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**Workshop on Implementing a  
Freight Fluidity Performance  
Measurement System**

*September 5–6, 2018  
The Keck Center  
Washington, D.C.*

*The National Academies of*  
SCIENCES • ENGINEERING • MEDICINE



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TRANSPORTATION RESEARCH CIRCULAR E-C240

# Workshop on Implementing a Freight Fluidity Performance Measurement System

September 5–6, 2018  
The Keck Center  
Washington, DC

*Sponsored by*  
Federal Highway Administration  
Office of Freight Management and Operations

Edited by Kathleen Hancock  
*Virginia Polytechnic Institute and State University*

November 2018

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## Preface

Performance of the freight transportation system is important to shippers and carriers, planners and policy-makers, as well as the general public because it affects the efficiency and costs of goods and services, and thus the general performance of the economy. Freight performance measures guide decisions about operations, investments, policies, and regulations. During the past decade, interest has grown in measuring freight performance, including multimodal supply chains that move products from production to consumption to disposal. This workshop highlights recent developments in multimodal freight performance measurement, from developments in the United States to advances in North America and Europe. The workshop explored emerging tracking and measurement technologies, including blockchain, and examples of multisector data sharing to capture multimodal freight performance.

### MEASURES

The Transportation Research Board (TRB) Task Force on Development of Freight Fluidity Performance, chaired by Joseph Schofer of Northwestern University, carried out the detailed planning for the workshop. The views expressed in this E-Circular paper are those of individual presenters and workshop participants and do not necessarily represent the views of all participants, TRB, or the National Academies of Sciences, Engineering, and Medicine.

The planning committee represented planners, analysts, and data specialists. The 60 persons attending reflected organizational diversity as follows:

U.S. Department of Transportation	12%
Federal, other	13%
State d	12%
Local, regional ports	3%
Association–nonprofit	20%
University	12%
Industry–commercial	10%
Consultant	15%

The Federal Highway Administration Office of Freight Management and Operations provided funding to support the workshop expenses.

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# Introduction and Objectives for the Freight Fluidity Measurement Program

CAITLIN HUGHES

*Office of Freight Management and Operations  
Federal Highway Administration*

This is the third in a series of workshops focusing on freight fluidity, where people who have the information and the data and who know how to use it get together and produce results. The idea is that through these workshops and the fluidity work that the Federal Highway Administration (FHWA) has been doing, we, as a nation, will know where our goods are going and be able to apply that to policy decisions.

Some of you may know that the concept for this work was to understand what Canada has done in fluidity and bring it to the United States. Canada was able to make a huge impact in their national freight strategic plan. They were able to identify key ports and key facilities around the nation that they wanted to invest in to increase their competitiveness. We collaborated with them to develop our models to identify where our most important freight facilities are and how goods are moving from one mode to another. As scientists, data specialists, and policy experts, we are all interested in obtaining the best information to support decisions both within and across borders.

Interest in freight fluidity goes beyond FHWA. I speak periodically at the U.S. Department of Commerce's Supply Chain Federal Advisory Commission, which is group of 30 to 40 representatives of industry, and they are very interested in our work on fluidity. They want to know what we have learned and how that can be useful to them. These areas of practice are in the highest and best interest for government and private-sector involvement and collaboration to support decisions and investments.

From a related project to support the Freight Analysis Framework (FAF), FHWA is working with the private sector to build mechanisms to enhance data sharing. We have some agreements in place with companies that already see the opportunities that are available with improved understanding of our freight system. However, we still have a lot of work to do to build the appropriate relationships and agreements with the broader private sector. I encourage everyone to think about creative ways to share data so that we can advance this body of work. Some considerations include the following. Can we reframe what we need? Are we too expansive? Can we narrow our requests to target specific questions or decisions? Can we anonymize the data? Should we consider a third party to act as an impartial broker? How do we develop the relationships that give companies the comfort level that the data is appropriately used? Only with effective partnerships between the public and private sectors will these projects be truly successful.

We have a lot of work before us. Thank you for taking the time to be part of this workshop.

## PERSPECTIVES ON FREIGHT PERFORMANCE

# Importance and Impact of Freight Performance *A Shipper's Perspective*

**FRED TOWLER**  
*International Paper*

The importance and impact of freight performance is presented from the perspective of International Paper (IP) with examples from their experience, providing a shipper's insight into the interaction between freight fluidity and the transportation system.

### IN CONTEXT

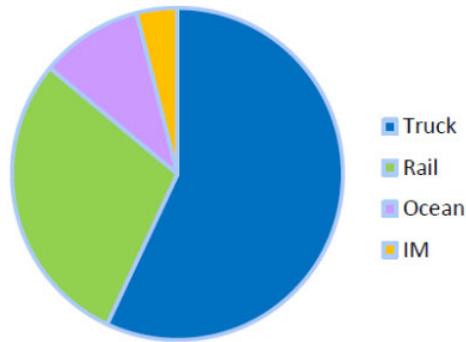
IP is a global producer of renewable fiber-based packaging, pulp, and paper products with manufacturing operations in North America, Latin America, Europe, North Africa, Russia, and India. We produce corrugated packaging products that protect and promote goods; for worldwide commerce including pulp for diapers, tissue, and personal hygiene products that promote health and wellness; and other paper products used to facilitate education and communication. We are headquartered in Memphis, Tennessee, and employ approximately 52,000 people located in more than 24 countries. Net sales for 2017 were \$22 billion. The company exports over 25% of what they produce domestically and relies heavily on freight performance to accomplish this.

IP operates a very large and complex supply chain. IP sources and acquires approximately \$16.3 billion in raw materials, operating supplies, and services used to manufacture products. Included in the \$16.3 billion are transportation costs of approximately \$2 billion. IP is the second largest exporter in the United States, shipping over 300,000 TEUs (20-ft equivalent units) and 500,000 break-bulk tons.

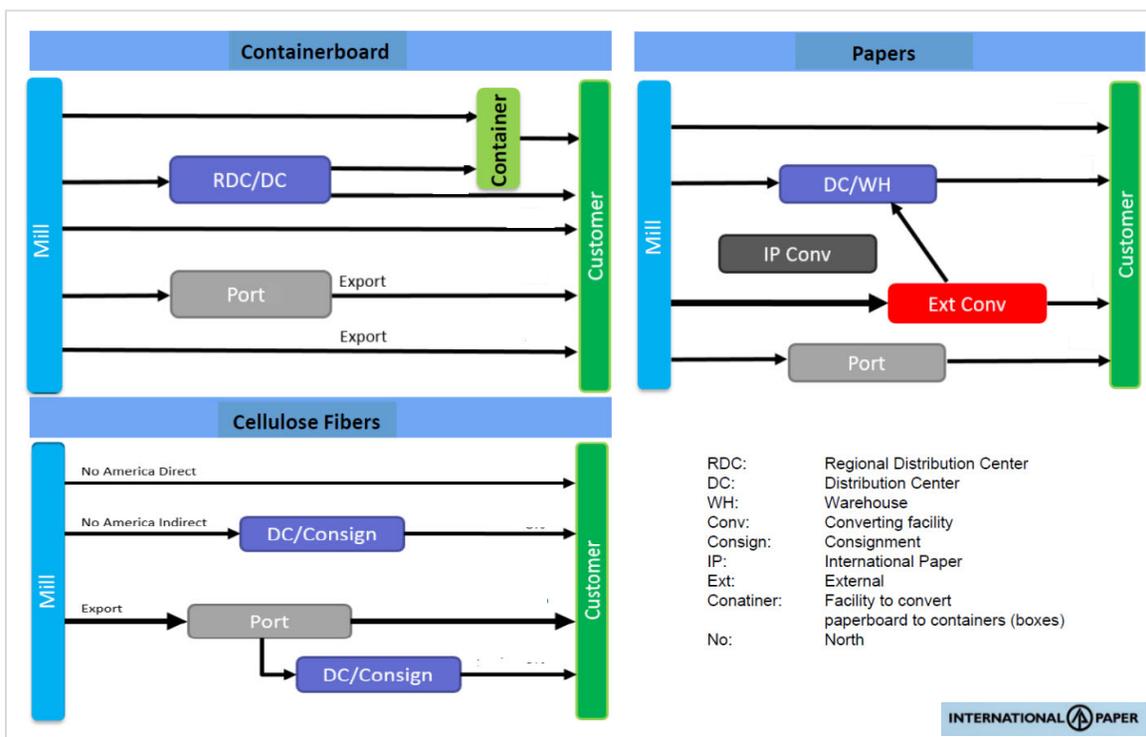
Even as a large shipper, IP is less than 1% of the market, which provides an indication of both the size and scale of the U.S. distribution network and the supply chains that are used. IP spends approximately 12% of their total costs on transportation, which is the second largest cost for the corporation. [Figure 1](#) shows the mode split for shipping products. When carriers and IP perform together, both benefit, and conversely, when they are not working coordinated, costs go up.

### FREIGHT PERFORMANCE

IP operates a set of complex supply chains. [Figure 2](#) provides a representation of these for each of their three primary businesses. In each schematic, the upper half of the diagram shows the in-country supply chain and the lower half shows exports. For example, containerboard is manufactured at their facilities and can be shipped to their converting facilities to be converted into finished boxes and shipped to the customer; shipped to a distribution center and shipped to



**FIGURE 1** Proportion by weight of shipments by mode.



**FIGURE 2** Multiple supply chains: complex integrated supply chain operating model.

the converting facilities and then to the customer; shipped to a distribution center and to the customer; or shipped directly to the customer. Pulp, or cellulose fibers, is primarily an export product with 85% shipped outside of North America. Approximately 60% of their paper or imaging business is shipped in country directly to the customer.

