responses (111 in total) were as follows: supply chain design and management were considered the most common barrier (59, 53%), followed by environmental barriers (24, 22% of responses), technological limitations (23, 21%), and personnel barriers (5, 4%); see Figure 8 below.

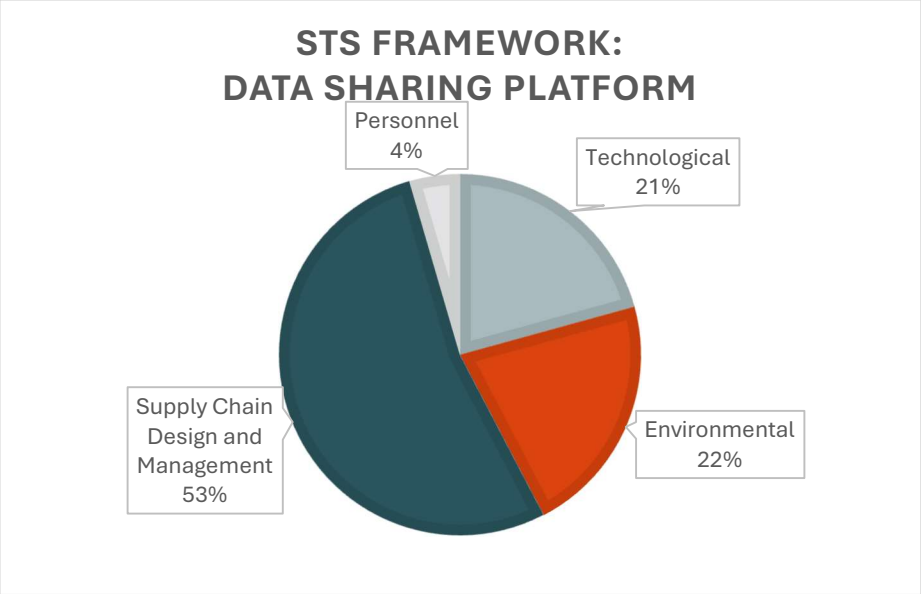


**FIGURE 8: STS FRAMEWORK RESPONSE CATEGORIZATION FOR THE DATA SHARING PLATFORM FOCUS AREA (111 RESPONSES)**

# High Level Narrative Summaries

## Data Sharing Platform

In the discussion on what is more important for receiving data, "near time" vs. "real time," the distinction was often from point-to-point delivery. Participants noted that the process flow was dependent on the type of delivery. For example, deliveries that are within close distance of the departure point, or movements that are direct from point-to-point make it easier to track data. Some participants defined real-time tracking as instant, or in milliseconds, but many expressed that very few use-cases actually need that level of real-time tracking. While real-time tracking makes sense in settings where AVs may need to make split-second decision making, for customers, visibility into a package's near-time anticipated arrival time is more important. Remote operators of AVs need real-time data, whereas container availability could be near-time (~5-minute lag between updates). A motor carrier may not need to know the availability of a container if they still have 4 hours of driving time ahead of them before they arrive to pick it up. Another parallel example a participant suggested was to use similar benchmarks as aviation on to how adapt to weather/congestion/delays. We should think about the data sharing platform as a way to provide data on delays and approximate arrival/departure times rather than a way to provide the granularity exemplified by passenger or luggage tracking.

For a vehicle cab, a 1–2-minute lag would be considered very efficient. Basic safety messages were suggested to occur within 10 milliseconds, as inside 300 meters is safety-critical and important for pre-emptive routing. For drone applications, GIS millisecond data would be crucial to operations for last mile delivery, especially when facing weather changes. Private cellular networks and smart corridors may help with providing more second-based data updates.

Fundamentally, the end-user wants to know the probable time of arrival, and the real-time confidence of that probability as the delivery process progresses. For example, for the end-user in construction, delivery time affects the ability to communicate accurately to a customer when a material will be available for an accurate project completion date. Lack of availability affects the customer's cost or may determine whether it is necessary to select a new supplier that can meet the deadline. Near-time information is important for supply chain availability. Time buffers already exist in the process to help address delays and lack of information, but these buffers are getting tighter. Several participants brought up the "Amazon effect," which has set an industry standard of data visibility to customers that is now the expectation everywhere, though it often cannot be met. Connecting partner data would help increase visibility into the "why" of a delivery time beyond exceptions of delays like weather or congestion. Connected data would also allow participants in different sectors to better understand a ripple effect, where a backup of one load impacts the next (e.g., performance of one carrier can impact another's schedules and performance) so they can better plan for scheduling appointment times to be received (and be properly staffed to receive the load) at a port or warehouse. Number of hours for drivers should

also be considered as a workforce data point that can have a ripple effect. Several participants suggested that this type of platform must include both some level of predictive modeling and raw near or real time data.

Concerns around data sharing mostly related to security and concerns about how the data could be used, how competitors might capitalize on knowing the availability of fleets, or security around military or government types of shipments. The granularity of data is also a concern for some sectors. Container level tracking would be fine, but contents within the container would be harder to share. Permissions to this type of data are generally restricted to only parties that have a business reason to access it, and access from suspicious inquiries are often rejected. Some suggested solutions were to start with data that is publicly available to demonstrate how it might work and to determine the benefits as well as required security measures. Data agreements would need to be in place that define who is receiving the data, how the data will be used, and the data retention policy. Participants also agreed that all data should be aggregated and de-identified of any personally identifying information.

