DOCK DOOR

STATE OF SUPPLY CHAIN GAP ANALYSIS REPORT:

Survey of Stakeholder Needs for Achieving Supply Chain Resiliency

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2023 State of Supply Chain Gap Analysis Report: A Survey of Stakeholder Needs for Achieving Supply Chain Resiliency

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KEYWORDS

Artificial intelligence, automated vehicles, automated-connected-electrified technologies, coalition building, data sharing, freight decarbonization, freight optimization, Industry 6.0, last mile delivery, logistics, secure communications, socio-technical systems theory framework, supply chain, supply chain resiliency, supply chain visibility

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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 2023 marked the first 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 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 automated and connected 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.

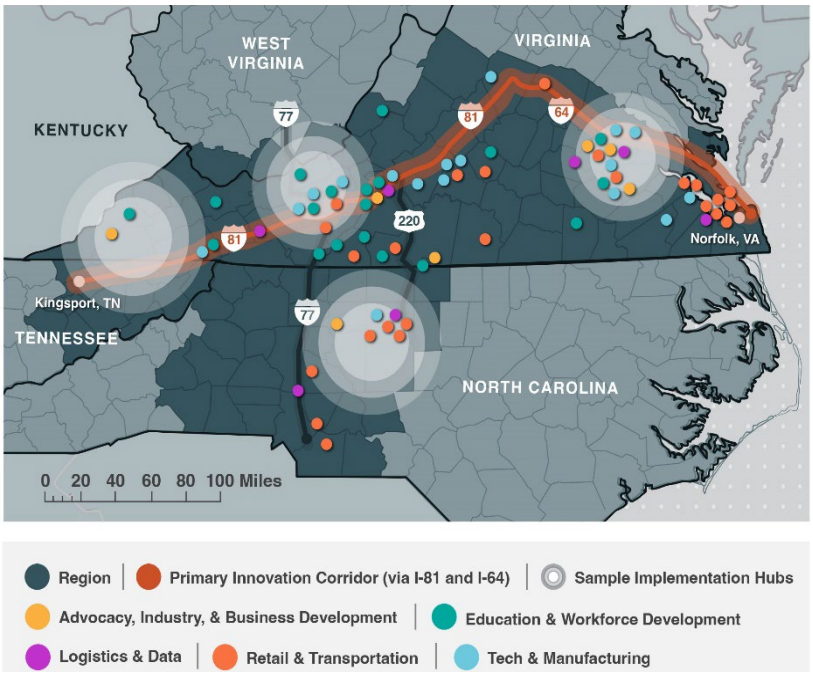

Figure 2: D2D Coalition region showing the location of key members.

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

Recent international conflicts, natural disasters, and COVID-19 have exposed fragility in our nation's supply chain. In conjunction with growing demand, disjointed logistics, worker shortages, and congested roads and ports, these factors threaten our environment, economic prosperity, equity, human health, and national security. A bold, comprehensive program is needed to improve weak links in the supply chain to move goods across all delivery points—whether rural or urban, near or far from a port or highway, easy or difficult to navigate, or in prosperous or economically challenged areas. To create a program that enables robust decision making and increased visibility between supply chain actors, a critical first step is to understand the needs and challenges, suggested solutions, and barriers to the implementation of those solutions.

Objective

An informed understanding of today's supply chain from stakeholders within a variety of sectors is needed to meet emerging challenges related 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. The objective of this research is to examine academic literature, current events, market projections, federal investments, and stakeholder feedback annually to determine what gaps exist. This work enables us to move towards our goal of identifying critical gaps and barriers to realizing a more resilient, environmentally sustainable, equitable, and secure supply chain. Technological solutions within Industry 6.0 such as data exchange, artificial intelligence (AI), and automated, connected, and electrified (ACE) vehicles are increasing in popularity. Using a socio-technical systems (STS) theory framework that considers how the introduction of technology affects multiple subsystems, this research explores the barriers to implementation and social justice considerations for a sampling of these technological solutions at a high level.

Methods

The research process was executed in three steps: literature scan, stakeholder interviews, and focus groups. The purpose of the literature scan was to identify the top supply chain challenge areas related to the transport of goods, recommended strategies, and suggested technological solutions. The literature scan used a combination of academic sources, current events, federal policy and investments, and market projections to inform this work. Using an STS framework, stakeholder interviews of supply chain actors helped to further narrow the scope of challenge focus areas and suggested solutions. Focus groups were performed to further investigate the details of these challenge focus areas, discover other proposed solutions, and better understand present-day barriers to implementation to these solutions. A qualitative analysis approach was used to synthesize and analyze the data.

Results

Much of the supply chain resiliency literature of this decade advocates for a model that is a combination of risk management and risk mitigation, which requires dynamic flexibility,

adaptability, increased communication flows, and adjustments to adapt to unexpected external disruptors. As a response to some of these disruptions, ACE technology platforms have become increasingly popular according to market projections and recent federal infrastructure investments. Automated and connected technologies drive efficiencies for freight optimization and increase reach and accessibility to communities. Electrified freight is a first step towards alternative fuels and decarbonization efforts in the transport of goods. Data-sharing platforms that use AI to phase out antiquated systems and increase visibility between supply chain nodes are also suggested solutions to supply chain challenges today.

To ensure an uninterrupted flow of goods and services, supply chain management requires a holistic approach for actors to collaborate and communicate in both upstream and downstream activities of the transport of goods. Using an STS framework is an effective way to identify how introducing new technologies to solve supply chain transport-related issues may affect different subsystems within society. More research is needed to determine how ACE technology platforms may affect freight flow and optimization, the economy, the environment, workforce development, and communities. Barriers to implementation are most often related to lack of policy to enable technologies or decarbonization efforts, workforce shortages and lack of educational programs for projected industries, disjointed logistics, lack of visibility and shared data between actors, degrading or lack of transportation, communications, and energy infrastructure, and lack of resources. When considering the results of the interviews and focus groups within the STS theory framework, the following findings were made:

- **Environmental** factors such as natural disasters, political conflicts, and a global pandemic continue to affect the efficiencies and risk mitigation capabilities of supply chain actors today. While ACE technologies are favorable for addressing many supply chain gaps, deployment depends on factors that influence the advanced mobility ecosystem and revolve around existing policies, regulations, and infrastructure that are not evolving at the same pace as automation and electrification.
- The maturity of automated vehicle **technology** represents a barrier to the growth of an ACE ecosystem, as do the high investment costs involved.
- **Personnel** barriers stem from insufficient education and promotion of the logistics and trucking industry to counter the increasing labor shortage attributed to low workforce satisfaction. Training for emerging sectors is needed now to adequately prepare the workforce for the future.
- **Supply Chain Design and Management** barriers stem from insufficient communication of data and lack of data standardization between different actors within the supply chain, which negatively affects supply chain performance, which is closely tied to customer satisfaction.

Key Takeaways

- *A stable supply chain is critical for economic prosperity, equity, human and environmental health, and national security.*
- *Results indicate that:*
  - *Supply chain management requires a holistic approach for actors to collaborate and communicate both upstream and downstream activities of the transport of goods in a secure manner.*
  - *Data sharing platform(s) that phase out antiquated systems and increase visibility between supply chain nodes are recommended solutions to supply chain challenges experienced today.*
  - *Automated and connected technologies provide significant opportunity to drive efficiencies for freight optimization and accessibility to communities in last-mile delivery.*
- *Barriers to implementation are most often related to:*
  - *Policy barriers related to technologies or decarbonization efforts.*
  - *Workforce shortages and lack of educational programs for projected industries.*
  - *Disjointed logistics and lack of visibility and shared data between actors.*
  - *Degrading infrastructure and lack of resources.*

Introduction & Background

In the sequence of logistical activities that occur from the moment a package arrives at the dock to the sorting, processing within warehouses, and long- and short-haul delivery stages to the store or customer, there are numerous points for internal and external disruptions. Disruptions to the supply chain often create a "ripple effect" in which a breakdown of one entity or node can have a domino effect in triggering failures for other entities. To ensure an uninterrupted flow of goods and services, supply chain management requires a holistic approach to both upstream and downstream activities of the movement of goods.[1] To understand how to execute a holistic approach for future programs that reinforce ties between supply chain actors, the first critical steps are to understand what gaps exists, what gaps are left to fill, and what approaches are needed to establish a more resilient and secure supply chain.

The goal of this gap analysis is to provide a formal process by which to frame supply chain issues, to identify the relationship of supply chain stakeholder needs to each other and the movement of goods, and to discover stakeholder perceptions of gaps in research, infrastructure, capabilities, and policies to enable supply chain transportation innovation.

Supply Chain Gap Analysis Scope

Supply chain management is a multi-disciplinary field and, as such, the definitions and concepts have many variations in the literature.[2] While the definitions of the different levels of the supply chain vary, they all generally share seven primary functional areas as illustrated in Figure 3 below. While supply, demand, procurement, and customer management are all elements of the supply chain, we chose to narrow the scope of this research through the transportation sector lens rather than the sourcing, processing, and ordering of goods. This allowed us to narrow the scope of the supply chain gap analysis and limit it to the transport or movement of goods within the steps of the inbound-outbound logistics perspective.[3]

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[1] Raja Santhi, A., & Muthuswamy, P. (2022). Pandemic, war, natural calamities, and sustainability: Industry 4.0 technologies to overcome traditional and contemporary supply chain challenges. *Logistics*, *6*(4), 81.

[2] Croom, S., Romano, P., & Giannakis, M. (2000). Supply chain management: an analytical framework for critical literature review. *European Journal of Purchasing & Supply Management*, *6*(1), 67-83.

[3] 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

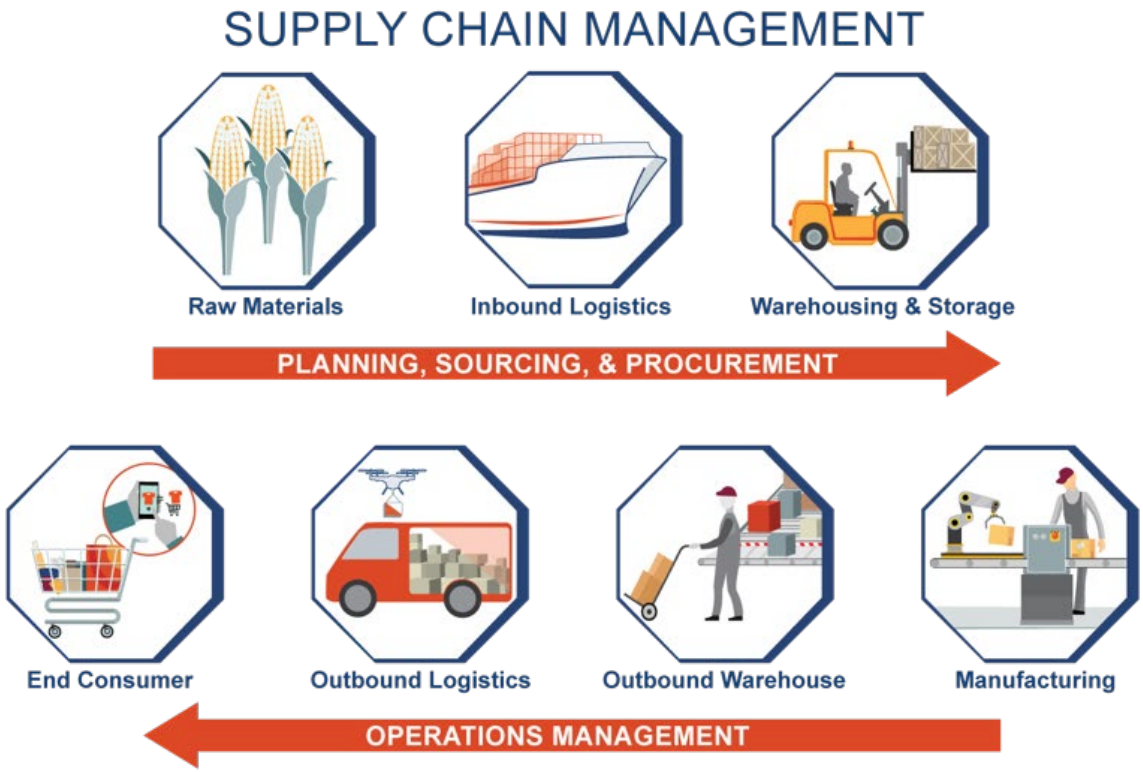

Figure 3: High-level example of the supply chain management system in terms of functionary role.

Socio-Technical Systems (STS) Theory Framework

An STS theory framework is a way to better understand how organizational systems can transform inputs into the desired outputs. It provides a comprehensive model for deconstructing a system into subsystems to more clearly analyze and shape desired actions and the resulting interdependencies. While there are many variations within academic literature,[4] relative to the supply chain, the STS framework can be applied to comprise four subsystems: (i) environmental, (ii) technological, (iii) supply chain design and management, and (iv) personnel.

Similar to a connected chain link, each of the subsystems does not function independently. Rather, they are interconnected with reciprocal influence and impact on one another. The actors or components that propel supply chain activities are affected at every level by the actions of the others. The STS theory framework has been found in multiple applications in the literature to

[4] 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.

identify efficient, cost-effective, and resilient supply chains in the age of new industry technologies and digital supply chain systems.[5,6,7,8]

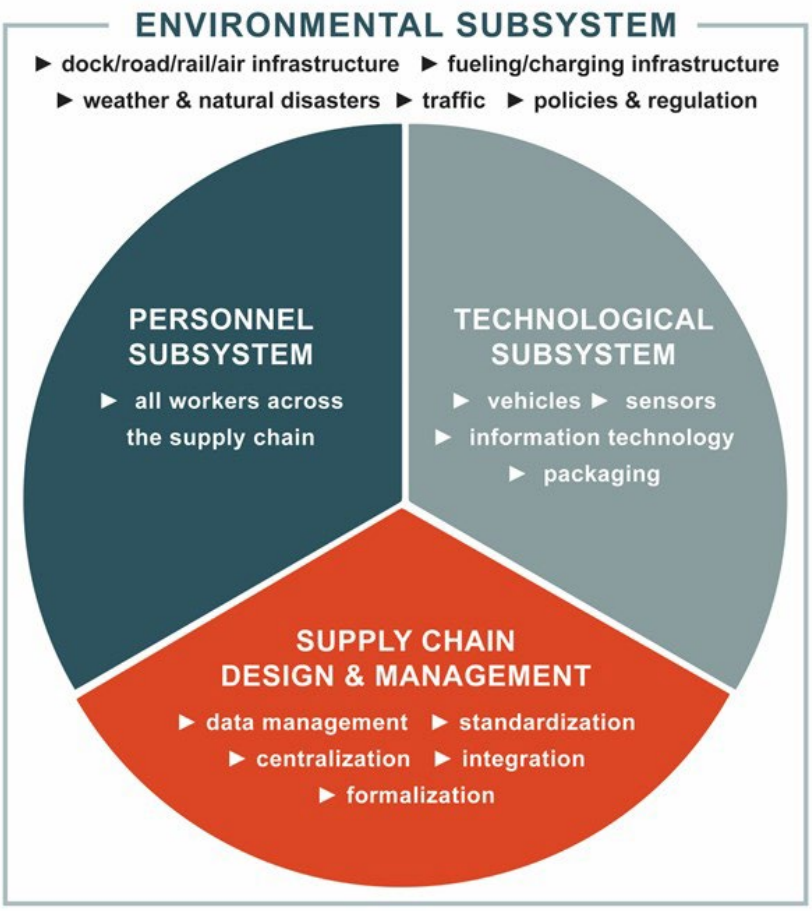

Figure 4: STS theory framework applied to the supply chain.

The environment or world in which the supply chain exists is an externally connected subsystem referred to as "environmental." The environmental subsystem may experience unforeseen disruptions to the supply chain from a variety of external unexpected factors, whether they be global pandemic or natural disaster, shortages of goods from international suppliers during political conflicts, or unanticipated fluctuations in consumer demand.

The "technological" subsystem in this case can refer to either the pre-existing technologies, device techniques, tools and mechanisms, or deployment of new technologies into the supply

[5] Eslami, M. H., Achtenhagen, L., Bertsch, C. T., & Lehmann, A. (2023). Knowledge-sharing across supply chain actors in adopting Industry 4.0 technologies: An exploratory case study within the automotive industry. *Technological Forecasting and Social Change, 186*, 122118.

[6] Ngowi, L., & Mvungi, N. H. (2018). Socio-technical systems: transforming theory into practice. *International Journal of Industrial and Systems Engineering, 12*(2), 310-6.

[7] Shan, S., Shou, Y., Kang, M., & Park, Y. (2022). The effects of socio-technical integration on sustainability practices: a supply chain perspective. *Industrial Management & Data Systems, 122*(2), 419-441.

[8] Vlachos, I. (2021). Implementation of an intelligent supply chain control tower: a socio-technical systems case study. *Production Planning & Control*, 1-17.

chain such as sensors, IT infrastructure, or automated, connected, and electrified (ACE) vehicles. This subsystem may experience challenges in areas such as weather monitoring and forecasting, capital expense and return on investment (ROI), or vehicle performance issues. These are the factors directly affecting the subsystem, but as the STS framework is interconnected, it is important to remember other subsystems will affect it as well. For example, the environmental subsystem in which it resides may introduce other issues such as declining or technologically outdated infrastructure.

The "supply chain design and management" subsystem refers to the exchange of information, the flow of processes, and management models related to supply chain activities. Data availability and sharing between supply chain actors enable the personnel and supply chain components of data and demand forecasting to function effectively. Challenges to the availability of data and the ability to share may affect transport efficiencies, trip optimization and reroutes, and resiliency against environmental subsystem disruptors to the transport such as delays due to weather, construction, or traffic.

The "personnel" are the workers of the supply chain who keep the system and activities alive. This can span every node of the supply chain from policy makers, logistics operators, and warehouse employees, to the end consumer ordering a product. Personnel such as educators and overall supply chain actors hiring the workforce may be most largely affected by workforce availability or the necessary workforce education that keeps pace with new technology deployment. Communities resistant to new technology acceptance may be experiencing social or culturally reinforced norms at all levels.

