# Implementing Sustainable Freight Technology Transfer Systems

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A White Paper from the Pacific Southwest Region University Transportation Center

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# Contents

**Acknowledgements** ..... 6

**Abstract** ..... 6

**Executive Summary** ..... 7

**Introduction** ..... 9

**Methodology** ..... 12

**Literature Review** ..... 12

**Results** ..... 25

Pre-survey Interview Results ..... 25

Survey Results ..... 26

Focus Group Results ..... 29

**Conclusion and Recommendations** ..... 31

**Works Cited** ..... 33

**Appendix** ..... 35

Appendix A: Survey Question Block ..... 35

Appendix B: Focus Group Protocol ..... 37

# List of Figures

Figure 1: Technology Transfer Process ..... 11

Figure 2: Stakeholder Matrix ..... 16

Figure 3: Technology Tool Usage ..... 27

Figure 4: Barriers to Data Sharing ..... 28

# About the Pacific Southwest Region University Transportation Center

The Pacific Southwest Region University Transportation Center (UTC) is the Region 9 University Transportation Center funded under the US Department of Transportation's University Transportation Centers Program. Established in 2016, the Pacific Southwest Region UTC (PSR) is led by the University of Southern California and includes seven partners: Long Beach State University; University of California, Davis; University of California, Irvine; University of California, Los Angeles; University of Hawaii; Northern Arizona University; Pima Community College.

The Pacific Southwest Region UTC conducts an integrated, multidisciplinary program of research, education and technology transfer aimed at *improving the mobility of people and goods throughout the region.* Our program is organized around four themes: 1) technology to address transportation problems and improve mobility; 2) improving mobility for vulnerable populations; 3) Improving resilience and protecting the environment; and 4) managing mobility in high growth areas.

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# Disclosure

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## Abstract

State Departments of Transportation seek to implement efficient, resilient, and sustainable freight infrastructure planning projects which require public sector agencies to gain knowledge of best practices from key stakeholders in industry, education, and government in the California supply chain. Without an efficient, seamlessly coordinated, and widely supported way to share information across the public, private, and governmental stakeholders in the California supply chain, stakeholders within the freight industry are exposed to increased vulnerability and missed opportunities for improvement. This white paper presents a gap analysis and assessment of best practices related to the current state of sustainable freight technology transfer and outlines initial implications of a still nascent area of research.

# Best Practices in Freight Technology Transfer

## Executive Summary

State Departments of Transportation seek to implement efficient, resilient, and sustainable freight infrastructure planning projects which require public sector agencies to gain knowledge of best practices from key stakeholders in industry, education, and government in the California supply chain. Without an efficient, seamlessly coordinated, and widely supported way to share information across the public, private, and governmental stakeholders in the California supply chain, stakeholders within the freight industry are exposed to increased vulnerability and missed opportunities for improvement. The purpose of this white paper is to provide a gap analysis, showcase a research response, and show successful opportunities to address obstacles and problems for stakeholders in the California supply chain. This white paper and the corresponding research represent an implication-based assessment of the current state of sustainable freight technology transfer and outlines initial implications of a still nascent area of research.

Sustainable freight technology transfer is an emerging area of study which developed out of the under-researched topic of freight technology transfer. Technology transfer became a subject of study within the context of supply chains in the United States after the 1980s and has continued to gain in use and application.[1] The working definition for sustainable freight technology transfer in this white paper is as a process by which tacit knowledge, technical equipment, capital goods, know-how of existing technology, and any industry-specific knowledge or skills are communicated from one organizational setting to another in pursuit of environmental sustainability, economic gain, and the mitigation of future adaptation costs. The use of sustainable technology increases production and/or transportation efficiency which then leads to a diminished consumption of natural resources.[2]

As this white paper represents an implications-based assessment of sustainable freight technology transfer activities, the researchers worked with a small group of subject matter

[1] Blohmke, "Technology Complexity, Technology Transfer Mechanisms and Sustainable Development"; Bozeman, "Technology Transfer and Public Policy: A Review of Research and Theory"; Hirt et al., "GUIDE FOR IMPLEMENTING TECHNOLOGY TRASFER."

[2] Karakosta, Doukas, and Psarras, "Technology Transfer through Climate Change"; Blohmke, "Technology Complexity, Technology Transfer Mechanisms and Sustainable Development"; Bozeman, "Technology Transfer and Public Policy: A Review of Research and Theory"; Hirt et al., "GUIDE FOR IMPLEMENTING TECHNOLOGY TRASFER"; Fernandes et al., "Green Growth versus Economic Growth."

specialists across governmental, public, and private stakeholders in the California supply chain. To gain insights into the current state, barriers, and gaps of sustainable freight technology transfer in the California supply chain, researchers conducted a series of pre-survey interviews, collected survey responses, and conducted focus group meetings.

The results indicate that there is a need for increased institutional prioritization for intentional and direct sustainable freight technology transfer. Key aspects thereof are (1) the establishment of synchronized baseline knowledge and (2) a prioritization to learn key synthesizing technology tools. Additionally, a conscious effort to focus on sustainable technology transfer activities across all freight sectors, including rail and air cargo, could greatly improve efficiency and collaboration across the California supply chain. Introducing common definitions at least within specific freight sectors and at least baseline knowledge thereof could greatly reduce uncertainties and ease regulatory oversight.

In terms of introducing and incorporating new sustainable technology tools, coordination between private industry, public sector, and governmental organizations is necessary to develop a right of way for emerging sustainable technology companies. This could reduce turnover in business and technology applications. Additional communication and coordination are needed to discuss legal barriers, including jurisdictional concerns, and the need to address uncertainty and apprehension. Finally, a broader effort to provide funding within various stages of technology readiness levels, such as for demonstration and feasibility studies, would mitigate and possibly alleviate the financial and competitive pressures for freight operators.

Sustainable freight technology transfer is a nascent area of research but shows tremendous potential and positive opportunities. This implications-based assessment outlines some of these opportunities and serves as a baseline of research into an exciting discipline.

# Introduction

State Departments of Transportation seek to implement efficient, resilient, and sustainable freight infrastructure planning projects which require public sector agencies to gain knowledge of best practices from key stakeholders in industry, education, and government in the California supply chain. Without an efficient, seamlessly coordinated, and widely supported way to share information across the public-, private- and governmental stakeholders in the California supply chain, stakeholders within the freight industry are exposed to increased vulnerability and missed opportunities for improvement.

The purpose of this white paper is to provide a gap analysis and assessment of best practices in sustainable freight technology transfer to assist stakeholders across the California supply chain to better address freight and logistics challenges in an era of increasing zero-emission regulations. This white paper and the corresponding research represent an implication-based assessment of the current state of sustainable freight technology transfer and outlines initial implications of a still nascent area of research.

# Defining Sustainable Freight Technology Transfer

Sustainable freight technology transfer is an emerging area of study which developed out of the still nascent research topic of freight technology transfer. Technology transfer became a subject of study within the context of supply chains in the United States after the 1980s and has continued to gain in use and application.[3] Technology transfer in its original definition describes the transfer of the knowledge necessary to manufacture products and develop applications or other services and became a part of mainstream research in the early 1970s.[4] During that time, technology transfer was mainly studied in the context of globalization and increasing transnational exchange as well as in the discipline of sustainable development. Technology transfer in its original context describes the process of bringing new technologies from industrialized nations, usually in the global North, to developing nations in the global South. In addition to importing new technologies, the goal of sustainable technology transfer is to enhance preexisting technological capacities in recipient nations. Literature surrounding

[3] Blohmke, "Technology Complexity, Technology Transfer Mechanisms and Sustainable Development"; Bozeman, "Technology Transfer and Public Policy: A Review of Research and Theory"; Hirt et al., "GUIDE FOR IMPLEMENTING TECHNOLOGY TRASFER."
[4] Ibid.

sustainable technology transfer has introduced a variety of definitions, however, for the purpose of this study we employ the following definition:

The working definition for **sustainable freight technology transfer** in this white paper is defined as a process by which tacit knowledge, technical equipment, capital goods, know-how of existing technology, and any industry-specific knowledge or skills are communicated from one organizational setting to another in pursuit of economic gain and the mitigation of future adaptation costs. The use of sustainable technology increases production and/or transportation efficiency which then leads to a diminished consumption of natural resources.[5]

Technology transfer has been introduced by past research and literature in many forms[6]. Earlier research highlights the importance of not simply viewing technology transfer as a sale or passing of industrial equipment, but to conceptualize it within the social and cultural context of power imbalances or dependencies, which can lead to mistrust and apprehension. Further emphasis is made on the importance of learning, understanding, and replicating technology to local conditions and to integrate such innovations with indigenous/preexisting technologies to make technology transfer successful. In the light of such considerations, technology transfer has been defined as a process by which expertise or knowledge related to aspects of technology is passed from one user to another in pursuit of economic gain. While economic gain in this context includes financial incentives and increased competitive advantage, researchers convey that economic gain includes the mitigation of future costs to adapt a new technology.

