



Advancing Freight Fluidity Performance Measures: Summary of a Workshop

DETAILS

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AUTHORS

Katherine F. Turnbull; Technical Activities Division; Transportation Research Board; National Academies of Sciences, Engineering, and Medicine

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**Advancing Freight Fluidity
Performance Measures**
Summary of a Workshop

December 9–10, 2015
The National Academy of Sciences Building
Washington, D.C.

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Summary of a Workshop

Katherine F. Turnbull
Rapporteur

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500 Fifth Street, NW
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Preface

The efficient and reliable movement of freight is essential to a vibrant economy and society. The multimodal freight transportation system is managed and operated by a variety of public and private entities that monitor and measure system performance in different ways. While freight is moved primarily by the private sector, there is a strong public interest in freight movement because of the use of public infrastructure—highways, waterways, and airports—and because of the centrality of freight to the country’s economic security and competitiveness.

The Transportation Research Board (TRB), in collaboration with the Federal Highway Administration’s (FHWA’s) Office of Freight Management and Operations, hosted a workshop to examine the development and use of freight fluidity performance measures and related analysis techniques to improve the freight transportation system. The Advancing Freight Fluidity Performance Measures Workshop was held December 9–10, 2015, in Washington, D.C.

The workshop brought together public agency personnel and private-sector supply chain managers to share information on monitoring and measuring different elements of the freight transportation system. Participants discussed the opportunities and challenges associated with expanding the use of freight fluidity performance measures.

The workshop began with an update on the FHWA’s activities related to freight fluidity performance measurement. The second general session featured the four background paper authors discussing applications of freight fluidity, the scale of analysis, data options and analytical issues, and implementation options. The other general sessions focused on stakeholder views of measuring supply chain performance and examples of applying freight fluidity performance measures and supply chain analyses at the state, regional, corridor, and local levels. The workshop concluded with an open discussion of possible next steps to help advance the development and use of freight fluidity performance measures.

TRB assembled a planning committee to help organize and develop the workshop program. The planning committee was chaired by Joseph L. Schofer from Northwestern University. Committee members provided expertise in freight fluidity, freight data, planning and modeling, performance measures, and policies.

The planning committee was solely responsible for organizing the workshop and identifying speakers. Katherine F. Turnbull, Texas A&M Transportation Institute (TTI), prepared this report as a factual summary of what occurred at the workshop. The conference PowerPoint presentations are available at <http://www.cvent.com/events/advancing-freight-fluidity-performance-measures-workshop/custom-35-720fe8533a6c4a5b82138f9ad82f28ca.aspx>.

The workshop attracted 51 participants, including representatives from businesses and corporations, federal agencies, state departments of transportation (DOTs), metropolitan planning organizations (MPOs), universities, consulting firms, and other groups. This document presents the proceedings from the workshop. The major topics addressed by speakers in the general sessions are summarized. The list of attendees is provided in Appendix B. The background papers are included in Appendix A.

The workshop planning team thanks Turnbull for her work in preparing the workshop proceedings and extends a special thanks to the FHWA Office of Freight Management and Operations for providing the support that made the workshop possible.

The views expressed in the proceedings are those of the individual workshop participants, as attributed to them, and do not necessarily represent the views of all workshop participants, the workshop planning committee, TRB, or the National Academies of Sciences, Engineering, and Medicine.

Introduction

WORKSHOP WELCOME

Joseph L. Schofer, *Northwestern University*

Joseph L. Schofer welcomed participants to the TRB Advancing Freight Fluidity Performance Measures Workshop sponsored by the FHWA Office of Freight Management and Operations. He recognized and thanked members of the Workshop Planning Committee, the background paper authors, and TRB staff for their help in organizing the workshop.

Schofer reviewed the workshop program. The first presentation by Nicole Katsikides provided an update on FHWA's activities related to freight fluidity performance measures. The second general session featured the background paper authors discussing the applications of freight fluidity, the scale of analysis, data options and analytical issues, and implementation options. The other general sessions focused on stakeholder views on measuring supply chain performance and examples of applying freight fluidity performance measures and supply chain analyses at the state, regional, and local levels. The workshop concluded with an open discussion of possible next steps to help advance the development and use of freight fluidity performance measures.

OVERVIEW OF FREIGHT FLUIDITY CONCEPT

Nicole Katsikides, *Federal Highway Administration*

Nicole Katsikides provided a welcome to workshop participants from the FHWA Office of Freight Management and Operations. She highlighted recent activities conducted by the FHWA and other groups to advance the development and use of freight fluidity performance measures, as well as potential next steps. Katsikides covered the following topics in her presentation:

- Katsikides thanked members of the TRB Task Force on Development of Freight Fluidity Performance Measures and TRB staff for their assistance in organizing the workshop. She recognized Louis-Paul Tardif of Transport Canada for continuing to share information on the development and use of freight fluidity performance measures in Canada. She also thanked Gaston Cedillo of the Mexican Institute of Transportation (Instituto Mexicano del Transporte) for attending the workshop and providing ongoing support.
- Katsikides discussed the importance of analyzing freight fluidity. She noted that the 2014 Developing System Freight Fluidity Performance Measures: A Supply Chain Perspective on Freight Performance Workshop helped develop support for examining freight fluidity and supply chains. She also recognized the U.S. Department of Commerce Advisory Committee on Supply Chain Competitiveness (ACSCC) for increasing awareness of the importance of freight transportation and supply chains. She noted that the ACSCC recommended that multimodal measures be used to better understand freight performance and to better align freight investments in the country.
- Katsikides highlighted the benefits of freight fluidity performance measures, which provides an understanding of multimodal, end-to-end flow of goods. Freight fluidity identifies where bottlenecks are occurring and the interrelationship with other modes and the total supply

chain. Freight fluidity performance measures also connect the discussions of transportation and economic development. It illustrates the global, national, and regional nature of freight infrastructure and encourages public and private partnerships. Freight fluidity also helps to engage the private sector in transportation planning, policy making, and project selection.

- Katsikides noted that the freight fluidity initiative also supported the focus in the Moving Ahead for Progress in the 21st Century Act (MAP-21) on freight and provides a solid base to address the freight requirements included in the Fixing America's Surface Transportation (FAST) Act. It also supports initiatives by other federal agencies, including the U.S. Departments of Commerce, Agriculture, and Energy, and the U.S. Army Corps of Engineers.

- Katsikides reviewed some of the recommendations and requirements included in MAP-21 and the activities completed by the FHWA and other groups, including the development of tools and approaches for measuring freight transportation, developing state freight plans, and establishing state freight advisory committees. MAP-21 also required the development of the National Freight Strategic Plan, the National Freight Advisory Committee, and the freight conditions and performance analyses. The FAST Act includes both a formula program and a discretionary program for freight. Further, it includes additional requirements for freight bottleneck analyses and freight performance measures, as well as state freight planning requirements for the use of some funds.

- Katsikides noted that there is a robust system for obtaining and analyzing data on passenger travel. While major improvements have been made recently in developing and using freight performance measures, she suggested that data and analysis gaps still exist. These gaps continue to limit the ability of public agencies to identify key freight bottlenecks and needed system improvements. She noted that more work is needed to fully understand freight supply chains and the need to link decisions on transportation improvements at all levels.

- Katsikides reviewed the development and use of the freight fluidity concept by Transport Canada, which Tardif described in previous workshops and conferences. The Canadian fluidity program analyzes combinations of freight trips and different modes to identify issues and bottlenecks, as well as opportunities for economic development. She noted that Transport Canada has used it successfully as an economic development and system performance tool.

- Katsikides reviewed existing public sector freight data, which included truck probe data and Highway Performance Monitoring System (HPMS) data. Other data include railroad waybill samples, air cargo landing weights at cargo airports, and marine tonnage, value, and vessels. The Freight Analysis Framework (FAF), the Commodity Flow Survey, and other truck count data are also used. She suggested that these sources provide a good base, but that additional public and private data are needed for a robust freight fluidity performance measurement system.

- Katsikides provided examples of using truck probe data from the American Transportation Research Institute (ATRI) for both routine monitoring of truck flows and analysis of specific bottlenecks. She noted that the top 25 domestic freight corridors are monitored. Individual analyses have focused on the impact of bridge and lane closures and other reductions in freeway capacity. She described an example of examining the movement of automotive parts from Windsor, Ontario, to Nuevo Laredo, Mexico, undertaken in partnership with Transport Canada. A total of 424 truck trips were analyzed, accounting for an average truck travel time of 70 h. A similar analysis using ATRI data resulted in comparable results. Transport Canada was able to conduct additional analyses on truck-rail combinations for the same trip. She noted that the I-95 Corridor Coalition's supply chain pilot project would be discussed in another workshop session.

- Katsikides reviewed the development of the four background papers for the workshop, which focus on some of the challenges with developing, implementing, and using freight fluidity performance measures. The background papers address the applications of freight fluidity, the scale of analysis, data options and analytical issues, and implementation alternatives. The authors presented the background papers in the next session.

- In closing, Katsikides summarized some of the potential next steps in implementing a U.S. and a potential North American fluidity measurement program. A key step is to work with public and private-sector partners to continue the development of state, regional, and corridor supply chain analyses for key commodities. Examining improved data and analytical options represents another step, as does investigating the use of big data from aggregated transactional data. She noted that this workshop will help advance these steps. She also noted that FHWA has designated the freight fluidity program as a strategic initiative. She stressed that ongoing cooperative public and private-sector partnerships will be needed to realize the benefits from the use of the freight fluidity performance measurement program.

Joseph L. Schofer, Northwestern University, presided at this session.

Next Steps to Implementing Freight Fluidity

How, What, Where, and When

APPLICATIONS OF FREIGHT FLUIDITY

Alan Pisarski, *Alan Pisarski Consulting*

Alan Pisarski summarized the first background paper addressing potential applications of freight fluidity. He described some of the key questions related to developing and using freight fluidity performance measures, and the varying perspectives, concerns, and approaches on freight fluidity. See Appendix A for Background Paper No. 1: Applications of Freight Fluidity. Pisarski covered the following topics in his presentation:

- Pisarski reviewed the following four questions that the first background paper was tasked with addressing:
 - Who would use a fluidity measurement system and how would they use it?
 - In what ways could a fluidity performance system support transportation, the economy, or other sectors?
 - Who would be the beneficiaries?
 - What are the potential policy impacts?
- Pisarski noted that for the purposes of the background paper, freight fluidity refers to the performance of transportation supply chains and freight networks. He further noted that freight fluidity can be a measure of the performance of a supply chain using a single mode or multiple modes of freight transportation, and that it can also be a measure of the performance of a freight network or a freight corridor serving many supply chains. He suggested that a shorthand term to reflect the meaning of freight fluidity in more current U.S. parlance might be supply chain performance measures (SCPM).
 - Applications of Freight Fluidity begins with a discussion of the goal for freight fluidity. Pisarski suggested that “the goal for transportation is to reduce the effects of distance as an inhibiting force in society’s ability to realize its economic and social aspirations.” In other words, he noted that transportation focuses on overcoming the tyranny of distance, with freight as a specific element. Freight fluidity provides a way to measure freight moving on the transportation system.
 - Pisarski described a number of questions and topics related to the overall goal of freight fluidity. A first topic focused on the value that the public sector adds to the discussion. A second related topic addressed if the very real and direct interests in adequate supply chains on the part of the private and public sectors were sufficient to serve national purposes. He also suggested there may be new and unrecognized opportunities for the private sector in providing needed data to the public sector.
 - Pisarski discussed the varying perspectives on freight fluidity, including the transportation view, the business logistics view, and the economic view. He suggested that the transportation view considers how well the system is working and what commodities the performance of the network affects. The business logistics view focuses on how system performance affects businesses in the region. The economic view considers how system performance and geographic and business consequences affect the national economy.

- Pisarski reviewed the key concerns identified in the background paper, which include national security, international competitiveness, general economic efficiency, and general health, welfare, safety, and environmental support. He suggested that ensuring that supply chains are protected for strategic commodities and products that are essential to national security was important. He noted it was also important to provide efficient supply chains to ensure international competitiveness. One concern focused on the general economic efficiency of serving businesses, goods, and people. Another concern encompassed factors not typically included in economic efficiency measures. These factors included health, welfare, safety, and the environment. He suggested that it is not enough to identify system bottlenecks. Identifying the commodities which are critical, perhaps strategic, to the nation, states, or local areas is needed.
- Pisarski discussed some of the approaches that could be taken to address these concerns and advance the development of freight fluidity or SCPM. Developing a typology of supply chain types represented a first approach. Focusing on key performance factors, including reliability, speed, and cost was a second approach. Using the system of national accounts as a driver to better understand supply chains was a third approach. Monitoring trends in transportation costs in the output of industries was a fourth approach.
- Pisarski described some of the factors that could be considered in developing a typology of supply chains. He suggested that the supply chain for automobile seats represented a limited-to-limited structure as an example. Toothpaste, which is widely distributed to drug stores, grocery stores, convenience stores, and hotels, represents a very different supply chain as another example. Related to performance factors, Pisarski suggested that continuous flow, just-in-time delivery, and safety and risk represented possible reliability measures, and that perishability and inventory costs were appropriate speed performance measures. He described the tolerance to transportation costs of different low-value and high-value goods and cost trends, as cost-related performance measures.
- Pisarski presented an example of county level commodity flows from 1976 based on data from the 1977 U.S. DOT report National Transportation: Trends and Choices. It included basic commodities flows from production counties to intermediate counties for processing, and to other counties for final consumption. He suggested the example provides a good visual presentation model, especially for policy makers.
- Pisarski discussed the National Accounts Use Table, which represents commodities produced and the industries that use those commodities and how the change in those commodities and their value affect those industries. The table identifies critical industries and the commodities serving those industries. In describing threats and opportunities, Pisarski suggested that there is a tendency to focus on legacy systems. A common approach is to consider threats, such as where ambient congestion impedes critical commodities generating reliability or cost effects. He argued that consideration should also be given to opportunities such as targeting opportunities for competitiveness gains. In terms of future system options, Pisarski suggested considering where and how general increases in system efficiency generate competitiveness gains for targeted commodities. He suggested the need to also consider passenger and freight interactions and to examine opportunities to improve the supply chain that will substantially enhance the economic opportunities of a region.
- In concluding, Pisarski described some of the substantial roles for the public sector. A first role is making the case for a greater focus on supply chains as a critical national, state, and local concern. That case could be brought to legislators and policy officials. The public sector can also demonstrate the importance of supply chains for national, state, and local strategic

interests. Pisarski suggested it was appropriate for public agencies to develop the data and analytical capabilities to support cooperative private and public decision making at all levels, and establish the criteria to assure that supply chains are specifically embedded in public investment analyses. He also noted the need to improve the ability to assess passenger and freight trade-offs at all levels. Embedding the analytical capability in the U.S. National Accounts, which are the ultimate arbitrator in what happens in a descriptive sense in the national economy, would be beneficial. He thought that the Bureau of Economic Analysis can develop a structure that would become a national standard and would be a very powerful capability.

- Pisarski noted that real measurement of supply chains cannot happen until it addresses flows at the commodity or product level. Information on where congestion impedes exports, critical commodities, strategic industries, and lost opportunities is needed. He suggested the need to recognize the opportunities provided by existing and new facilities and services in terms of national productivity benefits, the equity of those benefits in all areas of the nation, and to all segments of society. According to Pisarski, knowing the trends in the transportation share of product costs will be crucial for exports and overall general economic efficiency. He closed with the challenge of knowing when increased transportation expenditures are the result of inefficiencies in the system; or the result of conscious decisions about trade-offs, such as the rolling warehouse notion of just-in-time delivery.

FREIGHT FLUIDITY SCALE OF ANALYSIS

Bill Eisele and Juan Villa, *Texas A&M Transportation Institute*

Bill Eisele and Juan Villa discussed the second background paper focusing on the scale and geography for implementing freight fluidity performance measures. They presented definitions of freight fluidity, described the freight box analysis concept, and reviewed possible next steps in advancing freight fluidity performance measures. See [Appendix A for Background Paper 2: Freight Fluidity Scale of Analysis](#). Eisele and Villa covered the following topics in their presentations:

- Eisele reviewed the three questions which formed the basis of the second background paper. The questions addressed the scale or geography for applying freight fluidity performance measures, the options for analyzing corridors and gateways versus analyzing particular supply chains, and the factors that should be considered in determining the appropriate level of analysis.
- Eisele provided the following definition of freight fluidity developed by the background paper authors. “Freight fluidity focuses on transportation supply chain performance measurement that is the measurement of the travel time, travel-time reliability, and cost of moving freight shipments from end-to-end of a supply chain.” He noted that the intent is more than just monitoring freight origins and destinations; it encompasses each step and mode in the end-to-end trip. He also presented a slightly longer definition adapted from the Maryland State Highway Administration (SHA) freight fluidity activities, which includes temporal and spatial scale characteristics. He said that TTI is providing assistance to the SHA on the development of freight fluidity measures. “Freight fluidity is a broad term referring to the characteristics of multimodal supply chains and associated freight networks in a geographic area of interest, where any number of specific modal data elements and performance measures are used to describe the

performance (including costs and resiliency) and quantity of freight moved (including commodity value) to inform decision making.”

- Eisele reviewed the performance and quantity components of freight fluidity included in the background paper. Performance components focus on how well different elements of the system are working and the location of bottlenecks. Suggested performance measures address mobility, reliability, and cost. Resiliency, another performance component examines how well the transportation system and supply chains react to disruptions. He introduced four components of resiliency (or risk): robustness (the ability to withstand disruptions measured in time), rapidity (the time to respond and recover), redundancy (the availability of alternative routes and capacity), and resourcefulness (the ability and time to mobilize needed resources). The quantity component of freight fluidity focuses on how much freight is moved, measured by volume, weight, and value.

- Eisele described the freight box analysis concept presented in Figure 1, which was developed by TTI as part of early freight mobility research. The freight box concept covers the geographic area, the industry supply chain and commodity types, and different time periods. Within the larger box there are multiple cubes of performance and quantity for individual commodities. He noted that the freight box concept provides a good way to visualize the different freight fluidity components and to highlight actual conditions and target conditions for performance management activities.

- Eisele noted that the background paper presents the typical uses, associated geographic analysis scales, and frequency of analysis updates typically considered by different interest groups or jurisdictions. These geographic scales are broad—international, national, megaregions, states, and local. He suggested that the initial spatial geography (and associated transportation agency jurisdictions) to begin implementing freight fluidity performance measures were at the national, megaregion, and state levels. Furthermore, maintaining flexibility was important to respond to feedback from industries and agencies.

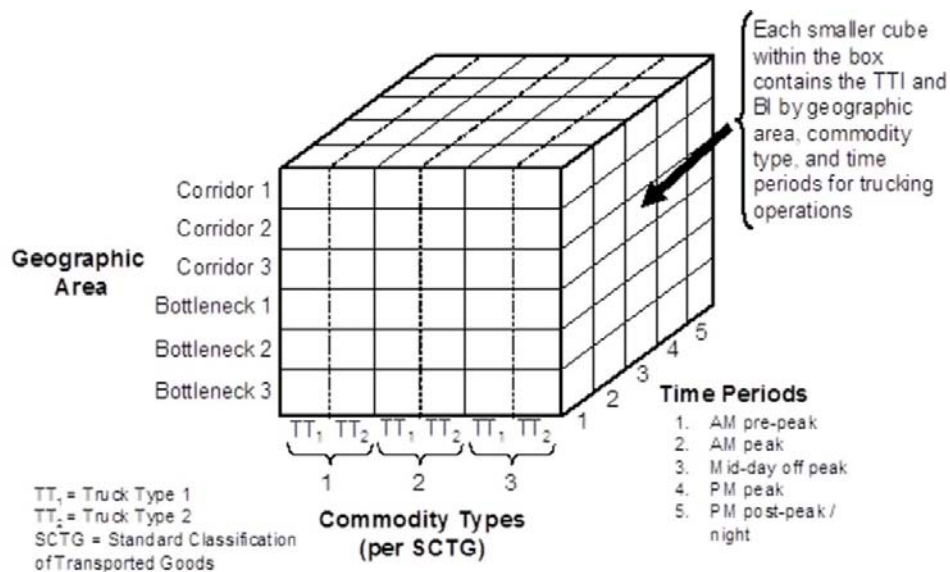


FIGURE 1 Freight box analysis concept. (Source: TTI.)

- Villa discussed considerations presented in the background paper for freight fluidity performance measure applications. He noted that the geographic scale is flexible, ranging from international to local communities. Discussions on geographic scale were inherently tied to the transportation application. Villa suggested that being able to analyze both supply chains and corridors was important. He thought that the freight box concept was useful to communicate and visualize spatial and temporal aspects of fluidity analysis. The background paper introduces possible supply chain measures, which are illustrated in the freight box and other tables. The need for improvements can be identified by comparing the existing situation to the desired targets.

- Villa suggested that focusing on supply chains as the critical analysis unit is needed to move from facility-based to trip-based analyses. The freight box concept is scalable, both spatially and temporally, and can aid in these analyses. He observed that the development of a freight fluidity tool should be flexible and expandable geographically and temporally. He also suggested that a systems approach is important to capture the performance of all supply chains and modes.

- Villa identified additional factors for consideration in determining the appropriate levels of analysis. He stressed again that both spatial and temporal scales are important. The frequency of updating the data should also be considered and that estimating freight fluidity over all geographic and temporal scales is generally feasible, limited largely only by data availability. He suggested that focusing initially on the areas of highest interest would be beneficial, with future expansions based on industry use and interest by public agencies and industry.

DATA OPTIONS AND ANALYTIC ISSUES

Joe Bryan, *Parsons Brinckerhoff*

Joe Bryan discussed the third background paper on data options and analytic issues associated with advancing the development and use of freight fluidity performance measures. He described the different sources of freight fluidity data, potential data analytical issues, and possible program approaches. Appendix A contains Background Paper 3: Data Options and Analytic Issues. Bryan covered the following topics in his presentation:

- Bryan focused on data for three supply chain performance factors—speed or travel time, reliability or variability of travel time, and cost as market price of services. Adding to the comments from Pisarski on perishable goods, he stressed that if goods are not available and on the shelf, businesses lose the sale. Thus, the opportunity to make a sale is also perishable. Bryan noted that speed, reliability, and cost were selected based on a combination of available data and the findings of the ACSCC. He reviewed the general operational and modal facets considered in the background paper. Operational facets included: line haul, staging, and pick-up and delivery. The modes included in the background paper are truck, rail, and water.

- Bryan described the sources of freight fluidity data and noted that the majority of data comes from private sources, which is logical given that freight is a commercial enterprise. Data from private sources represents a commercial opportunity, with a new market for the private sector. He commented that the recent public model was government purchase of data from private vendors for controlled use. He cited the FHWA National Performance Measurement Research Data Set (NPMRDS) as one example of this model. He suggested that this approach provides a resource that many agencies could not afford otherwise. He further noted that the use of public sources by mandate

are in the minority and are unlikely to expand. The FAST Act calls for greater collaboration between the public and private sectors in data resources.

- Bryan suggested that private data sources are not synonymous with private data vendors. He noted that shippers, carriers, companies, and other private-sector groups collect data for a variety of reasons, but are not necessarily in the business of selling that data. Such groups may be willing to share information with public agencies if proprietary and confidentiality concerns can be addressed. He noted that as the amount of data needed expands, the risks associated with confidentiality also increase. Approaches to address these concerns have included the use of intermediaries, as well as limitations on the release and use of data.

- The background paper summarizes data sources for travel time, reliability, and cost performance by mode. Information on the type of activity, such as roadway and border crossing travel times, and the vendors or data sources is presented. He noted that with one exception, travel time, reliability, and cost data are available for truck, rail, seaports, and waterways. The one exception is cost data for seaports. He suggested that the Major Ports Statistics Program included in the FAST Act may help address this data void.

- Bryan suggested that fluidity measures represent a potential new market for private suppliers. This new market could be leveraged to stimulate an expansion of data services, to close data gaps, and to reduce barriers to conducting business. He noted that the current competition among mobile source vendors demonstrates the viability of this approach. According to Bryan, this approach argues for a role by large public entities in market making. He noted that the U.S. DOT and some multistate coalitions are currently filling this role. The objective is to organize the market from the demand side to simplify the number and the diversity of transactions, create scale economies, and incorporate protections addressing confidentiality concerns. It can also clarify market opportunities to attract competition and assure continuing demand for services.

- Bryan discussed three major analytic issues: repeatability, comparability, and scalability. Related to repeatability, he noted that fluidity in data are most informative in time series because the direction and the degree of change is a basic performance indicator or a tracking tool. He suggested that comparability across locations and conditions may not initially be clear due to differences in infrastructure, operating facilities, and other factors. Repeatability is crucial and advantageous as it reduces difficulty in processing data, costs, and reporting time. He further suggested that repeatability indicates the stability of a process and provides an alternative check on data integrity when trade secrets are an issue.