As the subsequent section will detail, the literature scan provided background information that projects the future of supply chain activities to revolve around deployment of new technologies. The STS framework is considered a strong approach to achieving joint optimization and fostering trust between both social and technical systems when deploying new technologies for a seamless and efficient transition.[9,10]

The concept of the STS framework was used as the foundation for all stages of this research (the literature scan, interviews, and focus groups). This allowed for a more holistic view of the overall supply chain and the challenges experienced at every level relative to the scope of the transport of goods within the inbound-outbound logistics perspective. Participants in the focus groups were presented with the information above to encourage them to think about the challenges both at a personal level and for the sectors at other levels and to consider how suggested solutions and barriers to implementation might affect each interconnected part.

[9] 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.

[10] Hendrick, H., & Kleiner, B. (2001). *Macroergonomics: An introduction to work system design*. Human Factors and Ergonomics Society.

Literature Scan

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 decade from 2012-2023), a current event scan (news media outlets, supply chain and logistics reports from 2019-2023), a scan of recent federal policy and investments (supply chain related regulations, infrastructure and sector investments), and market projections (projected growth rates of ACE technologies for the next decade). The literature scan findings informed the structure, framework, and questions needed for the next step of the research process, stakeholder interviews.

Defining Supply Chain Risks and Challenges

Risk in the supply chain can be categorized as operational risks and disruption risks. Operational risks are the day-to-day challenges such as lead time fluctuations, delivery delays, and inadequate or overflowing demand fulfillment. These are risks that are high frequency, but low impact. Disruption risks, on the other hand, are low-frequency events that are major with high impact (e.g., global pandemic, extreme weather or natural disasters, declining international order and political sanctions, war, cyberthreats, terrorism).[11]

Some of the common supply chain-related risks include higher complexity and competitiveness; lack of supplier diversification (heavy reliance on sole-source supplier(s) from one geographical location) or excessive diversification; lack of transparency across the supply chain network due to dependence on outdated technologies; poor inventory management; failure to prepare for unforeseen disruptions from the economy, environment, or politics; and lack of cost control measures.

One sign of an agile supply chain with competitive advantage is its readiness to address external factors. For example, in response to changing customer behavior and external factors, an agile supply chain system would demonstrate preparedness and ease in adjusting to accommodate the rapidly increasing pace of product development or increased pace in the transport of goods.[12] This is otherwise known as an indicator of resilience through value chains, where efficiencies (or inefficiencies) that are structurally embedded within a system can be strategically cycled depending on broader system needs during periods of disruption risks. For example, an empty warehouse suffering from lack of inventory may be beneficial to another actor with overflowing inventory during a disruption risk. Resiliency between these two connection points would take the form of a plan for long-haul transporters to transport overflowing inventory from one location to the empty warehousing location.

[11] 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).

[12] Oliveira-Dias, D., Maqueira-Marín, J. M., & Moyano-Fuentes, J. (2022). The link between information and digital technologies of industry 4.0 and agile supply chain: Mapping current research and establishing new research avenues. *Computers & Industrial Engineering*, *167*, 108000.

Building Blocks Towards Supply Chain Resiliency

While unknown risk and unpredictable disasters are an ever-present factor, forming a network of resiliency through risk mitigation and management can establish a strong foundation to weather those storms without a catastrophic loss. With an increasingly interconnected system along the supply chain, environmental shocks and stressors can have a domino effect. The first step should be proper risk assessment and determining the level of vulnerability and threat to form strong risk planning and mitigation strategies. Prioritizing resiliency means focusing on how an entity might recover and adapt through operations and cost disruptions. Using formative resilience capabilities such as flexibility, visibility, and collaboration can influence supply chain performance and maintain market competitiveness.[13,14,15,16,17,18]

Social network theory has suggested that the communication, cooperation, and integration of partners around a common goal will contribute to and enhance the formative capabilities of resilience. Unification via strengthened communications and supply chain visibility is the key to risk mitigation through greater awareness, information sharing, and strategic pivoting in response to time-critical events happening along the supply chain.[19,20,21,22]

Many have also argued that the key to developing resiliency is related to increased visibility into the supply chain.[23] By strengthening logistics capabilities through increased visibility, such as a data-sharing platform, partners can grow individually and collectively to scale for stronger collaboration, flexibility, velocity, and visibility at the supply chain level to handle unpredictable changes. Research has found that using information technologies as a solution to data sharing and information connectivity can provide stronger supply chain integration and risk

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[13] Carvalho, H., Barroso, A. P., Machado, V. H., Azevedo, S., & Cruz-Machado, V. (2012). Supply chain redesign for resilience using simulation. *Computers & Industrial Engineering*, *62*(1), 329-341.

[14] Jüttner, U., & Maklan, S. (2011). Supply chain resilience in the global financial crisis: an empirical study. *Supply Chain Management: An International Journal*, *16*(4), 246-259.

[15] 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

[16] Scholten, K., & Schilder, S. (2015). The role of collaboration in supply chain resilience. *Supply Chain Management: An International Journal*, *20*(4), 471-484.

[17] Ponis, S. T., & Koronis, E. (2012). Supply chain resilience? Definition of concept and its formative elements. *Journal of Applied Business Research, 28*(5), 921-935.

[18] Seuring, S., & Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production, 16*(15), 1699-1710.

[19] 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.

[20] 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

[21] 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.

[22] 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.

[23] 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).

management.[24,25,26,27] Benefits to the supply chain as a result of information connectivity may include improved inventory control and monitoring, shorter turnaround times on fulfillment, increased efficiencies of production development cycles, predictive insights into end users, and overall enhanced logistics capabilities to design, monitor, and adapt delivery plans.[28,29,30]

Current Event Scan: Current State of the Supply Chain

In light of drastic global events that have occurred in the past 3 years, a scan of current event news articles confirms that the state of the supply chain continues to face fragility and vulnerability points within the system. Today's supply chains are facing historic challenges, a lack of resiliency, and weakened risk mitigation plans for transportation and distribution within inbound-outbound logistics. Due to the COVID-19 pandemic and ongoing war between Russia and Ukraine, accessibility to natural resources is limited and has yet to recover to the supply levels of previous years. The unforeseen disruptions to these materials both exposed and exacerbated the fragility in our nation's supply chain. The impacts of carbon emissions to the environment continue to disrupt weather patterns and sea levels, which makes logistical transportation of goods difficult to predict and re-route.

[24] Calatayud, A., Mangan, J., & Christopher, M. (2019). The self-thinking supply chain. *Supply Chain Management: An International Journal*, *24*(1), 22-38

[25] Gosain, S., Malhotra, A., & El Sawy, O. A. (2004). Coordinating for flexibility in e-business supply chains. *Journal of Management Information Systems*, *21*(3), 7-45.

[26] Hiromoto, R. E., Haney, M., & Vakanski, A. (2017, September). A secure architecture for IoT with supply chain risk management. In *2017 9th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (IDAACS)* (Vol. 1, pp. 431-435). IEEE.

[27] Song, D. W., & Panayides, P. M. (2008). Global supply chain and port/terminal: integration and competitiveness. *Maritime Policy & Management*, *35*(1), 73-87.

[28] Calatayud, A., Mangan, J., & Christopher, M. (2019). The self-thinking supply chain. *Supply Chain Management: An International Journal*, *24*(1), 22-38.

[29] Fawcett, S. E., Osterhaus, P., Magnan, G. M., Brau, J. C., & McCarter, M. W. (2007). Information sharing and supply chain performance: the role of connectivity and willingness. *Supply Chain Management: An International Journal*, *12*(5), 358-368.

[30] Gunasekaran, A., Papadopoulos, T., Dubey, R., Wamba, S. F., Childe, S. J., Hazen, B., & Akter, S. (2017). Big data and predictive analytics for supply chain and organizational performance. *Journal of Business Research*, *70*, 308-317.

Below are examples from case study research performed from 2020 to 2022 that categorize the effects and potential causes of these disruptions.[31,32]

- Antiquated logistics management systems
    - Lack of acceptance for shifting to newer efficient systems, or lack of technological infrastructure for data needs.
- Lack of technology and infrastructure
    - Disparate economic growth patterns concentrated in cities, leaving behind previously coal-dependent rural areas.
    - Transportation infrastructure unable to support traffic volumes, power needs, or delays from construction projects.
    - Lack of internet infrastructure needed for data transmission needs.
- Workforce shortages
    - Odd or mismatched migration patterns to regional industries due to COVID-19 business shutdowns, lack of job opportunity, or lack of technological expertise and highly skilled workforce development opportunities.
- Lack of inventory control
    - Due to poor demand forecasting or unanticipated disasters' effect on raw material availability for import.
    - Leads to product overflow or scarcity, backed-up warehouses, or 95% completed products waiting on one missing part.
- Lack of visibility into transport across sectors
    - Limited data accessibility around transport.
    - Lack of infrastructure to transmit live updates.
- Logistical challenges
    - Port congestion and long-haul and short-haul re-routes.
    - Affected by all of the above for trip optimization and labor planning.

A survey of current event news research from supply chain magazines, digests, expert blogs, and news media sources further confirmed the same grim outlook. This is outlined in Table 1 below.

[31] Atkinson, R., Muro, M., & Whiton, J. (2019*). The case for growth centers*. Brookings Institution.

[32] Jafarian, A., Rabiee, M., & Tavana, M. (2020). A novel multi-objective co-evolutionary approach for supply chain gap analysis with consideration of uncertainties. *International Journal of Production Economics*, *228*, 107852.

Table 1: Facts Representing the State of the Supply Chain Today

Supply Chain Risks and Challenges	Current Event
Congested Ports	• Shipping containers experiencing weeks of backup[33] • Skyrocketing shipping container costs[34]
Disjointed Logistics and Antiquated Inventory Systems	• 84% of chief supply chain officers cited "lack of inventory visibility" as their biggest challenge[35] • Root cause identified as prevalence of manual and disconnected systems[36]
Increasing Demand	• The e-commerce market is projected to increase from $3.3 trillion today to $5.4 trillion by 2026[37] • Global shipments are predicted to increase over 60% each year[38]
Heavy Carbon Footprint	• Transportation is the biggest contributor to climate change in the U.S., making up 27% of its planet-warming emissions in 2020[39]
Workforce Shortages	• In 2021, the United States saw a record shortage of 80,000[40] truck drivers, even though 72% of U.S. freight is moved by truck[41]
Accessibility to Goods	• The last mile represents 41% of the total supply chain cost in shipping[42] • Delayed deliveries, rising prices, critical shortages of essential goods, lack of transportation means in disadvantaged communities

[33] Siripurapu, A. (2021, December 13). What happened to supply chains in 2021? Council on Foreign Relations. https://www.cfr.org/article/what-happened-supply- chains-2021

[34] Siripurapu, A. (2021, December 13). What happened to supply chains in 2021? Council on Foreign Relations. https://www.cfr.org/article/what-happened-supply- chains-2021

[35] IBM. (2019). The future is here: How AI builds smarter supply chains. *IBM*. https://www.ibm.com/downloads/cas/MVOQEOAB.

[36] New study: Supply chains unprepared to meet future disruption due to disconnected teams, systems, processes. (2021, June 24). *Quickbase*. https:// www.quickbase.com/about-us/media/supply-chains-unprepared-to-meet-future-disruption.

[37] The surprising case for stronger e-commerce growth. Morgan Stanley. (2022, June 14). https://www.morganstanley.com/ideas/global-ecommerce-growth- forecast-2022

[38] Intelligence, I. (2023, January 7). Drone market outlook in 2023: Industry growth trends and forecast. Insider Intelligence. https://www.insiderintelligence.com/ insights/drone-industry-analysis-market-trends-growth-forecasts/

[39] United States Department of Energy (2023, January). *The U.S. national blueprint for Transportation Decarbonization*. https://www.energy.gov/sites/default/files/2023-01/the-us-national-blueprint-for-transportation-decarbonization.pdf

[40] Industry Short 80,000 Drivers Today, May Be Short 160,000 by 2030. (2021, October 25). Trucking.org. https://www.trucking.org/news-insights/ata-chief-economist- pegs-driver-shortage-historic-high.

[41] Goodman, P. (2022, February 9). The real reason America doesn't have enough truck drivers. *The New York Times*. https://www.nytimes.com/2022/02/09/business/ truck-driver-shortage.html?

[42] Jacobs, K., Warner, S., Rietra, M., Mazza, L., Buvat, J., Khadikar, A., ... & Khemka, Y. (2019). *The last-mile delivery challenge: Giving retail and consumer product customers a superior delivery experience without impacting profitability*. Capgemini Research Institute. https://www.capgemini.com/wp-content/uploads/2021/02/Report-Digital-%E2%80% 93-Last-Mile-Delivery-Challenge1-1-1.pdf

Recommended Strategies for Addressing Current Supply Chain Challenges

A scan of the current literature and recent events shows that delays and challenges during one stage of the transportation of goods can adversely affect other segments of the supply chain. To mitigate this ripple effect, a sector of supply chain research heavily focuses on supply chain resiliency. Before resiliency can be improved, risk identification, management, and mitigation must be addressed. While organizations frequently do this at an internal level, there is often a lack of connectedness between actors to ensure resiliency at the macro level.[43] This demonstrates the need for unification of partners around these risks, further strengthened through open communication flows. This unification creates a collective approach to address supply chain challenges through resiliency as they evolve and to adapt to unpredictable environmental and global changes.

Much of the literature scan also pointed to technology-based solutions to ensure more automation, more accuracy, and increased computing abilities around data to enable faster and more efficient processes. Common discussions related to "big data," artificial intelligence (AI), unmanned and automated vehicles at the manufacturing, logistics, and transportation levels, automated long-haul trucks, and unmanned aerial systems (UAS) for last-mile delivery.[44,45] In the last decade, sensors used in the automotive and transportation sectors were also identified as having the ability to reduce operational cost by 10% to 25%.[46] These solutions suggested by supply chain experts indicate that the ACE technology platforms are aligned with the current research on technological solutions to gaps and needs of the supply chain today.

Both federal and state initiatives, alongside market projections, confirm these are the areas of focus for future investment in research, development, and deployment. The most notable of policy initiatives in the last 3 years relate to decarbonization of the transportation sector. A sampling of these policy initiatives in support of this program area are provided in the next section.

Recent Policy Initiatives: Decarbonization and Sustainable Transportation

At a glance, as shown in Figure 5, recent federal investments across the U.S. have emphasized reducing emissions and improving efficiencies throughout the supply chain via freight automation. Automation initiatives have focused on both ground and air automated technologies to increase reach to rural areas. Automated technology testing via designated corridors and testing facilities are underway, as well as research and development into the use of clean alternative fuels.

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[43] 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

[44] Flämig, H. (2016). Automated vehicles and automated driving in freight transport. In M. Maurer, J. C. Gerdes, B. Lenz, & H. Winner (Eds.), *Automated Driving* (pp. 365-385). Springer Berlin Heidelberg.

[45] Jennings, D., & Figliozzi, M. (2019). Study of sidewalk automated delivery robots and their potential impacts on freight efficiency and travel. *Transportation Research Record*, *2673*(6), 317-326.

[46] 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

A glance at the national supply chain and investments

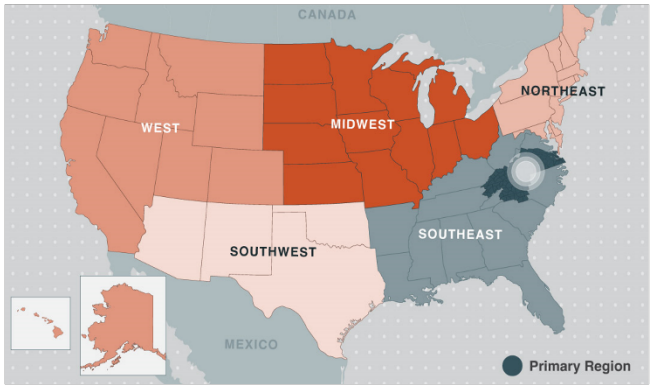
WEST

- Focused on port innovation with some of the largest ports in the country.
- A new US Green Corridors Initiative is aimed at cutting emissions in the shipping industry.
- The Port of Long Beach is working with several Asian ports to cut emissions by utilizing hydrogen and other green fuels.
- Home to a coastal "Green Highway" linking the US, Canada, and Mexico.

SOUTHWEST

- Developing freight automation on key interstates across key states.
- Efforts are underway to create an advanced regional mobility corridor to expand ground and air.

National Regional Map



FEDERAL INITIATIVES

FLOW · SMARTMOBILITY · Joint Office of Energy and Transportation · U.S. DEPARTMENT OF ENERGY

MIDWEST

- States in the "Smart Belt" corridor are using freight automation for various use cases, including getting perishable goods to market quicker in more rural areas and freight corridors.

SOUTHEAST NORTHEAST

- Piloting a range of automation and advanced air mobility, including setting up drone corridors and using UAS for inspection and mapping.
- Southeast features a wide array of associated efforts.

Figure 5: National supply chain investments.

The recently released *U.S. National Blueprint for Transportation Decarbonization*[47] confirmed that logistics efficiencies and sustainable transportation infrastructure were a focus for the U.S. administration for the future through 2050. The transportation sector, especially all modes of travel that relate to the supply chain (i.e., transport of goods from land, air, sea, and people), is the U.S.'s biggest contributor to climate change, making up 27% of its planet-warming emissions in 2020. This staggering statistic reveals a public health issue, as greenhouse gas (GHG) emissions have affected air quality for those people in disadvantaged communities close to heavily trafficked highway corridors.

The establishment of the new federal Joint Office of Energy and Transportation[48] further emphasizes the U.S. focus for the future on sustainable transportation infrastructure. This office was created in response to the Bipartisan Infrastructure Law (officially named the Infrastructure Investment and Jobs Act[49]) to facilitate collaboration between the U.S. Department of Energy and the U.S. Department of Transportation. The office will provide collaboration and funding in support of programs related to electric vehicle (EV) chargers, zero-emission fueling

[47] U.S. Department of Energy. (2023, January). *The U.S. national blueprint for Transportation Decarbonization*. https://www.energy.gov/sites/default/files/2023-01/the-us-national-blueprint-for-transportation-decarbonization.pdf

[48] https://driveelectric.gov/

[49] Infrastructure Investment and Jobs Act, H.R.3684 117th Congress (2021)

infrastructure, and zero-emission transit and school buses. The Joint Office's "Ride and Drive Electric Research and Development" funding opportunity[50] program will help address adoption and implementation of equitable EV charging networks and provide investment into EV workforce development opportunities.