For willingness to participate in a data sharing platform, participants expressed that they would need more training/webinars on how to use the data, especially data that was unfamiliar, or alternatively, they would like a dashboard that would standardize the data in a digestible way. Having a standard definition of what "arrived" means could help to solve the question of whether near-time vs. real-time information is more useful. A collaboration matrix of the data and what participants are viewing/using would also be helpful. DEIA access to this data for small businesses should also be considered for fair and equitable exchange.

If a data sharing platform were to be scaled at a national level, considerations for different types of infrastructure and traffic management should be considered. For example, there is not a standardized state-based data system or data feed, and states vary in their construction zone standards. While the East coast standards are fairly uniform, there is more variance on the West coast.

## Connected and Automated Vehicles

As it did last year, infrastructure remains a challenge for CAV technologies. Although the technology exists, there is a lack of implementation of the right infrastructure to support advanced vehicle technologies. Participants shared that while 4G connectivity is sufficient for most drones and telemetry operations, there is a lack of 5G connectivity, especially in rural coverage, to support CAVs. Fiber optics and towers are not currently available in all urban areas, or in many rural areas. For example, many regions still experience bandwidth restriction issues, and areas close to ports and some national parks do not allow cell towers. Participants expressed that as the future of freight leans more towards hub-to-hub and smart and connected communities, different infrastructure approaches may be needed. For connectivity, there may be

pathways to plan routes, but there's a fairly small driving range and more research and development is needed.

The lack of a national framework continues to be a challenge for this space. While many states have independent strategies for safety, testing, and deployment, there is not a federal model to follow like there is for EVs (e.g., ZEF Corridor Strategy). In addition, there are no standardized ground automation plans at the state level. The FAA's Beyond Visual Line of Sight regulations are still not industry friendly, which impacts last-mile delivery automation. Changes in political administration also affect economic incentives from the government for advancing these technologies. There is also a lack of alignment among OEMs as to when vehicle-specific dedicated technicians should be required.

Public perception of CAVs remains a struggle, as the media often highlights only negative events. Several participants discussed how there is a performance expectation that this technology must be fault-free in order to be accepted. For heavy vehicles, which are already perceived by the public as unsafe, this is an even greater challenge to incorporate automation for freight. Fear-based perception is also related to workforce, as many fear automation will result in jobs reduction or replacement. It would help to find ways to provide evidence that automated technology adoption would not take away jobs. Other solutions towards solving public rejection would be disseminating more fact-based information of an AV's safety performance level (versus coercion), slowing the introduction of distinct automated features, and demonstrating safety by showing inspection checklists and positive safety statistics over time.

## Sustainability & Decarbonization

For this focus group area, participants confirmed carbon credits and incentives have improved since 2023, and new national standards have resulted in increased capital flow. However, there is a lack of awareness about several of these incentives (e.g., more Diesel Emissions Reduction Act funding, credits are policy-based). The cost of new efficient equipment was clarified to be more of an equity issue for smaller businesses than for large corporations.

Other countries are charging 30% less for electric vehicles compared to equivalent vehicles with gas engines. The long wait times to purchase these vehicles has improved significantly since last year, but there is still a need to bring more battery production efforts domestically to the U.S.

Lack of a trained workforce to service future clean fuel technologies remains a challenge and priority. Suggested solutions leaned towards joint sector collaboration, such as OEMs working with community colleges on their specifications for training mechanics. This model has worked successfully in other regions, such as California. Providing opportunities for second-chance offenders came up again frequently this year as a suggested solution for addressing workforce shortages.

In regard to prioritizing certain fuels over others and the infrastructure available to support these developments, there was skepticism among participants as to whether focusing on EVs as the priority was the best solution. Research is needed into how EVs can handle extreme temperatures that impact the battery's efficiency and length of charge needed. This could be a concern for heavy vehicles and emergency operations such as snowplows. Challenges around the entire lifecycle of these batteries such as ethical mining of materials and especially the ability to recycle or proper disposal methods at the end of the cycle are a concern. There is also concern that electricity is still powered by fossil fuels such as coal and natural gas; charging using these sources is not true decarbonization. While EV's are a good starting point, hydrogen was proposed as the next generation fuel technology that may be a better solution for long term decarbonization goals.

There is still a lack of alignment around how to scale infrastructure for future alternative fuels. A more unified approach between government agencies and industry is needed to provide a clear pathway. Businesses remain lost in the uncertainty about the grid capacity, the timing of when infrastructure will be in place, and when the costs of the technologies will come down. These are all factors needed to make an informed decision about when to invest and convert.

Public perceptions around range anxiety and battery degradation need to be addressed through more education. Media often highlights misinformation, further contributing to the problem. There is a strong need for non-biased, non-political data that only addresses the scientific facts about new vehicle technologies.

## Workforce Development

Much of the workforce development conversation for this focus group area revolved around what we will refer to as the "talent pipeline." Several questions came up regarding this topic. How do we pique interest in supply chain jobs that have typically been viewed as unattractive? How do we bring in more of the current generation as the aging workforce retires and offer them a type of degree or certification and salary that matches today's economy? When is the appropriate time to target these folks (e.g., preschool, high school, adults re-careering, etc.)? What are the state approved programs and funding opportunities?