As indicated, IP has a vast network of mills, distribution centers, warehouses, and converters and it consumes an extensive amount of North American transportation capacity. Most of their facilities have an average of only 1 day of inventory space. While inventory is there to service the customer and ensure efficiency, too much inventory means cash is tied up and inefficiencies are produced. Therefore, it is critically important that the transportation network

perform effectively. When it does not perform, operations can be shut down which affects production.

An important consideration associated with the corporation's transportation consumption is the distribution between modes and short- and long-haul transport for each of its businesses. There are relative differences in ground transportation for each business line. Containerboard has a distinct short-mile and a long-haul-mile program. For greater than 500 mi, the dominant mode is rail. Less than 500 mi typically moves by truck. Papers move mostly by truck for distances shorter than 500 mi and is split between truck, rail, and intermodal for distances greater than 500 mi. In the North American pulp business, the mode by distance is similar to containerboard. However, the split by distance is reversed with the majority moving less than 200 mi, most of which are dray moves to ports for export.

When considering freight transportation performance, the customer is the primary driving factor for IP and customer's expectations are evolving. Even though IP is largely a business-to-business (B2B) corporation, the "Amazon Effect" is influencing operations<sup>1</sup>. Customers are asking, "Where's my truck," "Where's my product," and "When can I have it." In response, IP has implemented systems and measurements, which track this information. When the corporation performs as expected, customers reward it with their business. Nonperformance puts business at risk and customers sometimes pass the cost of inefficiency back to the corporation. The ability to deliver products on time depends on the fluidity of freight moving from production to consumption, which depends on effective partnerships between shippers and carriers, an optimal amount of inventory, and an effective transportation system.

Earnings also are impacted by freight transportation performance and are reflected in the areas highlighted in the following discussion. IP can lose revenue because of an inability to perform largely due to the transportation distribution network. Its facilities operate 24-7 including holidays and weekends. Transportation network disruptions result in overproducing inventory or sometimes shutting down facilities, which impacts productivity in terms of both output and labor. Similarly, operating costs increase. Cost to serve, an accountancy tool that analyzes how costs are consumed in the supply chain, allows IP to separate out the cost per ton associated with transporting product, providing an important measure of transportation performance. Increases in costs eventually affect working capital. When the system performs, efficiency improves which, for transportation, results in reduced emissions, which in turn enhances sustainability.

Some examples of metrics used by IP to measure freight transportation performance include the following:

- Actual number of shipments, accepted tenders, pick-up appointments, delivery appointments, and delivery appointments with arrivals for over-the-road carriers where each major carrier has its own scorecard;
- On-time shipments, boxcar supply, boxcar rejects, damage claims, boxcar dwell times, outstanding invoices for rail tracked by railroad;
- Rolled and split bookings<sup>2</sup>, vessel departing from port of loading, vessel departing from transship point, full container loaded for transshipment, full container discharged for transshipment, vessel departed from transship point, vessel arrived at port of discharge, full container discharged at port of discharge, empty container removed; and
- Transit time variability for ocean carriers.

To expand on rail and demonstrate why these metrics are critical, IP is one of the largest users of railroad boxcars in the United States. From September of 2017 to April of 2018, the U.S. rail transportation network experienced considerable variability across the entire system. Rail transit times dropped between 4% and 6%, which translates to a speed reduction of about 1 mph. At the same time, some of IP's facilities were disrupted by the inability of rail carriers to provide boxcars on a timely basis, which resulted in a direct impact to corporate earnings.

## **IN CLOSING**

Supply chain execution requires key abilities: sustainability, predictability, reliability, accountability, adaptability, visibility, and profitability. In particular, reliability: when the customer places their order with us, they want to know that their order is going to show up on time based on our promise to them when accepting their order. Next, there is a three-part accountability in making the whole supply chain work. Finally, visibility—if you can't measure it, you can't manage it. That is the ability to have visibility throughout the entire supply chain from the time that the order is placed to the time that it shows up on the customer's doorstep.

This has been a brief look into IP and its network and was intended to describe how the company transforms renewable resources into products that people depend on every day.

## **NOTES**

1. The Amazon effect is the ongoing evolution and disruption of the retail market, both online and in physical outlets, resulting from increased e-commerce. The major manifestation of the Amazon effect is the ongoing consumer shift to shopping online. <https://whatis.techtarget.com/definition/Amazon-effect>
2. A shipment loaded on a ship and delivered immediately.

## **PUBLISHER'S NOTE**

Transcribed and written for publication by Kathleen Hancock. Reviewed and approved by IP.

## PERSPECTIVES ON FREIGHT PERFORMANCE

### Freight Performance *A Broker's Perspective*

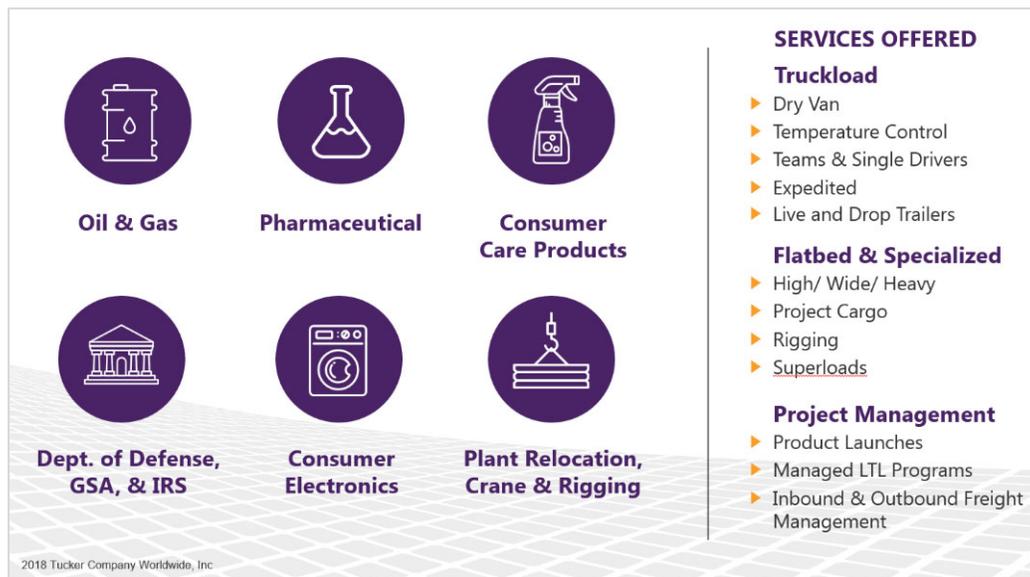
**JEFF TUCKER**

*Tucker Company Worldwide, Inc.*

#### IN CONTEXT

A freight broker is an intermediary that matches shippers with transportation services. A broker is able to leverage the shipments of multiple customers to obtain better pricing, and pass those savings on to their shipper clients. As such, they do not have any assets: no trucks or warehouses. Tucker Company Worldwide, Inc., has provided this service for more than 57 years and is the oldest privately held freight brokerage in the country. It is actively involved in both the shipper world, understanding what customers need, and in the carrier world, knowing the services available to meet that need. Tucker maintains a strong relationship with carriers, utilizes well-established transportation management tools, and implements ISO-audited processes to provide transportation capacity for large and small companies.

Tucker specializes in specific industries with unique requirements as shown in **Figure 1**. These industries have very different characteristics, but they all require knowing the individual client's standards of care and selecting the best carrier to meet their needs.



**FIGURE 1** Transportation services offered by Tucker Company Worldwide.

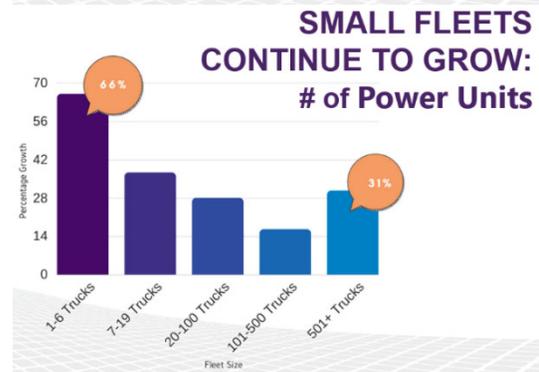
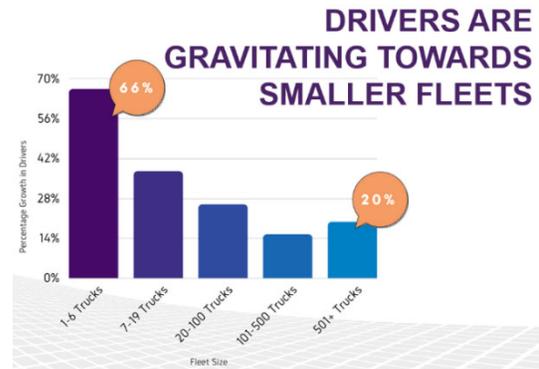
## PERSPECTIVE ON FREIGHT PERFORMANCE

Five factors that are affecting freight performance are presented: driver shortage and conversely fleet expansion, the economy, new regulations, the Amazon effect, and infrastructure.

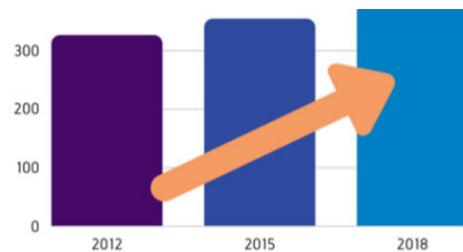
One of the things that is inherent in the trucking industry, even before the last 6 or 7 months, is a chronic driver shortage. For the last 10 to 15 years, driver turnover at large fleets is at or near 100%. This does not mean every driver changed companies but does include multiple turnovers for a relatively large percentage of drivers within a given year. This is still present in today's environment, but what is different is that drivers are offered larger incentives to move around. For example, some signing bonuses can be as high as \$50,000 for a team of drivers. Given that four of the top 10 reasons that drivers leave a carrier relate to money, this results in a lot of churn. As a result, large carriers are having difficulty retaining drivers, making them feel as if they are experiencing a driver shortage.