Related to alternative fuels, the Department of Energy Hydrogen Project[51] (400+ active projects, 200+ companies, 15 national labs), with funding awards ranging from a total of $100 million to $400 million per year, shows the investment in research and development of alternative fuels such as hydrogen. The project is also deploying $7.4 million in funding to develop innovative medium- and heavy-duty EV charging and hydrogen corridor infrastructure plans (seven projects across 23 states). The Bipartisan Infrastructure Law is awarding $9.5 billion specifically for clean hydrogen; $1 billion for electrolysis research, development, and demonstration; $0.5 billion for research and development of clean hydrogen manufacturing and recycling; and $8 billion for at least four regional clean hydrogen hubs that would co-locate the production and use of hydrogen.

At a state level, many policy initiatives such as the NEVI program for EV fueling infrastructure[52] are indicative of the future for sustainable transportation technologies. The Green Jobs state tax credit[53] in Virginia makes employers eligible for a $500 tax credit for each new green job created (up to 350 jobs, minimum salary $50,000) for industries relating to renewable or alternative energy, including hydrogen and fuel cell technology, landfill gas, and biofuels.

Market Projections: ACE Technology Platforms

Current event market projections reveal that realizing a resilient, environmentally sustainable, and equitable supply chain depends on the development, implementation, and deployment of ACE technology platforms. A summary of key points is provided below:

According to a Fortune Business Insights report, *U.S. Electric Vehicle Market Size, Share & Forecast, 2021-2028*,[54] the U.S. EV market is projected to grow from $28.24 billion in 2021 to $137.43 billion in 2028 at a compound annual growth rate (CAGR) of 25.4% in the 2021-2028 period. The U.S. is the third largest EV manufacturer in the world, and the transition to EVs has maintained its momentum as the country increasingly develops and adopts policies to accelerate growth in EV.

According to the *Autonomous Truck Market Size 2022-2028 GM Share Report*,[55] the automated truck market size exceeded $900 million in 2021 and will exhibit a growth rate of over 17%

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[50] Energy Communities. (2023). *BIL Joint Office of Energy and Transportation Ride and Drive Electric, Fiscal Year 2023 funding opportunity announcement*. https://energycommunities.gov/funding-opportunity/joint-office-of-energy-and-transportation-ride-and-drive-electric-fiscal-year-2023-funding-opportunity-announcement/

[51] https://www.hydrogen.energy.gov/

[52] https://afdc.energy.gov/laws/12744

[53] https://afdc.energy.gov/laws/8240

[54] Fortune Business Insights. (n.d.). *U.S. electric vehicle market size, share & forecast, 2021-2028*. https://www.fortunebusinessinsights.com/u-s-electric-vehicle-market-106396

[55] Global Market Insights. (2023). *Autonomous truck market size and share: Industry report, 2032.* https://www.gminsights.com/industry-analysis/autonomous-truck-

between 2022 and 2028. Rising safety concerns regarding road accidents and the emphasis of logistics companies on reducing transportation costs will enhance market representation. Driver shortages due to the COVID-19 pandemic are forcing various market leaders and logistics companies to opt for automated vehicle technologies. Road freight is the largest portion of logistics spending; carrier margins are threatened by low rates and high resource costs, and smaller carriers are under the most pressure.[56]

The global commercial UAS services market[57] is 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 CAGR of 14.8% and reach $23 billion by the end of 2033. With the substantial development of the e-commerce industry, the market has experienced huge demand for package delivery. Parcel and last-mile/same-day delivery is expected to grow from $6.4 billion in 2022 to $7.9 billion in 2027 (worldwide) with a CAGR of 18.8%.[58]

Given the vast reach and outsized importance of the supply chain economy, advances in supply chain logistics intrinsically provide opportunities for participation by many and give rise to a robust portfolio of new product- and service-based industries (e.g., advanced vehicle servicing, drone-based delivery, logistics optimization platforms).

market#:~:text=The%20market%20size%20of%20autonomous,the%20transportation%20and%20logistics%20sectors

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

[57] 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

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

Key Takeaways

- *Current supply chains are facing historic challenges and lack resiliency, which has far-reaching consequences for the economy.*
- *The scope of this gap analysis is the transportation aspects of the movement of goods and the inbound-outbound logistics of the supply chain.*
- *A sociotechnical subsystem framework was used as the foundation for all stages of this research (the literature scan, interviews, and focus groups).*
- *A literature scan of numerous relevant sources informed this research by:*
    - *Defining supply chain disruptions, risks, and challenges.*
    - *Identifying policy and investment priorities.*
    - *Identifying market projections.*
    - *Locating recommended strategies for addressing current challenges.*
    - *Building a foundation upon which to frame interviews and focus groups.*
- *Opportunities for significant impact on supply chain resilience include:*
    - *Open communication flows, visibility, and logistics capabilities between supply chain actors.*
    - *Development and deployment of ACE and other technology-based platforms, which enable automated, accurate, and efficient supply chain processes.*
    - *Significant growth in decarbonization of the transportation sector as prioritized by federal and state policy initiatives.*

Methods

As indicated, the research process was executed in three steps: literature scan to provide background (see previous chapter), which then informed stakeholder interviews and focus groups. The literature scan examined a variety of sources (academic, current events, market projections, policy, and recent federal policy and investments) to identify the top supply chain challenge areas related to the transport of goods, recommended strategies for supply chain resiliency, and suggested technological solutions.

Based on the literature and current event scan, regional assets, policy initiatives, and market projections, researchers proposed to solve supply chain gaps in four technical areas:

- Automation of ground and air vehicles.
- Transition to carbon net-zero freight systems.
- Secure and ubiquitous communications across the supply chain.
- Freight movement optimization.

These were labeled as "Ecosystem Initiatives" as shown in the subsequent Results section.

Using the findings from the literature scan to inform the state of the supply chain today, researchers then identified relevant supply chain actors from a variety of industries. Using the STS framework to guide the discussion, stakeholder interviews of supply chain actors helped to further narrow the scope of challenge areas and suggested solutions. Focus groups were then conducted to further investigate the details of these challenge areas, discover other proposed solutions, and better understand present-day barriers supply chain actors face in implementing these solutions. Data from both interviews and focus groups were then organized by theme, analyzed categorically using the STS framework, and by technological ecosystem initiatives as solutions. Qualitative analysis was used to synthesize and analyze the findings from both the interviews and focus groups. Each step in the research process is explained in more detail in the subsequent sections.

Stakeholder Interviews

As a first step in the interview process, the research team mapped out the regional supply chain ecosystem and stakeholders, identifying and prioritizing industry contacts for interviews to understand gaps and innovation opportunities and to determine if the focus of the research was relevant to regional stakeholders.

Interviews were conducted with organizations representing various supply chain roles involved in the "journey of a package," including the port, manufacturing, hubs, last-mile, data, and technology providers (Figure 6).

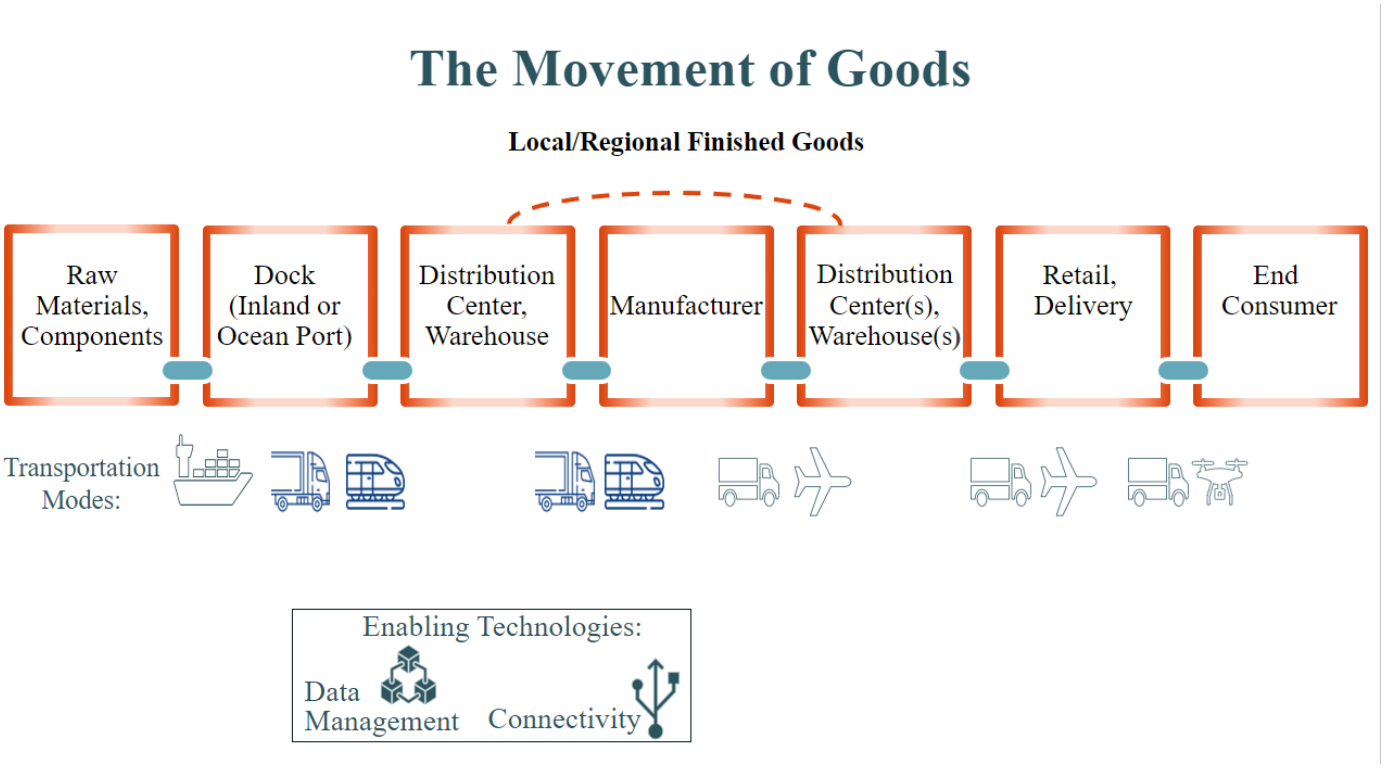


Figure 6: Supply chain stakeholder roles in the "journey of a package" used in the gap analysis process.

The interviews focused on addressing the following questions:

- Who are the organizations and stakeholders located within the defined four-state region that contribute to the advanced transportation innovation ecosystem and what are their roles and contributions?
- What are their technical, policy, or other challenges in moving goods from dock to door?
- What infrastructure and technologies are they currently using, or what do they plan to adopt to mitigate these challenges?
- Which areas of advanced transportation research do they suggest should have the greatest priority to solve their challenges?

The full guide used to perform the interviews can be found in Appendix A: Interview Guide.

The results validated the technological solutions found in the literature scan and materials around supply chain actors and functionary roles to form a meaningful classification system to structure the focus groups. The stakeholder interviews helped narrow the scope to seven focus areas. This helped to shape and structure the next step of the research process, the focus groups.

Stakeholder Focus Groups

Focus groups were performed to further investigate the details of challenges within these focus areas, discover other proposed solutions, and better understand present-day barriers to

implementing these solutions. Participants from supply chain sectors spanning industry, higher education, small businesses, non-profits, advocacy groups, and governments participated in three different focus areas that they self-identified as a priority for their organization. Focus groups were strategically grouped so that all sessions had a diverse representation of sectors in each level of the STS framework for a balanced and holistic perspective of the supply chain challenges within that focus area.

The objectives of the focus groups were to:

1. Ground truth and refine the gap analysis work performed to date (literature scans and stakeholder interviews).
2. Further scope supply chain performance gaps and opportunities most important to participants within our region.

The previous gap analysis results provided common categories and a shared language to frame the in-person discussions. To start, the gap analysis provided definitions to shape questions for participants to self-identify when registering for the event. Questions asked of participants upon registration were as follows:

1. **What is your organization's primary supply chain role?**
   Drop-down Selections:

   - Product Owners and Manufacturers
   - Product Transporters
   - Hubs/Storage/Distribution Centers
   - Developers and Providers of Technology
   - Economic Developers
   - Policy and Infrastructure
   - Workforce Developers and Workforce Training
   - Other: _____

2. **What would you identify as your organization's priority areas to improve supply chain and your business operations? (Select up to three.)**

   Drop-down Selections:

   - Automated Vehicle Technology
   - Data Management
   - Advocacy and Outreach
   - Economic Development
   - Logistics
   - Transportation Infrastructure
   - Sustainability
   - IT Infrastructure
   - Workforce Development
   - Policies and Regulations

- Diversity, Equity, Inclusion, and Accessibility (DEIA)
- Other: _____

Each participant was asked to select a primary supply chain sector for their organization, as well as three organizational priority areas, with the opportunity to write in answers if the options were not exhaustive.

The drop-down categories for selection provided a meaningful characterization of each potential participant and how they might serve a functionary role around supply chain gaps. Rather than looking narrowly at what industry they represent, this functionary characterization helped to identify how supply chain stakeholders might mobilize around issues in a participatory sense despite coming from different niche fields of expertise or industry types. Such identification also allowed for transdisciplinary overlap between gaps; as stated earlier, a disruption to the supply chain is most often not an isolated incident but rather a "ripple effect" felt by many.

These priority areas were then used to organize breakout discussion sessions for the focus groups. Participant responses to the question on supply chain role allowed for strategic focus group organization, bringing like-minded groups together when appropriate and diversity of perspective related to industry/company size/interest areas when needed. The results of these questions helped identify priorities and pinch-points for most companies, and we were able to incorporate top participant priority areas to focus the content of focus group breakout sessions where participants would have the most expertise or interest to further define gaps.

The participant registration data is illustrated for organizational supply chain role (Figure 7) and organizational priority area (Figure 8) below.

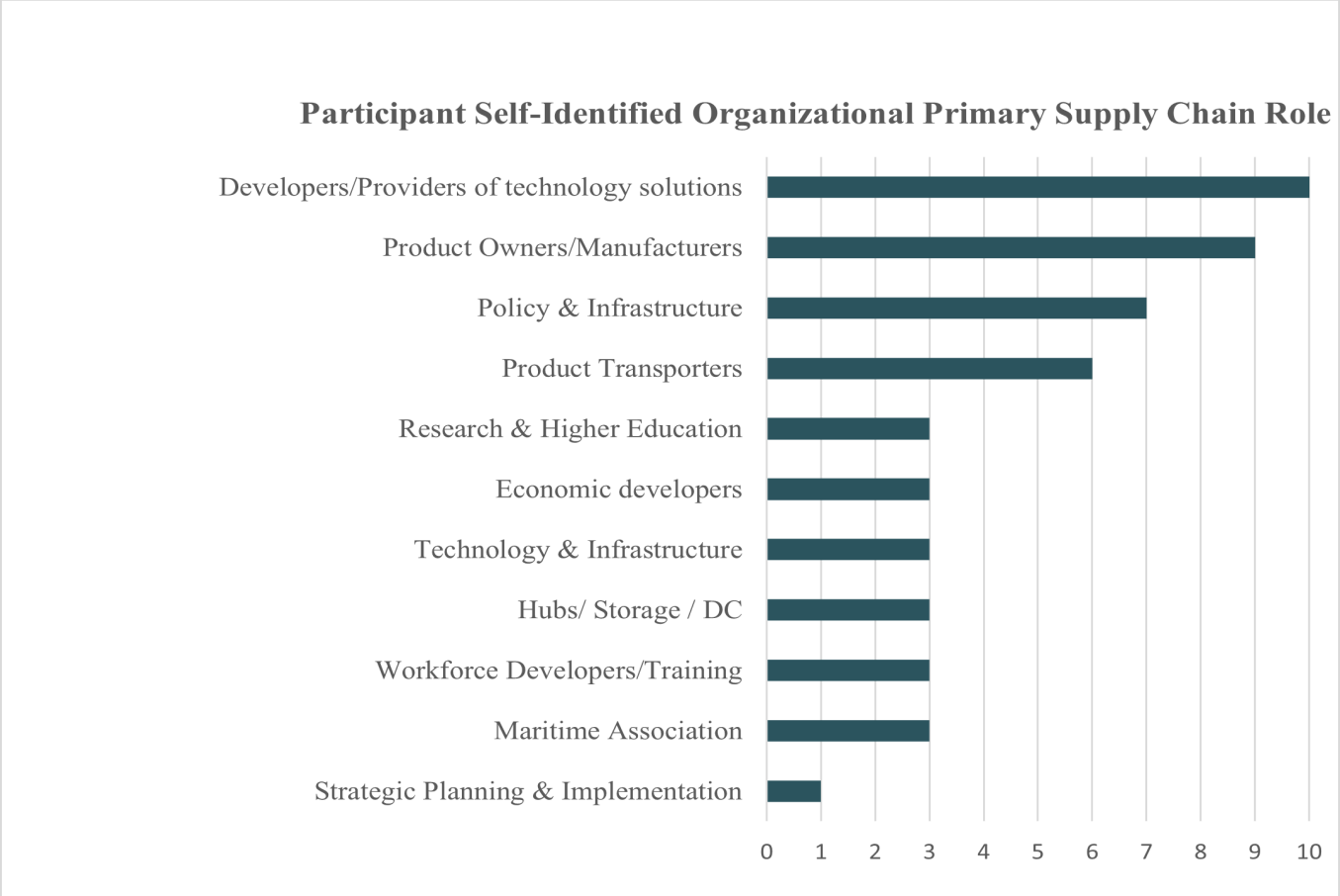


Figure 7: Participant registration responses to the question "What is your organization's primary supply chain role?"[59]

[59] Research & Higher Education, Maritime Association, and Strategic Planning & Implementation were all write-in answers.