A few suggested solutions said the introduction of STEM careers and future technology jobs should start with exposure at as young as possible (e.g., EV technician cartoons, robotic toys). Many participants made the point that most choose their career path before high school. Apprenticeships and stackable micro-credentialing programs are viewed as good opportunities to spotlight pay and help individuals determine if the job tasks are a good fit for a future career. There is also a societal value issue at play, as the traditional K-12 to Bachelors or Masters trajectories are usually given a greater value when determining future careers. Vocational schools and certifications should be promoted as more socially popular opportunities, especially

if they are meeting community needs by providing stronger high-demand skillsets for the job market compared to a 4-year university degree.

Collaborative solutions between partners were suggestions for more awareness about who is starting technical programs to meet today's technologies. Public-private partnerships that better connect industry and education could increase access, availability, and awareness (e.g., employees of companies teaching some classes). Guaranteed job or internship placements after training could also help incentivize graduates of these types of programs and benefit companies by providing a talent pipeline for the types of employees they want to train from the start.

Unique workforce model style ideas were also proposed by these focus groups. For example, "Training the trainer," where someone sits with the person doing the coding, then disseminates the relevant information to the technician working on the technology. Another idea related to data is to lean more heavily on internally trained AI Chat GPT for company specific purposes for easy troubleshooting, saving more complex issues for experienced personnel to save time and effort and purpose the workforce efficiently.

## Community Engagement

In this focus group area, several participants gave cautionary feedback that the burden should not be on the community to accept, understand, and perceive things correctly. When approaching a community with a new technology, the wrong approach is to say, "here's this technology, you need to accept it." Rather, the needs of the community should be the first step, and then as a second step the technology product or service can be tailored to help meet those needs. Funding round tables with communities to better understand their needs will help to better inform future programs. Building trust in the community can be done through word of mouth (e.g., disseminate information through school bus drivers or retirement homes). Encourage employers, localities, and local citizens to get invested together, and circumvent the perspective of "Not in my backyard" (NIMBYism). Community-based approaches such as educating youth, changing perceptions through a demo-day to highlight new and exciting technology (e.g., provide people the opportunity to ride in a new ACE vehicle) were also offered as solutions to both engage communities and create opportunities to align and break down challenges and perceptions.

# Conclusions

In conclusion, as evidenced throughout this gap analysis, the current supply chain is a dynamic and fragile system. Traditional methods may not be sufficient to find successful solutions for today's challenges. A more equitable, reliable, and sustainable future for the supply chain will require innovative solutions at each level of the STS theory framework. Most notably, building the case for supply chain resiliency is of utmost importance—this finding is both supported by recent academic publications and further emphasized by the results of this Gap Analysis.

In comparison to the responses from 2023, when organized by the STS framework, the frequencies of the focus group coded responses (465 in total) were as follows: environmental factors were considered the most common barrier to ACE technology adoption (179, 38% of responses), followed by technology limitations (93, 20%), personnel barriers (92, 20%), supply chain design and management (87, 19%), and uncategorized (14, 3%). Whereas the aggregated data total for 2024 were less, (329 in total) environmental factors were still considered the most common barrier (n=113, 34% of responses), followed by technological limitations (n=40, 12%), personnel barriers (n=76, 23%), and supply chain design and management (n=100, 31%). This demonstrates a 4% increase in environmental barriers, an 8% decrease in technological barriers, and 3% increase in personnel barriers, and a 12% increase in supply chain design & management barriers. Inferentially, environmental barriers remain the largest challenges to supply chain stakeholder needs. Personnel issues remained around the same frequency. For the largest changes, this may potentially indicate that technology research and development has progressed since last year, while the collaboration and standardization of partners within the supply chain have become increasingly fragmented. STS environmental barriers such as policy or actor alignment remain a barrier. Future program areas that adequately address these issues through solutioning will require a multi-actor approach that includes government, industry, academia, and non-profits.

If we look at the Connected & Automated Vehicles Focus Group, in particular, for technological barriers, the frequencies of the focus group coded responses (62 in total) were as follows: environmental factors were considered the most common barrier (24, 39% of responses), followed by supply chain design and management (19, 30%), personnel barriers (13, 21%), and technological limitations (6, 10%). More research would be needed to determine if an enabling environment to deploy these technologies is the problem, or if this was more so a balanced participation issue for this round of focus groups because there were fewer technology partners represented in these discussions compared to last year.

As shown by the breakdown of barriers by STS framework, a coordinated approach to solving these barriers will require both public and private partnerships within the supply chain. Supply chain design and management relies on several supply chain actors creating a coordinated approach through large-scale cooperation. Though there is still a need to address technological

barriers in terms of more research and development in the deployment of new technologies to solve supply chain issues, this was deemed as the least common barrier. Barriers to implementation are more often related to lack of policy to enable technologies or decarbonization efforts, workforce shortages and lack of educational programs for projected industries, disjointed logistics, and lack of a coordinated shared data platform between actors. The conclusive gaps and suggested solutions for each program area is detailed following.

**Data Sharing Platform –** Defining "near-time" vs. "real-time" data is an imperative first step in the development of a data sharing platform to increase visibility into the movement of goods. For this stakeholder group, although use cases may vary, the general consensus is that the end-user wants to know the probable time of arrival, and the real-time confidence of that probability as the delivery process progresses. The ability to provide a level of predictive modeling that gets to the "why" of a delivery time beyond exceptions of delays like weather or congestion was also suggested. This type of dashboard could inform other critical supply chain data points such as carrier performance or workforce shortages, and use of corridor trends for future infrastructure planning. For actors to participate, there must be proper training for equitable access and clear data agreements on who is receiving the data and how it will be used and de-identified of sensitive information.