It is important to note that a variety of definitions of technology transfer exist in both literature and industry, however, most of these definitions are extremely context- or industry-specific and would need to be adapted for the freight sector. Newer research, on the contrary, argues that technology transfer is composed of both technical equipment as well as tacit knowledge or know-how. Researchers further posit that technology transfer activities usually are based on market solutions and headed by private industry to achieve appropriate mitigation actions in the realm of sustainable and environmental technology transfer activities. Within this context, three categories within technology transfer were introduced: (1) the transfer of capital goods encompasses technological equipment as well as designs and/or specifications which can be purchased or licensed, (2) the transfer of know-how and skills as they pertain to existing technology, and (3). the transfer of knowledge and skills necessary for further developing an acquired technology. This bottom-up approach ensures that technology transfer is not viewed

[5] Karakosta, Doukas, and Psarras, “Technology Transfer through Climate Change”; Blohmke, “Technology Complexity, Technology Transfer Mechanisms and Sustainable Development”; Bozeman, “Technology Transfer and Public Policy: A Review of Research and Theory”; Hirt et al., “GUIDE FOR IMPLEMENTING TECHNOLOGY TRASFER”; Fernandes et al., “Green Growth versus Economic Growth.”
[6] Ibid.

in terms of a singular issue, but a multifaceted concept adaptable to its applicable circumstances.

Contemporary research defines technology transfer as a process of communication which results in putting research findings or new information into practice.[7] This definition of technology transfer includes both a communication and an implementation component. The communication component simply describes transferring knowledge from Point A to Point B. The implementation component describes the process of putting knowledge to work in the form of a new technological practice or policy.

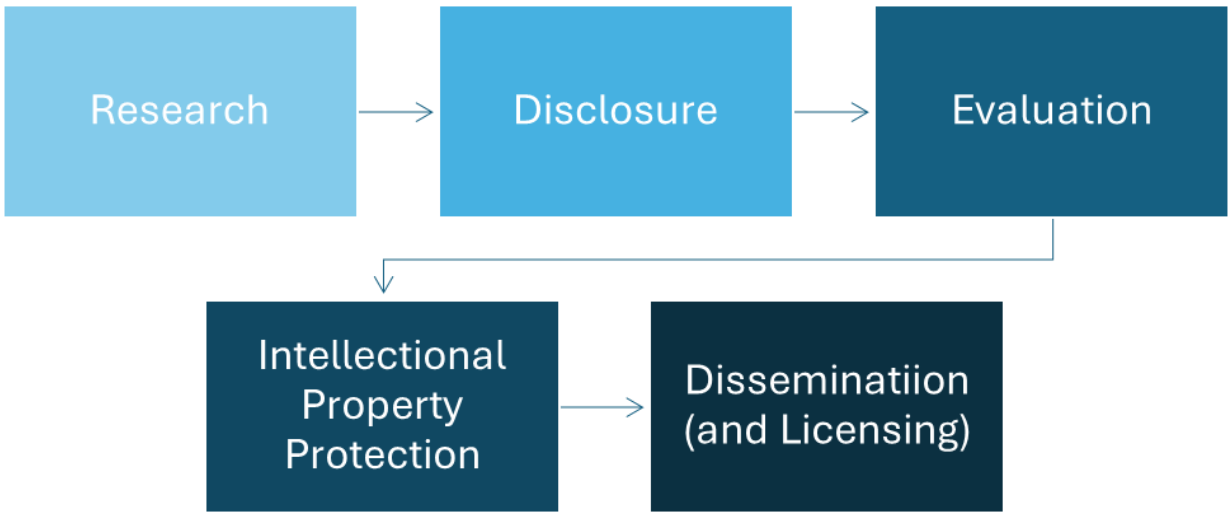


*Figure 1: Technology Transfer Process*

It is important to acknowledge the difference between technology transfer and knowledge transfer. Technology is usually defined as tools, methodologies, processes, products, and instruments for changing the environment. Technology inspires to ask how something works and could be improved upon. Technology is a tool evaluated by its ability to produce desired outcomes in an economical fashion. Information about technology is usually stored in blueprints, empirical equations, operating manuals or other formal documents. Knowledge encompasses broader learning evidenced in strategic thinking, culture, and problem-solving techniques. Knowledge inspires to ask why things are the way they are. Knowledge and broader learning are usually stored in theories, principles, and know-how of commercialization. Overall, knowledge is broader and often represents an umbrella term while technology transfer is

[7] Blohmke, "Technology Complexity, Technology Transfer Mechanisms and Sustainable Development"; Bozeman, "Technology Transfer and Public Policy: A Review of Research and Theory"; Hirt et al., "GUIDE FOR IMPLEMENTING TECHNOLOGY TRASFER."

narrower. It is important to acknowledge that knowledge is prone to subjectivity and human judgment, especially by organizational management. Technology, on the other hand, is more codifiable and less prone to subjective interpretation.

# Methodology

To provide a comprehensive overview of sustainable freight technology transfer among stakeholders in the California supply chain, the researchers used a methodological approach consisting of:

a) a series of pre-survey interviews with members of the California Department of Transportation,
b) a comprehensive survey of stakeholders related to sustainable freight technology transfer activities, and
c) a series of post-survey focus groups discussing survey results, innovative approaches, and positive opportunities.

As this white paper represents an implications-based assessment of sustainable freight technology transfer activities, the researchers worked with a small group of subject matter specialists across governmental, public, and private stakeholders in the California supply chain. The researchers conducted three 30-minute interviews with members of the California Department of Transportation representing a variety of occupations across the chain of command. The implications and insights gained from these interviews informed the subsequent survey development and helped the researchers introduce a more nuanced variety of questions which proved to be crucial in developing a comprehensive overview of sustainable freight technology transfer activities. The survey contained a set of thirteen subject matter questions and was distributed to sixteen key stakeholders across the California supply chain. The insights gained from the survey provided the foundation for the subsequent two focus group discussions, each lasting approximately one hour.

# Literature Review

The history of knowledge transfer goes back to the late 19th century, where it was mainly conceptualized as the carrying over of knowledge from individuals in one setting to individuals in another.[8] A key point was that the two settings had to be similar or at least overlapping.[9]

[8] Lobato, "Alternative Perspectives on the Transfer of Learning."
[9] Ibid.

Classical settings for knowledge transfer were considered schools or universities. Previous literature identified the main goals of knowledge transfer to be:

a) An individual's acquisition of understanding of a certain construct which would then allow the individual to generalize decision making and problem solving in similar situations, and
b) An individual's later learning capacity to be maximized.[10]

Researchers at the end of the 20th and beginning of the 21st century debated over the necessity of knowledge transfer as a research object as many believed intentional learning and unintentional knowledge transfer to be indistinguishable.[11] Despite such fundamental disagreements, knowledge transfer became an established research topic.

Literature surrounding technology transfer highlights the importance of defining technology itself. Classically, technology is viewed as a field of study or an applied science while in technology transfer it is seen more as a tool.[12] The question thus arises, which types of technology qualify as tools? An early 1980s definition defines technology as "configurations", observing that the transfer object, which is the "technology", must rely on a subjectively determined but specifiable set of processes and products.[13] The problem we face then is how to separate technology from its context, when and how do we know it has changed and what happens when technology is adapted through personal use? To address this issue, previous research defines technology transfer as "…the movement of know-how, technical knowledge, or technology from one organizational setting to another."[14] With this conceptualization, the definition of technology transfer changes from one industry to the next according to the discipline and purpose of research. In addition to organizational settings, institutional change and policies can influence the definition of technology transfer. This acknowledgement is crucial in the context of sustainable technology and a socio-political context where environmental policies are in the foreground.