However, [Figure 2](#) shows what has been happening behind the scenes based on Federal Motor Carrier Safety Administration (FMCSA) data. Despite the driver shortage narrative, all size fleets are growing. Drivers are steadily joining the industry, but they are gravitating to smaller fleets and not necessarily one-truck owner-operators. In the last 6 years, approximately 229,900 drivers have been added to fleets of one to 19 trucks. In fleets of 501 and greater, approximately 154,950 drivers have been added. The second graph shows similar growth by power units. This is completely the antithesis of what is happening in every other market. The last two graphs demonstrate that the trucking industry is expanding not consolidating: 56 more carriers with 501 or more trucks are in business today than were 6 years ago and the total number of trucking companies is exploding.

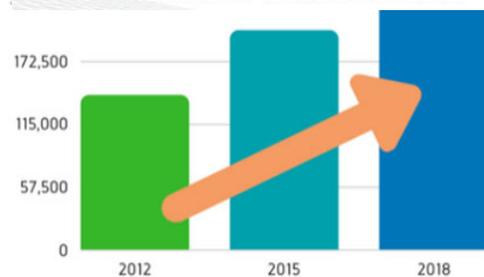
A big reason this is happening is technology. The tools that are available today to



### TRUCKING INDUSTRY IS EXPANDING NOT CONSOLIDATING



There are 56 more carriers in business with 501+ trucks since 2012



The total number of trucking fleets is at an all time high

Source: QualifiedCarriers.com – FMCSA data, Feb 2012 – July 2018

**FIGURE 2** Carrier trends.

trucking organizations at the owner–operator level are extraordinary. Data companies like truckstop.com and DAT provide a suite of technology tools to smaller trucking companies, which allows them to compete with the larger firms. Not only can they see the going rate today, but also they can see it over the last 7 days providing them unprecedented negotiating power. Carriers have visibility into what the market is doing in ways they have never had before. Because this technology is economical, replicable, and readily available, it is infused across nearly all operations.

The United States is in the second-longest economic recovery in its history and only half a year away from setting the all-time record. The current environment is similar to what happened in 2003 to 2005 growth period. Industry trends are indicating large increases in truckload demands. From DAT Trendlines, spot market loads are up 45% year over year for July 2018 to July 2017. Similarly, van load-to-truck is up 41% and flatbed load-to-truck is up 21%. Reefer load-to-truck is the only category that has remained stable. (Source: DAT Trendlines, August 18, 2018). These increases are on top of similar year-over-year increases from 2016 to 2017.

The current gradual economic recovery has had the impact of stretching thin the capacity of supply and demand, which has resulted in the market having less ability to absorb even minor disruptions. A recent polar vortex caused a ripple effect across the entire country. Regardless of where the storm occurred, within 2 days deliveries and pickups around the country were delayed. Additional factors are putting pressure on a system that is close to equilibrium and capacity, including the implementation of electronic logging devices (ELDs), the Food Safety Modernization Act, and the “Amazon effect.”

In January 2018, the ELD rule went into effect requiring all trucks to have a device that tracks a driver’s hours. Drivers can no longer modify their logbooks or have duplicate logbooks. Experts predicted overall capacity would experience a 3% to 7% capacity reduction. In an environment where a polar vortex caused a disruption around the entire country’s supply chain, the impact of ELDs had a significant impact on the market earlier this year.

An interesting and unexpected secondary effect that was shared anecdotally at a recent technology conference results from technology that provides drivers with their route, the hours that they have remaining and the location of a safe and available parking spot for the night. Drivers will stop 30 or 40 mi short of their hours to ensure compliance and, possibly, a shower. This means less miles are driven in a given day, which also affects overall capacity.

For transport of goods that require temperature-control, the Food Safety Modernization Act expanded the responsibility of food producers or owners, motor carriers and, when applicable, the broker. These responsibilities involve data integrity for the protection of the transported food. This is important because, prior to this Act, owner–operators were the backbone of the food hauling industry and many did not have the technology to record and track the temperature of their loads. As a result, food manufacturers began looking for alternatives but the Food Safety Modernization Act was enacted at the beginning of the capacity-constrained environment discussed earlier. The compounding factors resulted in shippers moving to larger, more tech-savvy fleets. In addition, some large pharmaceutical shippers began preemptively moving more of their products temperature control, increasing competition for refrigerated carriers.

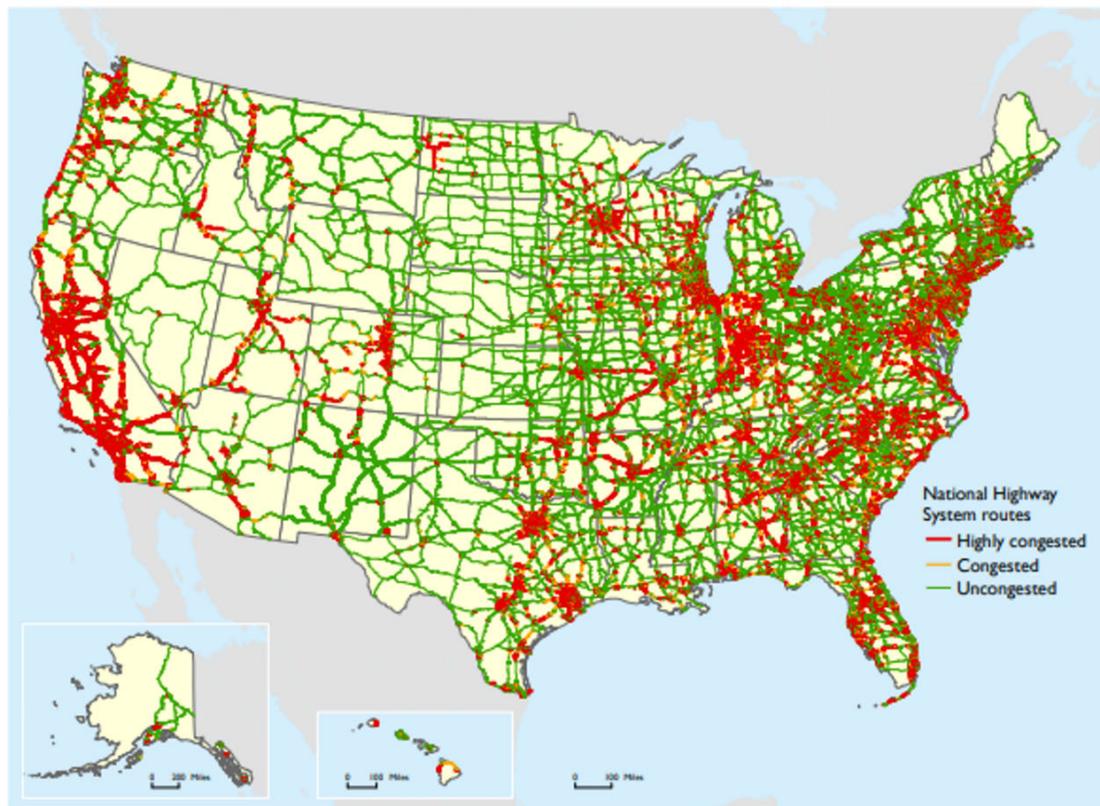
The Amazon effect is affecting the industry in several ways. In response to “I want it now,” retailers have implemented stricter delivery compliance fees. Last year, Walmart was one of the retailers that countered by reducing their delivery window from 3 days (the day before, the day of delivery, and the day after) to day-of delivery. In the new environment, a Walmart shipper potentially pays a penalty of 3% of the invoice value for the quarter of all product shipped if they

do not meet Walmart's requirements, which could easily translate to between \$1 and \$2 million per quarter in fees. Speed to market is critical.

The transportation infrastructure is stressed. Predictions for traffic in 2045 indicate large areas of congestion as shown in [Figure 3](#). This is potentially an under-representation of the problem. Consider the fees and penalties associated with speed to market. Customers who used to ship less-than-truckload (LTL) shipments with LTL carriers are now shipping a partial shipment as a half-empty truckload to ensure that it arrives at the customer on time, thus increasing trucks on the road. Warehousing has become an in-and-out event with transportation being the governing factor.

## IN CONCLUSION

One of the focuses of this workshop is metrics. One important metric from the "29th Annual State of Logistics Report" produced by A.T. Kearney in partnership with the Council of Supply Chain Management Professionals and Penske Logistics showed the cost of logistics as a percentage of gross domestic product (GDP) from the 1980s through today<sup>1</sup>. The United States has a \$15 trillion economy, and logistics costs are approximately 7.6% of GDP. Let that be justification to making infrastructure improvements—it is essential to being able to move our goods efficiently.



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, Version 4.3.1, 2016.

**FIGURE 3** Projected peak-period congestion on the National Highway System: 2045.

In my article published in the *Defense Transportation Journal* (<https://www.jstor.org/journal/defetranj>) on the anniversary of the highway system, I called the highways a national treasure, a national resource. Highways are a key piece of infrastructure that helps the United States grow, prosper, and compete effectively in the marketplace. With the increased urgency associated with deliveries and on effective transportation, it has never been more important. We need to nurture the highways, roads, bridges, and intermodal connections so that products move effectively, ensuring the future of the United States.

#### **NOTE**

1. [https://www.logisticsmgmt.com/article/29th\\_annual\\_state\\_of\\_logistics\\_report\\_carriers\\_take\\_the\\_wheel](https://www.logisticsmgmt.com/article/29th_annual_state_of_logistics_report_carriers_take_the_wheel).