**Connected and Automated Vehicles –** Infrastructure remains the largest challenge for deploying CAVs for both aerial and ground deliveries. There needs to be an increase in both 4G and 5G coverage in rural areas to realize the full potential of this technology. The lack of national framework also continues to be a challenge where states differ in deployment timelines, and there is not a federal model for industry to follow or to predict trends in terms of development. Public perception of CAVs, especially as it relates to fear of automation replacing jobs, requires a joint effort for workforce transitions of transferable skills and better educating the general public about fact-based AV safety performance.

**Sustainability and Decarbonization –** This space has improved significantly since 2023, with increased incentives, national standards increasing capital flow, and shorter wait times to purchase EVs. Infrastructure development still remains behind, especially for medium- and heavy-duty vehicles for supply chain applications. There is a lack of alignment around how to scale infrastructure for future alternative fuels, and more unity is needed between government agencies and industry for a clear pathway. There is an immediate need for workforce development for servicing either hydrogen fueling or EV charging stations, but without a clear market projection, it is difficult to scale the necessary educational programs. Public perceptions around hydrogen vehicle/EV range anxiety and battery degradation need to be addressed through more fact-based education.

**Workforce Development & Community Engagement –** As mentioned above, workforce development and public perception issues towards the reception of new technologies persist across all three focus areas above. Increasing more positive reception towards new technologies

will require community roundtables to better understand the community struggles and what tailored changes to technology are needed for these technologies to be a clear value-added change. Building trust through word of mouth, hands on experience, and educating the public could help change perceptions and engage local citizens to participate together in the deployment of these technologies in their communities.

For workforce development, the predominant challenge is facilitating a talent pipeline for an adequately sized workforce to service future technologies. Training in and introduction to these fields should feature varied and multiple solutions spanning grade school exposure to increasing offerings for vocational schools and earn-while-you-learn programs. Public-private partnerships that better connect industry and education could increase access, availability, and awareness (e.g., employees of companies teaching some classes). Guaranteed job or internship placements after training could also help incentivize enrollment in and graduation from these types of programs.

Through their participation in the focus groups, participants provided clarity on their needs and challenges and helped inform future directions and strategies for fostering supply chain resiliency among actors. The topics, needs, and challenges discussed above will be used to develop:

- Recommendations for federal and state funding priorities;
- Priority identification for an implementation plan of program areas that actively seek solutions through working groups of partners;
- Concept exploration for further research and development of solutions to gap focus areas; and
- Lessons learned when implementing plans for annual supply chain stakeholder focus groups for subsequent annual reports on stakeholder needs.

# Appendix A: Focus Group Guide

Workshop Focus Group Session Guide Friday, May 17th, 2024

Dock to Door: Understanding Challenges and Opportunities

Throughout the evolution of the Dock to Door (D2D) initiative to date, four priority topic areas have been identified as ways to close the gaps and transform the current supply chain to one that is truly equitable, transparent, sustainable, efficient, and predictable:

- Data Sharing Platform
- Sustainability & Decarbonization
- Community Engagement & Workforce Development
- Connected & Automated Vehicles

The D2D coalition meeting is an opportunity to work with partners to drill down into more specific challenges and opportunities associated with each priority focus area identified above. This exercise builds on feedback from last year's focus groups and will largely serve as a validation exercise and gap analysis. Their valuable feedback will help us to ultimately refine a research roadmap for each topic area.

There will be four concurrent breakout sessions for each of the four topic areas listed above. Workshop participants will participate in all breakout sessions, regardless of their industry area. They will sit at a table of 8-10 individuals for a 30-minute discussion. During the 10-minute break between each topic area, participants will be encouraged to switch tables in order to sit with different folks each time.

Using a discussion-based small focus group approach, we will engage the participants in a discussion about how to close the supply chain gaps within the context of each priority focus area. Specifically, we will:

1. Hear the needs and problems represented by each representing organization
2. Ensure everyone has an opportunity to speak
3. Foster an environment of networking and knowledge transfer between participants.

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Ground Rules

Before the deliberation begins, facilitators and participants should review the breakout session guidelines. Everyone should agree that:

- Everyone should participate.

- Listen to each other. No one or two individuals should dominate the discussion.
- The discussion should focus on the priority area.
- The group will maintain an open and respectful atmosphere for the discussion.

Role of the Moderator/Notetaker

- Ensure ground rules are being followed
- Ask probing questions and encourage participants to share their views with others.
- Use the question guide to lead the discussion for your session.
- Keep track of the time remaining in the session (each session is 30 minutes total). Notify the group when 20, 10 and 5 minutes remain. By the 5-minute mark, the session should move towards summarizing the discussion.

Moderator/Notetaker Instructions

**For the data sharing platform focus group**: There will first be a presentation and a panel discussion to prime participants' minds, followed by focus group discussions. Focus groups will be facilitated by a subject matter expert (SME) and a recording notetaker. The SME will ask the specific questions to initiate discussion- the notetaker will capture the responses to these questions:

We've found the tracking element is most important to increasing visibility into the movement of goods.