When talking about sustainable technologies it is important not to define such technologies by one characteristic, but to also consider the related applications thereof.[15] Sustainable technology cannot just address one critical issue related to sustainable development if it simultaneously aggravates another.[16] Additionally, we must consider how sustainable technology is perceived and used in the social context.[17] For example, does the use of sustainable technology effectively lead to increased competitiveness and innovation for an organization or industry, or is it simply adapted to gain political favor in a socio-political climate where environmental policies are

[10] Ibid.
[11] Lobato, "Alternative Perspectives on the Transfer of Learning."
[12] Bozeman, "Technology Transfer and Public Policy: A Review of Research and Theory."
[13] Ibid.
[14] Ibid.
[15] Mulder, Ferrer-Balas, and Van Lente, *What Is Sustainable Technology?*
[16] Ibid.
[17] Ibid.

increasing?[18] Similarly, are stakeholders simply adapting or utilizing sustainable technology in order to change the perceptions of their target audiences?[19] When looking at sustainable freight, the adaptation of sustainable technologies should be beneficial for all stakeholders involved, whether they represent private industry, public sector agencies, or public institutions. For the purpose of this project, we introduce the following definition for technology:

**Technology** is defined as a transferable object which relies on subjectively determined, but industry specifiable, set of processes and products aimed at achieving desired outcomes in an economical fashion. Technology is stored in blueprints, equations, operating manuals or other formal documents and is employed in the form of tools, instruments, or methodologies.[20]

Technology transfer in the United States usually occurs along three main axes:

a) technology transfer can occur among firms and organizations within a specific industry, such as the freight industry,
b) technology transfer can occur between private industry and universities, and
c) technology transfer can occur between governmental organizations.

Researchers identified that a majority of technology transfer activities happen either within university-industry partnerships or within firms of the private sector.[21] Technology transfer between industry, universities, and public sector agencies as they are addressed in this project are very rare. A key issue with partnerships outside of the university-government spectrum lies in the fact that while universities and government entities usually experience rewards in the form of new policies or publications, industry stakeholders need to remain competitive and seek economic gain through technology transfer activities.[22]

The goal of technology transfer within private industry is to increase efficiency and increase customizability for smart production systems for which the fourth industrial revolution calls.[23] Technology transfer within private industry often occurs through extended periods of collaboration, the hiring and exchange of skilled workers, and the purchase or licensing agreements between individual companies.[24] Technology transfer between firms of private

[18] Ibid.
[19] Ibid.
[20] Gopalakrishnan and Santoro, "Distinguishing between Knowledge Transfer and Technology Transfer Activities"; Bozeman, "Technology Transfer and Public Policy: A Review of Research and Theory."
[21] Bozeman, "Technology Transfer and Public Policy: A Review of Research and Theory."
[22] Ibid.
[23] Alkhazaleh, Mykoniatis, and Alahmer, "The Success of Technology Transfer in the Industry 4.0 Era: A Systematic Literature Review."
[24] Ibid.

industry often addresses its main barrier, concerning loss of competitiveness, through data privacy agreements or other such formal documents.[25]

Technology transfer between educational institutions such as universities and private industry is an ongoing process and occurs when universities provide or "transfer" research to firms within private industry.[26] This allows private firms to outsource Research and Development (R&D), in exchange for the acquisition of knowledge produced by its university or educational partners.[27] Outsourcing R&D allows firms to operate with increased efficiency, to remain competitive, and to keep up with the speed of innovation dictated by the fourth industrial revolution.[28] Such commercial knowledge transfer generally is conducted through licensing agreements, joint research ventures, and other contractual agreements.[29]

Technology transfer between government agencies and both public and private organizations has mainly occurred through the use of publicly available data and reports produced by government agencies.[30] The use of such data is mainly governed by patent applications, licensing agreements, cooperative R&D agreements, publications, and public software downloads of open-source governmental software.[31]

[25] Ibid.
[26] Siegel et al., "Commercial Knowledge Transfers from Universities to Firms"; García-Vega and Vicente-Chirivella, "Do University Technology Transfers Increase Firms' Innovation?"
[27] Ibid.
[28] Ibid.
[29] Ibid.
[30] Link et al., "Overview and Aanalysis of Technology Transfer from Federal Agencies and Laboratories."
[31] Ibid.

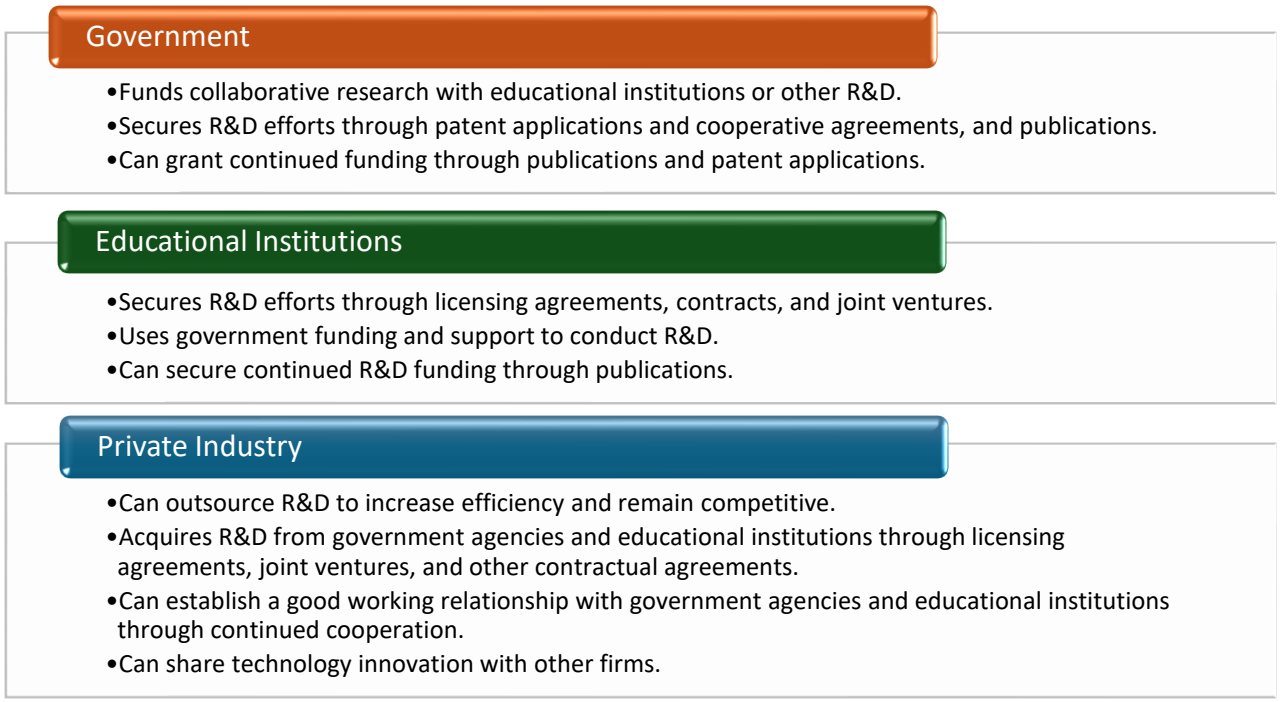


*Figure 2: Stakeholder Matrix*

For a technology transfer among any of the three main axes to be successful, the 7S framework, which analyzes a company's organizational design and utilizes those findings to better operationalize technology transfer activities, is often referenced.[32] The incorporation of such a framework echoes earlier assessments coming out of sustainable development research in which technology transfer activities are based on market solutions and driven by private industry.[33] By taking a firm's organizational structure into account, external stakeholders can make technology transfer more effective and aim to create tailor-made guidelines for a specific industry.

The 7S framework looks at a variety of organizational factors, however, the following three aspects are most vital for technology transfer activities:[34]

a) a company's strategy outlines any actions taken in pursuit of its overall competitive position, especially regarding its pursuit of knowledge and technology transfer,
b) a company's style represents its trust of a university partner as technology transfer activities are reflected in the company's symbolic behavior, and

[32] Gopalakrishnan and Santoro, "Distinguishing between Knowledge Transfer and Technology Transfer Activities."
[33] Ibid.
[34] Gopalakrishnan and Santoro, "Distinguishing between Knowledge Transfer and Technology Transfer Activities"; Jurevicius, "McKinsey 7S Model."

c) a company's support system refers to its university partner's policies for intellectual property rights, patent ownership, and licensing.