#### **PUBLISHER'S NOTE**

Transcribed and written for publication by Kathleen Hancock. Reviewed and approved by Tucker Company Worldwide

## PANEL DISCUSSION SUMMARIES

### United States Achievements and Innovations

**NICOLE KATSIKIDES**

*Texas Transportation Institute, moderator*

**SCOTT DRUMM**

*Port of Portland, recorder*

This session focused on the state of the practice in the United States. As presented in the opening session, interest in the concept of freight fluidity measures began several years ago in the United States, following the lead of other nations, particularly Canada. The session began with framing the importance of freight fluidity and measuring freight performance, which are critical to telling the story of freight, why the public sector needs to invest in freight infrastructure, and how it ties to economic well-being.

National, state, and local agencies in the United States have begun to develop and apply fluidity concepts when measuring freight performance. Nationally, FHWA continues to focus on the concept through work with the I-95 Corridor Coalition. At the same time, other federal, state, and local government agencies have begun to incorporate freight fluidity measurement tools and concepts into their own freight planning and programming. The panelists showed how they have applied these concepts to support the improved performance of their respective freight systems. While challenges remain with collecting and analyzing this kind of multimodal data, this session demonstrated how this approach supports public-sector decision-making.

#### **DEVELOPING FREIGHT FLUIDITY IN MARYLAND**

Subrat Mahapatra, *Maryland Department of Transportation*

Like most other state departments of transportation (DOT), Maryland faces many challenges in managing its transportation system: changing demographics, continually increasing freight volumes, emerging technologies and their role and impact, congestion and reliability, funding, and aging infrastructure. The state is home to a number of large, freight-generating facilities, such as the Port of Baltimore, Baltimore–Washington International Airport, and rail yards and intermodal facilities in addition to the highways system. Freight in Maryland accounts for about one-third of the state's jobs as well.

The State Highway Administration (SHA) is folding fluidity concepts and measures into its Transportation System Management and Operations (TSMO). Traditionally, the SHA has used performance measures such as truck average daily traffic–vehicle-miles traveled (ADT–VMT), delay, and incidence clearance times. Now it is turning to fluidity-based measures to evaluate and manage the system. These include accessibility/connectivity, reliability, identifying whom the system serves, and feedback on user experience. These fluidity measures will guide investment decisions and prioritization so the state more accurately understands what is needed and where and when.

Applying freight fluidity measures enables the SHA to understand the system multimodally, spatially, and temporally. By viewing the system's performance from a supply chain perspective, understanding origin–destination (O-D) patterns, resiliency, and reliability, SHA can identify and monitor the performance of key freight segments. They can display this kind of data and analysis using visualization tools to better tell the story to decision-makers.

A future need SHA has identified is to understand how connected vehicles interact with fluidity measures. Specifically, SHA staff will need to know what data is created and what data they need to make decisions.

## **FREIGHT FLUIDITY TEXAS: STATEWIDE**

Casey Wells and Eduardo Hagert, *Texas DOT*

Texas DOT is using freight fluidity measures to help with project prioritization and selection, and to identify bottlenecks in border-crossing corridors. By using supply chains as the frame of reference, Texas DOT is able to identify where problems are most acute and prioritize projects accordingly. Appreciating the value of fluidity measures, the DOT has a strong desire to align with other local, state, and national freight fluidity initiatives.

Texas uses a variety of both performance and quantity-of-goods-moved measures for each mode of transportation. Among others, these include travel time, reliability, and the cost of moving freight by different modes. One example of the application of fluidity measures is the identification of specific bottlenecks within congested segments of the system. Using the Urban Mobility Scorecard's top 50 freight bottlenecks list, Texas DOT identified a portion of I-35 in the Dallas–Ft. Worth area as a key segment for assessment. It then applied fluidity measures to identify when and where the specific chokepoint occurred within that segment.

Challenges it faces are knowing what the measures are, what data is available, how it can be collected, and how best to communicate information. Nonetheless, the DOT has found freight fluidity measurements to be helpful, and that this framework helps prioritize freight projects, aids in improving the Texas economy by improving local freight infrastructure, better defines possible solutions, and focuses on improvements that can create and attract jobs

The DOT also applies fluidity measurement to better understand and improve trade flows across the border between Texas and Mexico. This is the first application of freight fluidity at the U.S.–Mexico border. While delays at the border itself are well-documented Texas DOT wanted to know whether the border crossing was delaying freight or if there are other bottlenecks along the supply chain from the origin in Mexico through truck yards on both sides of the border to the destination in Texas. To do this, Texas DOT is developing a Border Fluidity Index (BFI).

This BFI consists of data on travel time, travel time reliability, transportation cost, and the volume of goods along each segment of the supply chain. The DOT is in the process of developing a long-term plan for BFI implementation to guide how they will calculate the index. The plan will focus on identifying key supply chains, finalizing data requirements, establishing incentives for data providers, developing data processing and dissemination procedures, and ultimately calculating the BFI.

## **MEASURING WATERBORNE FREIGHT SYSTEM PERFORMANCE VIA AUTOMATIC IDENTIFICATION SYSTEM DATA**

Kenneth Mitchell, *U.S. Army Corps of Engineers*

Automatic identification system (AIS) data is key to using fluidity measures in understanding the performance of the waterborne freight system. AIS provides real-time vessel data, including vessel identification, location (latitude–longitude coordinates), date–time stamp, course, course over ground, and vessel characteristics. While this real-time data is invaluable, historical analyses are also useful. For example, fluidity assessments using historical data can identify subtle events that only emerge when looking at the system as a whole, not just at individual vessels.

The U.S. Army Corps of Engineers (USACE) has developed several applications of fluidity using AIS data. One application is lock operations management. This includes lock planning and maintenance, current conditions on the system, and an operational view of the entire system. The data provides new insight into interactions between individual vessel operators and the system.

Another application is the Inland Marine Transportation System Travel Time Atlas. Currently in development, the Atlas will provide real-time data to vessel and infrastructure operators for voyage planning and operational decision-making. The Atlas will employ fluidity metrics such as travel time and travel-time reliability. Also benefiting from this kind of fluidity work is the Bureau of Transportation Statistics (BTS) Port Performance Freight Statistics Program. BTS will now be able to understand terminal dwell time, post-storm port resiliency assessments, tanker and TEU vessel dwell times and indices, and fluidity analysis hotspots of major inland commodity corridors.

The Port Fluidity Performance Measurement Methodology is another development of the USACE, which uses fluidity metrics. Incorporating some of the traditional highway fluidity measurement concepts, the methodology will enable USACE to look at port system time from anchorage to exit, cycle time from entrance to channel to exit, travel time, and travel time indices. These will allow USACE to assess more effectively the performance of the waterborne freight system and will guide future planning and investment decision-making.

## **FHWA NATIONAL FREIGHT FLUIDITY MONITORING PROGRAM**

Marygrace Parker, *I-95 Corridor Coalition*, and Joseph Bryan, *WSP*

The goal of this project is to design and implement a national freight fluidity-monitoring program to support state and regional implementation of fluidity measurement programs. The intent is to describe how the freight system performs at a national level from a supply chain perspective, going beyond traditional transportation performance measures.

**Figure 1** describes the program design. One of the keys to making this program successful is incorporating information from private-sector firms about the structure of their supply chains. Participating firms are motivated because they understand the role of public infrastructure in their operations and because the measures it will track are the measures that companies themselves track.

Ultimately, this program will produce a national freight fluidity dashboard. The dashboard will be populated with real data using public and private sources of supply chain data rather than regional or area data or model estimations. It will focus on four specific measures: travel distance, cost, travel time (speed), and reliability. It will enable users to look across

National Program Design	
Issues	Approaches
What we are measuring?	Travel time, travel time reliability, transportation cost Domestic movements – truck, rail, air, water Supply-chains (end-to-end across modes) and component segments
How much are we measuring?	Representative sample of critical US supply chains “Dow Jones Index” of key infrastructure, based on actual industries
How are index supply chains being chosen?	Selected for coverage of primary economic sectors and high-growth sectors Use of all modes, coverage of US regions Short and long-haul moves, domestic/cross-border/global supply chains
How is data being collected?	Target industries identified and recruited Industries tell us their primary supply chain (commodity/mode/O-D) patterns <ul style="list-style-type: none"> <li>• <b><u>No exchange of confidential information</u></b></li> <li>• <b><u>Real data, not models</u></b></li> </ul> Project team assembles data to tabulate metrics for supply chain patterns <ul style="list-style-type: none"> <li>• Supply chain level, not regional/area level (like FAF or Transearch)</li> <li>• Public and private sources have been identified</li> </ul>
What are the outputs?	Initial “National Fluidity <i>Monitoring</i> Dashboard” with continuous quarterly updates

**FIGURE 1 National fluidity measurement program design.**

corridors, modes, and industries, providing performance vectors to show where performance is improving or worsening so users can identify problems and invest in improvements.

A critical finding from this research is that businesses track and understand the reliability, time, and speed on their key travel lanes as part of their day-to-day business operations. Further, the industries contacted for this project indicated strong support for national, state, and regional fluidity programs so that they can transport their goods to markets more efficiently both here and abroad.

## PANEL DISCUSSION SUMMARIES

### International Applications

**CHANDRA BONDZIE**

*Federal Highway Administration, moderator*

**SUBRAT MAHAPATRA**

*Maryland DOT State Highway Administration, recorder*

This session focused on freight performance measurement outside the United States, including innovations and achievements that might be internationally transferable. The three distinct tracks included border crossings, regional freight fluidity, and urban last-mile freight delivery systems. The discussion included ongoing efforts, planned activities, and potential research opportunities.