- Comparability was the second analytic issue discussed by Bryan. He noted the necessity of totaling across stages and modes. Comparable metrics and reasonably comparable geography are needed. He further noted that comparability is vital for the selection of time frames to provide consistency in a time series analysis and to control for external influences, such as seasons, cycles, and other factors. According to Bryan, comparability is a key consideration in data budgets. Longer periods of time tend to mean more data and higher costs. Shorter time periods may require less data at a lower cost, but are also less informative. He noted that this situation also argued for larger purchasers, such as the U.S. DOT and multistate coalitions.

- The third analytic issue discussed by Bryan was scalability. He reviewed some of the important challenges in scalability. For example, roadway speed and reliability sum across network segments, while railway speed and reliability do not. Further, he noted that costs in the form of price of services are specific to lane and class in railroads and other modes. Bryan stated that local conditions still affect national results, further supporting the need for comparable and repeatable

indicators. He suggested that local productivity can be used as a proxy for costs, and productivity for trucks can be estimated from reliability buffers.

- Bryan discussed two major program implications. First, overarching managerial oversight of the end product is needed to meet the program objective of consistent, trackable, end-to-end measurement of supply chain performance. He noted that the purpose is to improve performance through the diagnosis of component deficiency by location, by mode, and by the characteristics of the deficiency. He suggested the need for a public parallel to private supply chain management, addressing component contributions to the total result. The second program implication is the need for a national, multijurisdictional program. He said further that there was a clear federal role, as well as a likely role for multistate coalitions. The roles of these large organizations, which included market making, supplier negotiation, and ensuring innovation, data integrity, comparability, repeatability, and scalability. He further suggested these responsibilities would be difficult for individual metropolitan planning organizations (MPOs) and states to undertake.

- In closing, Bryan outlined potential next steps. He suggested that one major activity was to negotiate with data suppliers. The negotiation process might include clarifying the budget and potential limitations on the use of the data, and exploring the cost, conditions, and capabilities for a national program.

IMPLEMENTATION OPTIONS

Lance R. Grenzeback, *Cambridge Systematics, Inc.*

Lance R. Grenzeback discussed the fourth background paper on implementation options for advancing freight fluidity measures. He described matching available data with potential markets for freight fluidity measures and possible priorities and implementation options for a freight fluidity performance measurement program. Appendix A contains Background Paper 4: Freight Fluidity Measurement Program: Implementation Options. Grenzeback covered the following topics in his presentation:

- Grenzeback suggested that freight fluidity or a freight performance monitoring system fills a missing link in existing data and analysis capabilities. He described the three levels of analysis and data sources illustrated in [Figure 2](#). He said that the top level, which focuses on the economy and markets using the FAF and the bottom level, which focuses on network flows and infrastructure using the HPMS, the FHWA's NPMRDS, and the Rail Carload Waybill Sample (CWS), were available. The top level focuses on how much freight is moving and where it is moving, while the bottom level focuses on how well the networks are operating. The missing link is the middle box, which focuses on individual trips, logistics, and operations, and freight fluidity fills in this missing link. He suggested that the objective should not be to duplicate what private sector logistics operators do, as that level of detail is not needed for public policy purposes. What is needed for public policy decisions is knowing when the general conditions and trends in supply chain performance are at a broader and larger scale, namely: information on problems facing supply chains in different parts of the country; information on whether those problems affect the economy; and information on whether those problems impede exports moving to ports would allow public agencies to possible solutions with shippers, carriers, and receivers. He noted that solutions may include infrastructure investments, operational changes, or regulatory and policy changes.

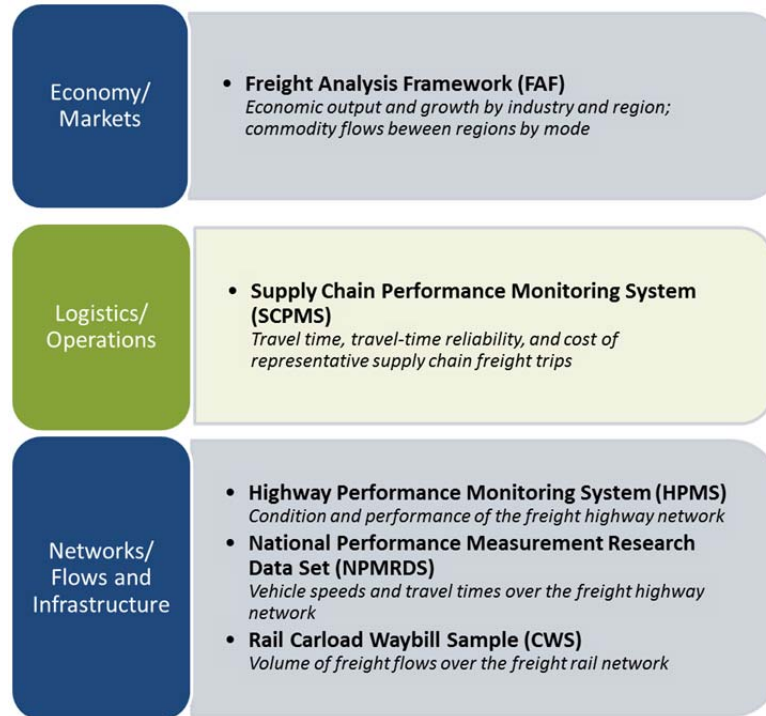


FIGURE 2 Freight performance monitoring system levels of analysis.
(Source: Cambridge Systematics, Inc.)

- Grenzeback described three potential markets for freight fluidity performance information, including agencies and firms focused on 1) international import and export transportation supply chain performance, 2) domestic and North American transportation supply chain performance, and 3) local and regional transportation supply chain performance. Figure 3 from his background paper summarizes the potential users and the scale of desired supply chain information. In the upper left of the figure are agencies and firms dealing with global and long-distance supply chains, while in the lower right are agencies and firms dealing with local and metropolitan supply chain and transportation issues. Coalitions, which address multistate transportation issues, and FHWA, which is charged with addressing state and national issues occupy the middle market. He noted that the markets are not exclusive; while most agencies and firms will focus in one area, they will be interested to various degrees in the full range of supply chain performance.

- Grenzeback described Figure 4 which highlights the availability and cost of supply chain performance measure data for different modes. He noted that data on travel time, travel-time reliability, and cost for domestic truck, rail, and barge was generally available, accessible, and affordable. He indicated that travel time, travel-time reliability, and cost data for ports were available, but not readily accessible because individual ports operated differently and have different tenant relationships. Safety and risk data on domestic supply chains was available, but generally not accessible.

	Global	NAFTA	US	Mega-Region	State	Metro
USDOC	B	A	A	A	C	C
USDA	B	A	A	A	C	C
Private Firm	A	A	A	A	A	A
FHWA	C	A	A	A	B	B
Coalition	C	B*	B	A	A	A
State DOT	C	C*	B	A	A	A
MPO	C	C*	C	B	A	A

A = primary interest, B = secondary interest, C = tertiary interest
 * May be A if on major border crossing/trade lane

FIGURE 3 Potential users and scale applications of supply chain performance measures.
 (Source: Cambridge Systematics, Inc.)

	Travel/ Dwell Time	Travel- Time Reliability	Cost	Safety	Risk
Truck	A \$	A \$	B \$\$	B \$\$\$	B \$\$\$
Rail	A \$\$	A \$\$	B \$\$	B ?	C \$\$\$
Barge	A \$\$	B \$\$	B ?	C ?	C \$\$\$
Port	B \$\$	B \$\$	B \$\$	C ?	C \$\$\$
Ship	B \$	B \$	B \$\$	C? \$	C? \$\$\$

A = readily available, B = somewhat available, C = less available

FIGURE 4 Availability and cost of data for supply chain performance measures.
 (Source: Cambridge Systematics, Inc.)

- Grenzeback reported that the background paper combines the information in the two figures to identify the potential markets, users, and priorities for implementing supply chain performance measures. He reviewed the suggested priorities included in the background paper, beginning with implementing national and North American supply chain performance measures. The megaregion and metropolitan supply chain performance represented the second priority, followed by global supply chain performance measures. If the FHWA and TRB choose to focus first on national and North American supply chain performance measures, he suggested using a “market basket” approach; that is, developing performance measures for a range of representative supply chains, rather than focusing on a single industry or region, would be beneficial. Since supply chain firms within an industry tend to operate in similar ways, examining a range of supply chains across a number of industries would help build templates or models that could be readily adapted to similar industries in other geographic regions. He further suggested that given the broad range of public sector policy and investment decisions related to freight transportation, an early look at multiple industries and supply chains would help ferret out the information of most use to planners and policy makers.

- Finally, Grenzeback reviewed the implementation options included in the background paper. The first option was a federally led program focusing on measuring supply chain performance and network fluidity at the national and megaregional scales, with subsequent expansion to support a North American system. The second option was a state and local led program, focusing initially on supply chain performance and network fluidity at the metropolitan, state, and corridor levels, with subsequent expansion to the megaregion and national scales. The third option envisioned the private sector taking the lead in developing a supply chain performance measurement program focusing on supply chain performance at the national and megaregion levels and serving public-sector clients at these or other scales as demand warrants. He noted that tables in the background paper sketches out the markets or mandates for each of the three options, possible organizational approaches for their implementation, and the level of resources (e.g., funding, staffing, and technology) needed to put each of the options into practice.

Joseph L. Schofer, Northwestern University, presided at this session.

Stakeholder Views on Measuring Transportation Supply Chain Performance

PRIVATE-SECTOR PERSPECTIVE ON SUPPLY CHAINS

Paul Newbourne, *Armada Supply Chain Solutions*

Paul Newbourne provided a private-sector perspective on supply chains and performance metrics. He described the primary objectives of supply chains, key elements of successful supply chains, and typical metrics for measuring supply chains. Newbourne covered the following topics in his presentation:

- Newbourne reported that Armada Supply Chain Solutions is an outsource-only logistics provider working primarily with major brands in the food and food service industry. He stressed that supply chains are important in the food service business to ensure that the right product is in the right place at the right time. He noted that a rule of thumb in the restaurant business is that it takes six months to attract a disappointed customer back, which is a major revenue loss.

- Newbourne noted that there are many different supply chains based on individual industries. While supply chains within each industry are similar, there are nuances in execution. As a result, he said that each industry and each company reacts differently to disruptions in a supply chain. He summarized the following key points related to supply chains, which are important for any raw material or finished product:

- Right **Product** in the
 - Right **Quantity** from the
 - Right **Source** on the
 - Right **Carrier** to the
 - Right **Destination** in the
 - Right **Condition** at the
 - Right **Time** with the
 - Right **Documentation** for the
 - Right **Total Landed Cost**

- According to Newbourne, traffic congestion and adequate peak transportation capacity are concerns for the private sector, as they influence the reliability, consistency, and cost effectiveness of supply chains. He suggested that accelerating infrastructure projects to address freight bottlenecks would be beneficial to shippers, carriers, and receivers.

- Newbourne discussed some of the key elements of supply chain success. Having a well-thought-out, written supply chain strategy was the first priority identified. The strategy and guidelines can be adjusted on an ongoing basis. He identified that efficient infrastructure, realistic and rational regulations, and affordable and available energy are also key elements of supply chains. Newbourne indicated that continuous network optimization is important for companies, which includes ensuring that the right source locations and the right distribution

locations are being used. He noted that companies are relentless in the use of performance measurements for supply chains.

- Newbourne described the typical supply chain metric categories, which include sourcing, inventory, manufacturing, transportation, and distribution. Most companies focus on three-to-five critical metrics in each of these categories that really have the biggest impact on driving the business. He observed that many companies use the “balanced scorecard” approach, which is a tactical approach to ensure that the strategic priorities of the business are being captured. The balanced scorecard typically focuses on finance-oriented measures, customer-oriented metrics, and internally oriented process improvement metrics.

- Newbourne stressed that measuring is only the first step in the process. He noted it was important to track key metrics on an ongoing basis to identify trends. Ensuring that there is a common understanding of the meaning and mechanics of the metrics and understanding how to leverage metrics for trends and opportunities is also important. He stressed that the key was to use metrics to drive results to better serve customers and that measuring and managing in parallel was important as they are not separate activities.

- Newbourne discussed the typical transportation performance metrics used by companies, which include freight cost per unit shipped, outbound–inbound freight costs, claims as a percentage of freight costs, and freight bill accuracy. Other metrics were accessorial and fuel costs, truckload capacity utilization, mode optimization and share, and the number of carriers per mode. Additional metrics were truck turn time, transit time, tender acceptance, on-time pickup and delivery, and shipment visibility. He noted that these metrics typically include a broad range of both financial and service elements, as well as process and results metrics.

- Newbourne noted that traffic congestion was a major concern for shippers and receivers. Congestion impacts the ability to provide reliable and consistent service, and has a direct impact on the cost of providing service. He suggested that obtaining input from shippers and receivers as part of the transportation planning process would be beneficial to targeting investments to infrastructure improvements addressing key bottlenecks. Other concerns voiced by shippers and receivers focused on roadway and bridge infrastructure conditions and capacity, truck productivity, and user fees, taxes, and tolls.

- In closing, Newbourne stressed the importance of investments in the highway infrastructure to ensure the ongoing viability and competitiveness of U.S. supply chains. He also suggested that every supply chain serves a purpose and that all supply chains are important to facilitate business growth and the economy.

FREIGHT FLUIDITY PERFORMANCE MEASURES: ADVISORY COMMITTEE ON SUPPLY CHAIN COMPETITIVENESS ENGAGEMENT **David Long**, *International Trade Administration, U.S. Department of Commerce*

David Long described the U.S. Department of Commerce International Trade Administration ACSCC. He discussed the ACSCC’s charter and objectives, membership composition, and activities. Long covered the following points in his presentation:

- Long described a simplified map of some of the physical flows in the global supply chain for the iPhone 5, which involved thousands of components and subassemblies. He noted that it represented many modern business models today, with global sourcing, competition

among supply chains, and information technology as a driving force. From a trade and investment perspective, he commented that supply chains involve moving products, ideas, and services, within the normal frameworks of flows of product, information, and financial flows. He noted that global sourcing and global supply chains greatly increase the number of border crossings, which make supply chains more complex to manage and operate. This places a premium on border operations to support international trade and investment.

- Long stressed the importance of engaging businesses in supply chain discussions. He thought that public agency consideration of freight policy over the past few years has been transformed to more closely resemble how businesses operate supply chains. Policy and investment priorities are being shaped to better address supply chains, rather than focusing only on individual modes. He noted that the involvement of shippers and receivers provides an operating level perspective. He suggested that the new agenda focuses on commercial modeling for networks and freight planning, border management, and systems of systems. He further suggested that matching freight and trade policies to the realities of the markets and to advancing technologies was important.

- Long discussed the ACSCC charter and objectives. The ACSCC was established to consider a broad set of competitiveness and trade-related questions affecting U.S. supply chains. These questions focus on how U.S. freight and infrastructure policies affect the competitiveness of exporters and importers and what the federal government should do and not do to improve these policies and increase U.S. competitiveness. He noted that more generally, the ACSCC charter focuses on supporting export growth and national competitiveness and innovation, facilitating the movement of goods, and advising on regulatory policy and investment priorities.

- Long discussed the ACSCC membership, which includes up to 45 representatives from the U.S. supply chain industry and experts from academia. He noted that members represent diverse interests and a wide range of industry perspectives, and are leaders in supply chain and logistics management. The group seeks to engage a user perspective in the debates over supply chain policies.

- Long reviewed the ACSCC's six broad themes and subcommittees focusing on U.S. competitiveness. Trade and export competitiveness, quality of information technology and data, and the effects of regulation represent the first three themes. Infrastructure investment and finance, freight efficiency and policy, and workforce development are the other three major themes. The ACSCC charter was renewed recently for another 2-year term.

- Long reviewed some of the activities and accomplishments of the ACSCC, noting that it continues to enjoy strong support within the U.S. Department of Commerce. He described the ACSCC's contribution to MAP-21 and the National Freight Strategy, noting that the ACSCC supported the freight fluidity modeling concept and recommended applying commercial supply chain techniques to policies for performance measures. Other activities included reviewing efforts underway on the International Trade Data System Single Window Program. ACSCC's work was recognized in the formation of the Border Interagency Executive Council, which is the interagency management committee inside the Single Window Program. He reported that the ACSCC provided recommendations on how to manage the program, which were adopted. The ACSCC also generated the North American Portal Study, which outlined the key elements to consider in designing an eventual North American Single Window portal. Further, the ACSCC examined finance and trade policy topics and provided recommendations on approaches. Long identified new projects and those nearing completion, including recommendations on port congestion issues identified in the recent slowdowns at the west coast ports, examining

permitting timelines in the regulatory approval process, and exploring supply chain issues in relation to Trans-Pacific Partnership countries.

- Long stressed the importance of the partnership with U.S. DOT. He noted that the 2009 Conference on Supply Chain Infrastructure hosted by the two agencies was followed in 2010 with a Commerce–U.S. DOT Memorandum of Understanding for broad cooperation in freight and global competitiveness. He noted that regional outreach sessions in 2010 and 2011 were held jointly with U.S. DOT officials. Further, U.S. DOT has been an active ex-officio member and partner in the ACSCC since it was established in 2012.

INDUSTRY PERSPECTIVE

Bruce Carlton, *National Industrial Transportation League*

Bruce Carlton discussed the National Industrial Transportation League (NITL), which is a trade association representing shippers. He described some of the topics of current interest to NITL members. Carlton covered the following topics in his presentation:

- Carlton noted that the NITL, which has been existence for 108 years, advocates for shippers, including providing comments on proposed legislation, regulations, and policies. He suggested that it was important to remember that supply chain and logistics operations are cost centers, not revenue centers for shippers. As a result, there is constant pressure to reduce costs. The metrics focus on monitoring reliability, productivity, and efficiency to drive costs down.

- Carlton suggested that the issues encountered with the West Coast ports in 2014 and 2015 provide an excellent example of what happens when the system all goes wrong. He noted that supply chains were destroyed for thousands of players, including shippers, receivers, dray operators, the trucking industry, railroads, intermodal centers, and distribution facilities. An objective assessment of the situation would benefit future planning and project development. He discussed the port performance metric requirement contained in the FAST Act, which directs the Bureau of Transportation Statistics (BTS) to examine the situation and recommend approaches to avoid similar occurrences in the future.

- Carlton suggested that using “freight performance metrics” rather than “freight fluidity” resonates better with shippers, carriers, and other private-sector groups. Shippers, receivers, and other groups in the supply chain focus on networks and origins and destinations. While the definitions of origins and destinations are different for different groups in the supply chain, everyone is focused on their beginning and end point and how can transportation in this segment be improved. He commented that ensuring that proprietary data would remain confidential was key to private-sector participation in data sharing. Carlton stressed the importance of reaching out to industry to solicit their participation on the development of supply chain performance measures. He discussed the port performance metric requirement contained in the FAST Act, which directs BTS to examine the situation and recommend approaches to avoid similar situations in the future.

- Carlton suggested that using freight performance metrics resonates better with railroads, shippers, carriers, and other private-sector groups. He also noted that shippers, receivers, and other groups in the supply chain focus on networks and origins and destinations. While the definition of origins and destinations are different for different groups in the supply chain, everyone is focused on their beginning and ending point and how transportation in this

segment can be improved. Ensuring that priority data would remain confidential was key to private sector participation in the data sharing.

- Carlton stressed the importance of reaching out to industry to solicit their participation. He also noted the pending rulemaking at the Surface Transportation Board (STB) on rail performance metrics with greater levels of detail, which provides additional useful data elements for all groups.

MEASURING SUPPLY CHAINS FOR FREIGHT FLUIDITY FROM A CORRIDOR PERSPECTIVE

Marygrace Parker, I-95 Corridor Coalition

Marygrace Parker described efforts by a multistate coalition representing a diverse group of public agency stakeholders to assess freight fluidity for transportation system improvements and infrastructure investment considerations. Her presentation focused on current and previous coalition activities linking to freight fluidity. Most recent among these efforts is a pilot project examining supply chains and freight fluidity performance measures for different commodities. This project was conducted by the I-95 Corridor Coalition in association with the FHWA freight fluidity efforts. She discussed the I-95 Coalition pilot project, including the data sources, the analysis techniques, and the results. Parker covered the following topics in her presentation:

- Parker noted that the pilot project objective was to demonstrate measurement of freight transportation using a supply chain perspective, including an end-to-end performance measurement concept across modes and stages. The pilot project was funded by the FHWA Office of Freight Management and Operations, with support from the U.S. Department of Commerce ACSCC and the I-95 Corridor Coalition. She recognized the support of the principal investigators and their teams (Lance Grenzeback from Cambridge Systematics, Inc., and Joe Bryan from Parsons Brinckerhoff). The I-95 Corridor Coalition project examined five representative supply chains within the I-95 system and nationally to better understand how the transportation system impacts performance of the supply chains and how the supply chain analysis can be used for investment decisions.

- Parker provided an overview of the I-95 Corridor Coalition region, which includes 16 states, including the District of Columbia. She said that the combined corridor has a \$4.7 trillion economy—or 40% of the U.S. gross domestic product (GDP)—21% of the nation’s road miles, and 35% of the nation’s vehicle miles traveled. She also noted that 5.3 billion tons of freight shipments occur annually in the multimodal corridor. Two Canadian provinces—Quebec and New Brunswick—also contribute to the economic vitality of the corridor. These factors influence the need for the Coalition and its member agencies to have a better understanding of supply chains performance measures and metrics and how these might apply or differ between different types of commodities and businesses.

- Parker noted that while supply chains are complex, they are also manageable. Shippers and carriers deal with complex supply chains daily and know the locations of “pain points” or bottlenecks. She suggested that addressing these pain points can make a supply chain more competitive.

- The pilot project included five supply chain case studies focusing on retail, automotive, food processing, agricultural, and electronic products. The automotive case study

focused on the movement of General Motors automobile parts by truck from suppliers in Canada and by rail from suppliers in Mexico to the General Motors automobile assembly plant in Spring Hill, Tennessee. The retail case study examined transporting Target consumer goods from the Port of Seattle and the Ports of Los Angeles and Long Beach to New York by rail via Chicago. The food case study examined transporting Perdue processed chicken by truck from facilities on the DelMarVa Peninsula through a consolidation center in Delaware to a wholesale distribution center in New York City. The electronics case study examined the movement of Panasonic electronics by truck between manufacturing and assembly facilities in San Diego, California, and Tijuana, Mexico. The agricultural case study examined transporting soybeans from Illinois farms to a Louisiana port for export by barge.

- Parker reviewed the five performance measures and metrics used in the study. The first measure was transit time, with the related metric of travel time in days or hours. The second measure was reliability, with a metric of 95% travel time in days or hours. Cost was the third measure, with the dollar amount as the metric. The fourth measure was safety, with fatality and injury rates as the metric. Risk was the fifth measure. One risk metric was disruption due to storms, labor issues, infrastructure failure, and political forces. A second risk metric was capacity expansion delays due to physical, regulatory, or other limitations.

- Parker reviewed the retail case study. She discussed [Figure 5](#), which illustrates examples of freight flows for Target. Goods are imported through the Port of Seattle and the Ports of Los Angeles and Long Beach. She noted that representatives from Target indicated that using multiple ports was part of their risk management portfolio. As shown in the insert, goods are unloaded at the Port of Seattle and taken to an import distribution center and then to an intermodal yard by truck. From there, the goods travel to Chicago by rail. At Chicago there is a change to an eastern railroad, which travels to an intermodal terminal in the Harrisburg, Pennsylvania, area. From there the goods are trucked to a regional distribution center where they are staged for delivery to stores in the east by truck.

- Parker commented there are numerous stages in the supply chains from the West Coast ports to the eastern stores. In addition, she said that risks, exposures, and delays are possible at every stage, especially at the connections in urban areas, such as Chicago. She described the data sources and the analysis of the transit time, reliability, and cost measures for the Seattle to New York supply chain. Data from ATRI, the NPMRS, TransCore, and Chainalytics were used in the analysis. Other data sources included Google Maps, the TTI Urban Mobility Scorecard, the STB Rail CWS, and additional private data vendors.

- Parker reported that the cost for the trip from end-to-end was approximately \$5,000. The total transit time was 204 h or close to 6½ days. Rail intermodal accounted for approximately 65% of the trip. Three different truck drayage moves accounted for 19% of the total. She noted that the data highlighted the long rail dwell time in Chicago, but not the reason for the delay.

- Parker reported that the project documented that it was possible for public agencies to identify and understand supply chains and to measure supply chain performance. She said that the analysis revealed the symptoms of concern with the supply chain, not the diagnosis and treatment. She suggested that solutions need to be cooperatively addressed, with the public and private sectors working together. Examples of multifaceted solutions may focus on adding infrastructure, improving operations, and developing new policies.