These three factors represent key aspects in knowledge transfer, as it usually takes place in "communities of practice", which refers to the interactions between scientists, researchers, personnel, and managers within an organization's rules and policies.[35] Researchers found that the hiring of skilled employees with tacit knowledge and/or two organizations having a long history of working together as key factors for successful technology transfer.[36] Stakeholders must also acknowledge the importance of transactive memory, which develops when groups or individuals work together over a long period of time and through collaboration create common language and knowledge of expertise, which in turn fosters trust.[37] Additionally, both the transferor and recipient must be motivated, especially when the technology is complex.[38]

To foster collaboration further, stakeholders need to analyze organizational functions which need to be achieved instead of applying a trial-and-error approach.[39] Furthermore, technology stored in blueprints and manuals may not always make sense for those using them in day-to-day operations, which is why the incorporation of personnel with tacit knowledge is key when creating new guidelines.[40] Tacit knowledge represents knowable reality in which individuals can make assumptions and associations based in tacit knowledge without being able to outwardly state why.[41]

Some of the key issues for effective technology transfer are:

a) the conceptualization of technology,
b) targeted communication channels, and
c) models of transfer.[42]

There are a variety of technology transfer models, such as the dissemination model and the knowledge utilization model, however, researchers point out that these older models are often fragmented and that there is a need for new models that include both micro and macroeconomic perspectives.[43] To develop effective new technology transfer models, the very definition of technology and technology transfer activities has to be context specific.[44] [45] In order to develop new successful technology transfer models, candidate solutions need to be based on industry-

[35] Gorman, "Types of Knowledge and Their Roles in Technology Transfer."
[36] Gorman.
[37] Ibid.
[38] Ibid.
[39] Gorschek et al., "A Model for Technology Transfer in Practice."
[40] Ibid.
[41] Ibid.
[42] Choi, "Technology Transfer Issues and a New Technology Transfer Model."
[43] Ibid.
[44] Ibid.
[45] See Technology Definition on Page 5

specific observations and tested before implementation.[46] Researchers also need to acknowledge the importance of involving all groups in information sharing as imperfect solutions can stem from more prominent practitioner groups at the expense of minority factions.[47]

There have been a variety of technology policy models in the United States, however, research highlights the cooperative technology paradigm.[48] This model features an active role for government actors and universities in technology development and transfer.[49] Such roles include the position of researchers, supplying applied research and technology to industry, and acting as brokers for policy development.[50] The cooperative technology paradigm is conceptualized as an umbrella term for a set of values emphasizing cooperation across the university, public, and private industry sector, but goes against a strong market paradigm.[51] In the case of sustainable freight technology transfer, the cooperative technology paradigm stands out due to its inclusive stakeholder incorporation.

Effective dissemination is a key aspect of technology transfer and requires an understanding of the recipient audience, the message, and the desired outcome.[52] Studies have found that research and technology transfer is very effectively distributed in geographically similar regions.[53] The key to develop a good dissemination strategy is to know which audiences need to be reached and which investments are necessary to establish and maintain those communication channels.[54] An example is a study in The American Association of State Highway and Transportation Officials (AASHTO) Region 3, which most likely could be adapted to AASHTO Region 4, which includes California.[55] The study emphasizes that the most impactful and cost-effective peer-to-peer technology transfer opportunities require specific guidelines to follow.[56] Researchers must further explore the role of intellectual property rights in sustainable technology.[57] Key questions which must be addressed include who controls the dissemination of sustainable technology and whether this will create new inequalities for those who are at the forefront of sustainable technologies.[58]

[46] Gorschek et al., "A Model for Technology Transfer in Practice."
[47] Ibid.
[48] Bozeman, "Technology Transfer and Public Policy: A Review of Research and Theory."
[49] Ibid.
[50] Ibid.
[51] Ibid.
[52] Hirt et al., "GUIDE FOR IMPLEMENTING TECHNOLOGY TRASFER."
[53] Ibid.
[54] Ibid.
[55] Ibid.
[56] Ibid.
[57] Gopalakrishnan and Santoro, "Distinguishing between Knowledge Transfer and Technology Transfer Activities"; Mulder, Ferrer-Balas, and Van Lente, *What Is Sustainable Technology?*
[58] Ibid.

Contemporary research introduced the concept of a Technology Executive Committee, which oversees not only the technology transfer activities, but also the technological development in the new environment.[59] The main tasks of a Technology Executive Committee are:

a) to highlight an industries' technical needs and provide policy analysis,
b) to foster cooperation with relevant stakeholders,
c) to recommend actions past the technology transfer,
d) to recommend best practices for the transfer itself, and,
e) to catalogue the steps of technology transfer in road maps and action plans.[60]

In order to introduce sustainable technologies into an industry and conduct sustainable technology transfer activities, stakeholders must be aware and work to balance both green growth and economic growth.[61] Green growth depends on technological and market innovations to improve production efficiency.[62] While improved production efficiency could mean less consumption of natural resources, economic growth must still be stimulated as firms and private industry generally bear the brunt of costs in green innovation.[63] National, statewide, or regional coordination is necessary to support both green and economic growth. To take appropriate mitigation measures, especially in terms of sustainable technologies like sustainable freight, making technology transfer activities efficient and thus mitigating adaptation cost is a key lesson to be taken from sustainable development technology transfer.

Research has shown that data sharing among supply chain stakeholders improves resilience, competitiveness, and cost.[64] Establishing visibility across the logistics ecosystem and collaboration between public-sector agencies and industry stakeholders should be prioritized in developing freight data exchanges, improving interoperability, and fostering competitive markets.[65] A key issue with U.S supply chains is that they are often decentralized and each stakeholder has their own set of rules in terms of decision structures and levels of visibility.[66] There are also issues with data quality and availability when multi-organizational cooperation is required, as data is rarely shared across supply chains and is usually only shared across firms within the industry.[67] This becomes an issue when private industry needs to collaborate with local government and public organizations. Interoperability is a key issue within the freight industry,

[59] Blohmke, "Technology Complexity, Technology Transfer Mechanisms and Sustainable Development."
[60] Ibid.
[61] Fernandes et al., "Green Growth versus Economic Growth."
[62] Ibid.
[63] Ibid.
[64] Iakovou and White III., "A Data-Sharing Approach for Greater Supply Chain Visibility."
[65] Ibid.
[66] Ibid.
[67] Ibid.

especially for shippers and carriers, which often use different tools for sharing data.[68] For example, the Port of Los Angeles and the Port of Long Beach use different software platforms.[69]

Researchers point out that the lines of authority for supply chains are unclear and that this has become a key issue after the global COVID-19 pandemic.[70] Large-scale disruptions are especially grave for lean and intertwined supply chains such as air freight and air passenger transit.[71] Both the Port of Los Angeles and the Port of Long Beach suffered major consequences due to the Chinese port closures and the zero-COVID policy.[72]

Supply chain data is a key component for supply chain managers to make good, economical decisions, for which greater visibility is needed.[73] Freight transfer points[74] are mostly privately owned, however, state and national authorities might have some decision power in overseeing these nodes.[75] This intersectionality illustrates the need for data-sharing platforms between private and public entities. Some private firms may still be resistant to storing technical data in a digital format and mutual communication, fearing potential competitive losses.[76] Additionally, independent firms are often suspicious or fearful of governmental or public-sector agencies requesting supply chain data due to legal or compliance issues.[77] These misapprehensions may make useful data unavailable, highlighting that such industry concerns need to be addressed.[78]

There have been various programs and initiatives intended to address the lack of data-sharing platforms and supply chain visibility, both voluntary and institutional level. Programs like the U.S Bureau of Transportation Statistics (BTS) Freight Data are usually only linked to public sector agencies, but such agencies do not carry any authority over the collection and analysis of data and are usually limited to public datasets from organizations like the FHWA[79] The Freight Data Program[80] is hosted by the BTS and contains six separate applications useful for a variety of stakeholders in the freight and transportation sectors. Applications include:

a) a Freight Analysis Framework,
b) a Commodity Flow Survey,

[68] Ibid.
[69] Ibid.
[70] Iakovou and White III., "A Data-Sharing Approach for Greater Supply Chain Visibility."
[71] Ibid.
[72] Ibid.
[73] Iakovou and White III., "A Data-Sharing Approach for Greater Supply Chain Visibility."
[74] Terminals, shipping lines, truckers, railroads, and warehouses
[75] Ibid.
[76] Ibid.
[77] Ibid.
[78] Ibid.
[79] NCHRP, "Freight Data Needs | NCHRP 08-119.", United States Department of Transportation and Bureau of Labor Statistics, U.S. Department of Labor, "BTS Freight Data Programs."
[80] United States Department of Transportation and Bureau of Labor Statistics, U.S. Department of Labor, "BTS Freight Data Programs."