#### **IMPLEMENTING A FREIGHT FLUIDITY PERFORMANCE MEASUREMENT SYSTEM: MEXICO EXPERIENCE**

*Juan Carlos Villa, Texas A&M Transportation Institute*

This presentation described the cross-border fluidity elements for trucks at the land border crossings between the United States and Mexico. Trucks that travel from Mexico to United States and vice-versa traverse five segments: trip segments 1 and 5 are long haul on either side of the border; segment 3 is the actual border-crossing process; and segments 2 and 4 are commodity processing on either side of the border that vary by commodity and direction. The presentation provided insights on the Mexico segment of the truck trip. Key findings included:

- Segments 1 and 5 do not vary by commodity.
- Segment 1 in the northbound (NB) and southbound (SB) directions for O-D close to the border are a function of local street-highway traffic conditions.
  - Segment 3 for NB traffic is captured by the Border Crossing Information System (BCIS) for Fixing America's Surface Transportation (FAST) and non-FAST Act shipments.
  - Segment 3 for SB shipments has relatively short travel-time variations.
  - Segments 2 and 4 require additional data through surveys or other sources of information, except for the border region supply chains.

The research suggested the following next steps:

- Establish formal agreements with carriers and shippers in Mexico to have a consistent source of information for the long-haul segment of the trip in Mexico.
  - Identify sources of travel time, travel-time reliability, and cost for segments 2 and 4 of the cross-border trip such as U.S. Customs broker data, local O-D surveys, and carrier information.

- Complement the commodity information with Census–BTS–U.S. Customs and Border Protection, INEGI–SAT, Aduanas, or similar data.
- Establish collaboration agreements with IMT Transport Logistics to increase data and experience sharing.

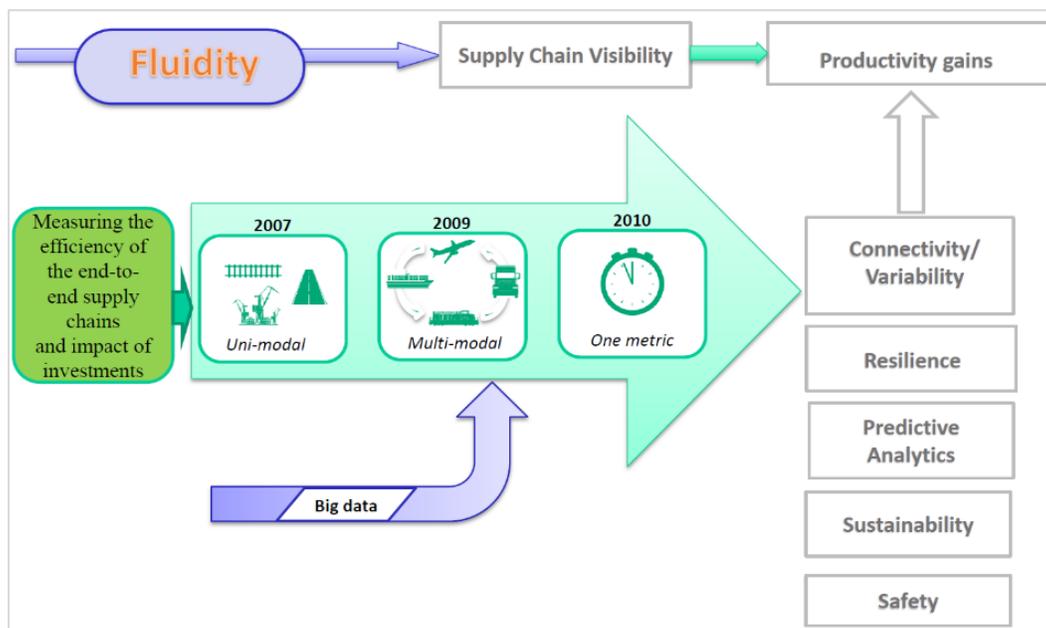
## FLUIDITY POLICY PATH: CANADA’S EXPERIENCE

Louis-Paul Tardif, *Transport Canada*

This presentation outlined the Canadian context and provided an evidenced-based project approach to improve efficiency and inform infrastructure investment. Discussion included first- and last-mile considerations, resilience, productivity, and trade corridors. Figure 1 shows the evolution of the fluidity concept in a policy setting. In addition, highlights of the Transportation and Trade Information System and the Transportation Performance Dashboard were presented. Four innovative “visibility projects” involving different aspects and geographic settings of the supply chain were covered. Next steps to understand Trade Corridor Productivity will include development of a framework to link productivity improvement to trade corridor investments at a link level.

### Discussion

- *What are the impacts of regulations, performance management needs and data sharing agreements?* In Canada, it was a policy decision to have more data for rail transport. This was triggered by shipper’s desire for transparency. Shippers know about their individual supply chains but lack information on system level performance. They want to understand rail performance to manage better their individual supply chains. Trucks are not subject to these new regulations.



**FIGURE 1** Evolution of the fluidity concept in a policy setting.

- *What do the productivity gains reflect (private side, public side, both)? What is the time horizon?* The productivity gains are the benefits that are realized by the private-sector such as revenue miles saved, etc., and do not include societal or public benefits of efficient supply chains. The planning horizon is very short, 1 week out to 3 months out, with a focus on real-time operational decisions. Long-term capital investment projects are handled by a different part of the agency.
- *How are the four Canada Fluidity pilots being funded?* The pilots are cofunded by Transport Canada and the pilot location entity.
- *How did the Canada fluidity data requirements come about? Are there any proprietary/open access challenges?* These requirements are part of a policy decision. These regulations are mostly a result of a strong focus on grain and forest product shipments. This requirement has resulted in a substantial amount of data and Transport Canada wants to make the best use of it. Resiliency is a key part of supply chain decisions and high-resolution datasets should provide improved insight. The rail data could be used to generate better performance metrics like velocity by unit trains, semis, revenue miles, etc.

## **USING FLEET MANIFEST AND MANAGEMENT DATA TO UNDERSTAND THE IMPACTS OF LAST-MILE PARCEL DELIVERIES**

T.J. Cherrette, *University of Southampton*

This presentation described empirical and visualization studies of last-mile delivery in London—work done under the British FTC2050 (Freight Traffic Control 2050) project—for the ultimate purpose of coordination to achieve efficiencies and environmental benefits. The wide variety of delivery modalities in use was outlined, including trucks, micro-vehicles, bicycles, walking, as well as the use of pickup centers and crowdsourcing. Both participant observation and real-time tracking methods were used to gather qualitative and quantitative data on freight operations, scheduling, and performance. Analysis and visualization tools were applied to explore delivery patterns and performance, and to estimate costs of different last-mile strategies. These data and visualization tools enabled amalgamation and interpretation of the delivery schedules of individual carriers to characterize overall performance, costs, and impacts. Using metaheuristic algorithms, the research quantified current impacts on energy demand and congestion and the potential benefits of different collaborative working scenarios.

### **Discussion**

- *Does the government look at the network and congestion relief benefits?* The potential is there but the current research focused on the carriers' efficiency.
- *How is the new model different from the postal service?* It is a different market as the shipment sizes are lot larger than what is served through the postal service.
- *What are the implications for infrastructure versus operational strategies?* Implications include investments in consolidation points or, shared consolidation points, looking at alternative models of dynamic data (crowdsourced consolidation points using models), and optimized routes versus driver knowledge based routing and deliveries.

- *Are there legal implications of these types of business models? Is it a complex process to sign-up?* The process is “alarmingly simple” and is designed for special age groups and communities such as university students.
- *What about middle-of-night/off-peak deliveries?* This was piloted during the Olympics and was very successful with a few comments on noise levels. This idea has gained traction.
- *What did it take to get carrier data? What was in it for them?* Carriers welcome this partnership because it provides a “living lab” to understand their operations better. The data sharing agreements cover their proprietary information and they receive advanced research on their systems and an understanding of the impacts of various delivery strategies at no charge. This presents an iterative learning process.

Additional opportunities include research in reverse logistics—starting from the end state and identifying what works and does not work—and understanding the potential of operational improvements related to the last 50 ft.

## **SUMMARY**

This session presented operational and research applications of freight fluidity measurements on the international stage in very distinct areas of the supply chain. The U.S.–Mexico border crossings work shows operational opportunities through collaboration, data sharing and agreements. The Canadian experience displays how freight fluidity can be taken as a business case to the freight community for overarching productivity gains. The London experience highlighted how practical strategies that take advantage of technology, human capital, and shared infrastructure can potentially yield more efficient last-mile delivery systems. Several potential research themes emerged out of the discussion following the presentations.

## PANEL DISCUSSION SUMMARIES

### Emerging Technologies and Data Sources

**JOSEPH BRYAN**

*WSP, moderator*

**JUAN VILLA**

*Texas A&M Transportation Institute, recorder*

This session focused on emerging technologies and their impacts in freight transportation performance. It particularly concentrated on data sources and how to analyze data to provide useful information.

#### **NCHRP 49: NEW SOURCES OF FREIGHT DATA FOR URBAN AND METROPOLITAN MOBILITY STUDY**

Donald Ludlow, *CPCS*

National data sets provide good intercity coverage and allow for the analysis of regional freight flows; however, persistent data gaps make it difficult to address some challenges in urban goods movement. These include focusing on improving truck observability and finer-grained data to address urban and metropolitan freight mobility challenges.

The first research question was “what are the problems that could be addressed by the application of new and emerging truck freight data movements and analytics?”

The associated problems that were identified include:

- Urban congestion, because highway and street congestion delays freight shipments;
- Last-mile access, because truck movements between freight facilities and mainline transportation links can be inefficient;
- Final 50-ft, because loading and unloading trucks can block lanes in urban areas;
- Shortage of truck parking, which indirectly affects mobility; and
- Land uses that are often not synchronized with freight demand.

The second research question was “what are the potential applications of new freight data sources?”

Key applications that the research identified include:

- GPS data applications that go beyond bottleneck identification;
- Urban truck sensing for delivery zones;
- Classifying trucks with inductive loop detectors;
- Computer vision that recognizes, tags, and classifies audio and video; and
- Use of real estate and business records to visualize freight and land use.