- In addition to measuring and tracking the high-level performance of representative supply chains with market-driven metrics, Parker noted that key measures and metrics are

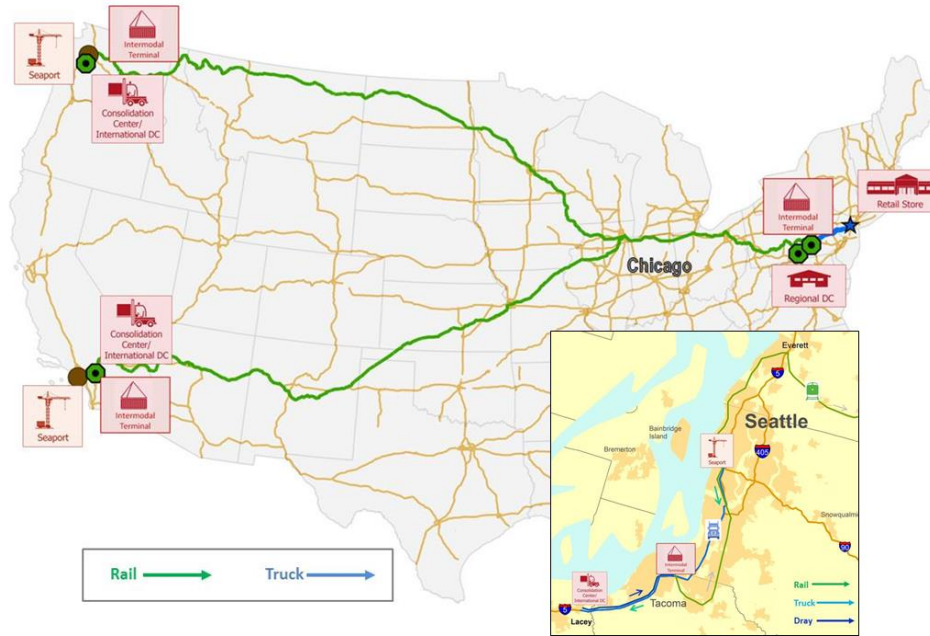


FIGURE 5 Examples of Target retail supply chains. (Prepared by Cambridge Systematics, Inc., and Parsons Brinckerhoff for the I-95 Coalition.)

common across supply chains and can be scaled for national, multistate, and metropolitan use. While travel time and travel time reliability data are available from public and private sources, she cautioned that additional work is often needed for specific applications. Cost data can be purchased from private suppliers. Safety data are available and risk data can be estimated, but it is not readily accessible. She noted that supply chain performance measurement has numerous benefits to state DOTs and MPOs, including addressing freight bottlenecks, targeting investments, and identifying critical supply chain routes and alternative paths for disaster and emergency recovery.

- Parker described earlier studies conducted by the I-95 Corridor Coalition examining supply chains and freight bottlenecks which were precursors to current efforts to understand performance. Building on the FHWA bottleneck performance activities in the early 2000s, the Coalition examined freight corridors and bottlenecks along I-95. The analysis identified bottleneck strings on I-95 in the New York–New Jersey area, around Wilmington, Delaware, and in the Baltimore, Maryland–Washington, D.C., area. The analysis also identified as a key performance metric the need to consider operational, physical, regulatory, and capacity issues from multistate perspectives in determining mitigation strategies to improve performance.

- Parker discussed an early project undertaken by the Coalition with respect to examining system performance and the I-95 Corridor Mid-Atlantic Rail Study, which was also conducted in the early 2000s, and examined truck and rail options for transporting projected increases in freight. Study participants included New Jersey, Pennsylvania, Delaware, Maryland, and Virginia, as well as rail partners CSX, Norfolk Southern, and AMTRAK. The project was supported by pooled funding from Coalition set-aside funds, the participating states, and the railroads. Parker noted that the study examined the types of commodities that might be diverted from truck to an improved rail system, and existing bottlenecks on the rail system. While no specific funding was available for the projects at the time, many of the identified rail bottleneck

improvements have been included in state and railroad plans and a significant number have been completed. She also described subsequent activities using vehicle probe data to examine real-time highway performance.

- Parker suggested it was important for public agencies to understand supply chains for a number of reasons, as supply chains reflect freight use of the transportation system. Stressing that supply chain performance is key to economic competitiveness, she noted that while performance is end-to-end and the sum of stages, improvements are typically made in individual stages that put local dynamics into a larger perspective. Moreover, understanding the user view and the market view were both important, as was understanding the role of public agencies. Further, the freight corridor approach takes advantage of working corridor coalition models that support multiple players and conditions, including megaregions and multijurisdictional economies. Corridor coalitions can also foster cooperative performance improvements and leverage data acquisition. She also noted that the freight corridor approach fits with the Nationally Significant Freight–Highway Program contained in the FAST Act.

- In concluding, Parker suggested some activities to help advance the applications of freight fluidity performance measures. The first was examining representative supply chains serving key industries across freight corridors. A second was working with transportation agencies to determine the appropriate performance measures and the data granularity needed, which may differ for industries, supply chains, and geographies. A third activity was continuing to improve the state of knowledge and practice related to supply chains, data, and performance metrics. A fourth activity was developing model data acquisition contracts for use on a corridor basis. Finally, that there may be opportunities for additional projects based on corridors and supply chains applicable to the FAST Act Nationally Significant Projects Program. Parker stressed the importance of understanding supply chains on a corridor basis because supply chains function across multiple jurisdictions and investment decisions need to consider the compendium of improvement projects to adequately address bottlenecks.

Stuart Anderson, Iowa Department of Transportation, presided at this session.

Federal Highway Administration Perspective

CAITLIN RAYMAN

Federal Highway Administration

Caitlin Rayman provided an additional welcome to participants at the Advancing Freight Fluidity Performance Workshop. She reviewed current and planned activities under way at the FHWA Office of Freight Management and Operations. Rayman covered the following topics in her presentation:

- Rayman recognized and thanked Louis-Paul Tardif of Transport Canada for sharing his expertise in developing the workshop and Gaston Cedillo of the Mexican Institute of Transportation (Instituto Mexicano del Transporte) for participating in the workshop and supporting the development of freight fluidity performance measures. She also thanked the private-sector representatives participating in the workshop for sharing their perspectives on freight fluidity performance measures and addressing supply chain bottlenecks. She recognized the Workshop Planning Committee and TRB staff for their assistance in organizing the workshop. She also thanked Nicole Katsikides for providing leadership within the FHWA to advance freight fluidity performance measures.
- Rayman noted that the public sector makes decisions for freight and passenger travel on the transportation network. Until recently, the historic focus has been on passenger travel, with less emphasis on freight. While there is a better understanding of freight and goods movement today, there was still a lack of data on supply chains and freight bottlenecks. She noted that without this understanding, it is difficult for transportation agencies to identify where operational, regulatory, or capital improvements are needed to help address freight bottlenecks.
- Rayman reported that in the past decade the FHWA and its partners have made progress in understanding freight bottlenecks through a strong partnership with the trucking community. Truck probe data has been used to identify bottlenecks and the impacts of these “pain points” on the freight system. She noted that these efforts have helped create policies and programs at the national level that support freight improvements and that bring attention to freight impacts and needs. These activities have led to a better understanding of the relationship between transportation and the economy and how impediments in the freight system impact the costs of goods, the cost of doing business, and jobs. She suggested that this growing awareness has helped to build support for considering freight and supply chain bottlenecks in the transportation project-selection process.
- According to Rayman, MAP-21 helped place a public-sector focus nationwide on freight policy, planning, and performance measurement. Further, MAP-21 was a catalyst in helping states and MPOs work with the private sector to understand freight flows and needed investments in the transportation network. She noted that the FAST Act places even more importance on freight improvements through the enactment of a discretionary and a formula program for freight projects, as well as a call for improved freight data and analysis, especially multimodal capabilities, to truly understand freight needs among all modes.
- Rayman noted that states, MPOs, regional partnerships, corridor coalitions, and other groups have been advancing an understanding and appreciation of freight flows through planning efforts and project development. She reported that only 30 states have freight advisory

committees, however, indicating that more work is needed to ensure that freight concerns are being identified and addressed. In addition, she noted that five states and Puerto Rico do not have state freight plans. Rayman reported that the FHWA released the draft National Freight Strategic Plan in October 2015. The draft plan will form the basis of the National Freight Strategic Plan required in the FAST Act.

- Rayman noted that significant bodies of research and applied efforts have been developed for measuring freight performance by mode, as well as building on efforts already underway to measure nonfreight transportation. She suggested that the more traditional methods have been used to provide a better understanding of freight congestion, delays, and bottlenecks. In addition, economic data, waybill information, and other data sources have been applied to explore freight tonnage, value, and other variables. She noted that all of the measures currently in practice do a good job of presenting freight movement, volume, and value by mode to some degree, but that there is still a need to sew these measures together to provide a more comprehensive, multimodal, end-to-end picture of freight.

- Rayman discussed FHWA's Strategic Initiative to build a Freight Fluidity Performance Analysis system and other activities. These activities compliment the other FHWA and U.S. DOT initiatives to better understand and improve freight transportation. FHWA is actively working to develop new approaches to freight measurement, including the development of new data and new methods for multimodal analysis such as fluidity. To develop new approaches, FHWA is tapping into the strength and expertise of offices throughout the U.S. DOT and public and private stakeholders. She noted that the FHWA is working with the TRB and other groups to close out the second Strategic Highway Research Program (SHRP 2) and National Cooperative Freight Research Program (NCFRP) projects, as well as exploring new opportunities for research. One example of this research effort noted by Rayman was SHRP 2 Project C-20: Freight Demand Modeling and Data Improvement Implementation Assistance Program and National Initiative project, which is underway. She also noted that the FHWA is developing the next generation of the FAF, a tool that integrates data from a variety of sources to create a comprehensive picture of freight movement among states and major metropolitan areas by all modes of transportation.

Supply Chain Performance and Transportation Policy

MICHIGAN PERSPECTIVE ON ADVANCING FREIGHT FLUIDITY PERFORMANCE MEASURES

Laura Mester, *Michigan Department of Transportation*

Laura Mester discussed freight-related activities underway at the Michigan DOT. She described cooperative projects with other state agencies, major infrastructure projects, and Michigan DOT priorities and leveraging tools. Mester covered the following topics in her presentation:

- Mester described the coordinated efforts of the Michigan Economic Development Corporation (MEDC), the Michigan Agriculture and Rural Development Agency, and Michigan DOT to identify the appropriate role of state government related to logistics and supply chains. She noted that the agencies have been working together over the past few years to develop priorities and to leverage resources to assist industries in the state, especially the automotive and agricultural sectors. The three agencies developed the Michigan Logistics and Supply Chain Strategic Plan, which was adopted in 2012. The plan's mission is to lower costs, reduce time, and remove risk for firms by developing an efficient logistics and supply chain ecosystem that leverages Michigan DOT's assets and provides opportunities for collaboration and partnership. The plan's objectives include creating more and better jobs, and collaborating with industry and regional partners to identify and prioritize initiatives to improve regional competitiveness. Other objectives are developing strategic marketing programs that promote the state's capabilities, prioritizing infrastructure and policy initiatives, and developing workforce skills and talent.

- Mester noted that Michigan DOT's role is to provide a world class transportation infrastructure. She described some of the challenges facing the state and the key large-scale transportation infrastructure projects. She noted the importance of trade with Canada for the state, and with Michigan serving as a gateway for goods flowing to and from other states and Mexico. She reviewed three current large-scale infrastructure projects, which when completed, will have a significant impact on the region's attractiveness as a trade hub for global supply chains. The three projects were the new Gordie Howe International Bridge between Detroit and Windsor, Canada, the Detroit Intermodal Freight Terminal, and the Continental Rail Gateway from Windsor to the United States. These projects, which are in various stages, require both public and private investments. She described the complexity of the Detroit Intermodal Freight Terminal, which involves three Class I railroads, the City of Detroit, the state, and Michigan DOT. She noted that aligning the different priorities and objectives of these groups is challenging.

- Mester discussed infrastructure projects at the local level. She noted that roads and bridges across Michigan are in need of repair, negatively impacting businesses through increased costs and delays in moving goods and commodities. To help address these issues, MEDC and Michigan DOT have partnered to combine resources to promote projects that result in needed infrastructure improvements. For example, the MEDC administers the Community Development Block Grant program and Michigan DOT administers the Transportation Economic Development Fund. According to Mester, Michigan DOT investment decisions are based primarily on asset condition. She suggested that a shift to examining the needs of key supply chains and commodity flows may be needed in the future, along with more active engagement

with industry. While a large percentage of the population lives in southern Michigan, supporting job growth throughout the state, including the Upper Peninsula, is important. She stressed the importance of addressing infrastructure needs to leverage the supply chain capabilities in all parts of the state.

- Mester discussed some of the Michigan DOT priorities and leveraging tools, including stakeholder engagement, pilot projects, and intermodal facilities. She described the mapping project, which highlights Michigan DOT assets and available carriers for businesses, and the Pure Michigan Marketing Campaign. She highlighted the activities of the Commission for Logistics and Supply Chain Collaboration, the Logistics and Supply Chain Steering Team, and industry and regional focus groups. She stressed the importance of not only developing the Logistics and Supply Chain Strategic Plan, but implementing the plan elements. She reviewed some of the challenges with implementation, including scarce resources, changes in agency personnel, and project timing.

LEVERAGING DATA TO OPTIMIZE COMMERCIAL SUPPLY CHAIN NETWORKS

Paul Trombino, *Iowa Department of Transportation*

Paul Trombino discussed the Iowa Statewide Freight Network Optimization project. He described the major industries in the state and the development and use of supply chains for the major industry groups. He recognized Debi Durham, the Director of the Iowa Economic Development Authority (IEDA), as a partner in the Statewide Freight Network Optimization project. Trombino covered the following topics in his presentation:

- Trombino described the key characteristics of Iowa. The state has a population of approximately 3.1 million people, with 1.7 million people in the workforce. He noted that the state's central location in the country provides a number of advantages, with almost 9.5 million businesses, 90 million people, and \$3.6 trillion in personal income within 1 day's driving distance. Iowa is well served by east–west and north–south interstate routes and state roadways, two river ways, and Class I railroads.

- Trombino reported that Iowa's GDP in 2014 was \$170.6 billion and that Iowa was one of only a few states currently holding an AAA bond rating. Iowa is also listed among the top five “best run” states. He noted Iowa is a production state and has experienced continued growth in exports. In 2014 Iowa exported \$15.1 billion in manufactured and value-added goods. Machinery, including tractors and farm equipment, represents the largest export category, followed by meat, cereals, and animal feed.

- Trombino discussed Iowa's key industries, which include financial services, biosciences, and advanced manufacturing. The biosciences category includes agriculture. He noted that biofuels is an important commodity in this category, with Iowa accounting for over 27% of total U.S. ethanol production. Iowa has the capacity to produce more than 315 million gallons of biodiesel annually and that the state's biofuels production impacts over 47,000 jobs. He also noted that in 2014, Iowa exported \$233.4 million in pharmaceutical products to 68 countries. With close to 1,250 biosciences entities in Iowa, Trombino suggested that pharmaceutical and bioscience were future growth industries for the state. Manufacturing represents approximately 18% of Iowa's GDP and employs 17% of the state's workforce. Food manufacturing and processing is also important in the state, with Iowa ranked first in corn, pork,

and egg production and second in soybean and red meat production. Iowa produces more than \$37 billion in food products each year and is home to 34 of the largest 100 food manufacturers and processors in the country.

- Trombino noted that the IEDA focuses on a strategic approach to economic development. Growing existing businesses and attracting new businesses that consume or provide for existing industry groups is a major part of this strategic focus. Growth through innovation is another key to the economic development strategy.
- Trombino described the Statewide Freight Network Optimization project, which encompasses a supply chain design for the state. The project vision is to effectively identify and prioritize investment opportunities for an optimized freight transportation network to lower transportation costs and promote business growth in Iowa. He noted that the project has changed the focus of the Iowa DOT. Rather than focusing primarily on infrastructure, the department is now examining the destinations of people and products inside and outside the state. He further noted that the Iowa DOT is working to optimize the statewide freight transportation network to reduce transportation costs for Iowa businesses. Further, the project brings a demand-based supply chain network design and optimization approach to Iowa DOT planning. He suggested that the project addresses transportation's contribution to supporting the economy of the state, which is a key role for the Iowa DOT.
- Trombino described the various elements of supply chain networks and optimization, including the physical components and sourcing policies. The transportation system forms the basis for supply chains and that transportation can cause constraints and inefficiencies in supply chains. He suggested that an appropriate role for transportation agencies is identifying and removing or reducing these constraints and inefficiencies.
- Trombino reported that the State Freight Network Optimization project developed supply chains for the 48 freight commodities transported in the state. He noted that a variety of data from the public and private sectors were used in the analysis. Supply chain demand data, network capacity data, demand forecasts, and network cost benchmarks are all input components. Examples of data sources include the FAF, a commercial data set, and other purchased data sets. He noted that Quetica assisted with the development of the supply chains and provided some of the private sector data sets.
- Trombino described the database for the 48 freight commodities. Origin–destination data are available by county to other counties in the state and U.S., and almost 50 other countries. The data includes the mode—truck, rail, water, and air—and transportation costs benchmark data. The costs are available for full truckload, less-than-truckload, intermodal, rail, barge, and ocean container. He noted that the data was also available by season, which is especially important in the agricultural sector.
- According to Trombino, all the state agencies use the same economic analysis data. He described the different quantitative and qualitative capabilities of the statewide freight network database and presented examples of analyses that have been conducted to date. Quantitative analyses focus on cost, capacity, economic viability, and return on investment. Qualitative analyses focus on strategic alignment, network resiliency, tax incentives and funding availability, service levels and transportation time, and project implementation risks.
- The first example Trombino described examined cross-dock facilities to consolidate freight shipments and reduce transportation costs in the state. The state was divided into four regions and the cost savings from cross-docking was calculated for each region. Annual cost savings to businesses of between \$700 million and \$900 million were realized across the four

regions. The region selected as the candidate site for a logistics park with cross-docking and intermodal facilities did not have the highest cost savings, but has access to Interstate highways. He noted that the facility would leverage freight consolidation to lower transportation costs, reduce long-distance truck traffic, and improve sustainability.

- Trombino described the intermodal facility case study, which would leverage railroad transportation and reduce transportation costs and truck miles. There is one intermodal facility in the state located in Council Bluffs, but that there is a shortage of containers for exporting commodities. He reported that the analysis, which included the cost of repositioning containers into the state, resulted in an annual net cost savings of \$23 million for the conservative alternative.

- Trombino reported that the Iowa DOT is working with businesses to examine their supply chains and to identify options to reduce supply chain costs. He suggested that the Iowa DOT data is more robust than data that individual businesses have because it includes data on other businesses so provides value to businesses in the state. Businesses sign nondisclosure agreements with Quetica and the Iowa DOT pays for the supply chain analysis. The businesses provide their data electronically, and Quetica runs the analysis. The data becomes part of the large data set and the baseline optimization identifies opportunities in the current network to reduce transportation costs and identifies recommendations to improve the supply chain. Other analyses can also be conducted, such as identifying locations of new facilities in the supply chains, assessing cost savings, and building business cases for investment.

- In conclusion, Trombino noted that the traditional response to business location decisions focused on capacity planning and did not consider possible cost-saving opportunities in a multimodal network. He suggested that knowing commodity flows is more valuable than knowing vehicle volumes in many instances as not all vehicles are equal in value. Implementing results to reduce the overall cost of freight transportation by leveraging better modal investments will reduce capital and maintenance costs. He reported that supply chain analyses for 10 businesses are currently underway, with the results expected in early 2016. Further, the business case for a full-service logistics park in eastern Iowa is under development. He also noted that there are opportunities to broaden the application of the tool for use in assessing air quality and agriculture production.

Debra Miller, Surface Transportation Board, presided at this session.

Regional Applications of Freight Fluidity

LOCAL PERSPECTIVE: USING FREIGHT FLUIDITY MEASURES IN THE SAN DIEGO CROSSBORDER REGION

Tina Casgar, *San Diego Association of Governments*

Tina Casgar discussed freight fluidity challenges in the San Diego Border Region. She described an initial effort in 2007 measuring freight fluidity as lost economic output and current activities to refresh the analysis in 2017. She highlighted measuring the environmental impacts of freight fluidity, and improving fluidity in the region with expanded capacity, smarter infrastructure, and intelligent transportation systems (ITS) solutions. She also discussed future efforts for monitoring freight fluidity with visualization tools and third party data. Casgar covered the following topics in her presentation:

- Casgar discussed the current conditions at the Otay Mesa Commercial Port of Entry (POE), with long lines of commercial vehicles waiting to enter the United States from Mexico. Otay Mesa is currently the largest crossing between California and Mexico. As the eighth largest metropolitan area in the country, the San Diego region maintains a blended economy, with the border crossings playing a key role in the movement of people and freight. She highlighted the new Crossborder Airport Facility, which was constructed on the U.S. side of the border at Tijuana by a private entrepreneur. Air passengers access the terminal, pay a fee, walk across a bridge into Mexico, and board their plane at the Tijuana Airport. She described the Otay Mesa East project, which involves binational planning, financing, and development. The project focuses on reducing bottlenecks and improving freight fluidity at the California–Mexico border.
- Casgar described the contribution of truck trade to the regional economy. She noted that growth in the value of the Otay Mesa truck trade has outpaced growth in the San Diego regional gross product since 2005. She reported that the 2014 trade value at Otay Mesa was approximately \$39.2 billion, with exports accounting for \$14.3 billion and imports representing \$24.9 billion. She further noted that in 2014 there were approximately 1.6 million truck crossings, with the key two-way trade commodities including electronics, agricultural goods, vehicles, and medical devices. The trend line from the passage of the North America Free Trade Agreement (NAFTA) in 1993 to 2014 was a 551% increase in the total value of imports and exports.
- Casgar described the Economic Impacts of Border Wait Times Study conducted by the San Diego Association of Governments (SANDAG) in 2007. Average wait times at the border crossing are between 1.5 to 2.5 h. The analysis considered the economic impact of this delay on people and goods. She reported that Mexico is the U.S.’s third largest trading partner, with 8% of U.S.–Mexico trade value crossing at Otay Mesa and Tecate, and that Mexico is California’s number one export market. The Otay Mesa POE is the third-ranking POE in trade dollar value between the United States and Mexico.
- According to Casgar, the study examined the economic impact on annual output due to delays at the border for both personal travel and freight movements. The study calculated an economic loss of approximately \$4.6 billion to California, \$2.2 billion to Baja California in Mexico, \$5.3 billion to the U.S., and \$3.3 billion to Mexico. She noted that the study also calculated a combined annual number of jobs lost due to delays in personal travel and freight

movements at the border for almost: 50,000 jobs in California, 12,600 jobs in Baja California in Mexico, 55,700 jobs in the United States, and 18,300 jobs in Mexico. In presenting the impact of the long delays suppressing economic activity, the \$7.2 billion in output lost in both countries equals the impact of hosting 18 Super Bowls in San Diego and the 62,000 lost jobs equates to the loss of employment of five Qualcomms. She noted that presenting the impacts in this way resonates with the public.

- Highlighting the need to update the 2007 study, Casgar described the initiation of a new economic impact study scheduled for completion in 2017. The study will again examine the impact of delays at the border crossings on personal travel and goods movement, both separately and combined. She noted that both static wait times and dynamic wait times will be examined. The project will also integrate vehicle emission data with wait times. She indicated that assessing the environmental impacts of the bottlenecks at the border was an important element of the study. Based on an Executive Order from California's Governor Jerry Brown, six state agencies, including the California DOT (Caltrans), are working together to develop a sustainable freight plan for California by July 2016. She noted that the preliminary analysis conducted by SANDAG indicated that reducing the border wait time to 20 min would reduce carbon dioxide (CO₂) emissions from both passenger vehicles and trucks by 45%.

- Casgar provided an overview of the Otay Mesa East POE project and the associated binational concept of operations (ConOps). She noted that the binational ConOps focused on ensuring a common understanding among users of the systems and related operations. It also allows all parties to visualize the expected operations and environments and serves as a tool for developing agreements. Further, she noted that the ConOps outlines the operational roles, responsibilities, and commitments of the various stakeholders. She reported that toll road financing was a key element of the project, and that there are 35 agencies involved in the project on the U.S. side of the border and an equal number in Mexico.

- According to Casgar, developing a smarter operating POE through the use of ITS and other advanced technologies is an important feature of the project. She described the elements of the binational operations and data sharing focused on reducing delays, including the use of traffic management centers, lane segregation, and variable tolling. In addition, Casgar discussed the Intermodal Transportation Management System, which would be coordinated with the existing Caltrans transportation management center (TMC), a new Tijuana–Secretaría de Comunicaciones y Transportes TMC, and the new SANDAG Regional Border Management System (RBMS). She noted that these systems would monitor the border traffic operations and share transportation, toll, and POE data. They would also coordinate traffic and incident management on approaches to the POEs. The systems would provide operational communication and coordination between border crossing agencies and provide improved data to border travelers. Casgar described the anticipated traffic management zones on both sides of the border, including the approach zones, the U.S. Customs and Border Patrol primary and secondary inspection zones, and the departure zones.

- Casgar described the concept of maquiladoras, factories in Mexico where raw materials or component parts are imported from the United States, assembled, and then exported duty free back to the United States. She highlighted the location of the Maquiladoras in relationship to the POEs and described the supply chain between twin Panasonic Maquiladoras on both sides of the border. She described the trip from the Panasonic Maquiladora plant in Baja California in Mexico to the plant in California. The distance from the Baja California Maquiladora to the Otay Mesa POE is 3.5 mi and typically takes 14 min. The congestion at the

POE results in a border wait time of 1.5 to 2.5 h. The distance from the POE to the California Panasonic plant is 5.2 mi, with a normal travel time of 11 min. The truck may then travel to Las Vegas in 5 h or to Los Angeles in a little over 2 h. She noted that the goal of the new operations is to reduce the border wait time at Otay Mesa to 20 min.