c) border Crossing/Entry Data,
d) the North American TransBorder Freight Dataset,
e) the Freight Transportation Services Index and Seasonally Adjusted Modal Data, and
f) ports Performance Freight Statistics.[81]

The Freight Transportation Data Committee, established by the Transportation Research Board (TRB), aims to identify and publicize sources of and needs for data on commodity movements and freight transportation activity and to advise data collection agencies on cost-effective means of fulfilling essential data needs.[82] While these efforts are important in synthesizing key freight data and improving supply chain visibility, they are often unable to gather sufficient time and resources to develop concrete policies or guidance on freight data use.[83]

The AASHTO Special Committee on Freight aims to gather data and provide methods for the dissemination of best practices in freight data with representation from all 52 state DOT's and other freight-related agencies.[84] The committee also develops policies regarding legislation and regulations related to the safe and reliable movement of goods and provides technical expertise and training for its members and other freight-related agencies.[85] The committee provides an important forum and discusses:[86]

a) social equity, public health and natural environments in relationship with the goods movement industry,
b) the roles of the private and public sector in the freight industry,
c) the resilience and interconnectivity of freight and passenger transportation modes and systems, and
d) the key interface requirements between highways, ports, railroads etc. for freight movement.

Despite this committee having significant membership from both governmental, private, and public sector agencies and thus significant potential to become a leading authority figure for sustainable freight technology transfer activities, no such considerations have been publicly made.

There have been federal frameworks concerning the organization of freight data, however, most are not used anymore.[87] A prominent example includes the 2003 Framework for the

[81] Ibid.
[82] Transportation Research Board, "TRB Standing Committee on Freight Transportation Data | NCHRP 08-119."
[83] Ibid.
[84] American Association of State Highway and Transportation Officials, "AASHTO Committee on Freight – About Us."
[85] Ibid.
[86] Ibid.
[87] NCHRP, "Freight Data Needs | NCHRP 08-119."

Development of Freight Transportation Data as part of a National Freight Data Program by TRB.[88] This framework not only outlined base information and provided examples and case studies showcasing the need for freight transportation data, but also highlighted limitations to current data while developing a new approach for a National Freight Data Program.[89] While this framework and approach are not used anymore, the project represents a prime example and possibly blueprint on how a new approach for sustainable freight data and technology transfer could look like.

Increased supply chain visibility should be a key priority, as it could increase strategic funding if industry stakeholders know that technology could move along with them.[90] Studies have shown that the freight private sector desires improved freight innovation systems.[91] Private industry is often skeptical about sharing its own freight data over concerns about privacy and competitive loss.[92] Simultaneously, public agency freight planners need to address freight needs and issues but have very limited data to make decisions.[93] This deficit in data has led to an overreliance on modeling in strategic decision making.[94] If freight planners had access to private data, a fuller picture of the freight sector would allow for better targeted funding, which could then address stakeholder needs.[95] While some industry specific data is usually publicly available, such collections often represent specific geographic regions and commodity details.[96]

The fundamental paradigm of the freight sector is that private industry is the key producer of freight data, and the public sector is the key consumer.[97] Since data sharing between private industry and public sector agencies can be very difficult, researchers have identified the following key barriers to freight data sharing:[98]

- Legal: These barriers include stipulations of contract law, and privacy policies.
- Resource: These barriers include a lack of personnel and/or funding, especially within smaller private businesses.
- Competition: These barriers include concerns that shared data might be used by other companies to obtain business advantages. Private industry seeks protection from this.

[88] NCHRP; Transportation Research Board, "A Concept for a National Freight Data Program."
[89] Ibid.
[90] Marsh, "The Future Is Now."
[91] Cambridge Systematics, North River Consulting Group, and University of Washington, "Freight Data Sharing Guidebook."
[92] Ibid.
[93] Ibid.
[94] Ibid.
[95] Ibid.
[96] Ibid.
[97] Cambridge Systematics, North River Consulting Group, and University of Washington, "Freight Data Sharing Guidebook."
[98] Ibid.

- Institutional/ Coordination: These barriers include coordination issues as well as questions over authority and leadership in data sharing.

To address these issues, researchers discovered and emphasize the following motivators:[99]

- the inclusion of nondisclosure agreements in data sharing projects would not only help overcome legal barriers but also mitigate concerns about privacy and loss of competitiveness,
- increased stakeholder engagement, especially for public sector leaders, would address institutional and coordination barriers and allow for industry misapprehension to be addressed upfront,
- strategic funding should be comprised of both public and private funds. This would allow industry participants to be reimbursed for their efforts while fostering a cooperative environment between key producers and consumers,
- the use of previously developed or employed technology innovations would help promote continued data sharing and to adapt and customize technology to the industry, and
- efforts to scrub or restrict sensitive data from public freight databases would mitigate industry concerns over privacy and competitiveness. By restricting noncritical sensitive data, both private industry and the public sector could benefit from sharing technology and access to new data.

Acknowledging barriers to and striving to implement motivators is an invaluable tool of communicating the value proposition of freight data sharing.[100]

While there are a variety of projects concerning freight data organization, the lack of a guiding authority figure or organization is a key issue.[101] Freight data acquisition and organizations needs to become more intentional as there is a concerning lack of communication between freight planners, data practitioners, and public sector leadership on the importance of technology transfer infrastructure.[102] The lack of leadership on how to collect and analyze freight data is a major obstacle to effective and successful freight data sharing, as many stakeholders have distinct policies on how to do this.[103] There is also a lack of coordinated data sharing and a unified exchange file format such as the General Transit Feed Specification for public transit agencies.[104] There is a need for increased communication and partnerships between local, regional, and state agencies and private industry in order to ensure data consistency.[105] Increased cooperation would further allow for purchasing and licensing of technology innovations as well as for the

[99] Ibid.
[100] Ibid.
[101] NCHRP, “Freight Data Needs | NCHRP 08-119.”
[102] Ibid.
[103] Ibid.
[104] Ibid.
[105] Ibid.

introduction of data sharing agreements.[106] This would in turn allow DOT's and other agencies to purchase data from private industry and share it with their respective cooperations and data sharing communities.[107]

Contemporary efforts to address supply chain visibility include the Freight Logistics Optimization Works (FLOW) initiative for voluntary exchange of intermodal freight data introduced by the U.S Department of Transportation.[108] This initiative is conceptualized to be self-sustaining as increased communication across supply chains and increasing participation of stakeholders would lead to more and better data becoming available, which then would speed up delivery times and reduce consumer costs.[109] The collected data will also help collaborative industry decision making.[110] Such initiatives encompass an essential component of sustainable technology transfer: increased efficiency, lower consumption of natural resources, and the promotion of green economic growth.[111] Current participants[112] include major freight stakeholders such as the Port of Los Angeles, the Port of Long Beach, MSC, Fenix Marine Services, Global Container Terminals, Maersk, and APL Terminals, and Flexport Freight Forwarder.[113]

In California, the Clean Air Action Plan represents a landmark air quality plan which introduces comprehensive strategies to mitigate port-related air pollution and related health risks and is a great example on how sustainable policy can be addressed without business competitiveness being neglected.[114] Supported by both the Port of Los Angeles and the Port of Long Beach, the CAAP is led by private industry and garnered a wide range of support from the public and public sector and showcases the innovative port-community interface which key freight transportation nodes can meaningfully contribute to.

When considering similar future freight data-sharing platforms, the inclusion of supply chain software leaders is crucial as the need for digital standards across specific industries is key to attain better supply chain visibility.[115]

[106] Ibid.
[107] Ibid.
[108] Iakovou and White III., "A Data-Sharing Approach for Greater Supply Chain Visibility"; "FLOW | US Department of Transportation."
[109] Ibid.
[110] Ibid.
[111] Fernandes et al., "Green Growth versus Economic Growth."
[112] For a full list of current participants, see Appendix Section X
[113] Iakovou and White III., "A Data-Sharing Approach for Greater Supply Chain Visibility."
[114] Clean Air Action Plan, "Clean Air Action Plan."
[115] Iakovou and White III., "A Data-Sharing Approach for Greater Supply Chain Visibility."