The third research question was “what are the practical, policy, and institutional challenges of using new freight data sources?” Three challenges were identified and included data fusion, analytical frameworks, and applicability of data to challenges.

As part of the research, an interactive web guide is being developed that will include 18 case studies linking data and analytics to specific applications.

## FREIGHT DATA COLLECTION AND USE CHALLENGES

Erik Starks, *FTR*

From the private-sector perspective, understanding transportation productivity is more important than fluidity. Productivity will dictate how many pieces of equipment are needed to handle freight because shippers and carriers care about the bottom line, which is cost.

Different technology trends have noticeable impacts in the transportation sector as summarized in [Table 1](#).

Several technologies are providing an enormous amount of data. However, the challenge is how to create a system and an environment where this data is readily available and usable.

**TABLE 1 Technology Trends**

Technology	Impacts on Transportation
Amazon effect	Negative for fluidity; creates more issues.
Autonomous vehicles	Net positive effect; driverless trucks will help reduce the impact of driver shortage, but integration and the resulting impacts will take time.
Artificial intelligence	Ability to optimize routes with alternatives and multiple points throughout the route.
OmniChannel	Brings together brick and mortar stores with distribution centers and all of their suppliers. Most retail companies are moving to this format.
Blockchain	This concept by itself does not provide productivity. It helps to organize information in a secure format.
Additive manufacturing	3D orienting, which radically changes some industries, particularly aftermarket.
Positive train control	It was difficult for rail companies to implement the system, but now intelligent freight cars can provide and share information that will make a more-productive rail system.
Real-time GPS	ELDs provide information on the driver and on the truck, which will make the system more efficient.

## **TRADELENS: EMERGING TECHNOLOGIES AND DATA SOURCES**

Ana Biazetti, *IBM*

Tradelens, a product developed in collaboration by IBM and Maersk, is an ecosystem that brings different players together using technology that allows them to maintain privacy while sharing data. With this system, inefficiencies such as data silos, data with different formats, data that are not shared and data that have manual errors, can be addressed.

All users can exchange information and documents through the blockchain platform in the end-to-end solution that links ports and terminals, authorities, ocean carriers, inland transportation, 3PLs, shippers, and others. The three main participants in the system are the network providers that include ocean carriers, ports, and terminals; the clients that are the consumers and beneficiaries of the platform; and the applications that offer value added to the ecosystem.

Blockchain is the technology behind the system and addresses the challenges inherent in collaborating across a distributed, fragmented supply chain ecosystem. The blockchain includes the shared ledger, which is an append-only distributed system of records and smart contract that is a shared business logic governing transactions written in the ledger, allowing privacy and trust as transactions are endorsed by relevant participants. This helps resolve the inefficient, expensive, and vulnerable point-to-point connections across the network.

## **BLOCKSHIPPING: GLOBAL SHARED PLATFORM FOR CONTAINER HANDLING**

Henrik Hvid Jensen, *Strategic Advisor*

Appropriate for this session, this talk was delivered from Denmark through video conferencing technology. Three key considerations were presented as questions.

- *Why is digital platform the incumbent's biggest fear?*

The digital platform has been the most successful model for the last 10 to 15 years. Incumbents do not have any of the investments needed to produce products, and they are piggybacking on other investors. Some industries have allowed digital platforms to move into incumbent home turf, such as Netflix producing its own series, or Amazon buying Whole Foods Market. This has the potential to change those industries forever.

- *Why is blockchain a weapon against being disrupted by digital platforms?*

The decentralization elements of blockchain technologies are a direct assault on the competitive advantages of the digital platform. Blockchain works better when there is a decentralized peer-to-peer structure of relationships, when the parties do not necessarily trust or know each other, but they need to do business together to make the ecosystem work, and the information involved is typically dynamically collected. Most importantly, when there is no central trusted authority, or there is not a willingness among the parties to give power to a central trusted authority, blockchain works as a solution.

- *What should the shipping industry do to use blockchain to disrupt the disruptors?*

Blockchain will disrupt digital platforms by allowing transactions to occur without an intermediary. Therefore, no associated fees are paid to the digital platform provide, thus removing their exclusive insight into customers behavior and ultimately removing suppliers leverage and control of the merchant's reputation.

The shipping industry should prepare itself. Three initiatives to move forward are proposed:

- Proactively drive business development,
- Solve the data interoperability challenge, and
- Dedicate significant efforts to construct the system.

## PANEL DISCUSSION SUMMARIES

### Institutional and Legal Issues

**TINA CASGAR**

*San Diego Association of Governments, moderator*

**KENNETH MITCHELL**

*U.S. Army Corps of Engineers, recorder*

In contrast to previous panel discussions, this session focused on institutional and legal challenges faced by freight fluidity performance measurement, and barriers associated with data collection and sharing. To underscore the need to confront these challenges, a not-so-distant future scenario was presented wherein information technology advances lead to ubiquitous freight transportation data, with next-day or even same-day delivery services considered the new normal in terms of consumer expectations. In such a scenario, it is reasonable to expect that public agencies would face increased pressure to play an active role in development of relevant freight fluidity performance measures to inform consumer as well as freight industry stakeholder behavior.

#### **LEGAL ISSUES**

Paul Bingham, *EDR Group*

An array of legal considerations and complexities was presented that should be considered for any activity that requires data collection and sharing towards development and application of freight fluidity performance measures. There is no comprehensive U.S. law but rather a mix of federal, state, and local laws and regulations as well as international agreements that all affect how data can be collected and shared. The legal environment is evolving but consistently lags behind the technology-driven advances in data collection and dissemination and the associated legal questions that subsequently arise. This is not necessarily a bad thing. Open-records laws are a key consideration, particularly when public agencies looking to develop freight fluidity performance measures require large amounts of data to do so.

Legal questions continue about the ownership and control of freight transportation and consumer data, which is increasingly seen as an asset in its own right. Copyright and patent laws enter the picture as new information technologies advance and greater volumes of data are generated. Privacy concerns and requisite cybersecurity protocols must also be considered as the legal picture continues to evolve, particularly as the online digital economy has made personally identifiable information easier to obtain and disseminate. As of May 2018, the European Union (EU) has begun enforcing the General Data Protection Regulation to protect its residents from privacy breaches. Notably, this legal framework applies to all companies that work with personal data of EU residents, regardless of where those companies are physically located.

Among members of the private sector who collect and store consumer information, the traditional objection to calls for increased data sharing and availability is the fear of enabling tighter regulatory enforcement or threats from civil litigation. Through the discovery process, civil litigants may succeed in obtaining what would otherwise be considered proprietary or

confidential information, thereby creating a strong disincentive for providing such data in the first place. There are also concerns about civil liabilities stemming from limitations in data completeness, accuracy, and verifiability, so corporate counsels often advise against sharing of such datasets. Finally, there are concerns about security and the potential for bad actors to exploit the enhanced visibility into critical supply chains.

The American Transportation Research Institute (ATRI) has been serving as a steward for trucking industry GPS probe datasets, and its approach might be considered a model for others. However, this approach also has limitations, which should be understood (e.g., truck probe data availability for freight fluidity research is still a challenge).

The *National Cooperative Freight Research Program (NCFRP) Report 49: Understanding and Using New Data Sources to Address Urban and Metropolitan Freight Challenges*, describes several guiding principles for public agencies including

- Transparency and openness;
- Purpose specification;
- Data minimization, retention, and use minimization;
- Data quality and accuracy;
- Accountability; and
- Security.

## INSTITUTIONAL ISSUES

Michael Meyer, *WSP*

Many of the institutional challenges that are encountered when attempting to acquire and work with large data sets are longstanding and have not changed much over the last decade. Public agency buy-in for freight fluidity performance measures can be summarized by the 4 Cs: the need to develop a *constituency* for the results that is led by *champions* towards a process that is *collaborative* and that responds to *customer* needs. A fifth C, namely *cash*, is also helpful when undertaking such initiatives.

Freight fluidity performance measures require that a range of decisions be made at a variety of spatial scales, from the global and multinational view to multistate trade corridors, to localized, site-specific lines of enquiry. Likewise, the temporal aspect of these questions ranges from essentially real-time logistical decision support informed by heuristics and data analytics to high-level econometric models meant to inform long-term strategic investment decisions where the impact will be felt for decades.

Institutional challenges can be categorized into five general areas:

1. *Resources*. Ensuring access to and efficient processing of the large data sets required for meaningful freight fluidity performance measurement without becoming overwhelmed by the data is critical. Data use agreements are important, as is maintaining sufficient staff capabilities to work effectively with private-sector stakeholders who are mindful of the legal complexities and risks raised in the previous presentations. Sufficient information technology resources are requisite to enable meaningful decision support.

2. *Interactions*. Communication chains and financial flows supporting the modern global freight transportation industry are complex and highly dynamic. A myriad of

organizations are involved, from shippers/suppliers; brokers; carriers; warehouses and distribution centers; terminals and port operators; customs officials; and ultimately the consumers. Keeping track of all these interactions insofar as it is necessary to inform development of freight fluidity performance measures can be a daunting challenge.

3. *Influences on decisions.* Implementation of freight fluidity performance measures could have unexpected effects on decisions made by stakeholders within the supply chain, particularly with last-mile options. Other aspects of the freight system that could be influenced include compliance fees and penalty structures for delays and missed deliveries. There are also questions about how fluidity measures could alter behaviors during network disruptions and how such information could affect performance from a resilience perspective.

4. *Motivation and institutionalizing in organization.* Achieving acceptance for new performance measures can be challenging. One strategy that has proven effective is to explain fluidity measures in terms of economic impacts. Including fluidity performance measures within the TSMO plans that many regions maintain could also be helpful.