- In closing, Casgar described a project to visualize freight fluidity. She provided an example of tracking a sample of 2,000 truck trips from the border crossing over 24 h, 48 h, 72 h, 5 days, and 7 days using ATRI data. She noted that NCFRP Project 49: Understanding and Using New Data Sources to Address Urban and Metropolitan Freight Challenges, which was just getting under way, should be of interest and use to workshop participants.

FREIGHT FLUIDITY: CHICAGO REGION PERSPECTIVE

Tom Murtha, *Chicago Metropolitan Agency for Planning*

Tom Murtha presented a perspective from the Chicago region on supply chain performance measures. He described ongoing improvements to the Chicago Metropolitan Agency for Planning (CMAP) freight system modeling process. The theme of his discussion was how new supply chain performance measures could support the long-term development, validation, and application of the freight system models. He also highlighted approaches to improve the understanding of the freight system in the region. Murtha covered the following topics in his presentation:

- Murtha described a congestion scan for I-55 in the Chicago area developed in 2009 using the data from freeway loop detectors. The congestion scan presents the average speeds by time-of-day by milepost. He pointed out the locations of intermodal terminals along I-55, which are easily identified by the lower speeds. Most importantly, he noted that while this visualization of operational data clearly identifies the bottleneck, it does not help in understanding or evaluating potential solutions to the problem.

- Murtha noted that the development of the GO TO 2040 Comprehensive Regional Plan in 2010 revealed deficiencies in CMAP's former trip-based freight models. He reported that the models were not responsive to policy options, facility improvements, and market changes. He also noted that the models were not able to analyze the economic development issues that propel regional interest in freight. A new freight model was called for and efforts to develop the model were begun immediately after the adoption of GO TO 2040; led first by Kermit Wies and now by Craig Heither of the CMAP staff.

- Murtha used a diagram by Cambridge Systematics to reiterate the theoretical relationship between freight system investments and economic growth, an important transportation system planning goal. The need to understand the effects on economic growth, competitiveness, productivity, and market access by changing such factors as travel time, cost, reliability, connectivity, energy, and greenhouse gas emissions necessitates a modeling framework.

- Murtha discussed the development of the CMAP Tour-Based and Supply Chain Freight Model. Because of the position of Chicago as a dominant hub in the nation's freight system, the CMAP freight model is national, and even international, in scope. Examples of input data included firm generation from county business patterns and producer firms' production capacity and consumer firms' purchase requirements from input-output tables. Data on imports and exports was obtained from USA trade online (<https://usatrade.census.gov>). According to

Murtha, the CMAP tour-based and supply chain freight model can simulate distribution channels, shipment size and frequency, and the cost of shipping via different modes. He noted that better data for validating and calibrating these simulations could be a major benefit from national freight fluidity performance measures. The model also calculates business transactions for various buyer and seller alternatives. Further, the model provides flexible extensions for scenario testing of macroeconomic conditions, transport and logistics costs, and business operating strategies.

- Murtha described the regional truck-touring model component of the CMAP tour-based and supply chain freight model. The model estimates the size of the shipment and trucks, tour patterns, the duration of stops, and start times. He described some of the model capabilities, including identifying bottlenecks and estimating the products and commodities affected. The model can also test scenarios, including policies, facilities, and economic relationships.

- Murtha noted that the initial development of the freight model was completed by Cambridge Systematics as part of a larger CMAP advanced travel model development program. The freight model was enhanced and expanded through a partnership with FHWA and Resource Systems Group, Inc., and is being adapted for use elsewhere in the country. He noted that the model is complex and is not fully operational, but its modular design facilitates incremental advancement.

- Switching gears to add perspective, Murtha discussed the complexity of planning for the Chicago regional freight system, and why the system is difficult to fully understand, much less model. He highlighted the truck routes and some of the physical limitations in the roadway system, including vertical clearances and bridge weight restrictions. He also reviewed issues with the oversize and overweight vehicle permits, delivery windows, and parking restrictions. He suggested that trucker hours-of-service regulations need to be considered in planning efforts.

- Murtha reviewed some of the current activities underway, including using ATRI data sets (1) to validate and calibrate the truck touring component of the regional freight models, and (2) to develop performance metrics. The ATRI dataset is being analyzed using PostgreSQL. In addition, the identification of freight bottlenecks is also underway on a parallel path using the NPMRDS, as is the development of quarterly congestion reports for trucks and for all vehicles.

- Murtha discussed the planning focus on intermodalism in the Chicago region. He highlighted the truck–rail terminals in the Chicago region and noted that the volume of freight moved through these terminals has been increasing steadily since 2000. Growth in these facilities is expected to continue. He described some of the benefits and economic advantages provided by facilities in the Chicago region, including the ability to competitively serve major metropolitan areas throughout the United States, Canada, and Mexico.

- In closing, Murtha reiterated the importance of the various models and data for planning and for freight investment decisions. As examples, he referred back to the congestion scan on I-55 and highlighted improvements that are planned to improve access for intermodal facilities in the corridor. He also described the Chicago Region Environmental and Transportation Efficiency program, a multibillion dollar rail system improvement program, separating conflicting passenger and freight movements and eliminating highway–rail grade crossings, as well as the overall complexity of the rail system serving the Chicago region.

KEY COMMODITY PROFILES AND FREIGHT FLOWS

Anne Strauss-Wieder, *North Jersey Transportation Planning Authority*

Anne Strauss-Wieder discussed the development and use of key commodity profiles and a freight forecasting tool at the North Jersey Transportation Planning Authority (NJTPA). She described some of the top commodity groups and central elements of the profiles, along with the forecasting tool. Strauss-Wieder covered the following topics in her presentation:

- Strauss-Wieder provided background on the NJTPA region, which includes 13 counties in northern New Jersey. With approximately 6.6 million residents, it is one of the most densely populated and most affluent areas in the country. The NJTPA region contains a number of leading gateways and distribution nodes. These facilities include the largest container port on the Atlantic seaboard with 5.8 million 20-ft container equivalent units (TEUs) in 2014 and over 804 million square feet of industrial property, with an additional 4 million square feet under construction. She noted that Newark Liberty International Airport ranks ninth in cargo among U.S. airports. The region is served by two Class I railroads, as well as the Conrail Shared Assets Area and several short line railroads. The region also has an extensive roadway network, including the New Jersey Turnpike. She noted that all of these facilities represent and support the economic engine for the area, the multistate area, and North America.
- She discussed the development of the regional key freight commodity profiles, which was an essential first step in better understanding critical freight flows in the area. Profile development began with the identification of the leading commodities and industries in the region. The profiles build an understanding of the commodity-specific supply chains and detail how they operate in the region. She noted that commodity supply chains are unique and that freight operations for a commodity can also vary by region. The profiles were additionally used to enhance the NJTPA's freight forecasting tool and will now support the development of freight fluidity and supply chain-specific performance measures. Additionally, the profiles and the freight forecasting tool help in focusing multimodal investment decisions and have been used by economic development organizations.
- Strauss-Wieder reported that a number of sources were used to develop the freight commodity profiles, including IHS Global Insight TRANSEARCH, Torto Wheaton industrial data, Co-Star industrial data, Freight Locator, and other databases. The top commodity groups were identified by examining the commodities with the largest tonnage and the greatest value in 2010 and the commodities with the greatest forecast growth in tonnage, value, and mode shift. The commodities supporting top industry sectors and top growth sectors were also examined. Strauss-Wieder noted that interviews were conducted with key industry officials to gain additional details, validate quantified information, and for insights into anticipated growth sectors. The results were also discussed with a technical advisory committee to gain feedback and to identify priorities and selection criteria.
- Strauss-Wieder discussed the leading commodity bundles and related industries resulting from the analysis. She noted some of the differences in the public and private data sets. For example, one public-sector data set lists warehousing as the largest commodity in the region. She suggested that warehousing is an activity that is part of the supply chain rather than a commodity. With over 804 million square feet of warehousing and approximately 300,000 employees working in the warehousing industry, she stressed the importance of knowing the location, configuration, and access needs of warehousing facilities in the region. She reported

that the food and beverage industry was one of the largest commodity bundles in the region, which is not surprising given the population base. Other large commodity bundles in the region are apparel and textiles, paper and printed materials, waste, construction, energy, and pharmaceutical chemicals. She highlighted the recent volatility in the energy sector and the complexity of the pharmaceutical supply chain as examples of the challenges public agencies face in assessing freight flows.

- According to Strauss-Wieder, the commodity flow analysis examined tonnage flow by direction and mode split. She described the industry location analysis, which identified the square footage and employment for major establishments. She noted that the result of this analysis highlights the importance of the access provided by the New Jersey Turnpike and other major roadways and freight infrastructure.

- Strauss-Wieder noted the importance of both quantitative and qualitative information in examining supply chains. She stressed that real-time information is needed as supply chains are dynamic, and that it is important to examine data inconsistencies and limitations with different data sources, such as facility locations versus commodity flows. She noted the importance of conducting additional field work, including interviewing business and economic development officials, as well as conducting site visits.

- Strauss-Wieder discussed the importance of presenting information to the general public and policy makers. She noted that the Regional Commodity Profile Reports are used to communicate key findings in simple, digestible formats that are intended for public officials, stakeholders, and the public. The reports include an introduction to the commodity bundle, a logistics flow chart and explanation, and industry locations and handling facilities in the NJTPA region. The reports also highlight highway network flows, key industry and logistics trends, commodity flows, and a list of resources offering more information.

- Strauss-Wieder reported that the NJTPA freight forecasting tool was originally developed for the 2040 Freight Industry Level Forecasts Study. It incorporates and adjusts for changes in key freight drivers and trends, and allows users to test the effects of future scenarios. The tool includes regional and state economic data and forecast scenarios, as well as translations to modal use by industry–commodity and origin–destination pairs. The model incorporates the “use matrix” from input–output modeling, particularly tailored to New Jersey. Toggles were included for changing assumptions on mode use, origin–destination pairs, volumes, and other characteristics. The tool can also generate commodity-specific truck trip tables interfacing with the North Jersey Regional Transportation Model–Enhanced (NJRTM-E). Strauss-Wieder provided the following links for additional information in the NJTPA profile reports and freight forecasting tool.

Link to download the Commodity Profiles: www.njtpa.org/planning/regional-studies/studies/regional-freight-commodity-profiles/regional-freight-commodity-profiles.aspx.

Link to learn more about freight in the NJTPA region: <http://www.njtpa.org/planning/regional-studies/freight.aspx>.

Scott Drumm, Port of Portland, presided at this session.

WRAP UP

Moving Forward with Freight Fluidity Performance Measures

JOSEPH SCHOFER

Northwestern University

The closing session provided workshop participants with the opportunity to share their ideas and suggestions on advancing the development and use of freight fluidity performance measures. The following common topics emerged from comments made by workshop participants, as summarized by the workshop rapporteur:

- Many participants noted that a lot of progress had been made in the development and use of freight fluidity performance measures and supply chain analysis methods since the 2014 conference. It was suggested that the national, corridor, regional, metropolitan, and local examples presented by workshop speakers highlighted the increased acceptance of the freight fluidity concept. Participants also commented that the examples illustrated the diverse public and private-sector groups involved in these projects, which are important for developing additional applications and ongoing interest.
- Some participants highlighted the role that freight fluidity plays in supporting economic development and global competitiveness. This link helps build support for examining freight fluidity and supply chains at all levels. Participants suggested that addressing freight bottlenecks through investments in transportation infrastructure and operations are economic development actions that enhance the quality of life for residents.
- Participants discussed the data needs for developing and analyzing freight fluidity performance measures. Some participants suggested that the experience with the examples presented indicate that the private sector is willing to share data under the right conditions. Continuing to develop relationships with the private sector through different data sharing arrangements, which address specific uses, expected outcomes, and confidentiality was further suggested. Presenting the benefits to the private sector from improvements in the transportation system was also noted as important.
- Participants also discussed the role that federal, state, and corridor coalitions could play as data acquisition brokers. Participants suggested that facilitating data acquisition, data reduction, and data dissemination were appropriate roles for these agencies that would foster greater use of freight fluidity performance measures, especially by MPOs and local agencies.
- Developing common definitions and approaches for freight fluidity measures were suggested by some participants. Other participants noted that accumulating the current examples and applications would be beneficial. Developing a compendium of freight fluidity and supply chain examples that highlight different scales and geographies was suggested, including summarizing the data, methods, and models used. Future steps would be continuing to develop additional examples, including key national supply chains, with support from agencies at all levels and the private sector.

- Participants discussed possible roles for different groups at all levels. The ongoing support of FHWA was noted as important, as was the ongoing assistance from TRB and coordination with the ACSCC. Reaching out to other groups, such as AASHTO, was also suggested. Outreach to private-sector groups was also noted as important to ensure an understanding of their needs and to obtain their participation and support.

APPENDIX A: BACKGROUND PAPER 1

Applications of Freight Fluidity

ALAN E. PISARSKI
Alan Pisarski Consulting

This is the first of four background papers developed by the TRB Task Force on Development of Freight Fluidity Performance Measures to inform a December 2015 Freight Fluidity workshop in Washington, D.C., with the objective of discussing the design of a FHWA freight fluidity measurement system.

WHAT IS FREIGHT FLUIDITY?

For the purposes of this paper, “freight fluidity” refers to the performance of transportation supply chains and freight networks.

Freight fluidity can be a measure of the performance of a supply chain using a single mode or multiple modes of freight transportation.

Freight fluidity can also be a measure of the performance of a freight network or freight corridor serving many supply chains.

In current U.S. parlance, freight fluidity focuses on transportation SCPM; that is, the measurement of the travel time, travel-time reliability and cost of moving freight shipments from end-to-end of a supply chain.

This paper is tasked to address the following questions:

- Who would use a fluidity measurement system, and how would they use it?
- In what ways could fluidity performance system support transportation, the economy or other sectors?
- Who would be the beneficiaries?
- What are the potential policy impacts?

WHAT IS THE GOAL?

It is advisable to begin this discussion with the enunciation of a broader term goal for transportation to guide performance measurement, other than the purely instrumental goal of serving business needs which might be suggested by a supply chain performance measurement process. While that is a very valid function, the broader transportation goal can be expressed as follows:

The goal for transportation is to reduce the effects of distance as an inhibiting force in our society’s ability to realize its economic and social aspirations.

This goal has the value of expressing equally our broad national interest in passenger and freight transportation conducive to enhancing and sustaining a better quality of life in America.

Who Would Use Freight Fluidity Measures? How? Are There Other Beneficiaries?

We need to differentiate here the major groupings of private and public sectors. There are two points to consider:

1. Initially we have to ask “Are we so smart that through our analyses we can see needs that others, those most directly involved, don’t see? Or, rather, are we providing tools for those directly involved to respond to their own needs as they perceive them, or, perhaps to give them a structure in which to permit them to give voice to their needs and to raise them in a public forum to be addressed by public policy?”

At first viewing it would seem hard to believe, given the very direct and intense interest of private or public players in managing their supply chains in terms of costs and reliability, that there is more we can add. These thoughts lead to a second set of questions.

2. Are the individual direct interests in adequate supply chains on the part of the private or public sector actors for their own purposes sufficient to serve national interest purposes? Does the sum of their interests equal the national interest? If not, why not? Is there a market failure here of some kind? Is this a case of “The Tragedy of the Commons”? Are there new, unrecognized opportunities perhaps?

If there is a case to be made it may be that the market failure that would clearly justify public involvement involves two aspects; one is that certain commodities may be considered strategic in a national sense but which may not receive appropriately elevated levels of concern for market reasons; the other is the concept of the tragedy of the commons in which the sum of rational and sound decisions will sometimes sum to very negative effects for both users and nonusers. In some respects the road system and parts of the waterway system have the attributes of the common—all users gain personal benefits from greater use of a “free good” and tend to overuse it, with the effect that such use imperils the use of others, who are similarly motivated, and ultimately imperils total usage for all.

Potential Uses and Impacts

There is an argument to be made here for the real value of simply making the case. That is, to assert the high value of the research community bringing to the attention of policy leaders the necessity and value of addressing these concerns. This may be related to national, state or local interests. It may be public or private. It may simply help direct resources to better appreciation, understanding and addressing of key problems. It can bring strategic focus and specificity to a general, sometimes amorphous and ill-defined concern.

In What Ways Could a System of Supply Chain Measures Support Transportation, the Economy, or Other Sectors?

As we consider the public interest in such a system and further recognize that we may be providing some contribution to the development of tools to help support those who already see the need to

better help themselves, we need to recognize that there are proprietary issues here in which firms do not wish to fully reveal the aspects of their logistics planning and activities. Are there ways in which the public sector can both protect those proprietary interests and still broadly benefit the public interest and the overall user community in data development that is anonymous and discrete? We must recognize further that the data demands of such an approach are extensive.

A Passenger Travel Analogy

This author and Tim Lomax often testified together in congressional hearings on congestion-related topics. Lomax, using the tools developed by TTI for the Urban Congestion Monitor, was talking about how well was the system doing, whereas I, using household interviews from FHWA's National Household Travel Survey and the Census Bureau's American Community Survey, was talking about how well travelers were doing. A fitting analogy to supply chains is apparent in that, while the road system or the overall transportation network may be working well or poorly, specific users of the system—perhaps specific products moving in the system—may have very different experiences.

Better freight fluidity measurement, SCPM, can produce important benefits to both public and private users in several dimensions such as:

- Public–national–fundamentally top-down measures:
 - Raising the topic and its concerns to the policy level for public policy response—simply getting supply chain challenges and opportunities on the national agenda at all levels.
 - America has developed a sophisticated system of just-in-time delivery of products, parts and other inputs to production. This comes at a time when congestion in our facilities and infrastructure weaknesses threaten our ability to assure timely arrival of needed inputs. Better supply chains are enablers of such low inventory approaches to logistics which save businesses' and customers' valuable resources.
 - Properly designed SCPM will expand the general understanding of supply chains and their value to business and the greater society. They will identify key areas for national or regional–local focus.
 - These measures will permit the generation of means to highlight areas of the country that are ill-served in an overall logistics system reducing economic opportunity in those areas and reducing total national output.
 - These measures will guide new ways of addressing freight data needs and freight data presentation.
- Public–state, local–fundamentally bottom-up measures:
 - The SCPM will support local interests in recognizing and assessing their supply chain challenges in both local governments and the private sectors.
 - On an ad hoc basis one might approach these challenges almost as case studies. This might be most clearly evident just as a thought experiment when a “one-industry town” sees the threat of loss of that industry. A key question could well be “How can we adjust the supply chain for this industry that will help keep it here?” “Is the resolution of

the supply chain issues enough to resolve the threat?” “What part of the potential loss is supply chain related?” “What are the trade-offs among logistics, labor costs, taxes, regulation, and other factors?” Of course this thought experiment can be extended to a small city or a state where there may be multiple industries some of which are challenged by supply chain issues.

- A question to be answered might be “What states or metro areas have a limited number of industries on which they are dependent, or recognize certain industries as key to their economic future?” “How are supply chain issues implicated in the potential gains and losses of those industries?”

- At a facility level a state or metro area might have 6 freeway interchanges throughout their region all equally threatened by congestion or declines in function. How then do they allocate resources among those options? Defining which facilities are central elements in critical supply chains of key industries or have other important strategic components would yield more sound mechanisms for making choices.

- The foregoing focused on legacy systems and the threats that their failure might engender. More broadly we need to recognize that there are both supply chain threats and opportunities regarding legacy systems and for future system options as well, as in the following matrix. Perhaps the strongest benefits of SCPM will be in identifying such opportunities:

	Legacy Systems	Future System Options
Threats		
Opportunities		

- All of these case examples fall under the umbrella of generating alternatives analyses to assess supply chain options, permitting the greater discrimination and quantification of investment options and priority setting.

- Private

- Much of the foregoing discussion generates private as well as public interest.

- The array of private players is extensive: shippers, suppliers, carriers, third party logistics providers and terminal operators.

- There are multiple levels at which the private sector might engage with a SCPM. The array would span from the smallest single product local firm to giant conglomerates with hundreds of products across world-wide supply chains.

- In many instance the smaller firms may in fact cooperate in a joint effort with local or state governments in the assessment of supply chain threats and opportunities.

- Larger firms with major logistical capabilities may directly benefit from public sector research efforts to make the case for the greater public policy recognition of supply chain investments and policy support at the local, state and national levels.

- Further, all would benefit from greater information and tools developed from public sector interest and involvement.

What Are the Possible Policy Impacts?

- The policy community is challenged to make the case for Supply Chain Performance Measurement to legislators and policy officials.

- There are data development and proprietary data security issues to be addressed.
- A role will exist for the policy community to establish means of cooperation and coordination between the private and public sectors.
- Analyses will need to demonstrate the key role that supply chains play in enhancing and preserving national productivity.
- A key role is to focus on supply chains as a tool in opportunities to improve economic and social well-being throughout the entire country and in all communities.
- Coordination among national, state and local public policy actors is central to success.

The Task Force on Development of Freight Fluidity Performance Measures, which met on October 6, 2015 developed and modified the following table based on the work of Rolf Schmitt. It provides a useful summary statement of the varying perspectives brought to this topic by the many participants in the process.

Perspective	Components	Measures	What Does It Tell Us?	Why Do We Care?
Transportation view	Shipper to consignee through intermediate points; region-to-region flows over the network	Network use and performance: commodity flows, fluidity, and user costs	How well is the system working and what commodities does network performance affect	Identify and correct critical bottlenecks; identify potential improved options; improve other areas of system performance; respond to disruptions
Business logistics view	Supplier to business to market; business-to-business flows over the network	Adding fluidity into market sheds (accessibility measures) and shipper costs: geographic consequences and regional economic development	How system performance affects users (businesses) in the region	Identify opportunities for attracting and keeping businesses; expand markets; respond to disruptions
Economic view	Raw material to basic manufacturing to assembly to wholesale to retail; industry-to-industry flows	Adding transport costs into I-O tables: national economic consequences	How system performance and geographic and business consequences affect the national economy	Monitor trends in transportation logistics costs; inform national transportation and trade policies to improve economic health

CENTRAL CONCERNS DRIVING GOALS AND PURPOSES

National Security

Areas of interest include the following:

1. Defense preparedness and mobilization. Assessing the level of support provided by supply chains in the movement and placement of strategic materials.
2. Emergency preparedness. Guiding the scale and scope of necessary system protection, resilience and redundancy.
3. Energy. The movement of energy products is a predominant element in the nation's freight transportation system and must be a central element of strategic concern. We have seen amply demonstrated lately the challenges of rapidly changing energy supply chains and the weaknesses in our present capabilities.

International Competitiveness

International competitiveness is presented here as the first concern after national security and can be seen as the central focus of supply chain analyses from a public policy viewpoint. At the same time it overlaps in value, meaning and content with the other elements identified here, particularly that of general economic efficiency. The major focus today is on our ability to generate exports to balance imports, protect jobs and maintain a strong position in world events. While trade in services is also a major factor the focus here is on export products and the industries that produce them. The central question here is “Where are supply chains a significant factor in export market failures or opportunities?”

- Exports and export gateways. Recent events accentuate the necessity to see both threats and opportunities regarding ports. This may be a key area for alternatives analyses.
- Intermediate moves to support exports pre- or post gateway. There may be tendency to too heavily focus on final production to Export Gateway supply chains, whereas the strength of the SCPM process may be in examining intermediate inputs and outputs supply chains feeding final production.
- Imports supporting exports. Imports cannot be neglected in these concerns. In some cases imports may be critical to domestic strategic or economic interests. In some cases, the best

Testing the National Logistics System

The last time U.S. DOT looked publicly at national defense impacts on the transportation logistical system was a study—conducted as part of the National Transportation: Trends and Choices report—of the 1990 transportation system's ability to support a two-front conventional war, such as World War II. More recently there have been limited assessments of the system responses to terrorist threats and natural disasters. The subject of resilience of the system is now on the front burner. The topic, formerly referred to as redundancy—that is, the ability to compensate for lost infrastructure, which was of significant concern in the Cold War era—is less well addressed. There are national freight and national defense networks that may benefit by being redefined supply chain analyses generated from the SCPM system.

An Export Tale from the Past with Strong Supply Chain Implications

The “Russian Wheat Deal” in 1972 was a major event in U.S. trade history with world policy implications. A disastrous winter had severely impacted Russian wheat production at a time when the United States was effectively the only producer with substantial exportable production in the world. Separate from the price issues, logistics became a matter of national competitive pride, especially given the cold war status at the time. The U.S. State Department’s goal was to “bury them” in wheat. Barges were backed up the Mississippi waiting to discharge in New Orleans for “a hundred miles” but the Russian import capabilities were far weaker. Wheat was being stored on the streets at the ports and was rotting. Later it was realized that Russia’s inability to feed its people was as much due to a failure of distribution logistics as of inability to produce food.

examples may be in the Mexico–United States; and Canada–United States vehicle manufacturing, where imports may be key to certain exports.