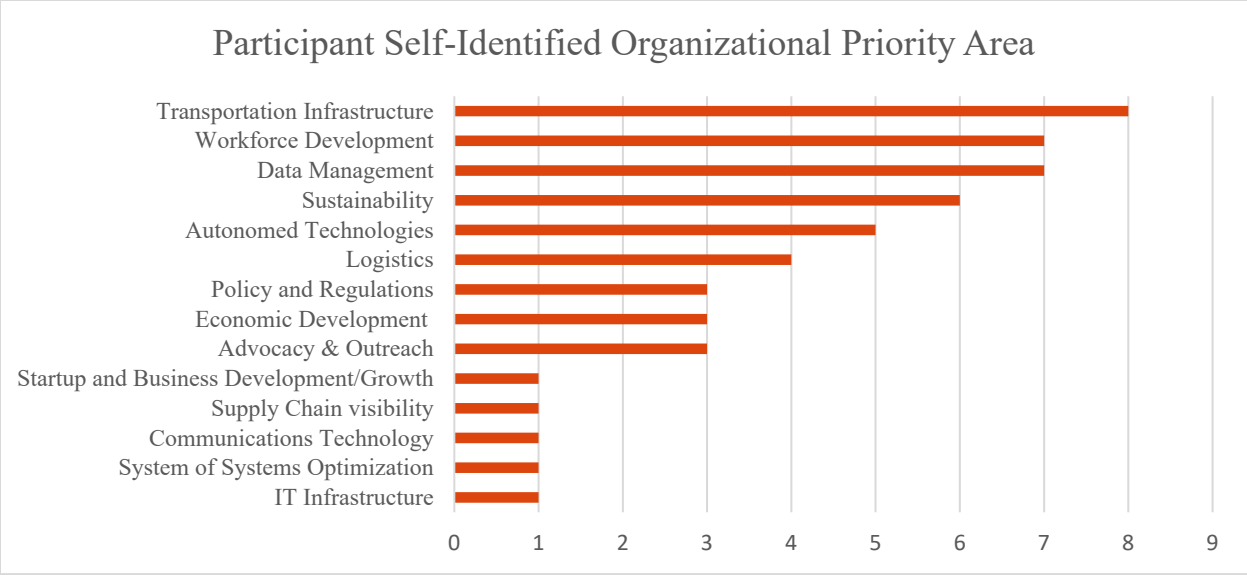


Figure 8: Participant registration responses to the question "What would you identify as your organization's priority areas to improve supply chain and your business operations?"

The registration responses revealed participant priority topics. Of the 11 topics provided during registration (in Figure 8, all responses except the last four were provided during registration), 10 were selected as themes for breakout sessions. DEIA—which was not selected by any organization as a priority area during the registration process—was embedded into the discussion for all the other categories. Several of the other categories were combined based on number of participants and similarity. IT infrastructure was absorbed into overall transportation infrastructure and discussed in the context of communications infrastructure. This resulted in seven focus areas for discussion focus groups:

1. Transportation Infrastructure
2. Logistics
3. Data Management
4. Sustainability
5. Automated Vehicle Technology
6. Advocacy & Outreach; Combined with Policy & Regulations
7. Workforce Development; Combined with Economic Development

The selection process during registration was a good secondary validation test of the categorization process, as there were minimal selections of "other." The write-in priority topics that participants provided in the "other" option included research, modeling, device connectivity, system of systems optimization, electric utility, and external evaluation and growth monitoring. While these write-in answers were more specific, the research team felt these could be adequately grouped under the general categories that had been defined.

Before the focus groups began, participants were provided with information to ensure they had a baseline perspective of the work performed to date on identification of overall supply chain gaps. The materials were presented in PowerPoint form and included the information as detailed in previous chapters in this report: (a) the research findings from the literature scan on supply chain

challenges and (b) examples of gaps that were identified through interviews. Focus group participants were then given a visual representation of the STS framework to guide the discussion around how the research team is approaching the identified gaps in the areas of environmental, personnel, technological, and supply chain design and management subsystems.

Focus group questions, while specific to the topic area, generally followed the same structure as follows:

- What are the **needs and challenges**?
- What are the **suggested solutions** to the needs/challenges?
- What are the **barriers to implementation** of the above solutions?
- What are **key DEIA strategies or challenges**?

Participants were encouraged to discuss the challenges they were facing in their own industry openly and honestly and to listen to the challenges expressed by others carefully. It should also be noted that these sessions were not recorded in the interest of encouraging transparency. The goal was to maximize knowledge transfer between participants around challenges that supply chain industries may be facing that others may not be exposed to or aware of. Focus group participants were also presented with three near-term programs proposed as potential technological solutions from the literature scan, validated by the initial research interviews:

- **Program 1: Coordination of freight flow through interconnectivity and advanced decision-making via a data sharing platform**
- **Program 2: Carbon-neutral, connected, and automated freight (ACE technologies)**
- **Program 3: Last-mile, automated aerial, and ground delivery**

While participants could voice their support for the programs as viable solutions, they were encouraged to not limit their ideas to only these solutions and to present new ideas; creative approaches and solutions were welcomed to further add to or refine general program areas.

For the focus group event, three separate breakout sessions were held in sequence, with each session including seven concurrent discussions on the above topics. Each concurrent discussion included approximately 10 participants per table per session and was facilitated by a subject matter expert and a dedicated scribe. Each organizational priority area was discussed by 30 participants in total. The breakout sessions provided a forum for discussion among participants without commitment to a specific course of action. Participants discussed a set of questions aimed at understanding the barriers to and opportunities for advancing the supply chain to one that is more sustainable, equitable, and transparent for each individual topic. Details on specific recommended questions to focus group leaders who were subject matter experts can be found in Appendix B: Focus Group Guide.

To offer participants a preliminary look at their results and exposure to other focus groups they did not participate in, each focus group subject matter expert presented the aggregate results of their tables to the full participant group. Focus group leaders encouraged open conversation by other participants to capture any other points that should be considered or clarifications. These presentations were recorded and cross-analyzed against the written summary results provided by each scribe.

Scribes of each focus group were therefore instructed to provide the key takeaways in a summary sheet that would represent the most cited statements for all three focus groups, categorized by each question. They were also instructed to take detailed notes for each focus group, which were then analyzed and cross-referenced with the summary sheets in post-processing of the data to ensure no comments were missed. Details around the instructions and focus group approach were given to the research team and can be found in Appendix B: Focus Group Guide.

As such, the results were categorized both through a narrative summary (provided in Appendix C: Narrative Summaries from Focus Groups) and a quantitative categorization of each mention in a manner similar to the interviews in terms of the STS framework. The coding mechanism for the summary (i.e., most common) mentions also went through an inter-rater reliability test among three researchers for validation.

Key Takeaways

- *The gap analysis methodology included an initial literature scan, interviews, and focus groups.*
- *Interviews with supply chain stakeholders were held to:*
    - *Expand literature scan findings.*
    - *Validate the regional viability of potential technical areas as solutions to supply chain gaps, which included:*
        - *Automation of ground and air vehicles.*
        - *Transition to carbon net-zero freight systems.*
        - *Secure and ubiquitous communications across the supply chain.*
        - *Freight movement optimization.*
    - *Determine the important aspects of the literature review to structure the focus groups, prioritizing the validated technological area solutions.*
- *Stakeholder focus groups further refined perceived gaps and challenges, proposed solutions, and present-day barriers to implementing these solutions in the following categories:*
    - *Transportation Infrastructure*
    - *Logistics*
    - *Data Management*
    - *Sustainability*
    - *Automated Vehicle Technology*
    - *Advocacy & Outreach, Policy & Regulations*
    - *Workforce Development, Economic Development*
- *The stakeholder focus group breakout sessions were intentionally designed to include a diversity of organizations and perspectives.*
- *Data was analyzed using qualitative methods and the STS framework to determine priority areas for finding solutions.*

Results

This section of the gap analysis report details the results of both the preliminary interview stage of the research process and the results of the focus groups performed to assess stakeholder needs/challenges.

There were 22 interviews in total that spanned 19 different organizations representative of the supply chain sector from dock to door.

For the focus groups, there was a total of seven focus areas. Each focus area was discussed with three different participant groupings, for a total of 21 different focus groups. There was a total of 71 participants representing 46 organizations that span the supply chain from dock to door.

Qualitative data from both interviews and focus groups were then categorized by theme, analyzed categorically using the STS framework, and by technological ecosystem initiatives as solutions. Qualitative analysis was used to synthesize and analyze the findings from both the interviews and focus groups to find common themes or consensus. The results are described in more detail in subsequent sections.

Stakeholder Interview Results

Stakeholder interviews of supply chain actors were conducted to validate the findings from the literature and continue to inform and expand the gaps, suggested solutions, barriers to implementation, and social justice issues supply chain actors are experiencing in the present day. A qualitative analysis approach was used to synthesize and analyze the data.

Data Coding Results

The interview responses relevant to the supply chain gap analysis were coded and organized based on the corresponding technological solutions and STS framework.

When organized by the STS framework, the coded responses (149 in total) from the interviews were related to gaps in the enabling environment for ACE technology adoption (55 total, 37% of responses), followed by technology and infrastructure (44 total, 29%), personnel barriers (28 total, 19%), and supply chain design and management (22 total, 15%; see Figure 9).

When organized by technological ecosystem initiatives, automation of ground and air vehicles received the most coded responses (57 total, 38% of responses), followed by freight movement optimization (49 total, 33%), carbon net-zero freight systems (29 total, 20%), and secure and ubiquitous communications across the supply chain (14 total, 9%; see Figure 10).

Comparing the STS framework with the proposed technical areas (see Figure 11), the greatest number of technological gaps occur in the automation initiative. The automation and net-zero initiatives have significant environmental gaps; these initiatives will need to influence other stakeholders to achieve change. The automation and freight movement initiatives link to significant personnel gaps; involving participants early on to align research with workforce challenges may be important.

When organized by the STS framework, most of the gaps relate primarily to the enabling Environment for ACE technology adoption

Few comments about gaps — **Many gaps mentioned**

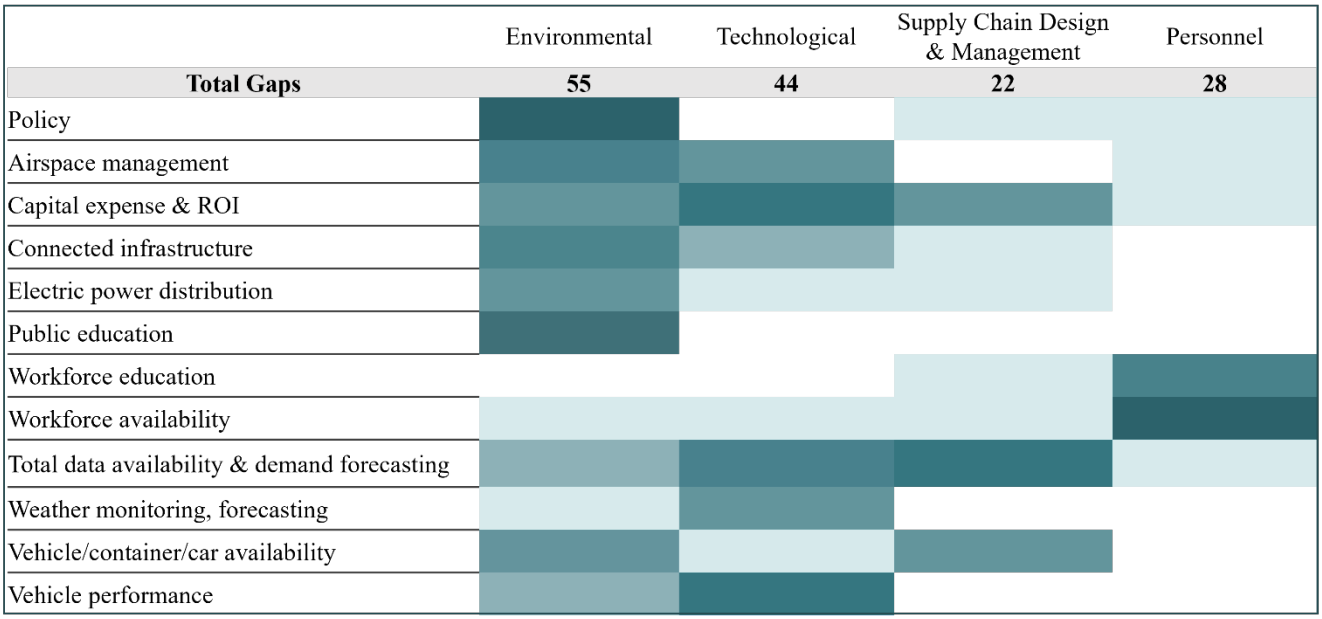


Figure 9: Grouping of coded interview responses based on STS framework category.

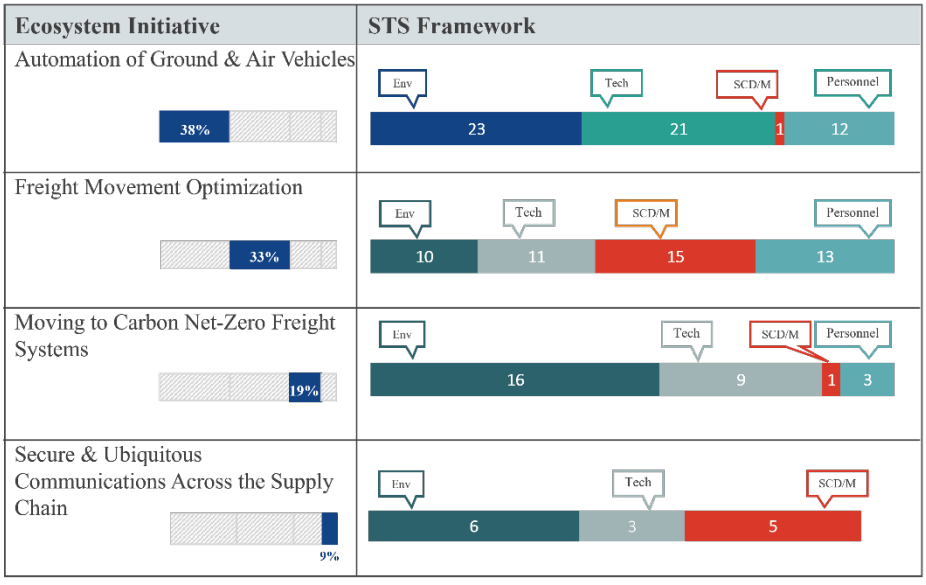
Automation of Ground and Air Vehicles initiative seems most aligned with the gaps that surfaced in the interviews.

Few comments about gaps — **Many gaps mentioned**

	Automation of Ground & Air Vehicles	Freight Movement Optimization	Moving to Carbon Net-Zero Freight Systems	Secure & Ubiquitous Communications Across the Supply Chain
Total Gaps	**57**	**49**	**29**	**14**
Policy				
Airspace management				
Capital expense & ROI				
Connected infrastructure				
Electric power distribution				
Public education				
Workforce education				
Workforce availability				
Total data availability & demand forecasting				
Weather monitoring, forecasting				
Vehicle/container/car availability				
Vehicle performance				

Figure 10: Grouping of coded interview responses based on focus area.

Technical focus areas suggested as ecosystem initiative solutions may link to the most gaps.



- Research linked the greatest number of technical gaps to the automation initiative.
- The automation and net-zero initiatives have significant environment gaps; these initiatives will need to influence other stakeholders to achieve change.
- The automation and freight movement initiatives link to significant personnel gaps; involving partners early to align research with workforce challenges may be important.

Figure 11: Technical focus areas (ecosystem initiative) and corresponding STS framework gaps.[60]

[60] Envir = Environmental, Tech = Technical, SCD/M = Supply chain design and management

High-Level Narrative Summary

The interview process resulted in the identification of the following challenges faced by the deployment of ACE technologies as well as gaps that may prevent or hinder an overall resilient supply chain:

- **Environmental factors** that influence the advanced mobility ecosystem revolve around existing policies and regulations that are not evolving to accommodate the rapid pace of growth in automation and electrification.
    - **Airspace management:** There is a lack of procedures, policies, systems, and technology for coordinating traffic between manned and unmanned aircraft of varying sizes across all altitudes. The lack of certification pathways and flight procedures limits current use cases. Data transfer challenges, the lack of unmanned aerial system flight procedures, and the need for situational awareness complicate airspace management.
    - **Connected infrastructure:** Robust, consistent, and reliable network coverage, whether via cellular networks or through connected infrastructure, is not yet available in all areas, but it is a necessity for automation. Updated cellular infrastructure, connected containers, traffic controllers, and location-specific sensors are all part of the solution.
    - **Electric power distribution:** Load capacity is an emerging problem with the increased use of vehicle chargers. Most of the impact from increased load demand will be on local distribution networks rather than national ones. Properly sizing distribution infrastructure to support electrification is location specific and takes significant time to coordinate.
    - **Policy:** Regulatory gaps exist in the understanding of automated vehicles and unmanned aircraft. Some state legislators fear negative public reaction when adopting new technologies. The lack of national and state policies limits technology development and adoption. Liability laws, drive time/weight/distance restrictions, and procedures to authorize unmanned flights are the key limitations.
    - **Public education:** A shift in public perception is needed to support the adoption of automated vehicles. The public and politicians need more information to fully understand the benefits. The public, and especially legislators, are not yet convinced that automated driving systems are safe and effective.
- The maturity of technology and infrastructure represents a barrier to the growth of an ACE **technology subsystem** within the logistics and transportation space, as well as a barrier to securing the high investment costs involved.
    - **Capital expense and return on investment**: The current cost of ACE vehicles, networks, and infrastructure is too high for many logistics businesses (already running on thin margins) to justify.
    - **Vehicle performance**: Mountainous and dense geographical regions decrease the performance of these vehicles. Charging time, finalizing trailer connections, and other challenges persist. Despite recent advances, further improvement in vehicle performance is needed to broaden the use cases for ACE solutions.