5. *National application.* To be meaningful, freight fluidity performance measures ought to be compatible and standardized nationwide, providing value to decision-makers and stakeholders at all levels. Metrics should be truly multimodal, providing a clear indication of the “state of the supply chain.” A platform for dissemination of measures such as robust travel-time statistics would provide stakeholders with the needed information to make productivity improvements, lower costs, and increased efficiencies.

## SUMMARY

- *Tools necessary to inform decisions given the limitations on freight fluidity data availability and quality.* Perfect data sets will never be the norm or even possible. The tool needed to inform decision-making using limited amounts of available data are dependent on the types of questions being addressed. There will always be limitations on data quality and availability, but that should not deter researchers and practitioners from pushing for progress in development of freight fluidity performance measures. Discussions of data availability are often too pessimistic about opportunities for progress even with existing limits on data. An example is how USACE has made progress working with archived AIS data from marine vessels and its own Waterborne Commerce data while still working on linkages with other transportation modes.

- *The value of the national perspective for freight fluidity, and the relative merits of a top-down versus bottom-up perspective when developing such measures.* Supply chains do not necessarily observe political borders. Therefore, attempts at modeling and development of fluidity measures for freight will be less accurate if they are limited in their geographic scope. Few would advocate for 51 separate state-level applications, and so the national (or even global) perspective is critical for many freight fluidity investigations. Measures that capture the nationwide view enable observation of relative levels of use and changes through time, which are essential pieces of information for guiding strategic investments. Future transportation legislation could help state-level DOTs support their required freight plans as would nationally targeting the worst congestion bottlenecks which are revealed by national fluidity measures for freight. The political landscape for making the trade-off decisions to address these critical freight bottlenecks is perilous, so it is essential that they be based on objective data that meaningfully captures the underlying dynamics of the freight transportation system.

- *Challenges encountered by agencies when acquiring and handling large data sets for freight fluidity investigations.* Quantifying the value added by more advanced performance measures compared to the costs to collect or process additional data is often difficult. Likewise, questions often are posed about whether new measures truly align with respective agency missions. In the case of large freight data sets, concerns are raised about public agency data sets stifling the emergence or continued development of private-sector markets for the data. The challenge of maintaining sufficient information technology and staffing capabilities to work effectively with large freight data sets was reiterated. Finally, the myriad challenges of cleaning and validating large freight data sets that apply nationwide tend to reduce confidence that the final resulting metrics truly relate back to the underlying questions. Improved data availability will help to grow that level of confidence.

## PANEL DISCUSSION SUMMARIES

### Science Fiction to Engineering Facts

**CRAIG PHILIP**

*Vanderbilt University, moderator*

**PAUL BINGHAM**

*EDR Group, recorder*

This panel discussed how the future may bring large changes in manufacturing, purchasing, distribution and freight performance measurement and management, each from a different perspective.

#### **ADAPTING TO BIGGER**

Walter Kemmsies, *Jones Lang LaSalle*

The economic context for trends in supply chains is grounded in balancing the drive for economies of scale and operational efficiency with the growth in product variety and delivery velocity with eCommerce. World trade liberalization has promoted manufacturing export-driven emerging market country growth, and growth of the consuming urbanized middle class population globally. Trade and freight volumes have grown accordingly. The growth in the length of unit trains, use of larger ocean vessels, pressures for increased truck size and weight limits, and growth in freight terminal and distribution center sizes are evidence of the drive to lower unit supply chain costs. However, unbalanced investment in supply chain capacity causes congestion and requires adjustments like omnichannel retail to improve use of space. Yet this practice offsets economies of scale. Information technology is being employed to use capacity more efficiently.

U.S. retail changes with eCommerce include the omnichannel retail strategy and a matching network distribution strategy. The types of distribution centers and fulfillment centers are changing to accommodate this shift. Regional distribution centers that were spaced around metropolitan areas have changed to more and smaller fulfillment centers and local distribution centers from which products can be delivered to customers more quickly in combination with larger, superregional distribution centers serving megaregions. This requires more inventory in total, while retail stores hold less inventory. Use of omnichannel requires more locations and more types of structures, with more expertise to design and manage this infrastructure. Inland intermodal rail yard development helps address the scarcity of truck drivers, increases business for the railroads, and helps shift seaport activity inland.

## **THE SCIENCE FICTION: AUTOMATION OF GLOBAL LOGISTICS OR IS IT REALLY COMING**

Alain Kornhauser, *Princeton*

The potential large gains from increased adoption and integration of technologies—especially automation—in freight transportation can provide broader advantages to society than mechanization alone because automation can reduce uncertainty and costs of operations. Most of this savings derives from reducing the human element, which is prone to error and unpredictability. Adding data storage (memory) and algorithms to the sensors and actuators of mechanization can improve reliability and lower costs in freight handling. Productivity, measured in the physical movement per employee hour, can be significantly increased by having human labor minimized to supervisory roles.

Automation can be used in all modes of freight transportation, including new uses of robots and drones. Automation already is being used for goods handling in controlled environments such as warehouses, distribution centers, and port terminals. Other existing examples include autonomous trucking used in mines and unit trains used to haul ore in Australia. Public reaction to automation may delay realization of its potential but perceptions can be changed. Changed perceptions of transportation automation technology have historical precedent, such as acceptance of use of elevators without human operators.

## **TRANSPORTATION TRENDS**

John Larkin, *Stifel Co.*

Transportation technology and eCommerce are transforming business, including firms in the transportation industry. The evolution of the retail supply chain is changing relationships between businesses, the physical transportation system, and the geography of supply chains. Current leading trends from Amazon.com and other eCommerce retailers are seeing omnichannel retail use of fulfillment centers, brick and mortar stores, and direct-to-consumer shipments from manufacturers. Future practices may reflect localized custom 3D advanced printing and automated made-to-order production, potentially leading to smaller quantity individual shipments.

Competition to meet increased customer expectations for delivery is driven and promoted by advances in transportation and communications technology. Alternative delivery options to serve consumers are proliferating with the last mile being the last frontier of delivery technologies, with activity tracking in real time whether involving humans in the deliveries or not. Traditional roles in the freight transportation industry are being disrupted by innovators and by new initiatives from surviving established firms. The pace of change is accelerating as large venture capital investments are being made in new ideas for goods movement, supply chain technologies, and measurement. Among technology applications, data analytics and artificial intelligence are transformative, while applications of blockchain technology for improving supply chain operations will be widely adopted before broad adoption of automation in trucking.

## PANEL DISCUSSION SUMMARIES

### Research Needs for Advancing Freight Performance Measurement

**ALISON CONWAY**

*City College of New York, moderator*

**JEFFREY SHORT**

*ATRI, recorder*

The goal of this session was to identify themes that emerged during the workshop (particularly themes that were not previously mentioned) and to then identify actionable next steps for research that can be undertaken in the future. Initial discussion came from the panelists followed by comments from attendees.

#### PANEL DISCUSSION

Kenneth “Ned” Mitchell, *U.S. Army Corps of Engineers, panelist*  
Christina Casgar, *San Diego Association of Governments, panelist*  
Nicole Katsikides, *Texas A&M Transportation Institute, panelist*

Alison Conway provided an initial overview, identifying use of performance measures to improve decision-making as a major theme with an emphasis on tools needed to produce appropriate measures for decision-makers. Additionally, data needs, and the realities of data, such as data completeness and data access, were discussed in detail throughout the workshop. Other prominent themes included data standardization, where data from different sources are compiled into a single consistent format; the need for and challenges related to sharing data and information across jurisdictional boundaries; and relationship development, in particular collaborations between the carrier and the shipper for the purposes of measuring or improving freight fluidity. Additional themes included measurements of inefficiencies in some last-mile movements and shifts taken by some carriers toward suboptimal routes.

Ned Mitchell focused initially on probe data, indicating that AIS and truck GPS data are not ubiquitous but are available. Because of this availability, many valid freight fluidity measures are possible. He then examined the extent and completeness of the Commodity Flow Survey (CFS) and FAF questioning whether an extra step was needed to calibrate these broad data sets using currently available probe data. He closed by stating that probe data had not yet been fully investigated, and challenged the freight fluidity community to look at the actual cross continental O-D flows for all modes.

Christina Casgar focused on best practices and coordination in measuring performance and fluidity at the metropolitan planning organization (MPO) level. Instead of each MPO establishing its own goals, aligning with state and national goals could provide economies of scale and improved coordination. She expanded on the technology aspect of freight fluidity measures, indicating tremendous opportunities for visualizing data using several data sources such as ATRI’s truck GPS data. For example, such visualization could be employed to identify

last-mile problems. To capitalize on this, expanding the skillset of the MPO workforce to keep up with future needs related to data analysis and visualization should be considered.

Nicole Katsikides identified standardization related to data and analysis products as a priority. She cited the specific data and analysis needs of freight versus passenger vehicles, stating that the freight experience is very different from passenger vehicle experiences. Other topics included the role of different levels of government in producing and analyzing freight fluidity measures, specifically considering what responsibilities reside at each level; linking freight fluidity measures with international trade; and exploring how freight fluidity measures can add to city and state economic competitiveness. She also identified the “data sharing hurdle,” and how documentation of the value of data and the value of data investments might help data stakeholders overcome those hurdles. For example, quantifying how acquisition and use of data translates into productivity benefits, economic benefit, and mapping the value of data and returns on investment could help promote use of data. She closed by indicating that connected vehicles offer an unprecedented opportunity for data related to operations.

## OPEN DISCUSSION

The following points were brought up by individual attendees. No importance is implied by the order.