General Economic Efficiency

The concept of general economic efficiency is an important one and overlaps strongly with the export focus. The parsing of transportation’s contributions to general economic efficiency may be more difficult than an approach focused on specific products–commodities. Two elements of real interest here are expanding general access to inputs, and providing more ubiquitous availability of products throughout the nation.

- **Key factors–key drivers.** The focus in the current era and for the foreseeable future will be on expanding productivity. With the very slow growth in the work force, output per worker will be a key concern. Both passenger and freight transportation will be significant in enhancing productivity by expanding access to workers and to resource inputs and markets. The commuter-shed will be joined by the market-shed and supplier shed.
- **Expanded sources–inputs.** The SCPM system will need to support industry and public policy makers in assessing opportunities for alternative supply chains and markets.
- **Private-sector competitiveness.** The sophistication of modern firms regarding supply chains is substantial. There is much that policy officials and researchers can gain with greater interaction. At the same time, the policy and research communities can add to value-added with better data and analytical tools, and with a broader perspective which can be valuable to private sector players. Heightened communication will be key.

General Health, Welfare, Safety, and Environmental Support

Health, welfare, safety, and environmental support is a perhaps too broad a topic to be addressed here in specific terms. It is here, as in the public policy side where purely economic criteria will be inadequate to decision making. One example is the movement of critical medical supplies to serve the national population’s general needs as well as emergency response. The breadth of availability of fresh food stuffs throughout all seasons of the year and of medical supplies are significant parts of the general health of the population.

- Critical medical supply. Many medical supplies are the quintessential example of high-value, highly time-sensitive movements, but some reflection will reveal others.
- Hazardous materials. Understanding and optimizing the flows of hazardous materials to assure timely, safe arrivals add a critical dimension to SCPM. Of importance will be minimizing exposure to the population and to critical elements in the economic system.
- Vehicle and cargo safety. Safety always must be uppermost in any planning scenario. In this case it involves the protection of transportation vehicles—craft and their cargoes, and of course their drivers—operators, from destruction and losses arising from human or natural influences. In many cases interactions between the freight fleet and the passenger fleet will be a central concern. Such issues go well beyond economic concerns.

APPROACHES

A Typology of Supply Chain Types

U.S. DOT's 1977 report, *National Transportation: Trends and Choices* (Figure 1), addressed the concept of structuring a typology of supply chains. This figure, based on county business patterns and the national input–output tables of the time, provides a coarse indication of the breadth of necessary flows within the national system. Current work in this area needs to be extended and expanded.

A characterization of one of the possible dimensions of supply chains based on the numbers and types of players involved is the following:

- Few to few (e.g., car seats and jet engine rotor blades). In some cases this may be the simplest and easiest of chains to address, with a limited number of players at both ends of the chain, with the exception that these chains today may be worldwide. This is perhaps more typical of manufacturing than other economic sectors.
- Few to many. Examples include toothpaste, which is made in a limited number of places but available in every store in America, most foods, and flowers—products that are ubiquitously available fall into this category.
- Many to few (e.g., most farm products going to farm product processing or agricultural assemblers may be typical of natural resources). Many to few may feed few to many—apples to distributors, flour to bakeries, and then on to final consumers.

Significant parts of this characterization are linked closely to stages in production. We must recognize whether it is final or intermediate consumption that we are addressing.

Performance Factors

There may be a large number of detailed performance factors that need to be considered in a SCPM system. At the broadest level there are three:

- Reliability. There are many cases of simply needing a continuous flow of inputs to production or to final consumption. Among the elements of the reliability measure would be on-time delivery, variation in schedule adherence, assured safety and risk regarding physical

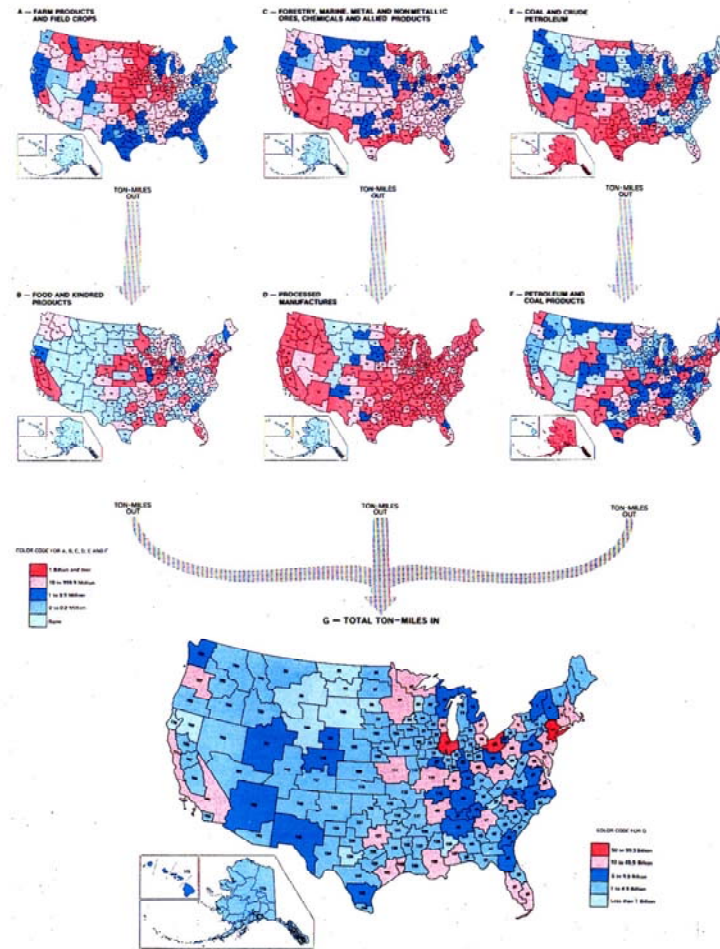


FIGURE 1 County-level commodity flows.
 (Source: National Transportation: Trends and Choices)

condition, damages, and theft. In its simplest form it involves reduced need for concern about that element of the supply chain.

- Speed (seen as time sensitivity). There are perhaps two classes of time sensitivity: the first is perishables (fruit and other foodstuffs) and a special kind of perishables such as competitiveness perishability (fashions and cell phones); and a second category, which is high-value goods with high inventory costs (computer chips) where time spent enroute or in a warehouse is a major expense.
- Cost. In some ways this is a strange distribution; some low-value goods have a high transportation share of final costs (lettuce, bananas, sand, and gravel) but still low total cost (bananas are \$0.19 each at a local supermarket); or have high transportation cost which is minor as a share of the total cost for high-value items (television sets). A key question for present and future consideration is “What is the tolerance to transportation costs of different products or intermediate goods?” Note that this needs to be seen in a narrow sense of costs of transportation—excluding regulatory or customs costs. It is to be noted further that the value of goods moved has been

increasing over time and is forecast to continue to increase as the value per ton of products grow, so a key driver of SCPM must be the system's responsiveness to increasing value of goods in motion.

National Accounts as a Driver

The United Nations defines its System of National Accounts as the internationally agreed standard set of recommendations on how to compile measures of economic activity. Linking and embedding supply chains in the accounts is the fastest and soundest way to making freight fluidity SCPM nationally significant. One obvious point is that the accounts present the share of any given product's total cost attributable to transportation. That share and its trends are the most direct measures of the relevance of transportation to the national economic structure. Testing the trend for increases in transportation costs as a share of product total costs would be a first round indicator of failing transportation services. Douglas Frechtling, Professor Emeritus at George Washington University, describes it this way:

Transportation predominantly serves as an intermediate input for commodity deliveries to final demand, not as a direct output to that demand. Therefore, we should focus on its forward linkages. Transportation fails to serve economic development to the degree that it grows as a proportion of total inputs. Rather, we want transportation to continue to decline in the proportion of total inputs of strategic industries, and addressing infrastructure constraints on transportation is an important way to do this. (Personal communication.)

While we can certainly see cases where there would be exceptions to this, such as transportation quality improvements, e.g., people shifting to first class rather than coach in air travel as their means permit, or people or goods shifting to air rather than ground transport as their value of time increases, as in just-in-time delivery, the observation is fundamentally sound and becomes an excellent point of departure for a class of investigations into transportation's role in the economy.

Perhaps the key point to recognize here is that real measurement of supply chains cannot happen until it addresses flows at the commodity or product level. Knowing that I-95 is congested and therefore affects supply chains, is certainly pertinent but not fully useful until we know what commodities, linked to what strategic national goals, and what levels of overall national and state economic output are affected and at what levels factors in the movement of goods are impacted.

We need to consider the following:

- Transportation as an input cost. Transportation input costs to products is the key first round indicator of the importance of transportation in that product's cost structure and of the role transportation might play in that product's success or failure. A potential weakness in present input-output (I/O) table capabilities is that a company's own internal transportation expenditures (e.g., from their own delivery fleet) may not be properly reflected. This would require extension of present "satellite" accounts to address this gap. Present accounts can identify the amount of "own account" transportation, usually trucking, a given industry might employ. This would need to be extended to the I/O structure to more accurately reflect actual transportation inputs. (A simple example could be an industry which employs its own jet aircraft to move parts and people for a portion of their needs, rather than purchased air services; or the more typical case of super market chains with their own truck fleets.)

- Transportation as a share of costs. This follows directly from the above discussion in the I/O structure. Transportation services employed as a share of a dollar's worth of output of an industry is a standard I/O product, but perhaps not at the levels of detail that would be most valuable to transportation analyses. In that case the general data products would be pertinent as a guide to required further research, again, subject to the considerations described above.
- Transportation's role in intermediate costs. While all costs are reflected in the I/O, that doesn't mean that the necessary detail is always available, therefore, being able to address the supply chains supporting intermediate products for a given main supply chain may require special analyses.
- Trends in transportation costs in the final output of industries. As noted in the Frechtling quotation there would be great value in tracing the trends over time in the transportation input costs of given industries with the provisos noted above. Distinguishing the two parts to this will be a challenge. They are 1) when are increased transportation expenditures the result of conscious decisions about trade-offs, such as the rolling warehouse notion of just-in-time; or 2) the result of inefficiencies in the system. It will be a very beneficial challenge in that this statistical measurement question has been a fundamental one about transportation investment decisions for decades. The late Senator Daniel Patrick Moynihan of New York raised these questions during the development of the Intermodal Surface Transportation Efficiency Act in a challenge to the trucking industry to increase what he thought was low productivity.

System Interactions

This is the necessary next step in the chain of planning events surrounding defining a structure for SCPM. This segment of the paper will not answer these questions but hopefully will construct them and examine them in ways that are helpful to further analytical treatment.

- Where does ambient congestion impede critical commodities generating reliability or cost effects? (Note: Commodities are used here in the sense employed in National Accounts rather than as raw materials or farm products in common understanding.), As cited earlier, congestion on I-95 or any Interstate highway has negative economic consequences but these are more vivid and more specific when the nature of freight on the facility is known. Such understanding provides more detailed justifications for investments and can guide specific project selection priorities.
- Where does system flow of critical commodities impact general flows? This may be a factor in some areas where the dominant flow or flows may be critical commodities and where their volumes are such as to affect overall travel on a facility. In these cases consideration of system alternatives for both critical and noncritical freight flows may be indicated. This relates to the ability to perform alternatives analyses discussed below.
- Where are target opportunities for competitiveness gains? An ideal analytical construct might be where two facilities under consideration for enhancement could be analyzed in terms of the commodity-specific supply chains affected and the total effects on international competitiveness, overall national economic productivity or other national or state goals. A simplified version of such an approach might occur where a major industrial center is known to be served by given transportation facilities and its scale of importance can be determined as compared to other centers served by alternate facilities based on characteristics of their products.

- How can we aid in identifying alternative opportunities? When critical commodity origin–destination flows can be established, alternative network paths or multimodal options can be evaluated more effectively.
- Where or how do general increases in system efficiency generate competitiveness gains for targeted commodities? Given an overlay of important supply chains an approach to alternatives analyses at the network level would be possible. An example may suffice to make the point. Where a state might be considering a statewide expansion of two- and three-lane rural facilities to four lanes, knowledge of supply chain flows could be a key ingredient in deciding if more or less critical facilities should be included in a plan.
- What are the effects of passenger interactions? At many stages there will be a need to better construct tools to perform side by side analyses taking into consideration the effects of freight movements on passengers moving in the same stream and vice versa. This could apply in almost any mode or set of modes. The issues of rail freight movements and Amtrak passenger travel are well known, but others, air freight (perhaps belly cargo) vs. passenger movements and road conflicts are also quite clear. Even river traffic of recreational or cruise vessels at locks and dams are a source of conflicts with freight flows. There are no clear mechanisms to make such trade-offs. The profession seems to lack the tools to perform such analyses.

Clearly, purely economic considerations are inadequate to the task. Social, cultural, equity, and political considerations are involved.

SUMMARY CONCLUSIONS

The key factor to recognize here may be the substantial role to be played by the public sector involving the following:

- Making the case for greater focus on supply chains as a critical national, state and local concern;
- Bringing that case to legislators and policy officials;
- Developing the tools, the data and analytical capabilities to support both private and public decision making at all levels;
- Establishing the criteria to assure supply chains are specifically embedded in public investment analyses;
- Improving our ability at all levels to assess passenger and freight trade-offs; and
- Demonstrating the importance of supply chains for national, state and local strategic interests.

We must establish where the sum of optimizing all the private supply chains still does not lead to the best overall national system for the country. Is there a case of market failure here that needs to be recognized? A key research concern will be to determine if there are aspects of the “tragedy of the common” in parts of the transportation system.

Both public and private actors must focus on better mechanisms for coordination and cooperation in assessing supply chain needs.

Perhaps the central fact to recognize here is that real measurement of supply chains cannot happen until it addresses flows at the commodity or product level.

A starting point for concern is where does ambient congestion impede exports, critical commodities or strategic industries generating reliability and cost effects or lost opportunities?

While assessing the challenges of legacy systems is important, it is also important to recognize the opportunities provided by existing and new facilities and services in terms of national productivity benefits and assuring the equity of those benefits in all areas of the nation and all segments of society.

Among the tools to guide the SCPM system will be developing the expertise in sister agencies to embed supply chain analytical capability in the U.S. System of National Accounts. Knowing the trends in the transportation share of product costs will be crucial for exports and overall general economic efficiency.

Distinguishing the two parts to this will be a challenge. The first part is the question of when are increased transportation expenditures the result of inefficiencies in the system. The second part is when are these increased expenditures the product of conscious decisions about trade-offs, such as the rolling warehouse notion of just-in-time, where a truck will be dispatched without a full load?

APPENDIX A: BACKGROUND PAPER 2

Freight Fluidity Scale of Analysis

BILL EISELE

JUAN VILLA

Texas A&M Transportation Institute

EXECUTIVE SUMMARY

This is the second of four background papers developed by the TRB Task Force on Development of Freight Fluidity Performance Measures. The research questions for this paper include the following:

- At what scale or geography can fluidity measurements be applied?
- What are the options for analyzing corridors and gateways versus analyzing particular supply chains?
- What factors should be considered in determining the level of analysis?

The paper focuses on how to determine the “what” that is analyzed. Suggestions have included looking at key corridors and gateways, aggregated supply chains, regions and megaregions, key industries and commodities, or freight sheds. Because fluidity can be measured at these different levels, this paper explores options for different scales–geographies in terms of feasibility, usefulness, and other factors.

The authors conclude with a number of recommendations and considerations related to the scale of freight fluidity analysis, which include the following selected highlights:

- Both spatial (geographic scale) and temporal scale of the analysis are important, and are defined based on the user’s needs.
- Geographic scale is very broad, ranging from local streets to global supply chains, and any “links” or “nodes” in between.
- The “freight box” concept presented in [Figure 1](#) provides a useful way to illustrate and understand all spatial and temporal aspects of a desired analysis, and scalable to handle various supply chains, “links,” “nodes,” and time scales.
- A systems approach should be applied to capture the performance of all modes and supply chains.
- There is a need for the fluidity tool to focus initially on the areas of highest initial interest and use rather than trying to meet the needs of all users immediately as shown in [Table 1](#).
- The fluidity tool must be created with spatial–temporal flexibility (and expandability) to handle the more common uses initially with an eye toward future expansion as it becomes clearer how industry will use the tool.

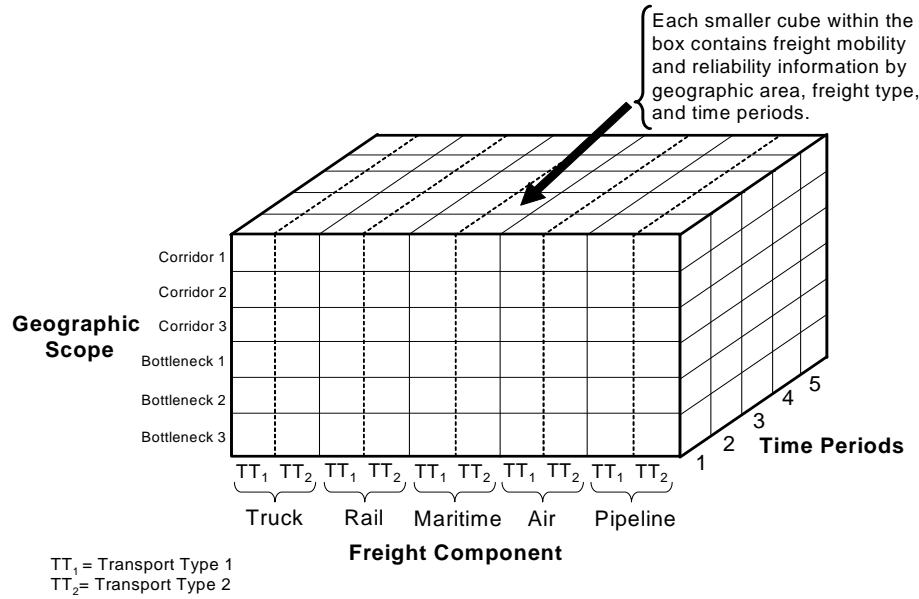


FIGURE 1 Expanded freight box for varied freight modes of the supply chain.

TABLE 1 Typical Jurisdictions and Uses with Associated Analyses Scales

Agency Jurisdiction (Examples)	Typical Geographic Analysis Scale	Typical Temporal Analysis Scale	Frequency of Analysis Updates	Example Use Case Question(s)
International (World Bank, private corporations)	Megaregion to global	Monthly, seasonal, annual	Seasonal, annual	<ul style="list-style-type: none"> • How is the global supply chain operating? • How is the country’s overall logistics operating? • Are my client’s suppliers receiving goods in a timely manner?
Federal (FHWA, chambers of commerce)	National Highway System (NHS), national; global; borders (gateways) and interconnectors	Annual	Annual	<ul style="list-style-type: none"> • Where are there bottlenecks in NHS continuity or connectivity? • Where are delays in imports–exports?
Megaregion (MPO, COG, chambers of commerce)	Regional or even global	Seasonal, annual	Seasonal, annual	<ul style="list-style-type: none"> • How does my region compete in comparison to peers–competitive regions?
State (DOTs)	Interstate and regional	Peak periods, monthly, annual	Monthly, annual	<ul style="list-style-type: none"> • How are corridors on the state freight plan operating? • How well are border crossings and ports operating?
Local (MPO, city, county, chambers of commerce)	Urban area or specific roadways	Peak periods	Seasonal, annual	<ul style="list-style-type: none"> • Where are specific freight bottlenecks on main street?

NOTE: The shading indicates the possible geographic scale range of a beta (initial) freight fluidity measurement system: regional, national, and borders–interconnectors.

What Is Freight Fluidity?

The transportation system is complex. It includes travelers and carriers using a variety of modes to make a multitude of trips. Understanding freight movement with an eye toward performance management requires multimodal data and supply chain information for informed decision-making on the freight network.

The concept of a “fluidity indicator” was first popularized by Transport Canada to evaluate the performance of trade corridors and multimodal supply chains. For Transport Canada’s applications, the fluidity indicator measures total transit time and travel-time reliability of goods along defined supply chains (1). TTI provided early technical assistance to Transport Canada to develop and test fluidity measures and demonstrate them along a supply chain, which is documented elsewhere (2).

In a recent presentation, Louis-Paul Tardif of Transport Canada—who is credited with coining the phrase “freight fluidity”—stated that “...the fluidity indicator provides evidence-based information to assess and analyze the efficiency of supply chains and assists Transport Canada’s work in identifying constraints in the transportation system” (3).

For the purposes of this paper, freight fluidity refers to the performance of transportation supply chains and freight networks. Freight fluidity can be a measure of the performance of a supply chain using a single mode or multiple modes of freight transportation. Freight fluidity can also be a measure of the performance of a freight network or freight corridor serving many supply chains.

In current U.S. parlance, freight fluidity focuses on transportation SCPM; that is, the measurement of travel time, travel-time reliability, and cost of moving freight shipments from end-to-end of a supply chain.

The following definition was previously put forth to define freight fluidity by researchers at TTI, working in concert with University of Maryland researchers to implement freight fluidity in Maryland and sponsored by the Maryland State Highway Administration:

‘Freight Fluidity’ is a broad term referring to the characteristics of multimodal supply chains and associated freight networks in a geographic area of interest, where any number of specific modal data elements and performance measures are used to describe the performance (including costs and resiliency) and quantity of freight moved (including commodity value) to inform decision-making (4).

This longer definition is provided here because it provides a more-detailed perspective on freight fluidity, one that touches upon the importance of the scale of freight fluidity which is the focus of this paper. This definition highlights that how “fluid” the freight network is can be captured by quantifying performance (including resiliency) and quantity of freight moved. The detailed elements of the definition are described further in [Table 2](#). The geographic area over which these elements are monitored could be a specific route (e.g., roadway, rail line, drayage line), supply chain (combination of routes and transload nodes), or statewide, regional, and global urban areas.

Some clarification of the selected suggested measures from [Table 2](#) is needed. The travel-time index mobility measure is defined as the ratio of the travel time during the peak period and the travel time during uncongested conditions. A value of 1.20 indicates that a trip that takes 30 min on average during uncongested conditions will take 36 min during the peak period (5). The planning time index reliability measure is defined as the ratio of the 95th percentile travel time during the

TABLE 2 Components of Freight Fluidity: Mind Your Freight Network “Ps and Qs” (4)

Components	Description	Selected Suggested Measures and Considerations ¹
Performance (“Ps”)	How well are the links/nodes and network operating? Where are there bottlenecks in the supply chain or freight network?	Mobility (e.g., travel time, total delay, delay per mile, travel time index); Reliability (e.g., planning time index); Costs ² (associated with delay, unreliability, wasted fuel).
	How well do supply chains and the system (infrastructure, users, agencies) react to disruptions (i.e., how resilient is the system)?	Resiliency ³ (or risk) has four aspects: Robustness (ability to withstand disruption, measured in time); Rapidly (time to respond and recover); Redundancy [alternate route (capacity) availability—access within a certain travel time]; and Resourcefulness (ability and time to mobilize needed resources).
Quantity (“Qs”)	How much freight is moved (and where)?	Volume (e.g., number of trucks, railcars, TEUs); Weight (e.g., pounds, tonnage); and Commodity value ² .

NOTE:

¹ These are selected measures and considerations. These measures are ideally obtained by mode and by commodity for complete supply chain and freight network evaluation. The measures are described in further detail in the text.

² Costs in the “performance” component and value in the “quantity” component capture the economic impact of freight fluidity. Methods to capture these economic values are documented elsewhere (5-7).

³ Resiliency (or risk) is an element of the “performance” component because current system resiliency is inherently captured in measures of mobility, reliability and associated costs. Note that the “4 Rs” (robustness, rapidly, redundancy, resourcefulness) of resiliency can typically be expressed in time, and hence, delay and associated cost measures. Resiliency is included in the freight fluidity framework here because it is critical for efficient goods movement during system disruptions. Evaluating and improving transportation system resiliency during disruptions serves to better understand and improve performance during challenging times of goods movement.

peak period and the travel time during uncongested conditions. It represents the amount of extra time travelers must plan to ensure they are on time for important trips. A planning time index (PTI) of 2.00 indicates a 30-min uncongested trip takes more than 60 min (30 x 2.00) only 1 day per month (5).

Table 2 includes costs in the “performance” component and the value in the “quantity” component to capture economic impact. Methods such as TTI’s Urban Mobility Scorecard capture costs of congestion due to wasted time and fuel due to congestion. The authors recommend similar methods for estimating congestion costs for freight fluidity. One way to estimate commodity values is the use of existing datasets such as FHWA’s FAF. The costs of unreliability are particularly impactful on the freight community, especially for just-in-time trucking operations. Because unreliability impacts different sectors, business practices, inventory, logistics and operations, etc. in varied ways, there is no universal agreed-upon methodology or “factor” to estimate the financial impact of unreliability.

Table 3 breaks down the phrases of the Maryland freight fluidity definition from the previous page into components for scoping questions that the analyst can use to better understand how freight fluidity is best applied to their specific application. The issue of “scale of analysis”—

he subject of this background paper—is implicit to all of the scoping questions highlighted in Table 3.