    - **Weather monitoring and forecasting**: Adverse weather conditions will affect automated vehicles, but current weather prediction and monitoring are not granular enough to confidently enable planning of long-distance trips.
- **Personnel** barriers stem from education and promotion of the logistics and trucking industry to counter the increasing labor shortage attributed to low workforce satisfaction.
    - **Workforce availability:** There is a national shortage of truck drivers and warehouse workers, which is caused primarily by low workforce satisfaction and inconsistency in demand for goods. Using ACE innovation technologies to make transportation and logistics jobs attractive and enjoyable may help close the gap.
    - **Workforce education:** Training a workforce to work on new kinds of vehicles is an unresolved challenge. Careers in the logistics field lack wide appeal, and companies cannot compete for top talent. Major investments in workforce training will need to be made, but it is unclear who will invest.
- **Supply chain design and management** barriers stem from insufficient communication of data between different actors within the supply chain, which negatively affects supply chain performance, which is closely tied to customer satisfaction.
    - **Data availability and sharing:** Data sharing between producer, warehouse, and customer is not advanced enough to support robust communication between actors in the supply chain, which affects demand forecasting. Siloed data creates inefficiencies in the supply chain, and systems to improve data sharing have not been developed or adopted.
    - **Vehicle/container/car availability:** Due to the surge of goods that need to be transported during the labor shortage, space in containers, warehouses, and vehicles is increasingly limited.

Focus Group Results

The narrative summary results of the most mentioned topics across needs and challenges, potential solutions and opportunities, barriers to implementation, and key DEIA needs or strategies for each focus group are detailed below. A qualitative analysis approach was used to synthesize and analyze the data.

Data Coding Results

The responses (465 in total) from the focus group breakout sessions were coded and assigned to both an STS category and a technical area category (same approach for the interviews). For a response to be categorized, two of the three inter-rater researchers had to agree on each category; otherwise, the note was labeled as uncategorized.

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 and infrastructure limitations (93, 20%), personnel barriers (92, 20%), supply chain design and management (87, 19%), and uncategorized (14, 3%; see Figure 12).

- **Environmental factors** that influence the advanced mobility ecosystem revolve around existing policies and regulations that are not evolving at the same pace as automation and electrification.
    - **Transportation Infrastructure, including power distribution:** Robust, consistent, and reliable network coverage is not yet available in all areas but is a necessity for automation. Updated cellular infrastructure, connected containers, traffic controllers, and location-specific sensors are all part of the solution. Electrical load capacity is a problem with increased use of vehicle chargers. Most of the impact from increased load demand will be on local distribution networks rather than national ones. Properly sizing distribution infrastructure to support electrification is location specific and takes significant time to coordinate.
    - **Policy and Regulations:** Regulatory gaps exist in the understanding of automated vehicles and unmanned aircraft. Some state legislators fear negative public reaction when adopting new technologies. The lack of national and state policies limits technology development and adoption. Liability laws, drive time/weight/distance restrictions, and procedures to authorize unmanned flights are the key limitations.
    - **Advocacy and Outreach:** A shift in public perception is needed to support the adoption of automated vehicles. The public and politicians need more information to fully understand the benefits. The public, and especially legislators, are not yet convinced that automated driving systems are safe and effective.
- The maturity of automated vehicle **technology** represents a barrier to the growth of an ACE ecosystem, as do the high investment costs involved.
    - **Sustainability**: Environmental technologies need to evolve in a way that minimizes environmental impacts (carbon capture, hydrogen, electrification).
    - **Automated Technology**: Implementation and applications of AI or automated vehicle technologies to help improve logistical inefficiencies and workforce shortages.
- **Personnel** barriers stem from education and promotion of the logistics and trucking industry to counter the increasing labor shortage attributed to low workforce satisfaction.
    - **Workforce Development, both availability and education:** There is a national shortage of talented workers in all sectors of the supply chain, which is caused primarily by low workforce satisfaction and inconsistency in demand for goods. Using ACE innovation to make transportation and logistics jobs attractive and enjoyable may help close the gap.
    - **DEIA needs to be prioritized.**
- **Supply Chain Design and Management** barriers stem from insufficient communication of data between different actors within the supply chain, which negatively affects supply chain performance, which is closely tied to customer satisfaction.
    - **Data Management and Sharing:** Data sharing between producer, warehouse, and customer is not advanced enough to support robust communication between actors in the supply chain, which affects demand forecasting. Siloed data creates

inefficiencies in the supply chain, and systems to improve data sharing have not been developed or adopted.

- **Logistics:** Analyzing, strategizing, and optimizing the planning for transporting goods throughout the supply chain are critical.

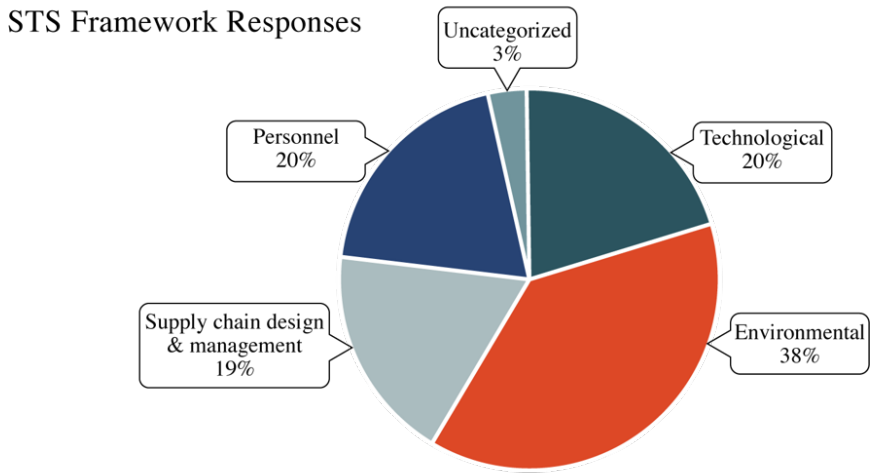


Figure 12: STS framework response categorization (465 responses).

When organized by proposed technological solutions to enable ACE technologies, secure and ubiquitous communications across the supply chain had the most coded responses (233, 50% of responses), followed by freight movement optimization (86, 19%), carbon net-zero freight systems (79, 17%), automation of ground and air vehicles (53, 11%), and uncategorized (14, 3%; see Figure 13).

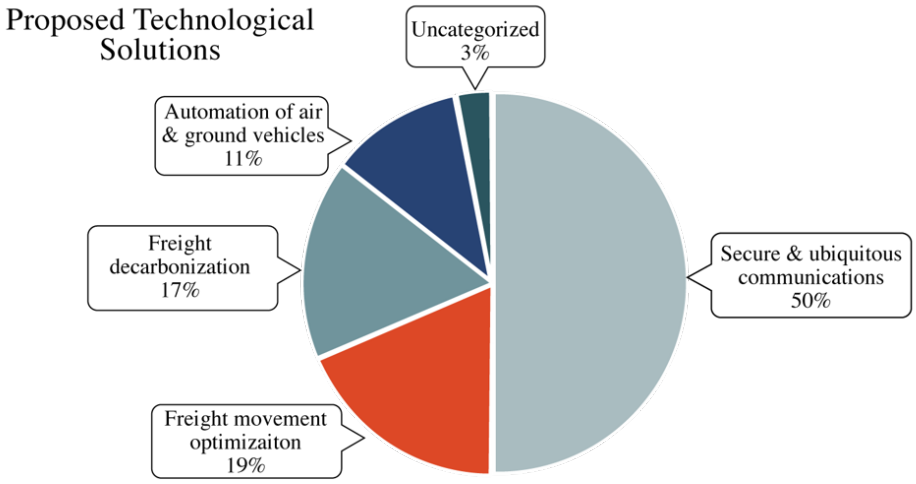


Figure 13: Focus group responses categorized into proposed technological solutions (465 responses).

There is consistency in the STS framework categorization between the interviews and the focus groups. When organized by the STS framework, coded responses (149 in total) from the interviews related to the gaps in the enabling environment for ACE technology adoption (55, 37% of responses). When organized by the STS framework, coded responses from the focus groups (465 in total) were also related to gaps in an enabling environment for ACE technology adoption (179, 38% of responses). Between both groups, roughly 38% of responses related to the environmental subsystem as a challenge for ACE technology adoption solutions to supply chain challenges and gaps.

Key Takeaways

When the data coding results were analyzed using an STS framework, the following were the most significant gaps identified by interviews and focus groups:

- ***Environmental Subsystem***
  - *Policies and regulations are not evolving to accommodate the rapid pace of growth in automation and electrification. This gap is specifically related to airspace management, connected infrastructure, electric power distribution, policy for research, development, and deployment, and public misperceptions due to lack of public education on these technologies.*
- ***Technological Subsystem***
  - *Maturity of technology testing and infrastructure represents a barrier to the growth of an ACE technology subsystem within the logistics and transportation space. This is related to high capital expense, mismatch of policy to maturity of technology that makes it difficult to invest or forecast, vehicle performance barriers on rural infrastructure, and lack of sensors for accurate weather monitoring and forecasting for trip optimization.*
- ***Personnel Subsystem***
  - *Barriers stem from lack of educators or equitable educational programs available to prepare the workforce for technologies of the future. Other barriers include labor shortages due to low workforce satisfaction, inconsistency in demand of goods, and harsh working conditions.*
- ***Supply Chain Design & Management Subsystem***
  - *Barriers stem from insufficient communication infrastructure for data sharing between different actors, limited visibility into the movement of goods, and lack of data equity within the supply chain. Vehicle and container availability continue to be an issue with disjointed logistics.*

High-Level Narrative Summary Tables

Transportation Infrastructure

Much of the discussion around transportation infrastructure **emphasized the need for a sustainable future** as well as **increased reach to rural areas** to enable efficiencies within the supply chain. The **power grid** as it exists today cannot accommodate new energy technologies without significant modifications. In addition to research and development, more **confirmation is needed from policy makers on which types of fuels to prioritize for investment and build to scale** for private industry and utility companies. **Lack of or weak communications infrastructure** was consistently cited as a challenge; installations of fiber infrastructure and 5G communications are difficult and costly to build in an already overburdened traffic situation.

Related to DEIA issues, many clean energy funding opportunities at the state and federal level exist but pose DEIA concerns, as **private companies looking to convert their fleets to alternative clean fuels are often not eligible to apply for federal or state funding** (limited to city or township, county, state, or special district governments, 501(c)(3) non-profits, public or private academic institutions, public housing authorities, or utility providers). Related to workforce development, several participants suggested we **need ways to stimulate interest in the emerging clean transportation infrastructure sectors** and **begin workforce training for these sectors now.**

The full discussion of all the gaps, solutions, and barriers to implementation identified in all three focus groups can be found in Appendix C under Transportation Infrastructure.

Please see Table 2 below for a high-level summary of most common mentions:

Table 2: Transportation Infrastructure Focus Group High-Level Summary

Topic	Needs and Challenges to the Supply Chain	Opportunities to Address the Challenges
Transportation Infrastructure	• Significant energy infrastructure needed to support growth, but this requires time and financial resources to accomplish • Design of renewable energy transportation infrastructure needs to be dynamic and resilient to enable efficiencies in the future • Insufficient infrastructure/grid capacity and access to some communities and populations • Lack of shared data, trackability, and efficiencies in supply chain management • Determining which fuel types to build capabilities around to support and scale • Expanded and secure communication capabilities needed • Transportation infrastructure needed to support supply chain companies' ability to service rural areas and enable community access • Lack of shared language between OEMs and utility companies • Private companies often not allowed to apply for federal or state funding • Not enough training for workforce development in clean transportation infrastructure • Overcoming misinformed social norms through DEIA strategies	• Public and private partnerships • Right of ways for communications, working with departments of transportation (DOTs) • Microgrids, especially for rural areas • Prioritization of rural community access • Installation of fiber infrastructure and 5G communications to occur in concert with other road improvement projects • Policy guidance, research, and development on which types of fuels to prioritize for investment and build to scale • Hydrogen, hydrogen fuel cells, and alternative fuels suggested for heavy vehicles and electric for small vehicles • Carbon capture and credits as a transition strategy • Stimulate interest in new emerging clean transportation infrastructure sectors (multi-tiered educational opportunities, higher paying jobs, credits for business to encourage hiring) • Certification programs through vocational and community college education with guaranteed job placement

Logistics

From the **logistics** focus group, participants commented that efficiency within logistics is a challenge due to the disruption in materials availability and the lack of communication infrastructure for tracking freight transport. Many participants expressed how they **continue to struggle with challenges from post-COVID-19 supply chain disruptions to inventories and industries**. Delays from inbound parts and materials would put nearly finished outbound goods on hold, where the item might be 99% complete and just waiting on one more part from inbound goods. This causes a domino effect on warehouse site demand and just-in-time manufacturing operations.

While both automated technologies and a data sharing platform were viewed as positive solutions to improve efficiencies, **stronger communication infrastructure is needed to support automated vehicles**, vehicle-to-vehicle (V2V) communication, and vehicle-to-infrastructure (V2I) communication. **Degrading transportation infrastructure without dedicated lanes for trucking** was also viewed as a gap and barrier to implementation of clean alternative fuels. Regarding hydrogen fuel cell solutions, research and development are needed to find ways to **extend battery life for long-haul freight transport**.

For workforce development, commercial driver's licenses (CDLs) are increasingly harder to get, and communities are unaware of the certification process. Logistics companies are finding a **high turnover rate because of harsh working conditions**, such as warehousing facilities without air conditioning, lack of respect and acknowledgement of heavy vehicle limitations on the road, limited labor causing overworked drivers, and not enough driver resting time between shifts.

The full discussion of all the gaps, solutions, and barriers to implementation identified in all three focus groups can be found in Appendix C under Logistics.

Please see Table 2 below for a high-level summary of most common mentions:

Table 3: Logistics Focus Group High-Level Summary

Topic	Needs and Challenges to the Supply Chain	Opportunities to Address the Challenges
Logistics	• Lack of communication infrastructure for freight transport tracking and to support automated and connected vehicles • Costs of new equipment • Unrealistic deadlines for implementations such as decarbonization • Dependency upon inbound goods impacts products that are nearly complete (just-in-time process disruption) • Warehouse space is not adequate to house inventories that are backed up • Traffic delays due to construction and other reasons • Lack of acceptance of new facilities and infrastructure changes by some communities • Lack of reliable grid/infrastructure for EVs and hydrogen fuel cell vehicles • Small, women-owned, and minority-owned (SWaM) companies lack resources/skills to take advantage of funding opportunities • Lack of adequate workforce/overworked and under-respected employees • Lack of CDL instructors; licensing is harder to obtain • Aging driver population • Younger drivers are too costly for small companies to insure • Unrealistic deadlines for implementation technology development	• Automated ground and aerial vehicles can improve on-time arrivals • Syncing data-sharing platform/increased communications infrastructure • Automation to allow remote operation and address workforce shortages • Separate lanes for trucks and/or automated vehicles; could utilize a reservation system • Increased LTE availability • Use DOT right-of-way for economical installation of communications infrastructure • Public-private partnerships • Tax incentives to lower barriers for new companies (DEIA strategy) • More incentives for on-time delivery by shippers and carriers • More incentives for fleets to go electric or with alternative fuels • More fueling infrastructure • Coordination of inbound and outbound freight • Coupling • Widen roads and tunnels • More research/development for hydrogen fuel cells for long-haul freight (extend battery life) • Implement “second chance” and older workers to address driver shortage

Data Management

For the data management group, there was consensus that COVID-19 disruptions to the supply chain have exposed the volatility of the transportation sector. The current barrier is not a lack of data, but rather the **lack of data sharing around the transport of goods between sectors**. While most data sharing is focused on trucking logistics, it is essential that we **extend data sharing to multiple modes such as nautical and aerial carriers**. Being able to collaboratively share data will improve flow efficiency in freight. Real-time visibility will help improve the flow of freight to forecast potential issues from the production to use stages of a product. Initial solutions may be for **AI to form predictions**, but all three groups mentioned **needing a digital twin to assess data quality** and how efficiently it translates to human use when coming across the network.

Data in a nonstandard format may impede data use completely or pose challenges to integration into other data workflows. Therefore, it is **imperative to define the purpose of the data and standardize the data format** to be usable by all actors. Participants emphasized the **need to share data equitably** across all potential players. Past efforts to centralize the **data management system have historically yielded a low return on investment or had cybersecurity concerns**. Data should be standardized and tested to build trust in its quality and prevent errors or potential for misinterpretation.

The full discussion of all the gaps, solutions, and barriers to implementation identified in all three focus groups can be found in Appendix C under Data Management.

Please see Table 4 below for a high-level summary of most common mentions:

Table 4: Data Management Focus Group High-Level Summary

Topic	Needs and Challenges to the Supply Chain	Opportunities to Address the Challenges
Data Management	• Non-standard data formats; thus, lack of data sharing • High effort and low return on data sharing • Difficulty fostering trust in quality and reliability of the data • Devaluing of data from SWaM businesses • Processes for cybersecurity of critical data needed for the data-sharing platform that is implemented • Volatility of transportation sector was exposed by COVID-19 disruptions to supply chain	• Improve flow and efficiency of multiple data terminals (nautical, aerial, surface) • AI and a digital twin can assess data quality and efficiency • Real-time visibility for forecasting potential issues • Standardize data metrics and the way data is shared • Learn from past endeavors at data sharing in order to improve return on investment • Foster trust around the quality and reliability of the data • DEIA issues are addressed when the data is shared equitably (e.g., SWaM) • Sharing agreements and open tools to create clarity, support, and verify • Define a purpose for sharing the data and communicate the return on investment • Explore ways that data sharing can promote opportunities for workforce development

Sustainability

For the sustainability focus group, the emphasis was on transportation infrastructure to support transitions to sustainable fuel technologies. Similar to other groups, participants voiced **concerns around grid capacity and its ability to support future EV technologies**. There are **accessibility issues in rural and small communities**, where there is insufficient grid capacity; even if local governments and agencies are willing to install new grids, they are not able to. **Non-green hydrogen options continue to be costly and time consuming** to produce and may result in a net increase in GHG production.

There is **not a unified front in terms of policy, state and federal actors, and public and private industry** to move towards a future of sustainable heavy vehicle infrastructure. Much of the public does not believe we have a problem, and there are **misperceptions around EVs and alternative fuels**. DEIA concerns were raised primarily by smaller fleets and included gaps in the capital costs to convert, maintenance of batteries, and **access to buying heavy truck EVs with long waiting lists**. **Workforce development is crucial today for the future of sustainable freight**. There are concerns that, if the sector does not start training the workforce now, we will not have a workforce available to build and maintain the future infrastructure and the vehicles and rolling stock that will use this system.

The full discussion of all the gaps, solutions, and barriers to implementation identified in all three focus groups can be found in Appendix C under Sustainability.