1. What is a greater priority for your organization: near time vs. real time tracking for predictive modeling?
2. What kinds of data are needed to enable that?
3. What would it take for you to be willing to share this in an encrypted peer-to-peer environment? Is your current system for storage of this data compatible with this type of environment?

**For the remaining 3 focus groups** *(Connected & Automated Vehicles, Sustainability & Decarbonization, Community Engagement & Workforce Development)*: There will first be a presentation or panel to prime the discussion. The focus groups, who have been randomly assembled at tables, will have a discussion based around the worksheets. Discussion of each focus will be facilitated by the notetaker who will also serve as a moderator. You will lead a table of approximately 8 people for a single 30-minute discussion session.

To begin, first:

- Ensure all members of your group have the appropriate focus group worksheet.
- Announce the focus group will now begin and review the ground rules.
- Allow approximately 5-7 minutes to complete the worksheet.

You will need to take notes on the discussion and responses to the following questions you will ask the group:

1. Did anyone have additional challenges that were not listed? Can you briefly describe it to the group?
    a. Does anyone have suggested solutions to this new challenge?
2. From the table on your sheet, which challenge did you mark as the most important to your organization and why?
    a. Were there any challenges you crossed out/found no longer relevant? Why?
3. Prioritize the discussion first around new challenges they add to the list. You can return to discuss which challenges each mark as the most important to your organization and why?
    a. Were there any challenges you crossed out/found no longer relevant? Why?

Collect all sheets filled out by the participants after each session.

Tips for Moderators/Notetakers

- Be okay with brief moments of silence. Sometimes pauses are needed to reflect.
- If one person is dominating the conversation, here is an example of how to handle:

o "That's a great point, Jamie. We haven't heard from Casey in a while, what are your thoughts on this?"

- You may find it hard to move on to another issue when there is so much more that could be said. The facilitator's role is to ensure that the group moves through the questions in a timely manner. However, if the discussion may go in an extremely productive direction, use your judgement to determine when to return to the questions. Feel free to use the guiding questions to bring the discussion back to focus should the conversation become less productive.
- We recommend reserving the last 5 minutes of each session as an accuracy checkpoint with the group to summarize findings.

Sustainability and Decarbonization: Notetaker Script

**Overall Directions:** Please fill out the information at the top of your sheet in terms of attendance at last year's event and partner category. We are going to do a few activities which center on the challenges and solutions for the D2D sustainability and decarbonization topic area

Confirming Challenges: (3-5 minutes)

Directions for Confirming Challenges

- Please read the list of challenges in the table below that are associated with this D2D topic area. These were identified last year during the May 2023 workshop. We want to confirm whether these challenges are still an issue and prioritize the ones that are most important.
- First consider if any of the challenges listed are no longer an issue. If so, draw a line through them.
- Next, note the most important challenge with an asterisk.
- In the end – you should have challenges that don't apply crossed out and the most important challenge for Sustainability and decarbonization noted with an (*).
- Please complete the activity independently. If time allows, we will discuss priorities. Questions?
    - **If they ask for an explanation of a challenge**: Apologies, I'm just facilitating, please complete the activity as best you can, you can also leave comments on pg. 2 with your name and we'll have someone get back to you.
    - **If they say they have an addition**: Hold onto that thought, we'll have another activity where you can list things that you don't see here.

**Confirming Challenges:** Cross out challenges that are no longer an issue. Then mark with an asterisk (*) the most important challenge for sustainability and decarbonization.

| #1 (*) | Sustainability and decarbonization |
|---|---|
| | Lack of a unified approach to moving towards a coordinated infrastructure to support heavy duty vehicles |
| | Identifying priority fuel types to build capabilities around and support at scale |
| | Unrealistic deadlines for implementations such as decarbonization |
| | Insufficient grid capacity for electric vehicle charging needs |
| | Insufficient infrastructure for electric vehicles charging needs |
| | More research is needed for hydrogen fuel cell vehicles |
| | Insufficient infrastructure for hydrogen fuel cell vehicles |

| | |
|---|---|
| | Lack of a trained workforce service clean fuel transportation options |
| | Lack of trained workforce to build and maintain the infrastructure needed to advance sustainability goals |
| | Overall cost for new, more efficient equipment |
| | Cost of new equipment too prohibitive for smaller fleets |
| | Long wait time to buy electric medium and heavy-duty vehicles |
| | Concerns over battery life for long-haul freight transport |
| | Concerns over high cost, future replacement, and recycling of batteries |
| | Public misperception on climate change and impacts and need for sustainability |
| | Public misperception on EV batteries and hydrogen fuel |
| | Lack of carbon credits or similar incentives for fleet transitions |

Additional Challenges: [15-20 minutes]

**Additional Challenges Directions [3-5 minutes]**: Now take a few minutes to brainstorm independently any challenges for sustainability and decarbonization that you think are missing from the table. If you are aware of or exploring any interesting solutions to those challenges, please include those on the sheet as well, and we can discuss those if time allows.

**Additional Challenges Discussion:** Please identify any additional challenges for sustainability and decarbonization that were not on the lists above that should be added. You can add as many as you think are needed. If applicable, please include any solutions that you are aware of or interested in exploring.

| Sustainability and Decarbonization Challenges |
|---|
| |
| |

Brainstorm additional sustainability & decarbonization CHALLENGES (10-15 minutes)

- Did anyone have additional sustainability and decarbonization challenges? Can you briefly describe it to the group?
    - Go around the table and let each person describe the challenges they noted. Document the responses. Any others we haven't captured?