# Results

## Pre-survey Interview Results

As the existing literature indicates, there are a variety of definitions for (sustainable) technology transfer. The three pre-survey interviews with members of the California Department of Transportation provided an ideal opportunity to discuss their understanding of freight technology transfer. A key aspect emerging from these discussions was the importance of identifying key stakeholders within the supply chain and providing them with the necessary knowledge and training to use the freight technology tools needed. For some of the interviewees, technology transfer encompasses knowledge transfer with the addition of industry-specific knowledge, skills, and abilities. For other interviewees, knowledge transfer is mostly confined to the academic setting and technology transfer describing academic institutions sharing technological research with private industry. In that context, knowledge transfer occurs mainly through courses and written material while technology transfer focuses on learning practical applications. Other interviewees see the knowledge transfer mainly in terms of practices and technology transfer in terms of data. The sharing of applicable technological knowledge as it occurs through freight technology transfer with public and private organizations is conceptualized to lead to the availability of better data and thus more efficient and sustainable practices within the freight industry.

The interviews also clarified the differentiation between vertical and horizontal technology transfer. While communication between governmental or public-sector agencies and private industry is considered vertical technology transfer due to the authoritative aspects ofregulatory bodies and sources of funding, communication among private industry is considered horizontal technology transfer.

While the conceived benefits of sustainable freight technology transfer activities certainly are exciting, the pre-survey interviews indicated a variety of obstacles. A key aspect thereof is the potential apprehension of private industry to work with governmental or public-sector agencies due to the incompatibility between a fast-moving private industry and a slower, often inconsistent government. Key aspects contributing to slower moving governmental organizations are that there is often a lack of communication and efficiency due to the top-down structure of these organizations. For example, middle and upper management usually do not directly interact with data or new technologies and tools but are responsible for assembling major reports for publishing. Due to this hierarchy, new data, technologies, and tools are often only exchanged horizontally before specific research groups feed the information into the area of responsibility for management. This results in leaders of governmental and public sector organizations often not being up to date with technological innovations. This delay in turn means that a wide rollout of innovative technologies by regulatory agencies is nearly

impossible. Consequently, the efficient sharing of new sustainable technologies becomes continuously more difficult and thus severely limits the availability of such information to the public. The interviews also implied that private industry has substantially better data, however for governmental agencies, the cost to acquire such proprietary data represents a major obstacle. In addition, proprietary data often is too granular for statewide work by regulatory agencies, thus creating a further barrier to efficient information sharing and reinforcing existing organizational siloes.

A further obstacle to technology transfer besides obtaining necessary data is restricted access to technology tools. Access to tools can be difficult to obtain for personnel besides research scientists. Additionally, management often is not responsible for approving the use of new tools, but the IT departments are. This is largely due to precautions regarding system compatibility as well as older and sometimes failing equipment. A positive aspect in continuity is that once new tools are approved, for a specific project, continued permission for usage is implied. It is important to acknowledge, however, that the technological sector and thus innovative tools and companies are ever evolving, thus creating a high turnover rate which can be problematic in regard to long approval processes within governmental agencies. These interorganizational silos further slow down technology transfer activities of governmental and public-sector agencies.

## Survey Results

The survey portion of this project consisted of a set of thirteen subject matter questions sent to sixteen key stakeholders in the California supply chain. The results provided the researchers with invaluable insights into the current state of sustainable freight technology transfer activities. Of the sixteen organizations approached, the researchers worked with a small group of six subject matter experts across a variety of organizations in the governmental, public, and private industry space.

A key objective of this white paper is to gain a better understanding of how sustainable freight technology transfer is conceptualized and defined among industry stakeholders. The survey results showed that while there are varying elements among the participants, there is a consensus regarding the following elements:

- technology is being transferred from one sector to another,
- making knowledge, lessons learned, and other information available to advance technology, and
- developing, evaluating, and demonstrating innovative technologies.

A specific example in terms of sustainable freight technology transfer is the transfer of zero-emission technology from light-duty to heavy-duty vehicles. This example illustrates how sustainability can represent a development with increased sustainability in mind. When asked

whether sustainable technologies are important for the future of the freight industry, all participants either agreed or strongly agreed, thus validating the focus of this white paper. Considering this result, the participants were subsequently asked which existing freight technology tools they most use. As the graphic below shows, there is a significant overlap between governmental, public sector and private industry representatives, with both public and proprietary data occupying top spots.

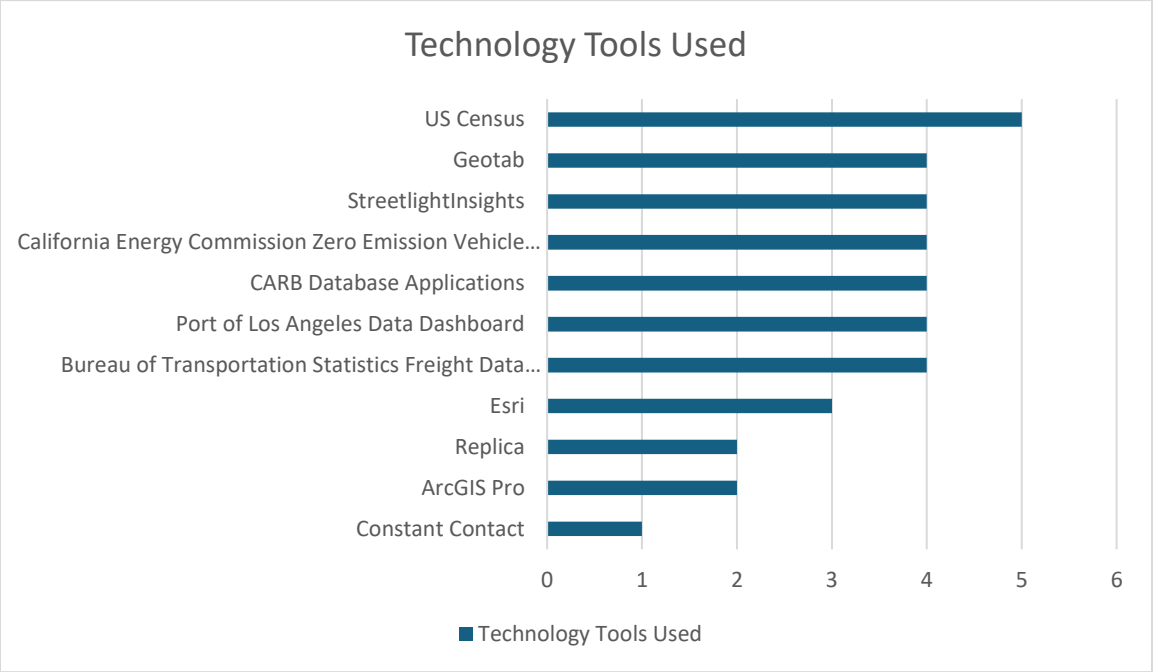


*Figure 3: Technology Tool Usage*

When asked which type of organization the participants interacted with most often, both private industry and public sector agencies came up most often, demonstrating that the frequency of such interactions warrants improved information and technology sharing. The survey results nevertheless indicated a need for an improved working relationship between governmental and public-sector agencies and private industry. When asked about the availability of freight data, participants of regulatory agencies expressed more dissatisfaction than those of established governmental organizations. When asked about the current state of freight data regarding quality and consistency, a majority of participants expressed their dissatisfaction. These results validate the discrepancies between governmental organizations and private industry expressed during the pre-survey interviews. Interestingly, a majority of participants expressed uncertainty when asked about the importance of supply chain visibility for efficient planning and decision making. While three participants agreed with this statement, the overall result calls to further investigate if the existing silos in terms of technology and information sharing reduces supply chain efficiency. Participants were subsequently asked what they thought the biggest barriers to technology transfer activities were. As the graphic below

shows, legal constraints such as contract law, privacy policies, or non-disclosure agreements (NDA's) are conceived to severely limit information sharing. Subsequent concerns are reduced resources in terms of personnel and/or funding as well as competitive concerns regarding unauthorized or misappropriated use of shared data. A smaller but nevertheless important barrier is coordination and communication among leadership and across organizations.