Please see Table 5 below for a high-level summary of most common mentions:

Table 5: Sustainability Focus Group High-Level Summary

Topic	Needs and Challenges to the Supply Chain	Opportunities to Address the Challenges
Sustainability	• No clear pathway to transition infrastructure to be sustainable, specifically for heavy vehicles • Resilient grid needed to provide power now and for the future • Rural and small communities have challenges installing new/sufficient grids • Some areas of the country have insufficient water for hydrogen production • Non-green hydrogen solutions can be counterproductive with respect to decarbonization • Green hydrogen solutions are costly and time-consuming • Lack of workforce to build and maintain future infrastructure and vehicles • DEIA challenges for smaller fleets (capital costs) • Waiting list to buy electric heavy trucks • Concerns over high cost of batteries as well as future replacement and recycling • Public misperceptions on climate change can be perceived as political • Public misperceptions on EV batteries and hydrogen fuel • No unified approach to moving towards a future heavy-vehicle infrastructure	• Prioritize workforce development by emphasizing trade programs • More and varying incentives to switch to alternative fuels depending on size of business • Begin with incentives to large businesses and then expand to smaller companies • Identify efficiency methodologies (data sharing, connected vehicles, cooperative driving scenarios) • Intermodal transfers (rail to trucks and trucks to rail) • Research into viable sustainable options for heavy vehicles (e.g., hydrogen, hybrid) • Public-private partnerships, incentives, and education to support the transition to electric, hydrogen, and other alternative fuels • More education of the workforce and educators to teach needed subjects (electrical systems) • Battery research (make them less expensive, lighter) and providing use cases that prove viability • Engage community colleges in recycling process for electric batteries • Expand domestic production of battery components (less dependence on foreign sources) • Explore community engagement lessons learned from models where electrification was implemented in rural areas • Emphasize the safety benefits to create community buy-in • Address public concerns/mistrust about electric- and hydrogen-fueled vehicles

Automated Technologies

Similar to the discussions in the sustainability group, the greatest challenge the automated technologies group expressed was for workforce shortages and lack of workforce development. People will often **resist implementing automation because they see it as a reduction or replacement of jobs for the workforce**. Increasing the training and job opportunities for "safety remote operators" of automated vehicles may be a way of using the workforce development challenge or public misperceptions as an opportunity for a solution. Safety remote operators are trained to detect issues that would prevent an automated vehicle from meeting certain safety certification requirements. Having such operators helps technology to reach safety standards more quickly, while also reinforcing trust with humans to understand the technological capabilities. While some states have shown enthusiasm for more workforce training in these systems, **more states should be adopting this strategy**. The largest challenge in the category of DEIA applicability is **how to tailor the message to communities that may benefit most from this automation** (such as communities that lack access to public transportation or who have disabilities).

The deployment of automated vehicles **needs clearer unified policy and stronger communication and transportation infrastructure to support the technology.** Participants cited timeline concerns as barriers to implementation and deployment of automated vehicles. Technology deployers should **think realistically about the timeline for testing versus deployment**. If we are just testing the implementation for a year, we need to make sure the infrastructure in place is not just for that year but can support the technology for a longer period.

The full discussion of all the gaps, solutions, and barriers to implementation identified in all three focus groups can be found in Appendix C under Automated Technologies.

Please see Table 6 below for a high-level summary of most common mentions:

Table 6: Automated Technologies Focus Group High-Level Summary

Topic	Needs and Challenges to the Supply Chain	Opportunities to Address the Challenges
Automated Technologies	• Qualified workforce shortages • Lack of workforce development regarding automated vehicles in many states • Lack of infrastructure, unified policy, and communications to support widespread automated vehicle use • Community acceptance of automated vehicle technology is a significant barrier; members of the public have concerns about safety and fewer jobs • Concerns about timeline for deployment of automated vehicles and the infrastructure needed for that	• Certification of an automated vehicle and transportation network • Tailoring deployment to communities that both need it most and can deploy/use it best to ensure positive user experiences • Educate public/workforce so they understand that these technologies are safe, convenient, can result in a net increase in jobs, and do not result in lower salaries • Increase the training and job opportunities for "safety remote operators" of automated vehicles • Public-private partnerships among supply chain actors can address misconceptions • More public funding for electrical vehicles and decarbonization • Coordinate activities for roadway improvements so automated and connected vehicle technologies can be efficiently incorporated

Policy, Regulations, Advocacy, and Outreach

The top challenge identified in the policy, regulations, advocacy, and outreach group was the lack of a national framework for things such as automated vehicle policy, beyond the visual line of sight, regulations, and Federal Communications Commission (FCC) spectrum issues. This **lack of framework is an obstacle for companies to knowing how to scale up** or where to invest. Participants commented that government is often risk-averse and can throttle technology development when **both policy and technology are trying to accelerate in tandem as safely as possible**. The quality of "risk averseness" also plays into issues such as insurance. Companies trying to get insurance for their carrier or business operations may encounter higher costs related to automated vehicles. Concerns for businesses relative to policy effects are also related to the future of workforce training. Participants expressed frustration around their **inabilities to plan how to staff appropriately for operations due to pending or recent legislative activities**.

Sustainable fuel policies face the perception of false dichotomies. Previous efforts have often presented EVs or gas as either the "one good" or the "one bad" option. There is **no room for growth with a mid-range option** or bridge solution such as clean diesel. While the public appears to want certain technologies and solutions such as automated vehicles, improved sustainable grids, or freight communication facilities to improve speeds of receiving their packages, they do not necessarily want the disruption or presence in their locations. There is a need for better education to **counteract misperceptions of new technologies** and promote the potential benefits these may have to a community.

The full discussion of all the gaps, solutions, and barriers to implementation identified in all three focus groups can be found in Appendix C under Policy, Regulations, Advocacy, and Outreach

Please see Table 7 below for a high-level summary of most common mentions:

Table 7: Policy, Regulations, Advocacy, & Outreach Focus Group High-Level Summary

Topic	Needs and Challenges to the Supply Chain	Opportunities to Address the Challenges
Policy, Regulations, Advocacy, & Outreach	• Community acceptance of new hubs, facilities, and other infrastructure ("not in my backyard") • Changing perceptions and misconceptions (battery safety, climate change, automated vehicles, etc.) • Lack of a national framework for automated vehicle policy, regulations, beyond the visual line of sight limitations, and FCC spectrum issues • The path for companies to scale up/invest is uncertain due to the unknowns • Government can throttle technology development when it is occurring simultaneously with policy changes • Insurance costs for companies using automated vehicles can be higher • Planning is difficult when dealing with pending legislation • Supply chain disruptions and technology development make staffing a challenge • False dichotomy around fuels can label gas as "bad" and electric as "good" • Lack of carbon capture credits for fleet transitions • Small businesses often are not aware of and/or are not eligible for funding	• Education to indicate quantified benefits ($X saved) and efficient delivery of goods • Ensure deployment occurs where those who need it most and can use it best • Centralized tracking of legislation, regulations, and funding • Implement repercussions for empty trucks on roadways • More incentives needed at the state and federal funding levels to improve logistics • Tax credits, space for implementing data sharing, investment in sustainable fuels are suggestions for incentives • A mid-range option such as clean diesel can bridge the divide between gas- and electric-powered vehicles • A coalition of partners can provide the coordination of information and support that will result in a unified effort to address issues • Carbon capture credits for fleet transitions • Provide DEIA players with mentors and centralized tracking of legislation, funding, and partnerships

Workforce and Economic Development

The greatest challenge according to participants in the workforce and economic development focus groups was accessibility to training and job opportunities. **Workforce shortages are overextending different levels of the supply chain**, and more opportunity for training is needed. Unfortunately, there is **a higher demand for educators than there are people to fill those positions**. Part of this challenge was attributed to the fact that those who are teaching the jobs are making less money than those who will go out and perform the jobs. This makes recruitment a challenge to find qualified people to teach.

Participants expressed that the paradigm needs to shift because **traditional solutions are not effective**. Earn-while-you-learn programs were suggested as a DEIA strategy to **overcome the traditional K-12-to-college trajectory**. There is a large barrier to attracting a workforce to train for new job functions because people may have to quit their current jobs to get the education required for a certification. This causes them not to pursue the opportunity if they have family or themselves to support financially.

As technology continues to develop, we need to make the jobs more accessible by changing the types of jobs and **start providing the training now**. Perhaps in the near term, an electric charging station technician is only needed for a part-time position for one company. This may **not attract many workers due to limited pay and lack of benefits**. If companies could share hiring resources, more than one company may be able to use this technician, resulting in a full-time job when job requests are combined.

The full discussion of all the gaps, solutions, and barriers to implementation identified in all three focus groups can be found in Appendix C under Workforce and Economic Development.

Please see Table 8 below for a high-level summary of most common mentions:

Table 8: Workforce & Economic Development Focus Group High-Level Summary

Topic	Needs and Challenges to the Supply Chain	Opportunities to Address the Challenges
Workforce & Economic Development	• Accessibility to training and job opportunities • Impacts every aspect of the supply chain • Lack of trained and experienced workforce is challenging, both for employees and instructors • Training needs to evolve to meet the skills needed (mechanics, installers, automated vehicles, and infrastructure) • Aging workforce • Employee satisfaction and retention in many supply chain careers (i.e., trucking) is low	• Increase awareness of career paths and certifications for trade jobs and engage all levels of learners • Second chance opportunities • Tiered educational approach that addresses K-12 students, parents, guidance counselors • Provide guaranteed jobs at the end of training programs • "Earn while you learn" programs can help address DEIA issues • Provide workforce skillset guide • Rebrand career opportunities for long-term, not temporary, work • Gamification could help to engage learners and encourage interest in technology jobs • Retitling jobs, even if the job itself does not change, may attract workers (DEIA strategy) • Combining two part-time jobs into a full-time position will fund a worker with increased income and benefits • Personnel sharing between companies can benefit both businesses and workers

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, which is both supported by recent academic publications and further emphasized by the results of this gap analysis.

As evidenced by the summaries of focus group results in the tables above, while each of the concurrent focus group discussions focused around one topic, they did not exclude the other topics. For example, for all seven topics, the workforce was identified as both a significant gap and a solution. The sustainability discussion was focused on workforce, infrastructure, and policies that impact sustainability outcomes. The political and regulatory landscape and access to funding for small businesses were also discussed for many of the topics. The need to change community perception and misperceptions on emerging technologies highlights that well-scoped solutions to supply chain issues cannot solely be technical solutions to be successful and must include community engagement and acceptance.

This transdisciplinary overlap between gaps, as stated earlier, demonstrates how a disruption to the supply chain is most often not an isolated incident but rather a "ripple effect" felt by many. For example, poor data management decreases visibility and therefore affects logistics. Underdeveloped IT infrastructure may affect workforce developments because of digital illiteracy, which then creates workforce shortages that affect economic development. Similarly, an improvement in one area may improve several. An improvement to transportation infrastructure such as a lane expansion may improve traffic, therefore improving logistics, while also paving the way for increased testing in automated vehicle technologies and increased sustainability efforts, should the improved transportation infrastructure allow for new EV charging stations.

The intersections of many of the organizational priority areas, and their cross-referencing of each other, reinforced that our supply chain challenges occur within a complex STS where the personnel, technical, and organizational subsystems all exist within an external environment with which they must interact and be influenced by. At many points, all four categories (automation of ground and air vehicles, transition to carbon net-zero freight systems, secure and ubiquitous communications across the supply chain, and freight movement optimization) overlapped and either informed or related to one another. A challenge could also be a solution, just re-directed. Alternatively, a solution may exist, but the barrier to implementation may be the existing challenge.

Achieving the vision for a sustainable and resilient supply chain will require large-scale cooperation spanning industries. The need for public and private partnerships in the supply chain effort was identified as a solution for several organizational priority topics. Joint optimization of the many moving parts is one way of viewing solutions that can work in harmony together.

Through their participation in the focus groups, the participants provided clarity on their needs and challenges, and they helped to inform future direction and strategy. The topics, needs, and challenges discussed above will be used to develop:

- Recommendations for federal and state funding priorities;
- Concept exploration for further research and development of solutions to gap focus areas;
- Priority identification for an implementation plan of a supply chain program that seeks to address weak links and promote supply chain resiliency; and
- Lessons learned to implement in plans for annual supply chain stakeholder focus groups for subsequent annual reports on stakeholder needs.

Key Takeaways

Transdisciplinary overlap between gaps demonstrates how a disruption to the supply chain is most often not an isolated incident but rather a "ripple effect" felt by many.

Building the case for supply chain resiliency is of utmost importance and requires large-scale cooperation spanning industries.

A more equitable, reliable, and sustainable future for the supply chain will require innovative solutions at each level of the STS theory framework, and these gaps demonstrated potential suggested paths to solutions:

- ***Environmental Subsystem Suggested Solutions:*** *More collaboration is needed between policy makers, utility providers, technology developers, and the community. Stakeholders working together towards resiliency against unpredictable environmental factors is beneficial.*
- ***Technological Subsystem Suggested Solutions:*** *More coordination between policy makers and technological actors is needed. Infrastructure investment and improvements are needed for further advancement and deployment of ACE technologies. Public education on technologies could be advanced through workforce development opportunities.*
- ***Personnel Subsystem Suggested Solutions:*** *Major investments in workforce training will need to be made, but it is unclear who will invest. Workforce programs should be expanded rapidly to prepare a workforce to meet the technology deployment needs of the future.*
- ***Supply Chain Design & Management Subsystem Suggested Solutions:*** *Improved communications infrastructure could enable 5G technologies, which may provide increased opportunity for logistics tracking and ACE technologies. Increased visibility into the movement of goods is needed and may benefit from more data sharing among supply chain stakeholders.*

Appendix A: Interview Guide

Background

Opening Prompt (may be paraphrased):

Thank you for taking the time to contribute to this effort. The coalition forming around a new proposed program is focused on creating an ecosystem of partners that delivers a resilient, efficient, environmentally sustainable, and equitable supply chain. Efforts funded under this proposed program must drive innovation that is informed by stakeholder needs and the limits and gaps in current research, technology, and industry practices. So that's where our discussion today is focused. Our team is interviewing several dozen stakeholders across what we are calling "the journey of a package" to inform a gap analysis that will be summarized in future materials.

This interview will be recorded. Would that be okay with you?

Interview Questions

Present graphic of freight/package flow in email to help frame interview discussions (to supplement the flyer describing the supply chain coalition).

Background

1. Please describe your expertise as it relates to one or more of the areas highlighted in the pictorial.
2. Are there other areas in which others in your organization are also involved?
3. What is your company's presence and role in the geographic region the research team is targeting (southern Virginia including the Appalachian areas, northeastern Tennessee, and most of the western half of North Carolina, except for the Great Smokey Mountains areas)?

General Challenges- STS Framework

1. What point of the supply chain from dock to door creates the most friction and delay of goods being transported or received?
2. We want to understand the root causes and impacts of this friction and delay across several areas:
    a. What are the Technological challenges for vehicles, sensors, or data systems?
    b. What are the Personnel challenges in the workforce?
    c. What challenges are a result of the Supply Chain Design, consolidation, or fragmentation?
    d. What challenges are a result of the surrounding Environment including the infrastructure, policies, and resources?
    e. Was the root cause a problem before the pandemic? Or is it specific to the pandemic?

Specific Gap Areas

3. Are there particular types or categories of goods that experience the most friction in the supply chain today, or are not well-aligned with emerging technologies?
    a. What makes these types of goods difficult to manage?
    b. Was this friction a problem before the pandemic? Or was it revealed or exacerbated during and/or after the pandemic?
4. Are there particular types of end users most impacted by supply chain issues?
    a. Are there particular types of end users not well-aligned with emerging technologies?
    b. Are there particular challenges experienced by small, women-owned, and minority-owned businesses?
    c. Are there particular challenges experienced by end users of low socioeconomic status or people with disabilities?

ACE-specific Challenges (Now that we've covered general challenges, we'd like to ask you specifically about gaps related to automation, connectivity, and electrification within transport logistics and supply chain)

5. Where in the supply chain—specifically focused on the transportation of goods—will advances in automated vehicles and automated warehouse operations bring the most improvements in resilience, efficiency, sustainability, or equity?
    a. Similarly, where would advances in connectedness of operations and data management/analytics/sharing bring the most improvements?
    b. Where can automation/electrification of vehicles bring the most improvements?
6. In general, what new and emerging technologies might have the most impact on supply chains?
    a. For example, this might include… (battery or hydrogen electric delivery vehicles, drones, automated trucking, automated last-mile delivery by ground or air, etc.).
    b. Similarly, what emerging operational practices might have the most impact on supply chains? For example, resource sharing, collaboration, improved package tracking, or improved data sharing across the supply chain.
7. What are the key barriers to development or adoption of automated, connected, and electrified solutions in logistics?
    a. *If needed, prompt: For example, this might include technology development and testing, cost, education, public acceptance, or legal considerations.*
8. How might these new technologies impact existing gender, socioeconomic, racial, or other inequalities? What can be done to expand equitable access to new solutions?

9. How could your organization play a role in the joint optimization process we seek to develop?

Appendix B: Focus Group Guide

Focus Group Breakout Session Guide

May 5, 2023

Seven priority focus 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:

- Transportation infrastructure
- Logistics
- Data Management
- Sustainability
- Automated Vehicle Technology
- Advocacy & Outreach/Policy & Regulations
- Workforce/Economic Development

The goal of this focus group is to drill down into more specific challenges and opportunities associated with each priority focus area identified above. There will be seven concurrent breakout sessions, each focusing on a different priority focus area. Focus group participants have either preselected and/or been assigned to priority areas based on their industry role and will participate in a total of three breakout conversations. Each breakout session is a purposeful mix of different participants, to maximize networking and representative voices for diverse information sharing.

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 speak.
3. Encourage knowledge transfer between participants.
4. Identify a pathway for resource pooling and solutions.

The discussion of each breakout session will be facilitated by a subject matter expert (SME) and a recording scribe. Each SME/scribe pair will lead the same session three times. Each priority topic area will have specific questions to initiate discussion (included at the end of this document). The intended outputs from each session are answers to the following questions:

- What are the issues associated with the priority focus area?
- What are the suggested solutions to the priority focus area?
- What are the barriers and/or pathways to implementation of those solutions for the priority focus areas?
- What are the key Diversity, Equity, Inclusivity, and Accessibility (DEIA) needs or strategies for the focus area?
- Other important discussion points to note.