IF TIME ALLOWS:

Brainstorm additional sustainability and decarbonization SOLUTIONS

- Do you all have any suggested solutions to these additional challenges?
    - **If they offer a solution and don't note which challenge they are talking about, ask**: Is that solution specific to a particular challenge that was mentioned? Document solution and note if it was directed toward a particular challenge.

Revisiting Prioritizing Challenges

- Now that you've completed the entire worksheet, let's go back and have each person share what they identified as the most important sustainability and decarbonization challenges and why you ranked these as #1. Document responses.

***Any final discussion points*:** Is there anything about sustainability and decarbonization that we neglected to cover that you would like to discuss? I'd like to open it up for our last few minutes.

**Additional Comments or Questions** for sustainability and decarbonization. Please leave your name with any questions and the program lead will contact you with a response.

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Make sure and collect sheets at the end!

Sustainability & Decarbonization: Partner Handout

**Attendance**: Were you able to attend last year's workshop (May 2023)?

- Yes _
- No __

**Partner Category:** Please check your partner category(s).

- Industry: ___
- Government: _____
- Nonprofit/Advocacy: _____
- Academia: __
- Small, Women, and Minority-Owned Businesses (SWaM): _____

Confirming Challenges:

- Cross out challenges in the table below if they are no longer an issue.
- Then mark with an asterisk (*) the most important current challenge for sustainability and decarbonization.

| #1 (*) | Sustainability and Decarbonization |
|---|---|
| | Lack of a unified approach to moving towards a coordinated infrastructure to support heavy duty vehicles |
| | Identifying priority fuel types to build capabilities around and support at scale |
| | Unrealistic deadlines for implementations such as decarbonization |
| | Insufficient grid capacity for electric vehicle charging needs |
| | Insufficient infrastructure for electric vehicles charging needs |
| | More research is needed for hydrogen fuel cell vehicles |
| | Insufficient infrastructure for hydrogen fuel cell vehicles |
| | Lack of a trained workforce service clean fuel transportation options |
| | Lack of trained workforce to build and maintain the infrastructure needed to advance sustainability |
| | Overall cost for new, more efficient equipment |
| | Cost of new equipment too prohibitive for smaller fleets |

| | |
|---|---|
| | Long wait time to buy electric medium and heavy-duty vehicles |
| | Concerns over battery life for long-haul freight transport |
| | Concerns over high cost, future replacement, and recycling of batteries |
| | Public misperception on climate change and impacts and need for sustainability |
| | Public misperception on EV batteries and hydrogen fuel |
| | Lack of carbon credits or similar incentives for fleet transitions |

**Additional Challenges:** Please identify any additional challenges with regards to sustainability and decarbonization that were not on the lists above that should be added. You can add as many as you think are needed. If applicable, please include any solutions to those challenges that you are aware of or interested in exploring.

| Sustainability and Decarbonization Challenges |
| --- |
| |
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| |

**Additional Comments or Questions** with regards to sustainability and decarbonization. Please leave your name with any questions and the program lead will contact you with a response.

| |
| --- |
| |

Please give this worksheet to your discussion facilitator. Thank you for your input!

Community Engagement & Workforce Development: Notetaker Script

**Overall Directions:** Please fill out the information at the top of your sheet in terms of attendance at last year's event and partner category. We are going to do a few activities which center on the challenges and solutions for the D2D community engagement & workforce development topic area. [**Only on this sheet**: *Please note that community engagement is a new addition to this topic area, the examples we have were pulled from other topic area discussions during the workshop last year. So, it is important that you help us identify the challenges and solutions you see for D2D community engagement.]

Confirming Challenges: (3-5 minutes) Directions for Confirming Challenges

- Please read the list of challenges in the table below that are associated with this D2D topic area. These were identified last year during the May 2023 workshop. We want to confirm whether these challenges are still an issue and prioritize the ones that are most important.
- First consider if any of the challenges listed are no longer an issue. If so, draw a line through them.
- Next, note the most important challenge with an asterisk.
- In the end – you should have challenges that don't apply crossed out and the most important challenge for community engagement and the most important challenges for workforce development noted with an (*).
- Please complete the activity independently. If time allows, we will discuss priorities. Questions?
    - **If they ask for an explanation of a challenge**: Apologies, I'm just facilitating, please complete the activity as best you can, you can also leave comments on pg. 2 with your name and we'll have someone get back to you.
    - **If they say they have an addition**: Hold onto that thought, we'll have another activity where you can list things that you don't see here.

**Confirming Challenges:** Cross out challenges that are no longer an issue. Then mark with an asterisk (*) the most important challenge for community engagement and the most important challenge for workforce development.

| #1 (*) | Community Engagement |
|---|---|
| | Lack of acceptance of new facilities and infrastructure changes by some communities |
| | Public misperceptions on climate change can be perceived as political. |
| | Public misperceptions on EV batteries and hydrogen fuel. |
| | Community acceptance of automated vehicle technology is a significant barrier; members of the public have |

| | |
|---|---|
| | concerns about safety and fewer jobs. |
| | Community acceptance of new hubs, facilities, and other infrastructure (“not in my backyard”) |
| | Changing perceptions & misperceptions (battery safety, climate change, automated vehicles, etc.). |
| #1 (*) | Workforce Development |
| | Access to training and job opportunities outside of the traditional K-12 to college trajectory (e.g., earn-while-<br>you-learn programs, trade schools, second-chance employees). |
| | Workforce shortages impact every aspect of the supply chain. |
| | Higher demand for educators than there are people to fill these positions |
| | Training needs to evolve to meet the skills needed for future technologies (mechanics, installers, automated<br>vehicles, and infrastructure). |
| | Aging workforce. |
| | Employee satisfaction and retention in many supply chain careers (e.g., trucking, warehouse) is low. |