- It is important for data stakeholders to demonstrate the value of data to the private sector.
- Decision-makers look at the policy side of the equation and the project side of the equation and are mostly interested in how freight fluidity affects the policy side.
  - The connection between freight fluidity and policy is the actual infrastructure, so thinking more expansively about infrastructure is important.
  - Fluidity measures have been used in the past at border crossings to show the value of addressing mobility issues.
  - Fluidity performance measures could provide the basis for government investments. The benefits would be shown to accrue to the state. Thus, in essence, the funding organization understands how it benefits from an investment.
- The bottom line is that the private sector will never give government-sensitive data until the public sector, through a legal contract, agrees to abide by the Hippocratic Oath. Industry cannot be harmed by its own data or industry will not share data.
- Separation between regulatory data and planning data was recommended as a consideration.

The session closed with a discussion of research and research products listed in no particular order.

- Case studies showing how the data is currently being used.
- Research identifying benefits to public and private sector of data sharing.
- Documentation of how vulnerabilities are addressed.
- Identification of workforce changes and potential new academic programs.
- Documentation of what users do with the data and how data are accessed by users.

## Concluding Remarks

JOSEPH SCHOFER

*Northwestern University*

This workshop addressed the breadth of issues associated with implementing freight fluidity performance measures, starting with motivations from the perspective of the sponsor, the FHWA, and from both a global shipper and national carrier. Recent U.S. achievements in freight performance measurement by state DOTs and the USACE were described and discussed, along with an update on progress of the multimodal I-95 Corridor Coalition performance measurement project, a model for a national performance measurement system.

Several international and border-crossing performance assessment efforts were described, including innovative use of management data to assess last-mile performance in the U.K. The variety of sources of freight performance data were then reviewed, followed by perspectives on emerging technologies that are or soon will define the availability of performance data, including digital sources such as Tradelens and blockchain, which supports it.

The next panel reviewed legal and institutional issues that affect the availability and sharing of freight performance data. The importance of maintaining a national perspective was emphasized because freight operations are not limited by political boundaries.

A panel of experts put together a scan of future and futuristic technologies and trends that may affect transportation, logistics, manufacturing, and retailing, all of which are likely to demand more from, and affect the development of, freight performance measures.

The penultimate panel, along with workshop participants, suggested research needs to advance freight performance measurement, and the workshop closed with a town meeting-style discussion of issues, needs, opportunities, and directions for the future. Among the key points discussed are the following. No consensus or agreement of attendees is implied or intended.

### KEY POINTS

- Focus on doable, feasible freight performance measures. Measuring end-to-end performance may not be feasible today so focus on nodes and links. Transfer points are generally the main sources of delays.
- Use fluidity measures to identify hotspots, places where additional capacity is needed. But there is always a risk that a hotspot focus that ignores network interconnections will simply relocate the hot spots and another place becomes the bottleneck.
- This calls for understanding the *big picture*. Transportation is a network system; changes at one point can affect performance, and competitiveness, at other places. Some, perhaps many, local investments contribute to national goals, to GDP. Sometimes most or all of the benefits are not local at all. This suggests the need to establish a national picture of freight performance, and to make nationally important investments at local sites. And it suggests a federal role for coordination and investments of national scope and value. The Transport Canada fluidity initiative is an example of the potential national value of freight system performance. Assuring freight fluidity can affect competitiveness and therefore location decisions at multiple scales.

- Need to show the value of performance measures both to secure resources to develop and apply them and to gain access to existing, proprietary data.
- Many actions and decisions related to freight performance are made at local and regional levels. As the dialog on freight fluidity moves forward, it will be important to engage MPOs as a vital part of the fluidity community.
- The world of freight, manufacturing, and purchasing is changing rapidly. Keep the freight performance metrics flexible, adaptable.
- In addition to seeking private proprietary data, free up and distribute public data.
- The public sector is mostly concerned with making long-term investments in infrastructure. Government is not that nimble.
- The case for sharing private performance data might be built on the use of that data to make infrastructure decisions that are beneficial to the owners of that proprietary data.
- Note that the role of government goes beyond investing in infrastructure. It includes other levers, such as regulation and deregulation, policymaking, direction setting, and jaw boning.
- Need to develop a balanced approach to deploying limited resources against a wide variety of problems: hours of service, the ELD mandate, and parking requirements for trucks; the increased volume of cargo supported by the Panama Canal expansion program; and penalties for missing the delivery window. These are externally driven factors that place added demands on the performance of the freight system.
- Consider the last mile—or last 50 ft—challenge in freight delivery and distribution. Note the conflict with most complete streets programs, which focus on pedestrians and bicycles. Efficient freight systems demand close, curbside access. Coordination between conflicting policies is critical—give freight its due.
- Define and develop freight performance measures in the relevant context: agree on the framework and manage the system within it. Recognize importance of context.
- Collect (only) actionable data:
  - What decisions are to be made?
  - What information is needed to make those decisions wisely?
  - What data is needed to produce that information?
- Finally, continuing to bring the freight performance community together to share ideas, data sources, and tools has value. This builds and reinforces the constituency.

## KEY TAKEAWAYS

- Contextual forces and factors—big picture perspective.
  - The trend toward vendor penalties for failure to meet delivery windows increases interest in supply chain performance. This may ultimately lead to pressures not only on carriers, but also on public-sector infrastructure owners.
  - Similarly, stricter food and pharmaceutical safety requirements (e.g., temperature controls) put pressure on supply chain performance and costs.
  - The availability of truck parking to accommodate mandated driver rest periods is an important factor in supply chain performance and costs.

- These are reminders that a variety of apparently external factors affect supply chain performance and place increasing demands on services and infrastructure. Such rules and policies can have unintended consequences.
- Networks, boundaries, and additional reasons to look at big picture:
  - Investment at place X affects competitiveness at other places. Who pays, who experiences the side effects? Components of network systems are not isolated from each other.
  - Supply chains do not recognize jurisdictional or political boundaries. This supports the importance of regional, corridor, and national measurement of supply chain performance.
  - These points help define the national interest in supply chain performance metrics.
- Freight performance has monetary value.
  - This means that service reliability can have a real and direct cost on supply chain operations.
- Last mile issues:
  - Vendor and carrier concerns for difficulties in the last mile and last 50-ft delivery step, even from a global manufacturer, will also lead to increased interest in supply chain performance measures and demands on public-sector infrastructure owners.
- Economic competitiveness.
  - State DOTs are increasingly aware of the relationship between supply chain performance and the economic competitiveness of their regions. This increases importance of performance measurement and it can motivate interest in performance of private-sector services.
- Freight performance measures (FPM) and public policy.
  - Canada has found policy and management value in a national supply chain performance dashboard. Similar value can be expected from a U.S. national freight performance monitoring system, particularly because supply chains do not respect political boundaries.
  - Case studies of specific supply chains have proven useful to facilitate understanding and measuring their performance.
  - Does the availability of freight and supply chain inform decisions about public-sector infrastructure management and investment decisions? There is broad acceptance that it does, but we would benefit from research, perhaps in the form of case studies, that documents the impact and value of such information.
  - For both assuring efficiency and addressing reluctance of private entities to share their data, it will be important to collect only the data that we can and will use, and to demonstrate the shared value of that use, i.e., the positive effect of data on public policy and investment decisions that redounds to those who share their data, and others. This is another way of saying that it is important to identify and demonstrate the connection between data and decisions.
- Goal-driven choice of FPMs.
  - Fluidity of freight operations does not necessarily correlate with productivity. Ultimately, productivity of resources is an end goal. The degree to which increasing fluidity enhances productivity needs to be addressed directly in planning and decision-making.

- Delivery of FPM.
  - Visualization of real-time supply chain and delivery options can enhance understanding of processes and suggest strategies for increasing efficiency through operational change or investments in infrastructure.
- Barriers.
  - The for-profit data industry, as well as primary data owners, want to monetize data, and therefore they are motivated to keep it proprietary.
- Resilience.
  - Addressing and preparing for disruptions is a primary concern in the design and management of supply chains.
- Data sources.
  - Blockchain seems to be a way of making supply chains more secure, and perhaps more efficient and less costly. It is not yet apparent that blockchain offers a new and better source of freight performance measurement.
  - The application of AIS makes it possible to get detailed information on the performance of waterways and ports, as well as the rebound and resilience of water infrastructure in the face of severe storms and other disruptions.

## **IN CLOSING**

This workshop, as with the previous ones, continued to be a catalyst for discussion and innovation among experts in the field, and resulted in innovative ideas and well-informed points for consideration. The participation of policymakers, transportation agency practitioners, academics, private sector stakeholders, and consultants provided insight into opportunities for advancing the implementation of and research into freight fluidity.

## APPENDIX A

### List of Abbreviations and Acronyms

3PL	third-party logistics
ADT	average daily traffic
AIS	automatic identification system
ATRI	American Transportation Research Institute
B2B	business to business
BCIS	Border Crossing Information System
BFI	Border Fluidity Index
BTS	Bureau of Transportation Statistics
CFS	Commodity Flow Survey
DOT	department of transportation
ELD	electronic logging device
EU	European Union
FAF	Freight Analysis Framework
FAST	Fixing America's Surface Transportation
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FPM	Freight Performance Measures
FTC2050	Freight Traffic Control 2050
GDP	gross domestic product
GDPR	General Data Protection Regulation
GPS	Global Positioning System
IP	International Paper
ISO	International Organization for Standardization
LTL	less-than-truckload
MPO	metropolitan planning organization
NB	northbound
NCFRP	National Cooperative Freight Research Program
O-D	origin–destination
SB	southbound
SHA	State Highway Administration
TEU	20-foot equivalent unit
TRB	Transportation Research Board
TSMO	Transportation System Management and Operations
USACE	U.S. Army Corps of Engineers
USDOT	United States Department of Transportation
VMT	vehicle miles traveled

## APPENDIX B

### List of Attendees

Scott Babcock  
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IBM

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EDR Group

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Juan Villa  
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Casey Wells  
Texas Department of Transportation

Michael Williamson  
Cambridge Systematics, Inc.

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