After each breakout session, the SME and scribe will fill in the session documentation form included below for *each individual session* (form below). After the final breakout session, each SME/scribe pair will create a high-level summary document integrating all three sessions (form below) that will be translated to a PowerPoint slide summarizing the information aggregated for all three breakout sessions. **The SME will present the slide after lunch.**

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.
- Consider the whole Socio-Technical Systems Framework (technical, personnel, supply chain design and management, environmental) when considering your responses.

The Role of the Subject Matter Expert

- Provide an overview of the focus group process and ground rules for each session.
- Ask probing questions and encourage participants to share their views with others.
- Use the suggested questions, including DEIA (in purple), as a guide to lead the discussion for each 40-minute session. We recommend reserving the last 5 minutes of each session as an accuracy checkpoint with the group to summarize findings.
- Ensure that all participants participate fully, and no one dominates the discussion.
- Facilitate the preparation of the Individual Session Summary **FOR EACH SESSION.**
- Facilitate the preparation of the Integrated Session Summary documentation with your scribe. This document is an aggregation of the input from all three groups, and you will need to give this sheet to Ginny Williams, Rick Walsh, or Kaitlyn Bedwell before lunch on Friday (this information will be transferred to a post-lunch presentation).
- After lunch, present the PowerPoint slide we created for you that summarizes your table's focus area findings (about 3-5 minutes).

The Role of the Scribe

- Assist the SME to ensure the ground rules are followed.
- Provide visible notetaking for focus groups to capture discussion point highlights. You will be provided with markers, an easel, and a large flipchart.
- If there are multiple participants agreeing around one point, keep a tally/star next to that idea when possible.
- Keep track of the time remaining in the session (each session is 40 minutes). Notify the group when 20, 10, and 5 minutes remain. By the 5-minute mark, the session should move towards summarizing the discussion.
- Work with the group SME to prepare the provided Individual Session Summary **FOR EACH SESSION (three sheets total).**
- If time allows, take photos of all notetaking documentation on the flipcharts.

- Work with the SME to prepare the provided Integrated Session Summary documentation, which is an aggregation of the input from all three groups. Collect all session forms (four total) and return them to Ginny Williams before lunch on Friday, as this information will be transferred to a post-lunch presentation.

Tips for Facilitators

Keep the discussion moving and focused on the issues.

You may find it hard to move on to another issue when there is so much more that could be said. This may be especially true when covering technical alternatives and emerging issues. 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. It is also important to encourage participants to consider the Socio-Technical Systems Framework (Technical, Personnel, Design and Management, Environmental) that we present in the focus group overview. When considering their responses, we want them to think beyond just technological or funding bottlenecks as the only limits to their priority focus areas.

Focus Area Table Assignments

#	Table Focus	SME/Facilitator	Scribe
1	**Transportation Infrastructure**	Tom Dingus	Ginny Williams
2	**Logistics**	Kimberly Ellis	Sarah Robinson
3	**Data Management**	Kevin Kefauver	Tarah Crowder
4	**Sustainability**	Andy Alden	Stephanie Baker
5	**Automated Vehicle Technology**	Andrew Krum	Jonathan Cowan
6	**Advocacy & Outreach – Policy & Regulations**	Tammy Trimble	Vikki Fitchett
7	**Workforce Development – Economic Development**	Pamela VandeVord John Provo	Nicole Akers

Individual Session Summary Documentation

May 5, 2023

Directions: Please prepare this document for EACH SESSION

SME: _____ Scribe: _____

Session # (1-3): _____ Priority Area: _____

Overall session summary: (please note group interactions/dynamics in addition to the thematic substance):

Summary of **needs and challenges** representing the group:

Summary of the **suggested solutions** to the needs/problems:

Summary of **barriers to implementation** of the above solutions:

What was the **key DEIA strategy or challenges** that were put forward from this group:

Describe any additional notes of interest (e.g., did everyone converge on certain issues, did anyone stand out as advocates for this issue, etc.):

Integrated Summary Documentation

May 5, 2023

Directions: This document is aggregated information for ***all three focus group sessions***, and will be the information you transfer to the post-lunch slide presentation

SME: _____ Scribe: _____

Priority Area: _____

Overall top priorities for this area:

Summary of **needs and challenges** representing ***all three groups***:

Summary of the **suggested solutions** to the needs/problems for ***all three groups***:

Summary of **barriers** to the above solutions:

Summary of key **DEIA** strategy or challenges**:**

Describe any additional notes of interest:

SME Suggested Format and Questions

Focus Groups May 5, 2023

Table 1: Transportation Infrastructure

Physical infrastructure that affects how products move throughout the supply chain (e.g., fueling infrastructure, rural drone aerial deliveries, automated lane markings and communication, development planning, traffic).

Suggested breakout session format and questions:

1. Share the Ground Rules and the definition of Transportation Infrastructure.
2. Participant introductions – Ask participants to share their name, organization, and expertise related to this area, and organization's presence and role in transportation infrastructure.

Questions:

Needs and Challenges:

In transportation infrastructure, what is **the biggest challenge** to your organization's success?

What supply chain challenges are a result of the surrounding Environment **in this region** (along 1-77, I-64, I-81 corridors) and **in rural areas** specifically?

Solutions

What do you perceive to be **possible solutions** to the issues transportation infrastructure currently presents?

Barriers to Implementation:

What are the **barriers to accommodating these possible solutions** in the future? (e.g., policies, structural changes, planning & development).

DEIA:

How do these corridors **impact existing gender, socioeconomic, racial, or other equality outcomes** in these local communities?

Table 2: Logistics

Analyzing, strategizing, and optimizing the planning for transporting of goods throughout supply chain.

Suggested breakout session format and questions:

1. Share the Ground Rules and the definition of Logistics.
2. Participant introductions – Ask participants to share their name, organization, and expertise related to this area, and organization's presence and role in logistics.

Questions:

Needs and Challenges:

What elements of the supply chain **pose the largest problem** for logistics management (planning and execution)?

Solutions:

In terms of increasing the resiliency and effectiveness of freight flow, what would be some **key enablers**?

Barriers to Implementation:

Are there particular types or categories of goods that **experience the most friction** in the supply chain today, or **are not well-aligned** with emerging technologies? What makes these types of goods difficult to manage? Barriers other than types of goods?

DEIA:

How might we impact equality through a more inclusive approach to planning and execution of logistics management?

Table 3: Data Management

Development and integration of shared platforms for using data (IT Infrastructure / Supply Chain Visibility / System of Systems Optimization / Communications Technology)

Suggested breakout session format and questions:

1. Share the Ground Rules and the definition of Data Management.
2. Participant introductions – Ask participants to share their name, organization, and expertise related to this area, and organization's presence and role in Data Management

Needs and Challenges:

What challenges exist today that prevent sharing and integrating data in the supply chain for your organization?

Solutions:

Where in the supply chain would advancements in connectedness of operations and data management/analytics/sharing **bring the most improvements**? (e.g., 5G connectivity and container sensors tracking freight)

Barriers to Implementation:

What is it about technologies or infrastructures that are **preventing better supply chain visibility** today?

DEIA:

How might we approach providing more equitable access to data? (e.g., various communities' distrust of collection of data and use of data…or how might community engagement occur to address mistrust in data collection and use.)

Table 4: Sustainability

Concerned with environmental impacts and environmental technologies related to transportation of goods (carbon capture, alternative fuels such as hydrogen, electrification of Class 7/8 trucks)

Suggested breakout session format and questions:

1. Share the Ground Rules and the definition of Sustainability.
2. Participant introductions – Ask participants to share their name, organization, and expertise related to this area, and organization's presence and role in Sustainability.

Needs and Challenges:

What are the **biggest challenges to carbon-neutral movement** of goods in the supply chain?

Are there **other transportation-related sustainability goals** outside of decarbonization we should consider?

Solutions:

What **approaches** to alternative fuels and electrification will **advance decarbonization**?

Barriers to Implementation:

What part of the system **needs to be developed** to effectively use electrification in vehicles? What about other alternative fuels such as hydrogen, natural gas, recycled propane?

DEIA:

How does the installation of, or design of, fueling stations impact existing gender, socioeconomic, racial, or other inequalities?

Table 5: Automated Vehicle Technology

Implementation and applications of AI or automated vehicle technologies of unmanned surface or aerial vehicles

Suggested breakout session format and questions:

1. Share the Ground Rules and the definition of Automated Vehicle Technology.
2. Participant introductions – Ask participants to share their name, organization, and expertise related to this area, and organization's presence and role in Automated Vehicle Technology.

Needs and Challenges:

What is the **greatest challenge** facing the **development or adoption** of automated vehicles for movement of goods within the supply chain?

What are the **technological challenges** for vehicles, for example, sensors, weather, or data systems?

Solutions:

What does efficient and safe automated **last mile delivery look like** for drones and surface vehicles in 5 years? 10 years?

Barriers to Implementation:

What aspect of our system **poses the greatest barrier to deployment** of these technologies? (e.g., policy, social acceptance, driver training programs, R&D needed, infrastructure)

DEIA:

How can we better advocate for equitable access and training on these technologies for all kinds of end users?

How might these new technologies impact existing gender, socioeconomic, racial, or other inequalities? (e.g., informed design [no flashing lights or certain colors]: refugees or veterans may be wary from past experiences of war zone vehicles, yet they would be groups that benefit from the accessibility of receiving goods directly to their door)

Table 6: Advocacy & Outreach / Policy & Regulations

Advocacy: Development of governmental and public support around eliminating barriers for supply chain improvement.

Policy: Federal, state, and voluntary regulations, codes, or standards related to the effective implementation of an industry strategy or practice (governmental, community, or organizational).

Suggested breakout session format and questions:

1. Share the Ground Rules and the definition of Advocacy & Outreach and Policy & Regulations.
2. Participant introductions – Ask participants to share their name, organization, and expertise related to this area, and organization's presence and role in Advocacy & Outreach, Policy & Regulations.

Needs and Challenges:

What policy or regulations today **pose the biggest challenges** to the supply chain?

What kind of **bottlenecks** with advocacy and outreach are supply chain actors experiencing?

Solutions:

What **changes in policy would enable** a more efficient and equitable supply chain system in the movement of goods?

How can the needs of organizations within the supply chain **be better communicated** to policy makers?

Barriers to Implementation:

In the policy or advocacy space, what are the most impactful barriers to implementing an industry strategy or practice?

DEIA:

What supply chain barriers exist in policy or advocacy & outreach for small, women-owned, and minority-owned businesses? Or by end users of low socioeconomic status or people with disabilities?

Table 7: Workforce Development & Economic Development

Workforce: Identification and creation of employment and skill-related spaces and groups.
Economic: Fostering and creating an ecosystem for supporting economic health through businesses and workforce.

Suggested breakout session format and questions:

1. Share the Ground Rules and the definition of Workforce Development & Economic Development.
2. Participant introductions – Ask participants to share their name, organization, and expertise related to this area, and organization's presence and role in Workforce Development & Economic Development.

Needs and Challenges:

What are the Personnel challenges in the workforce? Is it shortages, lack of expertise in specific areas, or both?

Solutions:

What supply chain focus areas would be most important to foster in education and workforce development programs in the next 5-10 years?

What can be done to expand equitable access to new solutions in economic development?

Barriers to Implementation:

What are the **bottlenecks** this focus area is experiencing when it comes to enacting solutions to supply chain economic and workforce development issues?

DEIA:

Are there particular challenges experienced by small, women-owned, and minority-owned businesses? Or by end users of low socioeconomic status or people with disabilities?

How do we increase diversity in the workforce and business ownership? How do we facilitate diversity in workplace culture?

Appendix C: Narrative Summaries from Focus Groups

Transportation Infrastructure

Much of the discussion around **transportation infrastructure** emphasized the need for a sustainable future to enable efficiencies within the supply chain. The power grid as it exists today was not built to support the expected level of energy demands, nor is the design able to accommodate new energy technologies without significant modifications. To implement renewable energy transportation infrastructure, we need to ensure the design itself is dynamic enough to accommodate growth of new technologies, microgrids, and alternative fuels.

All three focus groups mentioned microgrids as a potential solution for a sustainable future, especially for rural areas. However, barriers to implementation of microgrids were that many regions may not have the infrastructure to support fluctuating levels of power demand on both ends of the spectrum (that is, for either high power demand or not enough power demand) for efficient grid energy recycling and storage. Supply chain companies being able to service rural areas and enable community access requires increased investment and development to expand transportation infrastructure. However, barriers to implementation of this solution included recognizing that it will take quite a bit of time, resources, and community acceptance to achieve an effective system.

To reach decarbonization goals for a sustainable future, there was consensus that the use of public-private partnerships will be the key to solving needs, addressing challenges, minimizing barriers to implementation, and mitigating risk. However, fragmented communication structures often make these types of partnerships difficult. Due to the lack of shared data, trackability, and efficiency, the logistics of supply chain management relative to transportation infrastructure make this challenging. On a related note, lack of or weak communications infrastructure was consistently cited as a challenge. Participants expressed yet again an emphasis on the challenge of reaching rural areas. There is a need along transportation corridors for secure and ubiquitous communications for supply chain activities.

Solutions participants suggested included the installation of fiber infrastructure and 5G communications to enable secure and ubiquitous communications. Noted barriers to implementation included cost and impact to an already overburdened traffic situation for road/route shutdowns to build this infrastructure. Several participants suggested incorporating the construction of this infrastructure during existing department of transportation (DOT)-funded road improvement or construction projects. This approach was suggested to recover some costs and reach more rural areas while minimizing route disruption with one construction project rather than two.

Existing electrification efforts and expansion to alternative fuels were encouraged, yet there were specific targeting suggestions. Hydrogen was emphasized several times as a priority to pursue as a future sustainable fuel option alongside current efforts in electrification development. Some participants felt that existing electrification efforts should continue for small vehicles, whereas hydrogen or other alternative fuels should be encouraged for use in heavy vehicles. A few participants suggested that fueling time and fuel range are a concern for long-haul supply chain

modes of transport and that hydrogen or alternative fuels may provide better longevity than electrification. However, further research, development, and investment are needed to fully test alternative fuel capabilities for the most reliable and efficient transport. In the transition period, as new energy sources such as hydrogen begin to roll out, participants noted that we should explore transition strategies such as carbon capture and credits.

The future of alternative fuels is unknown and difficult to predict. Participants agreed more confirmation is needed from policy makers in addition to research and development on which types of fuels to prioritize for investment and build to scale for private industry and utility companies. It was also noted there is a lack of shared language between original equipment manufacturers (OEMs) and utility companies, which has made it difficult to understand how to match the technology to infrastructure. Furthermore, private companies are often not allowed to apply for federal or state funding, as opportunities may be limited to city or township, county, state, or special district governments, 501(c)(3) non-profits, public or private academic institutions, public housing authorities, or utility providers. Therefore, these private companies must rely on partnerships with these other types of institutions to correctly invest and align existing state and federal transportation infrastructure endeavors.

There was consensus that more training is needed for workforce development in clean transportation infrastructure. Several participants suggested we need ways to stimulate interest in the emerging clean transportation infrastructure sectors. The solutions could be through new programs at educational institutions, appeal through higher salaries, or credits for businesses to encourage hiring opportunities. A multi-tiered approach was recommended, whereby new programs would be implemented both at the higher and lower education levels—working with children in earlier stages such as middle school as well as in college and beyond. Some participants are already seeing some community colleges partnering with guidance counselors to encourage this kind of workforce development. The largest barrier to implementation was noted as overcoming misinformed social norms through DEIA strategies. We must find ways to encourage students that this sector offers high-paying jobs and good careers to people coming out of vocational and community colleges despite the fact that these jobs would not require going to a traditional 4-year university to receive certification. Implementing certification programs that guarantee job placement opportunities at the end of an individual's training period or certification may be a way to increase motivation to pursue jobs within this sector.

Logistics

From the **logistics** focus group, participants commented that efficiency within logistics is a challenge due to the disruption in materials availability and the lack of communication infrastructure for tracking freight transport. Many participants expressed how they continued to struggle with challenges from post-COVID-19 supply chain disruptions to inventories and industries. Participants mentioned that the delay from inbound parts and materials would put nearly finished outbound goods on hold, where the item might be 99% complete and just waiting on one more part from inbound goods. This causes a domino effect on warehouse site demand and just-in-time manufacturing operations.

The locations of ports have thus become very important to retailers importing goods to cut the time in which these goods need to reach their end destination. However, if a port is underperforming at the rate of processing inbound goods needed, and the retailer then selects a new location, this may take away economic activity from a region. Participants agreed that there should be more incentives for shippers and carriers to reach their destinations on time. As manufacturers and distributors are often across state lines, there is a lack of alignment between companies and expectations. Stronger communications, public-private partnerships, and adequate management and planning aids were suggested as solutions to enhance alignment.

Other challenges participants are facing are infrastructure limitations on facilities and narrow roads and tunnels with traffic delays. Virginia is lagging behind in improving its warehouse infrastructure near the ports. Some participants suggested coupling as a solution. Other solutions included construction to widen roads and tunnels. However, barriers to implementation include high costs; slowed construction zones, delays, and detours causing more traffic (which further exacerbates logistics inefficiencies); and issues of community acceptance of new facilities and infrastructure changes in their backyard.

There is a need to enable more communications, whether through a syncing data sharing platform or increased communications infrastructure. Contracting work requires significant coordination between companies, and the "drop-trailer" model requires many communications and protocols across individuation. Having technology with the ability to connect data systems would be helpful. Stronger coordination of inbound and outbound freight at facilities like the port will help ensure freight trucks do not leave empty. Participants repeatedly described logistics coordination and communication today as inefficient, challenging, or not integrated seamlessly. While communications advancements such as LTE may be licensed for a region, such technologies are not always available due to the infrastructure. Like the transportation infrastructure focus group, members of this group again suggested using DOT right of way to install communications infrastructure economically and to minimize construction projects.