Additional Challenges: [15-20 minutes]

**Additional Challenges Directions [3-5 minutes]**: Now take a few minutes to brainstorm independently any challenges for community engagement or workforce development that you think are missing from the table. If you are aware of or exploring any interesting solutions to those challenges, please include those on the sheet as well, and we can discuss those if time allows.

**Additional Challenges Discussion:** Please identify any additional challenges for community engagement & workforce development that were not on the lists above that should be added. You can add as many as you think are needed. If applicable, please include any solutions that you are aware of or interested in exploring.

| Community Engagement Challenges |
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| Workforce Development Challenges |
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Brainstorm additional community engagement & workforce development CHALLENGES (10-15 minutes)

- Did anyone have an additional community engagement challenge? Can you briefly describe it to the group?
    - Go around the table and let each person describe the challenges they noted. Document the responses. Any others we haven't captured?
- Did anyone have an additional workforce development challenge? Can you briefly describe it to the group?
    - Allow each person to describe the challenges they noted. Document responses. Any others we haven't captured?

IF TIME ALLOWS:

Brainstorm additional community engagement & workforce development SOLUTIONS

- Do you all have any suggested solutions to these additional community engagement and workforce development challenges? I'd like to open it up to the group.
    - **If they offer a solution and don't note which challenge they are talking about, ask**: Is that solution specific to a particular challenge that was mentioned? Document solution and note if it was directed toward a particular challenge.

Revisiting Prioritizing Challenges

- Now that you've completed the entire worksheet, let's go back and have each person share what they identified as the most important community engagement challenge and the most important workforce development challenge and why you ranked these as #1. Document responses.

***Any final discussion points*:** Is there anything about community engagement & workforce development that we neglected to cover that you would like to discuss? I'd like to open it up for our last few minutes.

**Additional Comments or Questions** for Community Engagement & Workforce Development. Please leave your name with any questions and the program lead will contact you with a response.

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Make sure and collect sheets at the end!

Community Engagement & Workforce Development: Partner Handout

**Attendance**: Were you able to attend last year's workshop (May 2023)?

- Yes _
- No __

**Partner Category:** Please check your partner category(s).

- Industry: ___
- Government: _____
- Nonprofit/Advocacy: _____
- Academia: __
- Small, Women, and Minority-Owned Businesses (SWaM): _____

**Confirming Challenges:** Cross out challenges that are no longer an issue. Then mark with an asterisk (*) the most important challenge for community engagement and the most important challenge for workforce development.

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|---|---|
| #1 (*) | Community Engagement |
| | Lack of acceptance of new facilities and infrastructure changes by some communities |
| | Public misperceptions on climate change can be perceived as political. |
| | Public misperceptions on EV batteries and hydrogen fuel. |
| | Community acceptance of automated vehicle technology is a significant barrier; members of<br>the public have concerns about safety and fewer jobs. |
| | Community acceptance of new hubs, facilities, and other infrastructure ("not in my backyard"). |
| | Changing perceptions & misperceptions (battery safety, climate change, automated vehicles,<br>etc.). |
| #1 (*) | Workforce |
| | Access to training and job opportunities outside of the traditional k-12 to college trajectory<br>(e.g., earn-while- you learn programs, trade schools, second-chance employees). |
| | Workforce development impacts every aspect of the supply chain. |
| | Higher demand for educators than there are people to fill these positions |
| | Training needs to evolve to meet the skills needed of future technologies (mechanics, installers, automated vehicles, and infrastructure). |

| | |
|---|---|
| | Aging workforce. |
| | Employee satisfaction and retention in many supply chain careers (i.e., trucking, warehouse) is<br>low. |

**Additional Challenges (and solutions):** Please identify any additional challenges for community engagement & workforce development that were not on the lists above that should be added. You can add as many as you think are needed. If applicable, please include any solutions to those challenges that you are aware of or interested in exploring.

| Community Engagement Challenges |
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| Workforce Development Challenges |
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**Additional Comments or Questions** for Community Engagement & Workforce Development. Please leave your name with any questions and the program lead will contact you with a response.

Please give this worksheet to your discussion facilitator. Thank you for your input!

Connected and Automated Vehicles: Notetaker Script

**Overall Directions:** Please fill out the information at the top of your sheet in terms of attendance at last year's event and partner category. We are going to do a few activities which center on the challenges and solutions for the D2D connected and automated vehicles topic area

Confirming Challenges: (3-5 minutes)

Directions for Confirming Challenges

- Please read the list of challenges in the table below that are associated with this D2D topic area. These were identified last year during the May 2023 workshop. We want to confirm whether these challenges are still an issue and prioritize the ones that are most important.
- First consider if any of the challenges listed are no longer an issue. If so, draw a line through them.
- Next, note the most important challenge with an asterisk.
- In the end – you should have challenges that don't apply crossed out and the most important challenge for noted with an (*).
- Please complete the activity independently. If time allows, we will discuss priorities. Questions?
    - **If they ask for an explanation of a challenge**: Apologies, I'm just facilitating, please complete the activity as best you can, you can also leave comments on pg. 2 with your name and we'll have someone get back to you.
    - **If they say they have an addition**: Hold onto that thought, we'll have another activity where you can list things that you don't see here.