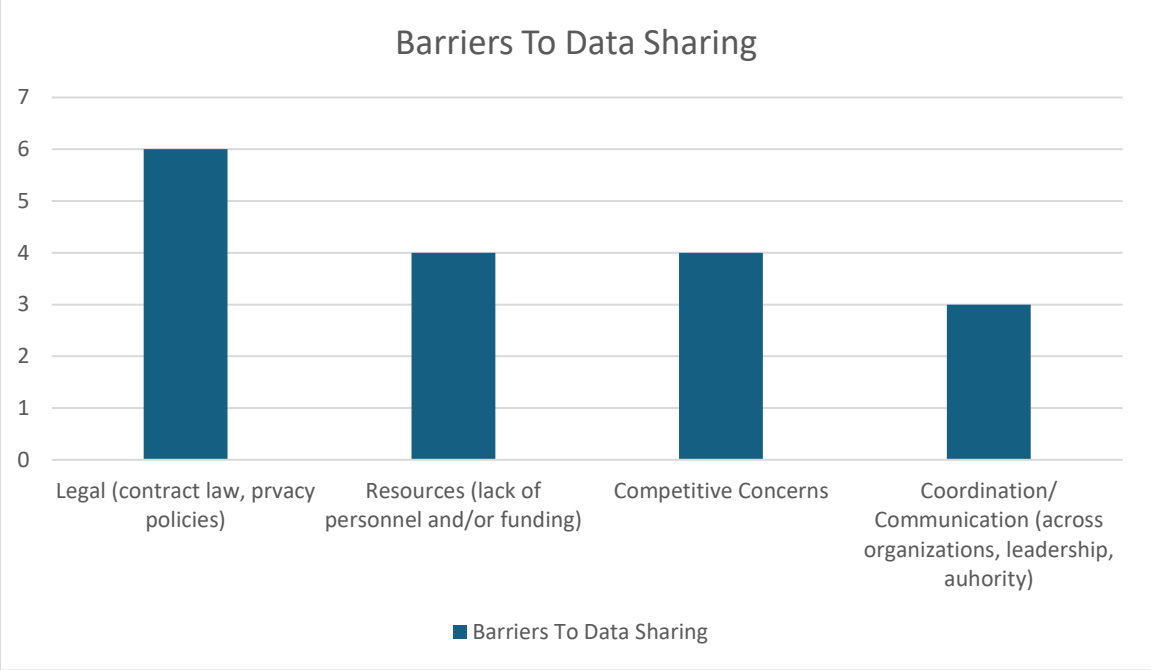


*Figure 4: Barriers to Data Sharing*

To overcome these barriers, the researchers proposed three potential new tools: (1) official guidelines or an authoritative body through which to coordinate data sharing, (2) an official clearinghouse or data platform, and (3) a conscious effort to standardize freight data. A strong majority of participants opted for the introduction of an official clearinghouse or data platform, followed by the introduction of official guidelines or an authoritative body. These results seem to correlate with the two major areas of concern, legal and resource limitations.

With the goal of introducing more efficient ways of information and technology sharing, the survey results indicate that new data and/or technologies are most often introduced through colleagues and co-workers, followed by leadership and research and development (R&D). While the variety of sources indicated seem to present a few positive opportunities, survey results showed that there still is considerable uncertainty toward communication with leadership and broad intraorganizational testing regarding introducing and incorporating innovative technologies.

## Focus Group Results

Two separate hour-long virtual focus group meetings were held after the conclusion of the survey. In each focus group meeting the researchers discussed the survey results and further explored a variety of related thoughts and topics.

A key issue discussed in both meetings are the significant differences between freight sectors such as trucking, railroad, and air. Not only do definitions, acronyms, and terms differ between these sectors, but operational procedures as well, which can make the adaptation of new technology tools more challenging. The discussions showed that sustainable freight technology transfer encompasses both the bridging of different software as well as operational optimization, the latter of which causing hesitation due to significant financial commitments, especially in terms of sustainable technologies. Representatives of both governmental and regulatory agencies expressed concerns over so-called sunset dates regarding sustainable development and the enormous financial pressure associated which can lead to privately owned organizations retiring early. This pressure is especially high in California, a national leader in sustainable development and strict regulations toward water and air quality. Financial pressures are especially high for the operational operators and infrastructure side of the supply chain, as developments such as zero-emission vehicle technology are mostly just becoming available for stationary or light-duty operations. For example, if the ports of Los Angeles and Long Beach fully switched to battery electric operations, it would require six to eight times the amount of power it currently does. To promote the adaptation of new technological tools and mitigate the concerns over financial pressures, the focus group participants discussed the positive opportunities with feasibility studies and providing funding for demonstrations.

Working off the Beachhead strategy, an argument was made that if funding for a sustainable technology tool was made available to a specific sector, then the technology could automatically seep into related sectors and spread further from there.

The focus group discussions revealed that there are not only technological or operational limits to sustainable freight technology transfer, but that different freight sectors contain niche spaces that are rarely addressed by conventional development. Such sectors include rail and air cargo. Participants also discussed operational limitations, such as manufacturing for a particular function. As opposed to manufacturers in an open market which has a nearly unlimited number of customers and can be stimulated by governmental support in mass commercialization, the freight sector has a finite number of customers and thus may be more hesitant to take on major expenses for operational optimization. Sustainable startup organizations in the freight industry face two key challenges: (1) they expand too fast and do not last, or (2), they ignore the right of way within the state. The latter example often describes small startups who look toward state agencies directly, aiming for immediate adaptation or promotion instead of aiming to establish collaborative efforts with local industry as well as city and county leadership. This is a pipeline dream in which a foundational idea may have promise, but the lack of horizontal collaboration

and securing of appropriate funds means that smaller companies who may be more inclined to data and technology sharing suffer simply due to a lack of procedural understanding. According to participants from state agencies, there is a feeling of willingness to work with sustainable startup companies provided there will be a serious commitment to established pipelines and increased lateral technology transfer.

A recurring theme during the focus group discussions was that governmental organizations are siloed and therefore, like regulatory agencies, have different priorities. Regulations differ due to inconsistency in definitions between academia, private industry, and governmental and public sector organizations. Key terms in sustainability such as zero-emission, hydrogen grades, and green technologies have no unified definition, thus making funding regulatory compliance difficult and funding opportunities often confusing. Focus group participants also pointed out the lack of vertical traction and communication between upper management across organizations. To address this, the participants suggested introducing a champion for each silo or freight sector who would be able to stay current with emerging sustainable technology and efficiently communicate with other sector champions.

Regarding freight data, the focus group participants found that while government data is widely available, it is often very general and proprietary data is often too expensive for government agencies to purchase. The issue with using mostly publicly available data is that it only shows a small glimpse of a problem, which makes it hard for planners and decision makers to see or understand the full extent of a problem. In addition, government data can be hard to work with for regulatory agencies, as it is often narrowly focused on logistics. There is also a lack of rail data, as it is traditionally a very siloed freight sector. This issue could potentially be mitigated by a clearinghouse or data platform. Aggregate data is generally available through platforms such as StreetlightInsights or Geotab, however past experience has shown that the data did not always match with the throughput and timeframe of other agencies, leading to uncertainty and questionable quality.

A further issue discussed in relation to data sharing were security and jurisdictional concerns. While employees at freight facilities such as ports are usually required to complete background checks, external staff of data or manufacturing companies are not. This can lead to issues as data used to monitor infrastructure or machinery could be weaponized to track staff members within a specific scope. For example, if a machine requires intermittent downtime due to manufacturing issues, data recording the downtime could be used to track supposed inactivity of staff. Employers and representatives from private industry are concerned about remote operability of heavy machinery which can pose a significant risk to staff and calls into question the jurisdiction over technologies and data.

When discussing how new technologies are introduced to the focus group participants, webinars and self-selected training or studying were the most common answers. Webinars were usually offered by regulatory agencies while self-selection into training mostly originated from the collection of freight study methodologies for various projects.