Among solutions suggested by the focus groups, there were several mentions that automated ground and aerial vehicles may help strengthen efficiencies and increase on-time arrivals. However, a stronger communication infrastructure is needed to support automated vehicles, V2V communication, and V2I communication. Recent advances from the FCC will help to address unmanned automated aerial vehicles, but participants expressed that many challenges remain moving forward with this new technology, especially during the initial piloting phase. Automation was also suggested for remote-controlled freight conveyance within warehouses to improve efficiencies and reduce workforce shortages. If we could cross-train employees to perform this one job function, even if only needed on a part-time basis, then employees could switch between roles and help in other areas, resulting in even more efficiency.

In terms of barriers to implementation, it was mentioned that technology development is facing rushed or unrealistic deadlines for implementation (e.g., carbon footprint; automated vehicles along a corridor within a certain timeframe). Policy challenges persist on the safety and reliability of automation. Dedicated lanes were mentioned as a solution for trucking, as there is a lack of acknowledgement and respect on the road for the size and safety precautions of these vehicles. One suggestion was to use a reservation system for these dedicated lanes. Separate or

dedicated lanes were also suggested as beneficial for future automated vehicles, yet they are costly and may be difficult to regulate once in place.

Participants expressed that public-private sector partnerships are crucial to overcoming many of these challenges. For the whole life cycle of logistics technology, we should consider the adoption, implementation, maintenance, and then upgrades to the new technology as it evolves, and as new inventions come on board. A DEIA strategy would be to provide tax incentives to lower barriers for new companies to enter the market.

While the implementation of EVs and hydrogen-powered vehicles was discussed, most comments related to the fact that there are not enough EV incentives to make it affordable for fleets. Costs are high for new equipment, vehicles, fuel, and employee compensation. More fueling infrastructure is also needed. There needs to be a resilient and reliable grid in place before such an implementation could be viewed as an efficient option. Regarding hydrogen fuel cell solutions, research and development are needed to find ways to extend battery life for long-haul freight transport.

DEIA barriers that participants identified included accessibility by smaller organizations to funding opportunities. The way grant solicitations and requests for proposals are currently written prioritizes larger teams. Many small businesses do not have the resources or skills to respond to these types of proposals. Public funding is also needed as a first step to lay the foundation for some of these technological improvements. Until public funding occurs, private contributions are unable to further advance these initiatives, and thus public-private partnerships or tax incentives are needed to lower the barrier for market entry.

Supply chain workers in logistics are seeing many workforce development issues, most notably a lack of job availability. Supply chain system inefficiencies had a domino effect on unions and available labor. Employee satisfaction and retention are also a challenge. Companies are finding a high turnover rate because of harsh working conditions, such as warehousing facilities without air conditioning. Freight transport workers are frustrated by the lack of respect and acknowledgement of heavy vehicle limitations on the road. The strained system of limited labor results in overworking the existing workforce with not enough driver resting time between shifts. Alternatively, the hours-of-service cap limits the ability to utilize an already limited workforce.

For the long- and short-haul industry, a commercial driver's license (CDL) is often required. There is a lack of awareness in the community for certification processes and a lack of availability of instructors. This has resulted in an aging driver population and a lack of new interest from prospective drivers. CDL licensing is increasingly harder to get, which creates a barrier to entry for job seekers. Unlike the suggested solutions from the transportation infrastructure group, even if we use a multi-tiered educational approach, the drivers would not be available until a certain age per CDL requirements. There is also a DEIA difficulty in recruiting because younger employees are more expensive to insure than an aging workforce, especially for small companies. DEIA solutions included using previously incarcerated second chance workers as employees in the transportation sector and more inclusion of an aging workforce.

Data Management

In light of COVID-19 disruptions to the supply chain, participants said the volatility of the transportation sector has been exposed. While data could potentially help inform better transportation logistics, the current barrier is the lack of data sharing around the transport of goods between sectors. While most data sharing is focused on trucking logistics, it is essential that we extend data sharing to multiple modes such as nautical and aerial carriers. Being able to collaboratively share data will improve flow efficiency in freight. Real-time visibility will help improve the flow of freight to forecast potential issues from the production to use stages of a product. While a potential solution may be for AI to form predictions, all three groups mentioned needing a digital twin to assess data quality and how efficiently it translates to human use when coming across the network.

As we share data, it may arrive in specific formats that are associated with a certain data supplier. Data in a nonstandard format may impede data use completely or pose challenges to integration into other data workflows. Therefore, it is imperative to define the purpose of the data and standardize the data format to be usable by all actors. Multiple data solutions can exist within the same network, but the data needed for freight logistics, for example, may differ greatly from decarbonization data. We should standardize data metrics and the way data is shared to ameliorate some efficiency and productivity issues associated with the different data formats.

Some barriers to implementing the solution for a decentralized partner data sharing platform may include cybersecurity and risks of potential data leaks. Past efforts to centralize the data management system have historically yielded a low return on investment. We will need to explore lessons learned from past endeavors to implement a partner data sharing platform effectively.

To foster trust in data sharing, it is important to show members what the return on the investment will be for providing their data and what it will accomplish. If members are not getting return on investment, they reserve the right to shut their portion of data sharing down. If a member is receiving data, how can we ensure trust in that data? We need to foster trust around data quality and reliability. Legal issues with sharing data were a concern, and participants asked what sharing agreements would be established. Roles should be defined, including if some members get more access than others. Data should be standardized and tested to build trust in its quality and prevent errors or potential for misinterpretation.

DEIA challenges mentioned during focus group discussions included that data can be seen as a currency for exchange, and some stakeholders are rich or poor in their access to data. DEIA strategies focused on ways to incentivize data sharing for small, women-owned, and minority-owned (SWaM) businesses. Participants emphasized the need to share data equitably across all potential players. Currently, there is not enough data available from these businesses, which causes people and companies to not prioritize that data (affecting data equity). We should explore ways that data sharing within the network could promote opportunities for workforce development or training to promote more equity within the supply chain.

Sustainability

For the sustainability focus group, the emphasis was to prioritize workforce development for the future of sustainable freight. There are concerns that, if the sector does not start training the workforce now, we will not have a workforce available to build and maintain the future infrastructure and the vehicles and rolling stock that will use this system. Culturally, today's educational trends are to encourage attending college immediately after graduating high school. Participants believe we should encourage students to move into trades at an earlier point in time and shift toward subjects such as electrical systems/electricity. This subject matter focus will be essential for the future of transportation for unmanned road and aerial vehicles, but it will also prepare us for more sustainable electrical technologies for other uses such as more efficient heat pump systems in homes. More education of the workforce and educators to teach this subject are needed.

Transportation infrastructure as it relates to a sustainable future was also a recurring theme. Participants voiced concerns around grid capacity and its ability to support these future technologies. There are accessibility issues in rural and small communities, where there is insufficient grid capacity; even if local governments and agencies are willing to install new grids, they are not able to. For hydrogen fueling, some areas of the country have limited access to the water needed to produce hydrogen because of their arid climates. Non-green hydrogen options continue to be costly and time consuming to produce and may result in a net increase in GHG production. More research is needed for hydrogen fuel cell vehicles. Relative to supply chain actors, many participants reflected on the challenges of how an established facility such as a freight trucking company or a warehouse or port would be able to convert to a fully electric or hydrogen-powered fleet without significant disruption to supply chain operations, in addition to the high-cost considerations. Middle, or bridge, solutions such as hybrid trucks still require a significant amount of development. More research should be done to see how hybrid vehicles may be a viable option in the near term.

Public misperceptions are the cause of a lot of delay in adoption, and participants are seeing less receptiveness in the U.S. than in Europe. Climate change was noted as a political issue, which should be presented to the public as a collective challenge to be solved by all for a healthy and sustainable future. Exploration is needed of the lessons learned from other models implementing electrification in rural areas and lessons learned of community engagement. For community engagement, participants noted we should explore where it may become a safety issue for some communities.

There is not a unified front in terms of policy, state and federal actors, and public and private industry to move towards a future of heavy vehicle infrastructure. Today's current state of the industry has shown that those who are willing to adopt these new sustainable technologies have been doing so in isolation as individual companies. Overall coordination is required to assemble a whole system that supports transportation of goods via heavy vehicles using either electric, hydrogen, or other alternative fuels. Collaboration is needed through public-private partnerships to propel this sustainable transport future forward.

DEIA concerns were raised primarily by smaller fleets. With smaller fleets, the capital costs that are required to change or update infrastructure and rolling stock to make the transition to sustainable technologies is a big challenge. There is also an accessibility issue, where several participants mentioned a waiting list to buy heavy truck EVs. Research is required on how batteries can be produced with more economical options or lighter materials. Maintenance of those batteries such as costs for replacement in the future may be a concern. Furthermore, the costs are still high for the consumer, and there needs to be more business use cases to prove viability, to then increase production, and to then lower public consumer costs.

As a solution to the challenges of companies or facilities switching to alternative fuels, more incentives could be used to encourage transitions to alternative power systems. It was important to note that those incentives may look vastly different for large companies versus small companies. Incentives should not be "one size fits all," but should vary based on company size. A strategic plan was offered to first target large companies to establish momentum for the greatest gains, and then expand incentives with the residual effects to smaller companies. To further encourage transitions to alternative fuels, there should also be more training and education around those technologies, in particular EV batteries. There is a lot of hesitation around battery materials and recycling ability. Many battery production materials may be sourced from outside the U.S., and more should be done to promote domestic production. Community colleges could potentially provide more training on how to recycle these batteries at the end of their life cycle.

The sustainability focus group thought of solutions outside of just sustainable technological solutions for vehicles. Through discussion, they explored more efficient ways to do things via logistics and data sharing to lower emissions. Connectivity between vehicles and cooperative driving scenarios were offered as ways to increase efficiency without changes to equipment. Stronger coordination planning and outreach and even the idea of intermodal transfers were suggested as solutions. Moving freight from rail to truck and then trucks to rail can help increase the overall efficiency of the system.

The barriers to implementation of above solutions were concerned with existing public misperceptions. Much of the public does not believe we have a problem with global warming or carbon reduction, and so while that belief stands, steps towards a sustainable future will not move forward or receive support. There are also misperceptions around EVs such as battery strength between vehicle charges or that EV batteries are made from scarce mineral mining and are non-recyclable. Public misperceptions around hydrogen often involve it being perceived as highly flammable, when in fact, it is lighter than gas and has less risk. More education and outreach efforts are needed to deal with the misinformation in the public space today.

Automated Technologies

Similar to the discussions in the sustainability group, the greatest challenge this group expressed was for workforce shortages and lack of workforce development. People will often resist implementing automation because they see it as a reduction or replacement of jobs for the workforce. One participant suggested a way to handle this resistance appropriately might be through awareness and education. When first implementing automation at a facility, it may help

to present a full model business plan to labor groups to raise awareness that by increasing efficiencies through automation, adoption of automated technologies predicted a net increase in jobs, not a decrease. It is also important to emphasize that salaries would not go down because of adopting automated technologies. Participants in the focus group emphasized public-private partnership as key to correcting existing misperceptions. This partnership is also key to having unified conversations among supply chain actors to examine the big picture and visualize the future together.

The deployment of automated vehicles needs clearer unified policy and stronger communication and transportation infrastructure to support the technology. However, the most notable challenge for the participants was the public perception and acceptance of automated vehicles. We need to find ways to better communicate with the public; these vehicles are safe and can perform well. Perhaps this this kind of messaging needs to happen with more exposure and hands-on interaction. Increasing the training and job opportunities for "safety remote operators" of automated vehicles may be a way of using the workforce development challenge as an opportunity for a solution. Safety remote operators are trained to detect issues that would prevent an automated vehicle from meeting certain safety certification requirements. Having such operators helps technology to reach safety standards more quickly, while also reinforcing trust with humans to understand the technological capabilities. While some states have shown enthusiasm for more workforce training in these systems, more states should be adopting this strategy.

Much of the public funding opportunity and awards have shown support for electrical vehicles and decarbonization, thus making it easier for the public to be receptive. More funding opportunities towards automation may help to change public perception. While states cannot control roadway design at every level based on existing infrastructure constraints, they should still seek to change as many areas as possible. If they have current plans to put in cellular network infrastructure, they could simultaneously adapt the roadway improvements and designs to support automation and connected vehicles. Participants cited timeline concerns as barriers to implementation and deployment of automated vehicles. Technology deployers should think realistically about the timeline for testing versus deployment. If we are just testing the implementation for a year, we need to make sure the infrastructure in place is not just for that year but can support the technology for a longer period.

Part of the problem in public perception may be related to the purpose of the automated vehicle. Transportation safety actors see automated vehicles as a safety benefit for human drivers and the potential of automation to save more lives. However, the public in fact has the opposite impression, where they feel their safety threatened by these unknown vehicles. A proposed solution may be that, if the public cannot understand the need for these vehicles in terms of safety, we may be able to convince them based on the need for more convenience in their personal lives.

The largest challenge in the category of DEIA applicability is how to tailor the message to communities that may benefit most from this automation (such as communities that lack access to public transportation or who have disabilities). Community engagement to better understand

considerations, especially for rural areas, is essential. Deployment should not be just a one-sided implementation. Conversations with the community on how best to serve them are crucial.

Policy, Regulations, Advocacy, and Outreach

The top challenge identified in the policy, regulations, advocacy, and outreach group was the lack of a national framework for things such as automated vehicle policy, beyond the visual line of sight, regulations, and FCC spectrum issues. This lack of framework is an obstacle for companies to knowing how to scale up or where to invest with so many unknowns on the path forward. Participants commented that government is often risk-averse and can throttle technology development when both policy and technology are trying to accelerate in tandem as safely as possible. The quality of "risk averseness" also plays into issues such as insurance. Companies trying to get insurance for their carrier or business operations may encounter higher costs related to automated vehicles. Concerns for businesses relative to policy effects are also related to the future of workforce training. Participants expressed frustration around their abilities to plan due to pending or recent legislative activities. They expressed uncertainty about how a company can plan to staff appropriately for operations with so many ebbs and flows in workforce demands due to supply chain disruptions or growing pains with technology deployment.

There is also a large challenge related to public advocacy and outreach because of general perceptions that express the sentiment of "Not in my backyard." While the public appears to want certain technologies and solutions such as automated vehicles, improved sustainable grids, or freight communication facilities to improve the speed of receiving their packages, they do not necessarily want the disruption or presence in their locations. There is a need for better education to counteract misperceptions of new technologies and promote the potential benefits these may have to a community.

Outreach strategies should seek better ways of quantifying these benefits to the community and to companies. Demonstrations are needed to show it is proportional, for example, that if an entity invests X amount of dollars, long-term projections are X amount of dollars in potential savings. In terms of supply chain, there should be more advocacy to drive out inefficiencies. In terms of decarbonization, participants noted that companies placing empty trucks on the roadways do not face any repercussions and thus have no incentive to change. There should be more incentives at the state and federal funding levels to improve logistics, whether it is through tax credits or creating a space for implementing new technologies such as data sharing, automation, or investment in sustainable fuels. However, relative to sustainable fuels, the barrier to implementation is the perception of false dichotomies. Participants indicated that previous efforts have often presented EVs or gas as either the one good or the one bad option. There is no room for growth with a mid-range option or bridge solution such as clean diesel.

Recommended strategies included improved funding initiatives (e.g., insurance, loans, target funding). A coalition of partners was viewed as a catalyst for pulling these groups together to bring some of that funding into place. More centralized tracking of legislation, regulations, funding, bringing together members, preparing proposal responses, and having cohesive advocacy responses is needed. This will enable DEIA key solutions, as participants expressed the

DEIA challenge that funding opportunities appear to be geared for larger organizations. We need to find ways to engage smaller organizations and take part in these activities. There is a need for intentional mentoring to help smaller companies to grow, develop, and improve.

Workforce and Economic Development

The greatest challenge according to participants in the workforce and economic development focus groups was accessibility to training and job opportunities. Workforce shortages are overtaxing different levels of the supply chain, and more opportunity for training is needed. Unfortunately, there is a higher demand for educators than there are people to fill those positions. Part of this challenge was attributed to the fact that those who are teaching the jobs are making less money than those who will go out and perform the jobs. This makes recruitment a challenge to find qualified people to teach.

There is a strong need to engage all levels of learners within the workforce according to where they are on their spectrum of learning. Engagement should include not just those who are unemployed, but those with jobs who may be re-careering, those looking for more opportunities, or the community members who want to understand what is going on with future technologies for themselves and for their children. A large part of this solution relies on changing public perception that typical job paths follow the traditional route from K-12 to college. Not everyone may need to have a bachelor's degree in the world ahead. We need to start talking about trade jobs as viable and profitable early career options to plan at the K-12 level for both parents and guidance counselors. The idea of guaranteed job placement could be an incentive to make trade job training more attractive.

Participants expressed that the paradigm needs to shift because traditional solutions are not effective. Earn-while-you-learn programs were suggested as a DEIA strategy to overcome the traditional K-12-to-college trajectory. There is a large barrier to attracting a workforce to train for new job functions because people may have to quit their current jobs to get the education required for a certification. This causes them not to pursue the opportunity if they have family or themselves to support financially. Temporary hiring agencies have traditionally had bad connotations for members of the public. We should potentially explore retitling or redefining temporary hiring agencies to attract the right type of workforce looking for longevity in their positions and not just temporary work.

Suggested solutions included ideas for stronger engagement and attraction to new and growing technology jobs. Gamification could help to engage learners in an active way as opposed to just passively relying on the topic or subject area to attract learners, and efforts could focus on remarketing jobs to give them broader appeal. We may be assuming everyone has the same level of exposure to technology and would automatically know the job function based on the title. However, this is a DEIA challenge, and we should look at how to retitle these positions to better reach people coming from different contexts. As technology continues to develop, we need to make the jobs more accessible by changing the types of jobs. Participants noted that it is important to draw workers with a passion for the job function and not just the title. For example, in changing "diesel mechanic" to "electric mechanic," the title does not matter, but keeping what someone loves about that job is important.

Another solution for inclusion may be to use a community-based approach to hiring by aggregating industries. Perhaps an electric charging station technician is only needed for a part-time position for one company. This may not attract many workers due to limited pay and lack of benefits. If companies could share hiring resources, more than one company may be able to use this technician, resulting in a full-time job when job requests are combined. Another suggested solution is to think beyond just each individual company's hiring opportunities. For example, a company's employee could serve as part-time adjunct faculty at community colleges as a way of sharing knowledge, filling instructor shortages, and having a direct benefit to recruiting their own students for hire.