**Confirming Challenges:** Cross out challenges that are no longer an issue. Then mark with an asterisk (*) the most important challenge for connected and automated vehicles.

| #1 (*) | Connected and Automated Vehicles |
|---|---|
| | Shortages in qualified workforce/lack of workforce development regarding automated vehicles |
| | Public perception and acceptance of automated vehicle technology due to safety concerns or fear of job reductions/replacement |
| | Conveying the benefits of automated/connected vehicles to those with no access to public transportation or who have disabilities |
| | Costs incurred for obtaining automated/connected vehicles and the related insurance costs |

| | |
|---|---|
| | Lack of or weak infrastructure and communications to support widespread automated vehicle use for the long term, including in rural areas |
| | Lack of a national framework for automated vehicle policy, regulations, beyond-the-visual-line-of-sight (BVLOS) limitations, and FCC spectrum issues |
| | Installation of fiber infrastructure and 5G communications (for vehicle-to-vehicle and vehicle-to-infrastructure) are difficult/costly to build and require roadway shutdowns in an already overburdened traffic situation |
| | Lack of shared language between OEMs and utility companies which is needed to match the technology to the infrastructure |
| | Concerns about timeline for deployment of automated vehicles and the infrastructure needed for that |

Additional Challenges: [15-20 minutes]

**Additional Challenges Directions [3-5 minutes]**: Now take a few minutes to brainstorm independently any challenges for connected and automated vehicles that you think are missing from the table. If you are aware of or exploring any interesting solutions to those challenges, please include those on the sheet as well, and we can discuss those if time allows.

**Additional Challenges Discussion:** Please identify any additional challenges for connected and automated vehicles were not on the lists above that should be added. You can add as many as you think are needed. If applicable, please include any solutions that you are aware of or interested in exploring.

| Connected and Automated Vehicle Challenges |
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Brainstorm additional connected and automated vehicle CHALLENGES (10-15 minutes)

- Did anyone have additional connected and automated vehicles challenges? Can you briefly describe it to the group?
    - Go around the table and let each person describe the challenges they noted. Document the responses. Any others we haven't captured?

IF TIME ALLOWS:

Brainstorm additional connected and automated vehicle SOLUTIONS

- Do you all have any suggested solutions to these additional challenges?
    - **If they offer a solution and don't note which challenge they are talking about, ask**: Is that solution specific to a particular challenge that was mentioned? Document solution and note if it was directed toward a particular challenge.

Revisiting Prioritizing Challenges

- Now that you've completed the entire worksheet, let's go back and have each person share what they identified as the most important connected and automated vehicle challenges and why you ranked these as #1. Document responses.

***Any final discussion points*:** Is there anything about connected and automated vehicles that we neglected to cover that you would like to discuss? I'd like to open it up for our last few minutes.

**Additional Comments or Questions** for connected and automated vehicles. Please leave your name with any questions and the program lead will contact you with a response.

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Make sure and collect sheets at the end!

Connected and Automated Vehicles: Partner Handout

**Attendance**: Were you able to attend last year's workshop (May 2023)?

- Yes _
- No __

**Partner Category:** Please check your partner category(s).

- Industry: ___
- Government: _____
- Nonprofit/Advocacy: _____
- Academia: __
- Small, Women, and Minority-Owned Businesses (SWaM): _____

Confirming Challenges:

- Cross out challenges in the table below if they are no longer an issue.
- Then mark with an asterisk (*) the most important current challenge for connected and automated vehicles

| #1 (*) | Connected and Automated Vehicles |
|---|---|
| | Shortages in qualified workforce/lack of workforce development regarding automated vehicles |
| | Public perception and acceptance of automated vehicle technology due to safety concerns or fear of job reductions/replacement |
| | Conveying the benefits of automated/connected vehicles to those with no access to public transportation or who have disabilities |
| | Costs incurred for obtaining automated/connected vehicles and the related insurance costs |
| | Lack of or weak infrastructure and communications to support widespread automated vehicle use for the long term, including in rural areas |
| | Lack of a national framework for automated vehicle policy, regulations, beyond-the-visual-line-of-sight (BVLOS) limitations, and FCC spectrum issues |
| | Installation of fiber infrastructure and 5G communications (for vehicle-to-vehicle and vehicle-to-infrastructure) are difficult/costly to build and require roadway shutdowns in an already overburdened traffic situation |

| | |
|---|---|
| | Lack of shared language between OEMs and utility companies which is needed to match<br>the technology to the infrastructure |
| | Concerns about timeline for deployment of automated vehicles and the infrastructure needed for that |

**Additional Challenges:** Please identify any additional challenges with regards to connected and automated vehicles that were not on the lists above that should be added. You can add as many as you think are needed. If applicable, please include any solutions to those challenges that you are aware of or interested in exploring.

| Connected and Automated Vehicles Challenges |
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**Additional Comments or Questions** with regards to Connected and Automated Vehicles. Please leave your name with any questions and the program lead will contact you with a response.

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Please give this worksheet to your discussion facilitator. Thank you for your input!