The second row of Table 3 specifically mentions geographic scale of the analysis. Many of the subsequent definition phrases (e.g., network performance, quantify of freight moved, etc.) also have a temporal scale component. The question of “scale of analysis” is twofold: spatial (geographical) and temporal (peaks, all day, seasonal, etc.).

Fluidity Scale

The specific spatial and temporal scales of analyses are best defined through consideration of the specific freight application. Before this paper discusses specific applications and related scales, the authors provide an illustration that can better represent the relationship to analysis scale and the performance measures that might be produced through a freight fluidity measurement system.

To better illustrate the concept of freight mobility and reliability, in 2010 researchers at TTI published the “freight box” illustration presented in Figure 1. As a box in three-dimensions, the three axes of the relationship for trucks are 1) geographic area, 2) commodity type and 3) time period. These axes directly relate to, and visually illustrate, the three critical issues under consideration; specifically, where is the area under study? (geographic area axis), what are the time periods of interest? (time periods axis), and what type of trucks are of interest? (commodity types axis). The freight box captures all elements of freight fluidity discussed earlier in Table 1.

Geographic Area

The first axis along the left-side of Figure 1 is the geographic area. Geographic area is certainly a key consideration of truck mobility and reliability. The transportation system naturally includes industry supply chains, bottlenecks, corridors, and/or gateways where freight mobility and reliability are critical for economic vitality. The geographic level of the analysis could be more aggregated as well—statewide, regional, or even global.

TABLE 3 Investigating Key Aspects of the Freight Fluidity Definition (4)

Freight Fluidity Definition Phrase	Scoping Questions for Analyst to Ask
“...multimodal...”	What freight modes are included?
“...geographic area of interest...”	What is the geographic scale?
“...specific modal data elements...”	What are types of data elements going into the analysis?
“...network performance...”	What network performance measures are needed? How well are the links–nodes and network operating? Where are the bottlenecks in the system?
“...quantity of freight moved...”	How much (volume, weight, value) freight is moved (and where)?
“...resiliency...”	How well does the system react to disruptions?
“...to inform decision making.”	What decisions do you plan to make with the freight fluidity network characteristics? What is appropriate study scale, measures, and study scope to ensure you can impact these decisions with the results?

Commodity Type

The type of commodity being transported (and associated value), and delayed in congestion, has economic implications. The axis along the bottom of the freight box is commodity type. Commodity types are typically identified per the Standard Classification of Transported Goods. Three commodity types and two truck types (size) are illustrated in Figure 2 though more can be tracked in the freight fluidity application. If the geographic area is a specific supply chain to analyze, the commodity type will be driven by the selected industry supply chain.

Time Periods

Trucking operations and freight movements in general, are sensitive to congestion levels or supply chain disruptions that change over time. The third axis incorporates the temporal aspects of goods movement by truck. The time periods illustrated in Figure 2 are peak period, monthly, seasonal, semiannual, and annual. Another example for the time period axis in Figure 2 are for a specific day (e.g., typical morning and afternoon peak periods as well as the off-peak periods between the peak periods).

Freight Box Contents

Now that there is an understanding of the axes, what is in the box itself? As illustrated in Figure 2, each smaller cube within the larger box contains information about the Ps and Qs (see Table 1). This includes mobility, reliability, quantity, and resiliency information by geographic area, commodity type, and time period for trucking operations.

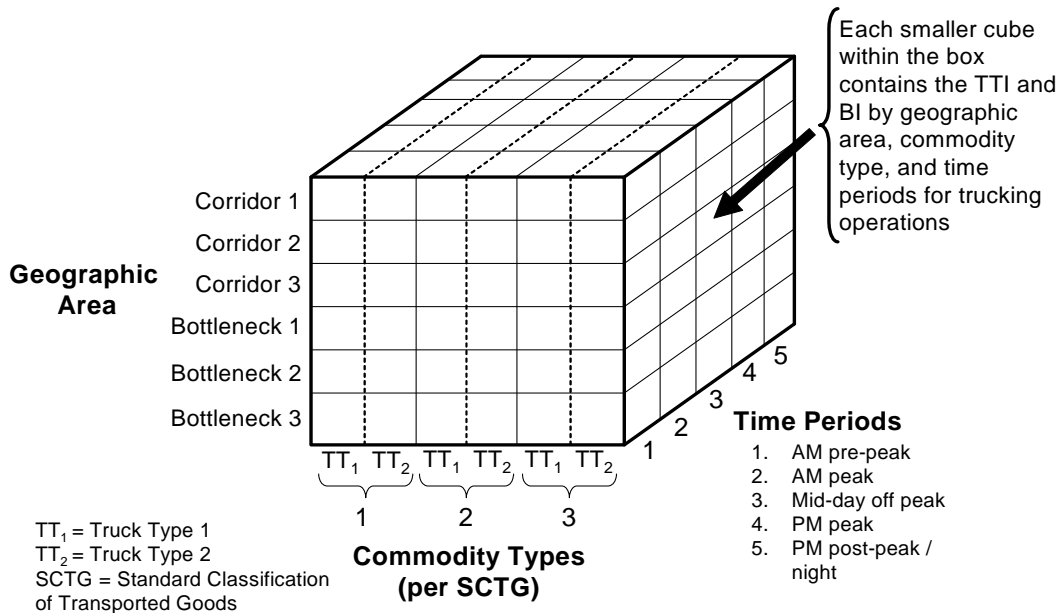


FIGURE 2 Freight box conceptual framework applied to trucks (7).

One could take this a step further for performance management and consider that for each geographic area of interest, there could be a box populated with “target” cubes that incorporate local goals and establish targets for the Ps and Qs. In concept, there would also be a freight box of “observed” cubes for each geographic area of interest. This cube would include the field observation of these trucking metrics. The two boxes (target and observed) could then be compared to identify where operation is satisfactory or unsatisfactory.

This framework applied to freight fluidity also has geographic scalability. A freight box can be developed for key supply chains, bottleneck locations, gateways, or corridors. Theoretically, portions of a state or region could have their own freight box containing cubes with freight mobility and reliability targets.

The framework shown in Figure 2 provides flexibility in analysis. For example, analyses could be categorized by industry (agriculture), large region (e.g., Midwest), or urban area. The framework is also flexible in that it incorporates improved datasets and broader analysis in the future. For example, if commodity information is not readily available, the “commodity types” axis might simply be “trucks” and “passenger cars” in the most basic sense. All trucks could be aggregated, and future adaptations of the methodology could include commodity types and truck size as more data become available. Similarly, there might only be interest in one or two of the time periods, and a shorter time scale can be used. In the development of the initial national freight fluidity measurement system, it is likely that additional datasets can be incorporated as data matures.

Considering All Freight Modes and Intermodal Facilities

While the discussion above has focused on urban trucks, Figure 3 shows the expansion of the freight box concept to all freight modes – a critical consideration because freight fluidity measurement systems should cover multiple modes. This includes truck, rail, maritime, air, and pipeline. The geographic scope and time period axes remain as before. In this illustration, the third axis is changed to include all freight modes along the bottom of Figure 3. While in Figure 2, truck type was used to represent the size of the truck, Figure 3 uses “transport type” to represent the “size” of the freight component used (e.g., double-stacking of rail, container ship size, cargo airplane size, pipe size).

In concept, the framework would apply in a similar manner as illustrated previously for trucks. Each cube within the box contains freight mobility and reliability information by geographic area, freight component, and time period. As before, the information in each cell can be a measured value or a target value based upon goals and objectives of the region(s) and community or communities. These can then be compared to observed conditions to identify needs.

This framework (and freight fluidity application) could easily be expanded to intermodal facilities, distribution centers, borders, or ports. The analysis could be disaggregated to the container level to assess mobility and reliability through intermodal facilities or supply chains at international gateways. For example, by removing the “Air” and “Pipeline” freight components from Figure 3, one could construct a freight box for an international supply chain that contains three corridors and three gateways using modes of truck, rail and maritime.

Certainly each freight mode or logistical structure would require a unique analysis and associated models. The different freight modes have unique operations and capacity constraints. Freight modes can be aggregated together by commodity value or tonnage or other appropriate value to obtain an aggregate index value for all freight in the area of interest. An example of this is shown elsewhere.

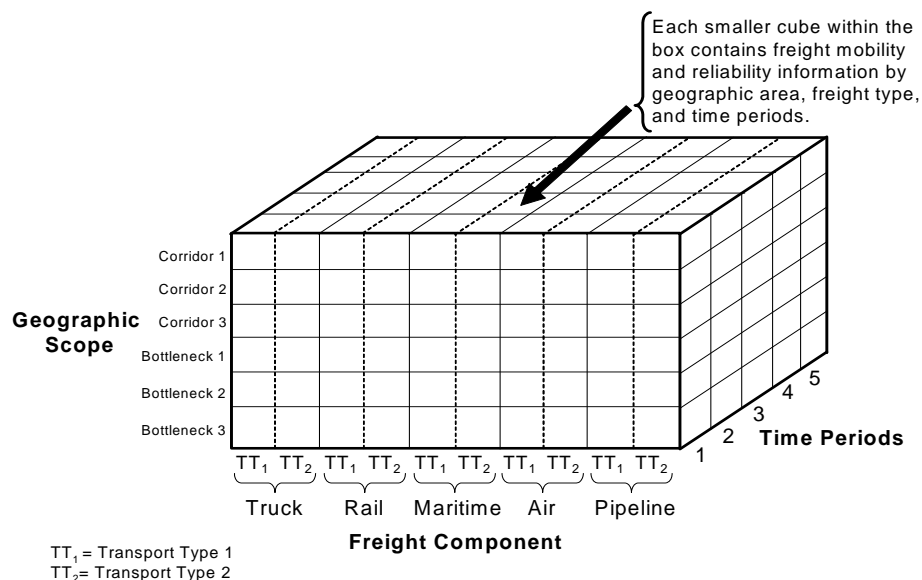


FIGURE 3 Expanded freight box for varied freight modes of the supply chain (7).

Analyzing Corridors and Gateways versus Analyzing Particular Supply Chains

Supply chains are directly related to industrial sectors, and this could be any step in the supply chain from raw materials, to production and distribution of final products. Supply chains are linked to economic development in a particular region where any step in the supply chain takes place. The freight fluidity analysis should not be viewed as an option of analyzing specific industry supply chains, corridors or gateways, rather the freight box concept is scalable allowing the visualization and fluidity analysis to be catered to any specific need (i.e., an analysis of an industry supply chain made up of several corridors and gateways, or an analysis of a particular gateway in the network irrespective of supply chains).

The actual scale of the analysis will be defined by the final goal of the user of the fluidity measures included. For instance, regional development agencies might be interested in a particular supply chain that generates employment in the region. This could be at a corridor level because the supply chain uses the transportation system in a corridor in a region, or at the gateway level because the region is in or near an international gateway (maritime port or land port of entry).

It is important to note that the performance of a particular supply chain is influenced by volumes of other commodities that use the particular corridor and gateway, so a systems approach is important. Adding the performance of all supply chains in the corridor or gateway, plus volumes of private vehicles for roadway corridors provides for system analyses.

Discussion of Fluidity Scale

Armed with an understanding of how to define freight fluidity and how to visualize the freight fluidity tool with the aid of the freight box concept, this paper turns to considerations for possible applications and related scales of analyses.

Table 3 illustrates potential users of the freight fluidity measurement tool, and the associated scales. A cursory review of Table 3 reveals four takeaways rather quickly:

1. Geographic scale is very broad—from the specific local roadway level to global;
2. There are two aspects of the temporal scale to consider:
 - a. What is the temporal scale of the analysis (as discussed in Figure 1 and Figure 2)?; and
 - b. How often will the freight fluidity analysis be updated?;
3. Because the geographic scale is the supply chain—this includes measuring fluidity along the links (segments of road, rail, etc.) and also at the nodes (transload locations or jurisdictional boundaries); and
4. Because the broad analysis scale shown in Table 3 can be daunting to consider all at once, there is a need to consider what is the “biggest bang for the buck” and focus on that geographic scale for the initial (beta) version of the freight fluidity tool rather than trying to meet the needs of all users immediately (see Table 3 shading).

The key is making the tool flexible for various scales and time periods, irrespective of the specific applications. Applications as we consider them now are only as good as our imaginations. While the authors have great imaginations, they are not so bold to think they have considered everything. There is no doubt that if the freight fluidity measurement tool is rolled out as envisioned, there will be many unanticipated users who will benefit from the tool. Therefore, the recommendation is that the tool be created in a flexible and expandable manner to handle the more common and anticipated industry uses, while planning for future updates after it is observed how varied stakeholders use the tool.

Recommendations and Considerations

Beginning with a definition of freight fluidity, this paper describes the scale of analysis anticipated for a freight fluidity measurement system. The paper describes methods to illustrate and better understand typical analysis scales and their implications as it relates to typical applications. In light of this discussion, the paper provides the following recommendations and considerations, organized around the three research questions proposed at the beginning of this background paper.

Geographic Scale

- Geographic scale is very broad—ranging from Main Street (local streets) to global supply chains (international), and any links or nodes in between; and
- Any discussion about geographic scale is inherently linked to the transportation application.

TABLE 3 Typical Jurisdictions and Uses with Associated Analyses Scales

Agency Jurisdiction (Examples)	Typical Geographic Analysis Scale	Typical Temporal Analysis Scale	Frequency of Analysis Updates	Example Use Case Question(s)
International (World Bank, private corporations)	Megaregion to global	Monthly, seasonal, annual	Seasonal, annual	How is the global supply chain operating? How is the country’s overall logistics operating? Are my client’s suppliers receiving goods in a timely manner?
Federal (FHWA, chambers of commerce)	NHS–national; global; borders (gateways) and interconnectors	Annual	Annual	Where are there bottlenecks in NHS continuity or connectivity? Where are delays in imports–exports?
Megaregion (MPO, COG, chambers of commerce)	Regional or even global	Seasonal, annual	Seasonal, annual	How does my region compete in comparison to peers–competitive regions?
State (DOTs)	Interstate and regional	Peak periods, monthly, annual	Monthly, annual	How are corridors on the state freight plan operating? How well are border crossings and ports operating?
Local (MPO, city, county, chambers of commerce)	Urban area or specific roadways	Peak periods	Seasonal, annual	Where are specific freight bottlenecks on Main Street?

NOTE: Shading indicates the possible geographic scale range of a beta (initial) freight fluidity measurement system—regional, national and borders/interconnectors (i.e., beta version likely excludes international uses given current data availability difficulties and likely excludes specific local roads where disaggregation of commodity flow data is difficult).

Options for Analyzing Corridor and Gateways versus Specific Supply Chains

- The freight box concept discussed in this paper provides a useful way to illustrate and understand all spatial and temporal aspects of a desired analysis (Figure 1 and Figure 2).
- Based on the definition of freight fluidity presented in this paper, key measures and considerations (freight Ps and Qs) are outlined that relate to the performance and quantity components of interest in the freight fluidity tool (Table 1).
- The freight box concept is easily applied to the freight fluidity Ps and Qs measures, and the analysis of these measures is possible along all geographies of the supply chain or at specific locations (gateways, corridors).
- The cubes within the freight box can be populated with performance measures of the existing conditions and compared to target cubes that incorporate local goals and establish

targets for the Ps and Qs measures, allowing the observed and targets to be compared to identify where operation is satisfactory or unsatisfactory in the freight network.

- Because the geographic scale is the supply chain—there is a need to measure fluidity along the links (segments of road, rail, etc.) and also at the nodes (gateways, transload locations, or jurisdictional boundaries).
- The freight box concept (Figure 1 and Figure 2) is temporally and geographically scalable to handle various supply chains, links, nodes, and time scales.
- The freight fluidity measurement tool should likewise be flexible—expandable geographically and temporally.
- The freight box concept can encompass specific supply chains for a fluidity analysis.
- A systems approach should be applied to capture the performance of all modes and supply chains.

Factors to Consider in Determining Level of Analysis

- This paper presents a definition for freight fluidity, and the components of the definition are linked to the scale of analysis (Table 2).
- Both spatial (geographic scale) and temporal scale of the analysis are important, and are defined based on the user's needs.
- Another important temporal consideration for the fluidity measurement tool is how often users will desire to update results (and the associated implications for data needs and data collection).
- Freight fluidity estimating over all geographic and temporal scales is generally feasible, limited largely only by data limitations—the subject of Background Paper 3.
- There is a need for the fluidity tool to focus initially on the areas of highest initial interest and use rather than trying to meet the needs of all users immediately (see Table 3 shading).
- The fluidity tool must be created with spatial–temporal flexibility (and expandability) to handle the more common uses initially with an eye toward future expansion as it becomes clearer how industry will use the tool.

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APPENDIX A: BACKGROUND PAPER 3

Data Options and Analytic Issues**JOSEPH BRYAN***Parsons Brinckerhoff***EXECUTIVE SUMMARY**

This paper is third in a series of four reports. It reviews the data options for evaluating freight fluidity in the United States and associated considerations for performance analysis. The overarching objective is to establish consistent, trackable end-to-end measurement of freight performance in supply chains. The paper proceeds from a market and user standpoint, in which total performance across the whole supply chain is the critical focus, and the end-to-end result is what matters to the market and to economic competitiveness. Defining an end-to-end supply chain profile—the course of the trip followed by the shipment of goods—entails understanding the sequence of plants, distribution centers, ports, terminals, modes and routes that may be involved. Selection of supply chains for a fluidity program should capture a cross-section of industrial types important to the economy and the welfare of the population. This is true at the national and the state or regional level, although as geography moves toward the local, supply chain activity is more likely to be a subset of a larger, end-to-end system.

The discussion of data sources in this paper concentrates on three factors, reflecting what is readily measurable and findings of the ACSCC of the U.S. Department of Commerce as to what is most important: speed or travel time; reliability or variability of travel time; and cost, expressed as the market price of transportation services. The data to be captured have two general facets. First are the operational components of intercity line haul, staging functions, and pickup and delivery functions. Second are modes; this paper examines trucking, railroading, and waterborne carriage.

The majority of fluidity data derives from private sources, since freight transportation is chiefly a commercial enterprise and the growth of data sources today is driven by commercial opportunity. Public sources established by mandate are the minority; the more recent model is private data purchased or accessed by government, such as the HERE and ATRI data supplied by the FHWA NPMRDS program. [Table ES-1](#) further summarizes the suppliers of U.S. freight fluidity data for travel time, reliability, and cost performance. Commentary on the suppliers appears in the body of the report.

Private data sources are not synonymous with data vendors, and both face challenges in moving from national level to nationwide data. For the former, a relatively small number of traffic lanes for key types of supply chains can serve as national indicators. For the latter, many more lanes in greater detail are required for statewide and metropolitan purposes, which can compromise the supplier's need for proprietary and confidentiality protection. Solutions have tended to involve intermediaries to aggregate and anonymize data, and to impose limitations on release and use. Even so, fluidity measurement offers a new market to private sector suppliers, and this fact can stimulate the expansion of services, the closing of data gaps, and the invention of fresh ways to reduce the barriers to doing business. Competition between vendors of mobile source data has already begun to demonstrate this. These points argue for a role for large public

TABLE ES-1 Fluidity Data Suppliers by Performance Dimension and Mode

Performance Dimension:	Data Suppliers by Mode:			
	Truck	Rail	Seaport	Waterway
Travel Time	<u>Roadway & border crossing:</u> <ul style="list-style-type: none"> FHWA NPMRDS ATRI INRIX, others <u>Basic estimate:</u> <ul style="list-style-type: none"> Google, others 	<u>Intermodal linehaul & dwell:</u> <ul style="list-style-type: none"> TransCore Railinc? <u>Carload linehaul & dwell:</u> <ul style="list-style-type: none"> RSI Railinc? 	<u>Vessel turnaround:</u> <ul style="list-style-type: none"> USACE/USCG NAIS <u>Truck turnaround:</u> <ul style="list-style-type: none"> ATRI <u>Shipment thruput:</u> <ul style="list-style-type: none"> Terminal operators? 	<u>Linehaul & lock:</u> <ul style="list-style-type: none"> USACE/USCG NAIS
Reliability	<u>Roadway & border crossing:</u> <ul style="list-style-type: none"> FHWA NPMRDS ATRI INRIX, others <u>Urban buffer:</u> <ul style="list-style-type: none"> TTI 	<u>Intermodal linehaul & dwell:</u> <ul style="list-style-type: none"> TransCore Ralininc? <u>Carload linehaul & dwell:</u> <ul style="list-style-type: none"> RSI Railinc? 	<u>Vessel turnaround:</u> <ul style="list-style-type: none"> USACE/USCG NAIS <u>Truck turnaround:</u> <ul style="list-style-type: none"> ATRI <u>Shipment thruput:</u> <ul style="list-style-type: none"> Terminal operators 	<u>Linehaul & lock:</u> <ul style="list-style-type: none"> USACE/USCG NAIS
Cost	<u>Truckload (van, reefer, flatbed):</u> <ul style="list-style-type: none"> Chainalytics 	<u>Intermodal:</u> <ul style="list-style-type: none"> Chainalytics <u>Carload:</u> <ul style="list-style-type: none"> STB CWS 	N/A	<ul style="list-style-type: none"> USDA (index) USACE PCXIN Operator Associations?

SOURCE: Joseph Bryan.

entities in making a market for fluidity data. This role could be filled by U.S. DOT or by multistate coalitions. The objective is to organize the market from the demand side by doing the following:

1. Simplifying the number and diversity of transactions;
2. Creating scale economies;
3. Incorporating proprietary and confidentiality protections;
4. Clarifying the market opportunity to attract competition; and
5. Assuring continuing demand for services.

ANALYTIC ISSUES: REPEATABILITY

Transforming fluidity data into effective management information entails a number of analytic issues touching on the character of data sources and the means and purposes of application. An essential consideration is that fluidity data are most informative in time series, because the direction and degree of change is a basic indicator of performance, and because it is not initially clear how to compare performance across multiple locations facing different conditions. This means that the repeatability of measurement is a crucial principle, and it is important in several dimensions. A prominent practical issue in working with fluidity data is difficulty in processing —yet the difficulty is greatest the first time an analysis is performed. When it is repeated, the same analytic routines can be employed, the set-up costs are lower, and the processing is more efficient. Another dimension of repeatability concerns data integrity. Private providers of

proprietary services handling confidential data may not share statistical evaluations; sample bias can be estimated but may not be fully known. However, the stability of the provider's process—the methods by which data are collected and processed—offers an alternative way to understand data integrity, because a consistent process should produce comparable results, and superiority of method is one of the ways competing vendors distinguish themselves. Thus the repeatability of process is a reasonably knowable and useful indicator.

COMPARABILITY

Performance across the stages of a supply chain must be totaled to produce the end-to-end result. Since supply chains commonly are multimodal, this means that measurement must use comparable metrics and reasonably comparable geographic units. Consistency is vital in the selection of time frames, whether for summing across stages or for analysis of time series, and is a fundamental way to control for such external influences on performance as weather and market demand. However, data costs can be an important constraint on the selection of time frames and the frequency of measurement. While annual and quarterly periods make the most sense for general performance tracking, such longer time frames can mean larger volumes of data, which can drive up expense. This can cause a data budget to seek a “lowest common denominator” in the form of a shorter time frame than may really be required for adequate interpretation. This point is another in favor of a data program organized by the federal government or multistate coalitions.

SCALABILITY

There are significant difficulties in the scalability of data. Roadway performance normally can be summed across a sequence of segments, allowing the local contribution to the larger result to be understood appropriately. Railroad performance cannot be summed this way because the unit of production is a train, composed for a particular lane and class of service, and a variety of types can operate over a line. If the line is congested, services may not be equally affected, because the railroad may prioritize one class of train over another. Costs in the form of the price of services also are specific to lane and class, in railroading and in all other modes. Price is sensitive to operating costs but is driven by market factors as well, making the local contribution to the lane price difficult to discern. One solution is to consider local productivity as a proxy for cost, which for motor carriage can be measured by reliability buffers. Scalability matters because local conditions do affect national results. Thus some indicators of the local contribution are necessary, and they should be comparable and repeatable.

PROGRAM IMPLICATIONS

Two broad implications for the formation of a freight fluidity program emerge from this paper. The objective is to construct consistent, trackable end-to-end measurement of supply chain performance. The purpose is to improve that performance by the institution of targeted policies and investment. Tracing performance across the stages of supply chains allows performance

deficiencies to be diagnosed in their location, mode and character. Private sector supply chain managements do exactly this so they can address performance in their processes and with their product and service providers. The requirements are the same for public performance management: there is a need for overarching managerial oversight of the end product, and the contributions of national and local providers must be diagnosed and addressed.

The second implication is that a national, multijurisdictional program is required, with a clear federal role and a likely role for multistate coalitions. The arguments in favor of this include market making, supplier negotiation in respect to usage restriction and price, continual exploitation of supplier innovations, and assurance of data integrity, consistency, and repeatability. The right next step is to begin negotiation with data suppliers, which will clarify the budget and restrictions, and allow serious exploration of the cost, conditions, and capabilities to undertake a larger, nationwide program.