To address the challenges discussed, the focus group participants largely agreed that the introduction of a clearinghouse, official data platform, or data sharing guidelines would be beneficial for sustainable freight technology transfer activities. The participants iterated the importance of such an addition containing a source category for data and definitions as well as an advance technology readiness level explaining the status of a given technology such as theoretical applications only, in feasibility studies, testing applications, and so forth. The participants further discussed that a clearinghouse or data platform should be crowdsourced by subject matter experts, not regulatory agencies and that it should be peer-reviewed and unbiased, citing the corresponding process in academia. These key features would help mitigate bias or apprehensions towards working with certain organizations. Through collaborative efforts such as a clearinghouse, more freight sector buy in could be garnered and subsequently performance could be improved, thus increasing visibility and reducing uncertainty.

## Conclusion and Recommendations

The findings from this white paper suggest a need for increased institutional prioritization for intentional and direct sustainable freight technology transfer. Key aspects thereof are the establishment of synchronized baseline knowledge and a prioritization to learn key synthesizing technology tools. Additionally, a conscious effort to focus on sustainable technology transfer activities across all freight sectors, including rail and air cargo, could greatly improve efficiency and collaboration across the California supply chain. Introducing common definitions at least within specific freight sectors and at least baseline knowledge thereof could greatly reduce uncertainties and ease regulatory oversight.

To establish synchronized baseline knowledge of sustainable freight technology transfer, regulatory agencies operating at the state level such as Caltrans could offer regular targeted training, both for specific freight sector employees as well as cross-organizationally with the private sector. Additionally, targeted trainings could be implemented across different levels of the chain of command to account for relevant organizational structure and information flow.

Such training would also allow for collaborative efforts between private, public, and governmental organizations to establish funding for training with technology platforms and systems that are essential to the freight industry. This would also present an opportunity for private sector organizations to communicate potential hazards, and to address jurisdictional concerns with corresponding technology partner.

These efforts would allow all relevant stakeholders to strategically map intersecting organizational nodes, which would improve communication and allow for more detailed evaluations regarding lateral and vertical technology transfer activities.

In terms of introducing and incorporating new sustainable technology tools, coordination between private industry, public sector and governmental organizations is necessary to develop a right of way for emerging sustainable technology companies. A right of way, or an established pathway would allow emerging sustainable technology companies to follow from proof of concept through feasibility and testing to potential endorsement or adaptation within the freight sector and all relevant stakeholders. This could reduce turnover in business and technology applications. Additional communication and coordination are needed to discuss legal barriers, including jurisdictional concerns and to address uncertainty and apprehension.

Finally, a broader effort to provide funding within various stages of technology readiness levels, such as for demonstration and feasibility studies, to mitigate and possibly alleviate the financial and competitive pressures for freight operators. The development of an advance technology readiness level explaining the status of a given technology such as theoretical applications only, in feasibility studies, testing applications, and so forth could support this effort tremendously.

Sustainable freight technology transfer is a nascent area of research but shows tremendous potential and positive opportunities. This implications-based assessment outlines some of these opportunities and serves as a baseline of research into an exciting discipline.

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# Appendix

## Appendix A: Survey Question Block

You are being asked to participate in a research study.

Dr. Tyler Reeb and team from the Center for International Trade and Transportation at California State University Long Beach are conducting a study regarding best practices in sustainable freight technology transfer activities. We invite you to complete a survey about the nature, barriers, gaps, and strategies of sustainable freight technology transfer.
The results of this survey will help identify and document gaps and barriers to sustainable technology transfer within the freight industry. State DOTs seek to implement efficient, resilient, and sustainable freight infrastructure planning projects which require public sector agencies to gain knowledge of best practices from key stakeholders in industry, education, and government in the California supply chain. The researchers will analyze the survey results to develop guidelines for best practices and strategies regarding technology transfer in the freight industry.

Survey data used in the final report will be anonymized. A report of this study will be published and only group results will be communicated, not individual responses. If at any time in the final report an individual response is referred to, the reference will not include any information that could be used to identify the respondent, such as their name, email address, or employer. At no time will names or email addresses be shared with individuals outside of the research team. Any information collected from you in this study will be stored in a secure location and will not be shared with anyone who does not have appropriate provisions to access the information.
If you have any questions about the study or other questions later on, please contact Lena Wild: Lena.wild@csulb.edu

**Demographics**

- Name
- Organization Represented
- Organization Category (Private, Public Sector, Governmental)
- Title
- Email Address

***Technology Transfer Foundational Questions***

- What is your definition of technology transfer?
- What is your level of agreement with the following statement:
    - Sustainable technologies are important for the future of the freight industry.
    - Strongly agree, agree, unsure, disagree, strongly disagree
- Which of these technology tools do you use?
    - Geotab
    - US Census
    - California Energy Commission Zero Emission Vehicle and Infrastructure Statistics
    - CARB Database Applications
    - Replica
    - Streetlight
    - Bills of Lading Database
    - Port of Los Angeles Data Dashboard
    - ArcGIS Pro
    - Esri
    - Constant Contact
    - Bureau of Transportation Statistics Freight Data Programs
    - Other (please specify)

***Freight Industry***

- Which type of stakeholder does your organization interact with most often?
    - Private Industry
    - Public sector Agency
    - Governmental Organization
- Are there any concerns regarding cooperation with any of the following stakeholders (Private Industry, Public sector agency, Governmental Organization)? Why?
- How do you feel about the availability of freight data to make strategic decisions in your industry?
    - Very unsatisfactory, unsatisfactory, adequate, satisfactory, very satisfactory
- What is your level of agreement with the following statement:
    - Supply chain visibility is important for efficient planning and/or decision making.
    - Strongly agree, agree, unsure, disagree, strongly disagree

***Data and Technology Specifics***

- How would you describe the current state of (freight) data consistency and quality?
    - Very unsatisfactory, unsatisfactory, adequate, satisfactory, very satisfactory
- Which of the following would you like to have introduced into the freight sector?
    - Official guidelines or an authoritative body when it comes to data sharing and technology transfer.
    - An official clearinghouse/data platform
    - Standardization in freight data

***Organizational Questions***

- How are new technologies or data sources introduced to you?
  - Through colleagues or co-workers
  - Through leadership
  - Through research and development
  - Through written communication (e.g. manuals, workbooks etc.)
- Which, if any, of the following barriers do you see with data sharing?
  - Legal (contract law, privacy policies)
  - Resources (lack of personnel and/or funding)
  - Competitive Concerns (data being used to gain competitive advantage)
  - Coordination/Communication (coordination across organizations, leadership, authority)
- What is your level of agreement to the following statement:
  - I can communicate openly with organizational leadership about incorporating new technologies or datasets
  - Strongly agree, agree, unsure, disagree, strongly disagree
- What is your level of agreement to the following statement:
  - Including diverse groups of employees within various departments of an organization in testing new technologies or data sources is beneficial to evaluate a potential adaptation.
  - Strongly agree, agree, unsure, disagree, strongly disagree

## Appendix B: Focus Group Protocol

- Welcome
  - Welcome participants
  - Introduce the research team
  - Re-introduce the duration and intention to record the meeting

- Opening question: What is your definition of (freight) technology transfer?
  - Present results from corresponding survey question
  - Discuss differentiation from knowledge transfer

- What freight technology transfer activities do you know about within your organization?
  - Discuss use of data, innovations, technology tools
  - Present results from corresponding survey question

- Which stakeholders does your organization share data, innovations, and technology tools with?
    - Present and discuss results from stakeholder interaction survey question
    - Present and discuss survey results regarding concerns about stakeholder cooperation

- Which barriers do you see with data sharing?
    - Present and discuss survey results

- How do you feel about the availability of freight data to make strategic decisions in your industry?
    - Present and discuss survey results

- How would you describe the current state of (freight) data consistency and quality?
    - Present and discuss survey results

- How important is supply chain visibility for efficient freight planning and decision making?
    - Present and discuss survey results

- How are new technologies or data sources introduced to you?
    - Do you mostly use publicly available or proprietary data?
    - Present and discuss survey results regarding communication with organizational leadership
    - Present and discuss survey results regarding broader level testing of new technologies

- Which proposed additions (official guidelines, official clearinghouse/data platform, standardization in freight data) would you like to see introduced into the freight industry? Why?
    - Present and discuss survey results

- Is there a particular project or policy which stands out to you for its use of freight technology transfer?

- Conclusion

    - Is there anything else you would like to mention/discuss before we conclude this meeting?
    - Thank everyone for their time and participation.