INTRODUCTION AND SUPPLY CHAIN SELECTION

Third in a series of four reports, this paper reviews the data options for evaluating freight fluidity in the United States and associated considerations for performance analysis. The overarching objective is to establish consistent, trackable end-to-end measurement of freight performance in supply chains. As recognized in prior papers, this can be approached from a network standpoint, in which performance on infrastructure segments and corridors contributes to an assumed whole, and from a market and user standpoint, in which total performance across the whole supply chain is the critical focus. This paper proceeds mainly from the latter standpoint, for two reasons. First, the end-to-end result is what matters in the market and thus to the competitiveness of American industry and the national economy. Capturing it is a key way that fluidity measurement diverges from traditional practice. Second, the accumulation of segment performance requires a view to the whole for accuracy. For example,

- The route a truck may follow between origin and destination can be influenced by conditions and related temporal factors, so it is necessary to understand the trip in order to understand the performance achieved;
- Railroads compose trains on an origin–destination and industrial service basis, so that intermodal, carload and unit train service may be different on the same section of track, as can the service destined to different markets; and
- Cost construed as the market price of services is set by the origin and destination, influenced by but not determined by the route.

Defining an end-to-end supply chain profile—the course of the trip followed by the shipment of goods—entails understanding the sequence of plants, distribution centers, ports, terminals, modes and routes that may be involved. This is difficult to ascertain from commodity flow data because the flows are not linked. Thus, a shipment of food by rail from A to B may continue by truck from B to C, yet while both segments may be visible in the commodity data, their interconnection is not. Barring development of a supply chain approach to flow data, interviews with private industry have proven an effective alternative, and were used successfully in the Freight Performance Measurement pilot study prepared for the I-95 Corridor

Coalition (the I-95 Study). Beyond the obvious fact that industry has expert knowledge of its own activity, there were two further factors favoring success:

- A small sample of supply chain activity was selected for examination, which limited the reporting company's risk of exposing sensitive information to competitors;
- The performance data used to measure the supply chain trip came from outside the reporting company. This yielded a representative, market-based assessment of performance for public planning and monitoring purposes, without revealing the specific, confidential performance the reporting company was able to achieve.

Selection of supply chains for a fluidity program is a topic for another paper. Suffice it to say here that the selection should capture a cross-section of industrial types important to the economy and the welfare of the population. This is true at the national and the state or regional level. However, as geography moves toward the local, the likelihood grows that supply chain activity within the geographic boundaries is a subset of a larger, end-to-end system. Local boundaries may encompass:

- One end of the system and have local beneficiaries (producers or consumers);
- An intermediate staging point such as a distribution center (DC) that generates local jobs but may have less direct connection to other local economic activity;
- A pass-through corridor whose local participants are few if any, and whose performance has its greatest importance in other locales.

This in turn can affect the data relevant for measurement. For example, while prices for services are a good measure of cost for an origin–destination lane, the cost effect of the first and last miles of the lane may be better understood in terms of productivity. This point is discussed further below.

Factor Selection

The ACSCC of the U.S. Department of Commerce defined five main dimensions of freight performance in supply chain logistics:

- Speed, or travel time, including throughput or dwell time in staging facilities;
- Reliability, or variability of travel time, including the buffer time required to assure on-time arrival;
- Cost, normally expressed as the market price of transportation services;
- Safety, chiefly concerned with the incidence of fatalities, injuries, and property damage;
- Risk, which ranges from property theft to system disruptions and performance deterioration.

The ACSCC and the subsequent I-95 Study concentrated particularly on the first three—speed, reliability, and cost—because they are the most readily measureable on a national basis. They are typically the top criteria as well those purchasers of transportation services seek from their carriers. The discussion of data sources in this paper also will concentrate on these factors.

Functional Definition

The data to be captured for the depiction of supply chain performance have two general facets. First are the operational components between the producing point (such as a factory or farm) and the consuming point (such as a retail outlet or industrial facility). These can be summarized under three types of activity:

- Staging functions, such as distribution centers, terminals and ports;
- Pickup and delivery functions, such as drayage and other first, last, and transfer mile operations;
- Intercity linehaul, such as long distance travel by truck or train.

For public planning and management purposes, the performance inside private warehouses and DCs can be passed over as strictly an industry concern, but pickup and delivery activity serving such facilities occurs over public infrastructure and belongs in the public sphere. Railroad terminals could also be viewed as private operations, but railroads are common carriers and there is a public stake in their terminal functions as much as in the rest of their operations.

Modes are the second facet. This paper will examine trucking, railroading, and waterborne carriage, the last including marine and inland waterways and associated port activity. Consideration will be restricted to activity at and within the borders of the United States, so as to match the purview of most U.S. public agencies, and for the sake of simplicity will set aside special cases such as marine service to Hawaii. Air and pipeline modes will not be examined, in the case of pipelines because they are private infrastructure with little public data available. (Intermodal pickup and delivery functions—such as truck service from petroleum tank farms—are covered in most respects through the analysis of other modes, as would also be true for airport drayage.) Air is set aside for the pragmatic reason that it is the fastest and most reliable mode, and handles the least physical volume. While air is not free of performance challenges, it does not need to be a primary concern for the initial development of fluidity measures.

Data Sources

The I-95 Study conducted a reasonably thorough review of sources for speed, reliability, and cost performance by truck, rail, and water modes. This section begins by synthesizing its findings, and then continues with observations about data provision.

Data Suppliers

Table 1 below summarizes the suppliers of U.S. freight fluidity data in the performance dimensions of travel time, reliability, and cost, according to the modes they support. Commentary on the suppliers follows after the table, organized by dimension and mode.

TABLE 1 Fluidity Data Suppliers by Performance Dimension and Mode

Performance Dimension:	Data Suppliers by Mode:			
	Truck	Rail	Seaport	Waterway
Travel Time	<u>Roadway & border crossing:</u> <ul style="list-style-type: none"> FHWA NPMRDS ATRI INRIX, others <u>Basic estimate:</u> <ul style="list-style-type: none"> Google, others 	<u>Intermodal linehaul & dwell:</u> <ul style="list-style-type: none"> TransCore Railinc? <u>Carload linehaul & dwell:</u> <ul style="list-style-type: none"> RSI Railinc? 	<u>Vessel turnaround:</u> <ul style="list-style-type: none"> USACE/USCG NAIS <u>Truck turnaround:</u> <ul style="list-style-type: none"> ATRI <u>Shipment thruput:</u> <ul style="list-style-type: none"> Terminal operators? 	<u>Linehaul & lock:</u> <ul style="list-style-type: none"> USACE/USCG NAIS
Reliability	<u>Roadway & border crossing:</u> <ul style="list-style-type: none"> FHWA NPMRDS ATRI INRIX, others <u>Urban buffer:</u> <ul style="list-style-type: none"> TTI 	<u>Intermodal linehaul & dwell:</u> <ul style="list-style-type: none"> TransCore Ralininc? <u>Carload linehaul & dwell:</u> <ul style="list-style-type: none"> RSI Railinc? 	<u>Vessel turnaround:</u> <ul style="list-style-type: none"> USACE/USCG NAIS <u>Truck turnaround:</u> <ul style="list-style-type: none"> ATRI <u>Shipment thruput:</u> <ul style="list-style-type: none"> Terminal operators 	<u>Linehaul & lock:</u> <ul style="list-style-type: none"> USACE/USCG NAIS
Cost	<u>Truckload (van, reefer, flatbed):</u> <ul style="list-style-type: none"> Chainalytics 	<u>Intermodal:</u> <ul style="list-style-type: none"> Chainalytics <u>Carload:</u> <ul style="list-style-type: none"> STB CWS 	N/A	<ul style="list-style-type: none"> USDA (index) USACE PCXIN Operator Associations?

SOURCE: Joseph Bryan.

TRUCK TRAVEL TIME AND TRAVEL: TIME RELIABILITY DATA

- NPMRDS:** Data on truck travel times are available from FHWA’s NPMRDS, which is a repository of historical and monthly vehicle probe data. It provides a nationwide database of average roadway travel speed and times by five-minute increment for use by states and MPOs. Freight data are compiled by ATRI from satellite GPS truck position records shared by motor carriers and aggregated to protect confidentiality. Passenger vehicle data are compiled by HERE North America, LLC, from a number of sources including mobile phones, vehicles and portable navigation devices. The NPMRDS covers the entire NHS and reports travel time by road segments, which are of variable length and are identified by traffic message channel location reference codes. Segment distances are defined, and road numbers and names, latitude/longitude and direction are provided. Times are reported in seconds and computed at five minute intervals, 24 h daily for every day of the year. Highway segment data must be assembled into routes, and the travel speed along the routes must be calculated to represent temporal factors such as peak hour exposure and driver hours of service.

- ATRI:** The strong quality of ATRI’s data and its coverage of the NHS help explain its selection for the NPMRDS. Nevertheless, there are analyses ATRI can conduct that cannot be performed from the federal data set because ATRI is able to work from microdata under stringent confidentiality and usage agreements with its suppliers. The microdata follow the paths of individual trucks, which means that the routes selected are known, the time of day and seasonal variables are fully reflected and the hours of service effects are visible. Public agencies may purchase analyses from ATRI tailored to their needs.

- INRIX and others: The I-95 Corridor Coalition and a variety of state DOTs purchase probe data from INRIX, and there are other business vendors offering mobile source data of similar form. INRIX distinguishes travel by commercial vehicles and continues to develop sources to segregate freight traffic from other commercial types. Data are offered for route segments much as the NPMRDS provides, although it is conceivable that vendors could utilize source signatures to trace actual vehicle paths.
- TTI: TTI incorporates INRIX data in its publicly available Urban Mobility Scorecard, which measures roadway congestion and freight delay for a large number of cities of varying size. TTI estimates travel-time reliability through a PTI, which provides a buffer factor.
- Google Maps: Google and other widely available mapping software offer estimated travel times for specified routes. Mapping software increasingly reflects historical average times and utilizes crowd-sourced information to predict travel speeds based on current conditions. Averages can be combined with TTI buffer factors to produce approximations of transit time and reliability. Data must be accessed lane by lane and there is nothing specific to truck travel, but data are freely available and have an improving basis in empirical observation.

RAIL TRAVEL TIME AND TRAVEL-TIME RELIABILITY DATA

- Trans Core is a commercial vendor that collects rail performance data through its services in inventory tracking and freight management. Its coverage is limited to major intermodal lanes, for which it reports line-haul transit and terminal dwell times along with calculations of reliability derived from them.
- RSI Logistics is a commercial supplier that captures transit time and variability for rail carload traffic as part of its business in managing and tracking railcars, great numbers of which are owned or leased by shippers. Terminal dwell time presumably would be included, since railcars spend significant amounts of time in yards. The company does not track rail intermodal activity.
- Railing is a wholly owned subsidiary of the Association of American Railroads (AAR), on whose behalf it provides a range of customer and other services including equipment and shipment tracking and tracing. Railing has the capability of supplying comprehensive data on rail travel time and reliability, but it is not a commercial vendor and procuring data from this source would require the agreement of AAR membership.

BARGE TRAVEL TIME AND TRAVEL-TIME RELIABILITY DATA

- National Automatic (vessel) Identification System (NAIS). Waterway and port operations data are available from the U.S. Coast Guard (USCG) via the U.S. Army Corps of Engineers (USACE), and from port authorities. The USCG's NAIS is a high-quality, public source of travel time on inland and coastal waterways that the USACE accesses by agreement. Capturing GPS-based vessel locations and identities for navigation management purposes, its coverage of U.S. waterways is substantial and expanding. Custom handling is required, because the specific vessel position data are held in confidence, and USACE serves as an intermediary to aggregate and summarize data for approved applications.

PORT DWELL TIME AND DWELL TIME RELIABILITY DATA

- NAIS data can measure the turnaround time for container ships arriving at and departing port terminals. ATRI believes it is capable of capturing truck turnaround time at marine terminals by geo-fencing the location and observing truck arrival and departure times. However, from the shipment performance perspective, the critical metric is the elapsed time from ship arrival to shipment exit from the port, which can exceed both of the other measures. At this writing, the only systematic source for this information is individual port terminal operators.

TRUCK COST DATA

- Chainalytics is a benchmarking consortium of major shippers who share confidential information about freight shipping rates. Data are extensively cleaned and aggregated by a third party manager so that no participant's rates are visible to others. This is a high-quality, repeatable, primary source for freight cost information, covering truckload movements in dry vans, reefers and flatbeds. It encompasses long- and short-haul lanes within the United States and for U.S.–NAFTA shipping, defined by postal codes. The database does not include bulk or less-than-truckload carriage and no private or dedicated fleet costs are covered, although the truckload data can be used as proxy for many private and dedicated fleet operations.

RAIL COST DATA

- Chainalytics also tracks cost information for rail intermodal shipments, with the same coverage and quality as for truckload activity. It does not capture rail carload shipments.
- STB Rail CWS. The CWS reports railroad revenue (shipper cost) data for all sampled shipments and is used for regulatory purposes by the U.S. DOT's STB. The revenue data are masked but the figures for carload traffic are used as benchmarks by shippers and can be adopted as a representative fallback source for shipment cost information. The CWS covers NAFTA waybill traffic moving in the United States and among the United States, Canada and Mexico. It captures long- and short-haul rail moves, but it does not cover local shipments made on short line railroads. The CWS is available to U.S. DOT and to states from the STB.

BARGE COST DATA

- The U.S. Department of Agriculture (USDA) Agricultural Marketing Service reports weekly barge shipping rates as a percentage (index) of the 1976 tariff benchmark rate. Private-sector brokers provide current rate quotes based on the index. However, actual spot market rates and rates charged by barge operators owned by or under contract to major growers are not publicly available because there are limited numbers of carriers operating along major waterways. Nevertheless, industry experts suggest that it may be possible to obtain rate information from barge operator associations if the data were stripped of individual company and client identifiers. The USACE Planning Center of Expertise for Inland Navigation analyzes barge transportation economics and could be an additional source.

- Freight payment clearinghouses, such as Parsons (Cass), may capture some barge rate data. There is a charge for access and custom processing, which is necessary to satisfy confidentiality restrictions. Clearinghouses are also sources for cost data in other modes as well, but coverage is a function of the participating companies' customer bases, which are not uniform across industries and geographies and can change over time, so that analyses are not necessarily repeatable.

Data Provision

The majority of the fluidity data derives from private sources. This is not surprising since freight transportation and the supply chains it serves are chiefly commercial enterprises and the explosion of data in today's Information Age creates and is substantially driven by an enormous and continuing commercial opportunity. Public sources established by mandate, such as the STB CWS and the USACE AIS, are the minority and neither the mandate nor the design of the data program is motivated by fluidity measurement. The more recent model is private data purchased or accessed by government or contractors so as to make it public, and often accompanied by usage restrictions. Examples are the HERE and ATRI data supplied by the FHWA NPMRDS program, and the processing of INRIX data in the TTI Urban Mobility Scorecard.

Private data sources may or may not be commercial vendors offering data for sale, and their data programs may or may not be designed for public usage:

- Chainalytics is a private benchmarking consortium and not a data vendor. It appears willing to make data available for sale for public benefit and to aid in the funding of its operations, but whether that willingness extends from select national traffic lanes to broader and potentially more revealing coverage remains to be seen. Consortium members share data for aggregate, mutual benefit, but would have concerns if their data informed nonparticipating competitors.
 - RSI collects and sells railcar movement data to help shippers manage service and fleet utilization. It is a vendor and should be able to supply national data for select traffic lanes. Whether it can gear up for a broader program remains to be seen, and proprietary risks will arise if wide ranging data sets enter the public domain. Similar risks have been successfully treated through usage restrictions in the federal NPMRDS program, and by TTI through aggregation into indices and reliance on historical data (which has less commercial value than recent data).
 - Google offers roadway routing and travel time information through crowd sourcing and user tracking, supplied as a service but not assembled into data sets, and provided free because usage creates advertising opportunities. It is not freight data and therefore requires knowledge of truck routes for freight fluidity application.

This discussion brings out several points for development of a freight fluidity data program. First, private data sources are not synonymous with data vendors, and both face challenges in moving from national level to nationwide data. For the former, a relatively small number of traffic lanes for key types of supply chains can serve as national indicators. For the latter, many more lanes in greater detail are required for statewide and metropolitan purposes, which can compromise the supplier's need for proprietary and confidentiality protection. Suppliers may not have the capacity to serve this demand, nor know how to price their services

appropriately for a different kind of customer. Second, existing solutions to such challenges have tended to involve intermediaries to aggregate and anonymize data, and to impose limitations on release and use. Third, suppliers are mainly in the private sector and fluidity measurement offers them a new market. If the market is attractive enough, this fact can stimulate the expansion of services, the closing of data gaps, and the invention of fresh ways to reduce the barriers to doing business. Competition between vendors of mobile source data has already begun to demonstrate this, as each strives to improve and differentiate their products.

These points argue for a role for large public entities in making a market for fluidity data. This role could be filled by U.S. DOT or by multistate coalitions, although even in the latter case, use of federal program funds and development of standards and transactional models indicates a need for federal participation. The objective would be to organize the market from the demand side by (a) simplifying the number and diversity of transactions nascent vendors would need to contend with; (b) creating scale economies to reduce expense; (c) incorporating protections for proprietary and confidentiality interests; (d) clarifying the market opportunity in order to attract competition; and (e) assuring continuing demand for services to justify investment. Whether this is a long-term role or whether states and MPOs may emerge as individual buyers later will be learned over time. Both could occur, because the relatively small budgets devoted to public freight planning favor consolidation, and the diversity of freight activity and planning goals across the country favor some degree of local customization.

ANALYTIC ISSUES

Transforming fluidity data into effective management information entails a number of analytic issues touching on the character of data sources and the means and purposes of application. An essential consideration is that fluidity data are most informative in time series, first because the direction and degree of change is a basic indicator of performance needs and the success of implemented solutions, and second because it is not initially clear how to compare performance statistics across multiple locations facing different operating conditions. Are large cities necessarily comparable, or do we need to compensate for their density and modal networks? Looking ahead to the likely introduction of connected and automated vehicle systems, should a region that adopts them be expected to make performance gains or undergo a long shakedown period? The significance and comparability of measurements will not be well known until they have been collected multiple times.

Repeatability

This means that the repeatability of measurement is a crucial principle, and it is important in several dimensions. A prominent practical issue in working with fluidity data is difficulty in processing—as the I-95 Study puts it, the fact that “some assembly is required.” This is especially true for highway travel time and reliability data, because the size of the national network and the number of separate segments for which data are collected are vastly greater than any other mode. Origin to destination routes must be defined and the effects of time of day and DOT hours of service regulations on trip time must be represented. An alternative is custom processing by a supplier who can track individual trips from disaggregate data, which for reasons of confidentiality cannot otherwise be accessed. However, these difficulties are greatest

the first time an analysis is performed. When it is repeated, the same analytic routines can be employed, the set up costs are lower, and the processing is more efficient. This ought to hold true whether the processing is done by the user or the vendor. A corollary point is that once a set of supply chain measures is defined, it should be changed infrequently, both to protect efficiency and aid the interpretation of results.

Data Integrity

Another aspect of repeatability is concerned with data integrity. Private providers of proprietary services handling confidential data are not going to share statistical evaluations the way a public survey would. Sample bias can be estimated but may not be fully known. For example, Chainalytics principally works with Fortune 100 companies, whose market power may win them lower costs in some lanes; ATRI collects data from satellite tracking, which tends to be used by large national fleets and less by local carriers. However, more may be knowable about the methods by which data are collected and processed. The stability of process offers an alternative way to understand data integrity, because a consistent process should produce comparable results. While a vendor's methods also are proprietary and to some extent will not be revealed, a total black box is an unattractive product and superiority of method is one of the ways competing vendors can distinguish themselves. Thus the repeatability of process is a reasonably knowable and useful indicator, and combines with repeatability of measurements for a sound data program.

Comparability

Performance across the stages of a supply chain must be totaled to produce the end-to-end result. Since supply chains commonly are multimodal, this means that the measurement of travel time, reliability, and cost must use comparable metrics. This can be as simple as expressing time in terms of hours or days, or reliability as the same buffer factor, or it can be something more complex such as the representation of shipment costs in terms of loads or weight. Comparability of geographic units is necessary in time series, but can be somewhat looser in analysis of stage components. For instance, cost differences can be large between market areas, but typically are less so between zip codes within these areas, so that the loss of precision if a mixture is used probably is immaterial.

Time Frames

Consistency is vital in the selection of time frames, both for summing across stages and for analysis of time series. Time of day, day of week, time of month, position of holidays, and the seasonal effects of weather, harvest, and business cycles all can affect conditions, volumes, and performance. Costs can change because of freight demand or the markets for input factors like fuel and labor, reliability can change because market demand creates an equipment shortage. Consideration of influences like these is a normal requirement of performance analysis, but controlling for the same influences is crucial and assuring consistency of time frames is a fundamental way to do it.

Data costs can be an important constraint on the selection of time frames and the frequency of measurement. Annual and quarterly periods probably make the most sense for

general performance tracking, because they capture the major seasonal, cyclical and demand effects, although they average the influence of factors like time of day. However, longer time frames often can mean larger volumes of data, which can drive up the expense of data acquisition and processing. Moreover, the cost of acquiring full year data of one type might be lower than the cost of one month for another, depending on the vendor and the market they cater to. This can cause a data budget to seek a “lowest common denominator” in the form of a shorter consistent time frame than may really be required for adequate interpretation of external influences. How large a problem this may be has not been determined, because implementation of a full-scale fluidity measurement program has not yet been attempted, and serious budget negotiations with a full range of suppliers has yet to occur. If the concern proves out, it will be another element in favor of a data program organized by the federal government or multistate coalitions on behalf of state and MPO constituents.

Scalability

Even so, there are difficulties in the scalability of data, whether moving from the national to the local or the other way around. Roadway performance normally can be summed across a sequence of segments, allowing the local contribution to the larger result to be understood appropriately. Railroad performance cannot be summed this way because the unit of production is a train, composed for a particular lane and class of service, and a variety of types can operate over a segment of line. If the line is congested, services may not be equally affected, because the railroad may prioritize one class of train over another.

Costs in the form of the price of services also are specific to lane and class, in railroading and in all other modes. Price is sensitive to operating costs but is driven by load balance and other market factors as well, making the local contribution to the lane price difficult to discern. One solution is to consider local productivity as a proxy for cost, which for motor carriage can be measured by reliability buffers. The amount of work that a truck can perform in a day has substantial influence on the price it can afford to charge. The larger the buffer in a market area, the less work can be accomplished, the lower the productivity, and the higher the effective cost.

Scalability matters because local conditions do affect national results. End-to-end performance is the sum of supply chain stages, and if stage performance is not necessarily determined by local conditions, they certainly shape it. Returning to the railroad example cited above, services on a congested line are not equally affected because some may be prioritized. However, all services are at risk, and when line capacity approaches gridlock, every service is harmed. The conclusion is this: while stage performance is not always the total of local components, the components are material to the outcome. Thus some indicators of the local contribution—such as the truck productivity suggested above—are desirable to have, and they should be comparable and repeatable even when they cannot be summed to the stage measure.

PROGRAM IMPLICATIONS

Two broad implications for the formation of a freight fluidity program emerge from the matters discussed in this paper. The objective from a data perspective is to construct consistent, trackable end-to-end measurement of supply chain performance. The purpose is to improve that

performance by the institution of targeted policies and investment. Tracing performance across the stages of supply chains allows performance deficiencies to be diagnosed in their location, mode and character. Private-sector supply chain managements do exactly this so they can address performance in their processes and with their product and service providers. The requirements are the same for public management of performance: there is need for overarching managerial oversight of the end product, and the contributions of national and local providers must be diagnosed and addressed. Again from the data perspective, this means that local contributions must be measured. Where the local components are cumulative, as they are for travel time across roadway segments, data to do this are defined and available. Where the local components are not cumulative but do influence the stage result, as in the case of cost, the stage data are defined and available. The local influence requires further definition, yet as the discussion of productivity illustrates, the tools to capture it can be at hand.

The second implication is that a national, multijurisdictional program is required, with a clear federal role and a likely role for multistate coalitions. The arguments in favor of this from the data perspective include market making, supplier negotiation in respect to usage restriction and price, continual exploitation of the innovations of the Information Age, and assurance of data integrity, consistency, and repeatability. The larger argument is that end-to-end performance demands end-to-end management, as the supply chain users of the nation's transportation system can attest. The data budget requirement for a national program is not defined but appears in reach for a market basket of supply chain indices: probably on the order of several hundred thousand dollars, without transfer charges for the existing NPMRDS data set. The right next step is to begin negotiation with the suppliers, which will clarify the budget and restrictions, and allow serious exploration of the cost, conditions, and supplier capabilities to undertake a larger, nationwide program.

APPENDIX A: BACKGROUND PAPER 4

Freight Fluidity Measurement Program *Implementation Options*

LANCE R. GRENZEBACK
Cambridge Systematics, Inc.

SUMMARY

Information on how transportation supply chains perform from the perspectives of shippers, carriers and receivers is critical to knowing if supply chains are working or failing, and that information is, in turn, critical to determining if and where public investment or changes in policy and regulation might improve freight system performance and support economic competitiveness and growth.

This background paper outlines options for implementing a freight fluidity measurement program, which measures the general performance of representative transportation supply chains and their networks over time. It builds on the findings and conclusions of three companion papers that examined potential users and benefits, geographic scales, and data needs and availability for a freight fluidity measurement program. The key conclusions were the following:

- There are three potential markets for freight fluidity information:
 - Agencies and firms focused on international import–export trade;
 - Agencies and firms focused on domestic and North American (NAFTA) transportation supply chain performance; and
 - Agencies and firms focused on local and regional transportation supply chain performance.
- Three sets of data are available about supply chain performance:
 - Data on travel time, travel-time reliability, and cost for freight movement by domestic truck, rail and barge are available, accessible and affordable.
 - Data on travel time, travel-time reliability, and cost for freight movement through ports are available, but not readily accessible.
 - Data on supply-chain safety and risk are available, but generally not accessible.
- Consideration of the potential markets and the availability of data suggests that the order of priority for developing a freight fluidity measurement program should be as follows:
 - National–North American supply chain performance, focusing on travel time, travel-time reliability and cost for truck, rail, and barge moves;
 - Megaregion–metropolitan supply chain performance; and
 - Global supply chain performance.
- Finally, a freight fluidity measurement program must:
 - Be capable of measuring supply chains of different lengths, using different combinations of freight transportation modes and serving different industries;
 - Be applicable at different geographic scales;
 - Use measures and metrics that are common across transportation supply chains; and
 - Report trends in the high-level performance of the supply chains.

This paper outlines three options for implementing a freight fluidity measurement program:

- Federal program lead, focusing on measuring supply chain performance and network fluidity at the national and megaregion scales with subsequent expansion to support a North American system;
- State and local lead, focusing initially on supply chain performance and network fluidity at the metropolitan-, state-, and freight-corridor levels with subsequent expansion to the megaregion and national scales; and
- Private-sector lead, focusing on supply chain performance at the national and megaregion levels and serving public-sector clients at these or other scales as demand warrants.

INTRODUCTION

This background paper outlines options for implementing a freight fluidity measurement program—a program that measures the general performance of representative transportation supply chains and their networks over time.

- For the purposes of this paper, freight fluidity refers to the performance of transportation supply chains and freight networks.
- Freight fluidity can be a measure of the performance of a supply chain using a single mode or multiple modes of freight transportation.
- Freight fluidity can also be a measure of the performance of a freight network or freight corridor serving many supply chains.
- In current U.S. parlance, freight fluidity focuses on transportation supply chain performance measurement; that is, the measurement of the travel time, travel-time reliability, and cost of moving freight shipments from end-to-end of a supply chain.

A transportation supply chain is an end-to-end path of freight moves. A supply chain may be a trip accomplished by a single truck move or a trip accomplished by a combination of truck, rail, ship, airplane or pipeline freight moves. A supply chain may be a short trip within a single metropolitan area, state, or region or a long trip spanning regions and continents.

Information on supply chain performance is needed to fill a gap in public-sector transportation and economic development planning and investment. The public sector is accustomed to looking at freight transportation system performance in terms of network and corridor capacity, infrastructure condition and safety. As a consequence, transportation planners and engineers tend to focus on the average condition and performance of a system or facility, not on the performance of an individual trip or shipment moving through the network. Moreover, because their jurisdiction is often limited to a single state or metropolitan area, it is difficult for public sector planners and engineers to assess the end-to-end performance of supply chains, many of which extend across state and national boundaries. As a result, the public sector may not be as effective as it could be in making strategic investments in the freight transportation system that directly improve supply chain performance. The result may be a less cost-effective freight transportation system, with less competitive industries and lost economic opportunity.

Information on how transportation supply chains perform from the perspectives of shippers, carriers, and receivers is critical to knowing if supply chains are working or failing, and

that information is, in turn, critical to determining if and where public investment or changes in policy and regulation might improve freight system performance and support economic competitiveness and growth.

Information on transportation supply chain performance is also needed to support national freight system planning and reporting. In MAP-21, Congress declared that “It is the policy of the United States to improve the condition and performance of the national freight network to ensure that the national freight network provides the foundation for the United States to compete in the global economy....” Congress called for development of a national freight strategic plan, designation of a national freight network, preparation of a national freight network condition and performance report, and establishment of performance measures for states to use to assess freight movement on the Interstate system. Congress specified that all four actions were to be informed by performance measures.

A freight fluidity measurement program (or transportation supply chain performance monitoring system) would provide the middle of the three levels of information necessary for an effective Freight Performance Monitoring System. The three levels, illustrated in [Figure 1](#), are: information about the economy and the demand for freight transportation; information about supply chains—the paths along which freight shipments move—and end-to-end trip performance; and information about the condition and performance of the highway, rail and other networks and facilities that carry freight trips.

The U.S. DOT and the FHWA have successfully developed information for the top level—information about the economy and freight demand. The FAF describes and forecasts economic output by region and industry and the resultant commodity flows over the highway and rail networks. They have also successfully developed information on the condition and performance of the highway network for the bottom level. The HPMS provides detailed information on truck volumes and pavement conditions by roadway segment. The new NPMRDS complements the HPMS by providing information about truck travel speeds and travel times over the NHS roadway segments. The Rail CWS provides information on the types and tonnage of commodities hauled over the major rail lines.

What is missing is a sustained program at the middle level to describe and measure the performance of transportation supply chains—to understand how well the highway, rail and other networks support the timely and cost-effective completion of freight trips and whether those trips satisfy the needs of business and industry to compete and grow in national and global markets.

This paper outlines options for implementing a freight fluidity measurement system—a SCPMS—that will provide information on the travel time, travel-time reliability, and cost of freight trips over representative supply chains.

GUIDANCE FROM BACKGROUND PAPERS 1, 2, AND 3

This Background Paper is one of four papers commissioned to explore the feasibility of setting up a program to measure the fluidity of transportation supply chains and their freight networks.

- Background Paper 1 explored “who” and “why”—the potential users and benefits of a freight fluidity performance measurement system. It discussed the ways in which information about transportation supply chain performance might be applied and how that information might impact transportation planning, policy, regulation and investment.

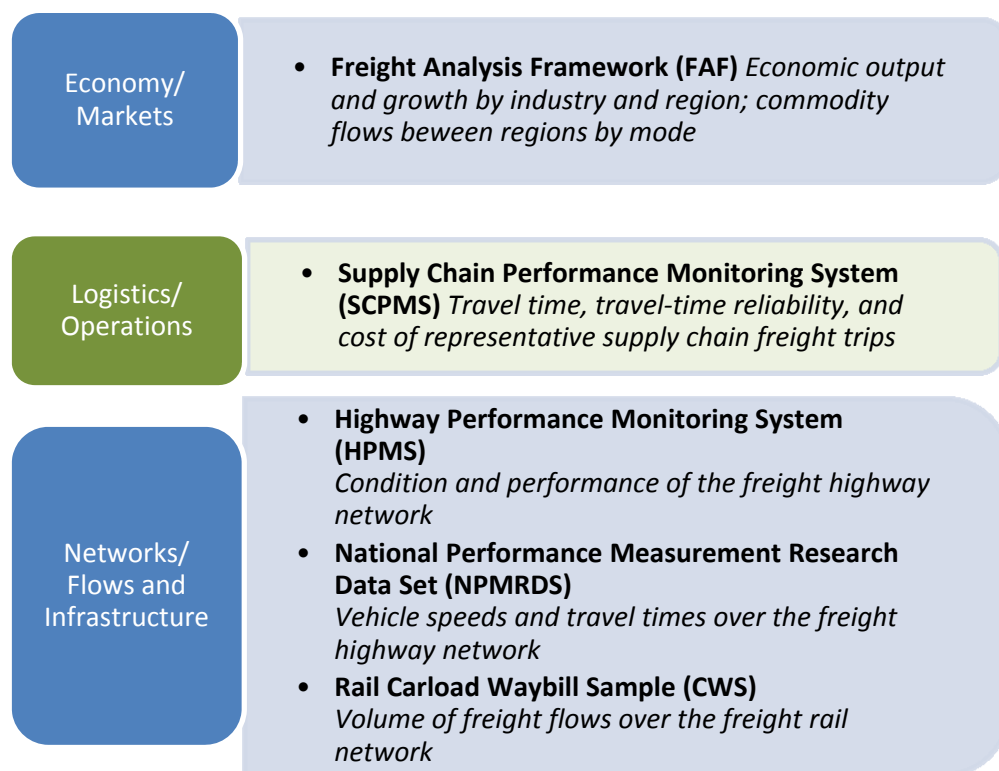


FIGURE 1 Freight Performance Monitoring System. (Source: Lance Grenzeback.)

- Background Paper 2 discussed “what” is to be measured—the scale and geography of a freight fluidity measurement program. What industries supply chains should be followed? How many? At the local, regional, megaregion, national or North American levels? How should freight trip performance be monitored along corridors, at gateways or across national borders?
 - Background Paper 3 described “how”—the data needed and available to support fluidity measurement. Are valid, reliable and affordable data available from public and private sources and how might the data be obtained and analyzed cost-effectively?

Background Paper 4 builds on the findings and conclusions of Background Papers 1, 2, and 3. The key conclusions of those papers were as follow:

There are three potential markets for freight fluidity information:

- Agencies and firms focused on international import–export trade; examples would include the U.S. Department of Commerce, the USDA, and private-sector shippers–receivers;
- Agencies and firms focused on domestic and North American (NAFTA) transportation supply chain performance; examples would include FHWA, state DOTs, regional freight coalitions and private-sector shippers–receivers; and

- Agencies and firms focused on local and regional transportation supply chain performance; examples would include regional coalitions, state DOTs, MPOs, and private-sector shippers–receivers.

Table 1 illustrates how the markets are differentiated by arraying potential users against the geography–scale of the supply chains of central interest to each.

Examples of potential users are shown in the rows. The geographic scale of transportation supply chains is shown in the columns. The letter entries in the cells indicate the expected level of interest in supply chain performance measurement by user and scale, where A is primary interest, B is secondary interest, and C is tertiary interest. For public agencies, the level of interest reflects their mandate and jurisdiction. The market clusters are indicated by the red ovals, but should be read as broad generalizations. In practice, there will be considerable overlap and variation in the level of interest across users.

Three sets of data are available about supply chain performance:

- Data on travel time, travel-time reliability, and cost for freight movement by domestic truck, rail and barge are available, accessible and affordable. Truck data are available from public and private sources. Rail data are available primarily from private sources. "Some assembly is required" in all cases.
- Data on travel time, travel-time reliability and cost for freight movement through ports are available, but not readily accessible. The accessibility of data on the movement of

TABLE 1 Potential Users and Scale of Application of Supply Chain Performance Measures

	Global	NAFTA	US	Mega-Region	State	Metro
USDOC	B	A	A	A	C	C
USDA	B	A	A	A	C	C
Private Firm	A	A	A	A	A	A
FHWA	C	A	A	A	B	B
Coalition	C	B*	B	A	A	A
State DOT	C	C*	B	A	A	A
MPO	C	C*	C	B	A	A

A = primary interest, B = secondary interest, C = tertiary interest
 * May be A if on major border crossing/trade lane

Source: Lance Grenzbeck

shipments through a port varies widely by port and terminal, reflecting differences in ownership and competitive position. Data on travel time, travel-time reliability and cost for freight movement by ocean-going vessels are available, but also not readily accessible.

- Data on supply-chain safety and risk are available, but generally not accessible.

Truck, rail, barge, port and ship safety data available from state and federal sources, but must be allocated to specific routes and then apportioned to representative supply chains, which is time-consuming, expensive and statistically challenging. Many shippers develop estimates of supply-chain risk, but those estimates are at least partially subjective and generally treated as confidential business information.

Table 2 summarizes the availability of performance measurement data and the approximate cost of acquiring the data by the type of measure (travel time, travel-time reliability, cost, safety and risk) and mode of freight transportation. The freight modes are shown in the rows; the trip performance measures in the columns. The letter entries in the upper left of each cell indicate the availability of data today. The dollar signs in lower right of cell indicate the anticipated cost to obtain and analyze the data. The ovals define the three sets of data as differentiated by availability and cost.

Consideration of the potential markets and the availability of data suggest that the order of priority for developing a freight fluidity measurement program should be as follows:

1. National–North American supply chain performance, focusing on travel time, travel time reliability and cost for truck, rail and barge moves;
2. Megaregion–metropolitan supply chain performance; and
3. Global supply chain performance.

Finally, the papers conclude that a freight fluidity measurement program must be:

- Capable of measuring supply chains of different lengths, using different combinations of freight transportation modes and serving different industries;
- Applicable at different geographic scales (multistate–megaregion, corridor, state and metropolitan) and be logically consistent with Canadian and Mexican freight fluidity measurement programs;
- Use measures and metrics that are common across transportation supply chains and can be readily scaled to different geographies, modes and networks; and
- At a minimum, be able to report trends in the high-level performance of the supply chains along the public and quasipublic freight transportation system links and nodes, that is, along highways and rail lines and through ports, which are the focus of most public-sector policy, planning, regulatory, and investment programs.

A freight fluidity measurement program should not duplicate the day-by-day and hour-by-hour performance tracking done by the shippers, carriers and receivers. That level of detail—usually treated as confidential business information—is not required to support most public-sector decisions. The program also need not capture detail on the time that freight shipments spend within private-sector warehouses and distribution centers. The time that shipments spend within warehouses and distribution centers affects the overall time required to move freight along a supply chain, but the dwell time within these facilities is determined and controlled by

TABLE 2 Availability and Cost of Supply Chain Performance Measures

	Travel/ Dwell Time	Travel- Time Reliability	Cost	Safety	Risk
Truck	A \$	A \$	B \$\$	B \$\$\$	B \$\$\$
Rail	A \$\$	A \$\$	B \$\$	B ?	C \$\$\$
Barge	A \$\$	B \$\$	B ?	C ?	C \$\$\$
Port	B \$\$	B \$\$	B \$\$	C ?	C \$\$\$
Ship	B \$	B \$	B \$\$	C? \$	C? \$\$\$

A = readily available, B = somewhat available, C = less available

SOURCE: Lance Grenzeback

private-sector business decisions and market conditions. The public sector will usually not have access to this information.

IMPLEMENTATION OPTIONS

Considering potential users and benefits, geographic scales, and data needs and availability, three options for implementing a freight fluidity measurement program are offered for initial discussion:

- Federal program lead, focusing on measuring supply chain performance and network fluidity at the national and megaregion scales with subsequent expansion to support a North American system.

The program would cover two dozen representative industries and supply chains, track their performance at the national and mega-region scales, and report on their performance quarterly or annually. Subsequent phases could add major North American trade routes and corridors and expand regional and state coverage through on-going planning grants to regional coalitions, states and MPOs.

The program would be designed primarily to inform federal policy and investment priorities in freight transportation and meet MAP-21 mandates. Responsibility for the program would be lodged with the FHWA Freight Office, which would assign two to three staff to the effort. The staff would be responsible for management of the program; procurement of data

collection, interview and processing services; and web-based dissemination of information to stakeholders. Once established, the FHWA could consider migrating the program to the BTS to ensure long-term consistency in data collection and reporting. For initial planning purposes, the program is assumed to be of similar scale and cost to the FAF program.

- State and local lead, focusing initially on supply chain performance and network fluidity at the metropolitan-, state-, and freight-corridor levels with subsequent expansion to the megaregion and national scales.

The program would track performance at the metropolitan-, state-, and freight-corridor levels, initially covering a dozen representative industries and supply chains in each of six megaregions (out of the approximately 12 U.S. megaregions). The objective would be to rapidly deploy a program that would build an atlas of information on upwards of 70 to 80 supply chains. Subsequent phases could expand coverage to other megaregions and focus on linking megaregions to provide national coverage.

The primary focus of the program would be to inform state and local freight policy and investment priorities and support local economic development. Lead responsibility for development of the program could be assigned to multistate coalitions or state DOT planning–freight offices in the larger state DOTs that have sufficient staff capacity. These groups would serve as program centers, with one to two staff in each center responsible for management of the program; procurement of data collection, interview and processing services; and web-based dissemination of information to stakeholders.

To ensure consistency across the program centers, a FHWA Freight Office liaison would be charged with coordinating the efforts of the centers. The development of data procurement, analysis and reporting methods and protocols could be accelerated through a TRB program, modeled after the SHRP programs, and by leveraging University Transportation Center (UTC) research grants. Again, for initial planning purposes, the program is assumed to be of similar scale to the FAF program, with the U.S. DOT funding the major share of the cost of the coalition- and state-operated centers.

- Private-sector lead, focusing on supply chain performance at the national and megaregion levels and serving public-sector clients at these or other scales as demand warrants.

The third option is to outsource the program to one or more private-sector firms (or consortia of firms). The private sector firms would track and report the performance of specific transportation supply chains as requested by their clients. The supply chains could range from local to global in scale and reporting could range from weekly to annually, depending on the jurisdiction and interest of the client.

Initially, U.S. DOT would be the primary client. Over time, it is expected that half of the clients would be federal agencies, including U.S. DOT, the U.S. Department of Commerce and the U.S. Department of Agriculture; a quarter would be a mix of regional coalitions, state DOTs and economic development agencies, and MPOs; and the remaining quarter would be private clients using the data for market research, benchmarking and investment planning. Each firm would likely dedicate five to eight staff to the effort. Coverage and continuity would be determined by client demand and the profitability of the service over time.

Table 3 summarizes these options. The program leads are shown in the column headings and the program elements are shown in the row headings. The elements used to define each option are:

TABLE 3 Implementation Options

		Federal Lead		State and Local Lead		Private-Sector Lead	
		Initial Phase	Subsequent Phases	Initial Phase	Subsequent Phases	Initial Phase	Subsequent Phases
Market-Mandate	What, When, Where	Track performance at the national and megaregion scales. Cover 2 doz. representative industries and supply chains. Report quarterly or annually.	Add regional and state coverage through grants or on-going planning funds to regional coalitions, states and MPOs. Add major North American trade routes and corridors.	Track performance at regional/metro scales. Cover a dozen representative industries and supply chains in each of six megaregions (out of ~12 regions?), so potentially upwards of 70 to 80 supply chains. Report quarterly or annually.	Add additional megaregion coverage. Add national coverage.	Track performance as requested by clients. Assume half of sales to federal clients, one-quarter to regional and metro clients and one-quarter to private clients. Report cycles range from weekly to annual.	Expands with market demand.
	Why	Inform federal policy and investment priorities in freight transportation. Meet MAP-21 mandates.		Inform state and local policy and investment priorities in freight transportation. Support local economic development.		Provide profitable data service to public- and private-sector clients.	

(continued on next page)

A d v a n c i n g F r e i g h t F i u i d i t y P e r f o r m a n c e

C o p y r i g h t N a t i o n a l A c a d e m y

TABLE 3 (continued) Implementation Options

		Federal Lead		State and Local Lead		Private-Sector Lead	
		Initial Phase	Subsequent Phases	Initial Phase	Subsequent Phases	Initial Phase	Subsequent Phases
Organization	By Whom	FHWA Freight Office	Migrate to BTS? Establish research program within TRB (SHRP X?) to develop methods, etc.?	Multistate coalitions and state DOT planning–freight offices in the larger state DOTs.	Leverage regional UTC programs?	One or more private firms.	
	How (process)	FHWA direction; contracted data collection, interview and processing services.		Contracted data collection, interview and processing services. FHWA liaison to coordinate programs.		Own or subcontracted data collection, interview and processing capabilities.	
Resources	How Much (funding)	\$__M/year (comparable to FAF program?)		\$__M/year		\$__M/year	
	Staff and Skills	2-3 responsible for management, procurement and dissemination.		1-2 per coalition or state responsible for management, procurement and dissemination.		5-8 responsible for management, procurement and dissemination.	
	Technology	Data storage and web-based dissemination to stakeholders		Data storage and web-based dissemination to stakeholders		Data storage and web-based dissemination to clients.	

Source: Lance Grenzeback

- **Market–Mandate.** What is covered (types of industries and supply chains)? When (time periods)? Where (geographic scale)? Why (benefits of using transportation supply chain performance information)?
- **Organization.** Who implements the program (allocation of roles and responsibilities)? How is the work done (data acquisition, analysis methods and dissemination procedures)?
- **Resources.** How much money is needed to develop and sustain the program (capital and operating budgets)? What staffing is required (number of people and skills)? What technology is required (specialized equipment, etc.)?

APPENDIX B

Attendees

Russell Adise
U.S. Department of Commerce

Stuart Anderson
Iowa Department of Transportation

Laurence Audenaerd
MITRE Corporation

Scott Babcock
Transportation Research Board

Scott Brotemarkle
Transportation Research Board

Joe Bryan
Parsons Brinckerhoff

Bruce Carlton
National Industrial Transportation League

Tina Casgar
San Diego Association of Governments

Miguel Gaston Cedillo-Campos
IMT Transportation Systems & Logistics
National Laboratory

Stephen Clinger
Federal Highway Administration

Scott Drumm
Port of Portland

Ronald Duych
Bureau of Transportation Statistics

Bill Eisele
Texas A&M Transportation Institute

Ryan Endorf
Office of the Undersecretary for Policy
U.S. Department of Transportation

Victoria Farr
Port Authority of New York and New Jersey

Chester Ford
Bureau of Transportation Statistics

Scott Greene
Federal Railroad Administration

Lance Grenzeback
Cambridge Systematics, Inc.

Michael Henry
Arkansas State Highway and Transportation
Department

James Hinckley
U.S. Census Bureau

Tiffany Julien
Federal Highway Administration

Nicole Katsikides
Federal Highway Administration

Matthew Klein
Federal Aviation Administration

Stephanie Lawrence
Federal Railroad Administration

Mai Quynh Le
Transportation Research Board

David Long
U. S. Department of Commerce

Donald Ludlow
CPCS

Subrat Mahapatra
Maryland State Highway Administration

Vicente Mantero
CH2M

L'Kiesha Markley
Maryland State Highway Administration

Thomas McQueen
Georgia Department of Transportation

Laura Mester
Michigan Department of Transportation

Deb Miller
Surface Transportation Board

Kenneth Mitchell
U.S. Army Corps of Engineers

Thomas Murtha
Chicago Metropolitan Agency for Planning

Vidya Mysore
Federal Highway Administration

Paul Newbourne
Aramada Supply Chain Solutions

Tom Palmerlee
Transportation Research Board

Birat Pandey
Federal Highway Administration

Marygrace Parker
I-95 Corridor Coalition

Alan Pisarski
Alan Pisarski Consulting

Caitlin Rayman
Federal Highway Administration

Emily Rhodes
New York City Economic Development
Corporation

Michael Ruane
Dealware Valley Regional Planning Commission

Kaveh Sadabadi
University of Maryland

Rolf Schmitt
Bureau of Transportation Statistics

Joseph Schofer
Northwestern University

Stephen Shafer
Maritime Administration

Jeffrey Short
American Transportation Research Institute

Seneca Sok
Maritime Administration

Michael Sprung
Bureau of Transportation Statistics

Anne Strauss-Wieder
North Jersey Transportation Planning Authority

Edward Strocko
Bureau of Transportation Statistics

Michael Sussman
OnTrackNorthAmerica

Louis-Paul Tardif
Transport Canada

Ford Torrey
American Transportation Research Institute

Paul Trombino
Iowa Department of Transportation

Katherine Turnbull
Texas A&M Transportation Institute

Juan Villa
Texas A&M Transportation Institute

Michael Williamson
Cambridge Systematics, Inc.

Johanna Zmud
Texas A&M Transportation Institute

APPENDIX C

Acronyms

ACSCC	Commerce Advisory Committee on Supply Chain Competitiveness
ATRI	American Transportation Research Institute
BTS	Bureau of Transportation Statistics
Caltrans	California Department of Transportation
CMAP	Chicago Metropolitan Agency for Planning
CO ₂	Carbon Dioxide
Commerce	U.S. Department of Commerce
ConOps	Concept of Operations
CWS	Carload Waybill Sample
DOT	Department of Transportation
EDA	Iowa Economic Development Authority
FAF	Freight Analysis Framework
FAST	Fixing America's Surface Transportation Act
FHWA	Federal Highway Administration
GDP	Gross Domestic Product
HPMS	Highway Performance Monitoring System
I/O	Input–output
IT	Information Technology
ITS	Intelligent Transportation Systems
MAP-21	Moving Ahead for Progress in the 21st Century
MEDC	Michigan Economic Development Council
MPO	Metropolitan Planning Organization
NAFTA	North America Free Trade Agreement
NCFRP	National Cooperative Freight Research Program
NITL	National Industrial Transportation League
NJRMTM-E	North Jersey Regional Transportation Model – Enhanced
NJTPA	North Jersey Transportation Planning Authority
NPMRDS	National Performance Measurement Research Data Set
POE	Port of Entry
RBMS	Regional Border Management System
SANDAG	San Diego Association of Governments
SCPM	Supply Chain Performance Measures
SHA	Maryland State Highway Administration
SHRP 2	Strategic Highway Research Program 2
STB	Surface Transportation Board
TEUs	Twenty Foot Equivalent Units
TMC	Transportation Management Center
TRB	Transportation Research Board
TTI	Texas A&M Transportation Institute

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