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Innovations in Freight Data

2023 Workshop

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Innovations in Freight Data

2023 Workshop

September 19–21, 2023
The Keck Center
Washington, DC

With Support from
Iowa Department of Transportation Pooled Fund Partners

Brittney Gick
Texas A&M Transportation Institute
Rapporteur

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Transportation Research Board
500 Fifth Street, NW
Washington, DC
www.trb.org

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Innovations in Freight Data Planning Committee

Transportation Research Board Staff

Transportation Research Board
500 Fifth Street, NW
Washington, D.C.
www.trb.org

Preface

The Transportation Research Board (TRB), with support from Iowa Department of Transportation (DOT) pooled fund partners, hosted a workshop to share recent innovations in the acquisition, integration/fusion, analysis, modeling, and visualization of freight data. The 4th Innovations in Freight Data Workshop was held September 19–21, 2023, at the Keck Center of the National Academies of Sciences, Engineering and Medicine in Washington, DC. This workshop builds on the findings and outcomes of predecessor workshops in 2017, 2019, and 2021. Based on the progression of the workshops over the years and as part of the workshop planning efforts, planning committee members were very conscious about developing a program that acknowledged the past learnings and evolutions in the freight data space. They also sought to make this workshop not only a foundation for where we are but also a springboard for what's to come.

The workshop brought together private freight data professionals, public agency personnel, academics, and other key freight stakeholders to explore and learn about how to analyze, model, fuse, and visualize freight data sources. The workshop included presentations on the latest applications of existing and emerging freight data sources and data fusion methods that can meet local, state, federal, and international freight planning and policy decision-making and performance measurement requirements, as well as best practices for using freight data sources and addressing challenges with emerging freight data sources. As a result of the discussions, several central themes emerged about freight data. There have been advances in

- Federal data products;
- Visualizations and storytelling;
- Vehicle emission analysis, emissions reduction, and electrification;
- Applications and data fusion;
- Data granularity; and
- Modeling.

TRB assembled a planning committee to help organize the workshop program. Alison Conway, City College of New York, chaired the workshop. Committee members provided expertise in current and emerging freight data sources, planning and decision-making, stakeholder collaboration, and innovative uses of freight data.

The workshop attracted approximately 110 attendees, including those from businesses and corporations, federal agencies, state departments of transportation, local agencies, associations, universities, consulting firms, and other key stakeholder groups.

Special acknowledgments go to the following individuals for assisting with notetaking and summarizing concurrent sessions: Carla Tejada Lopez, University of Illinois Chicago; Subhadipto Poddar, University of Arkansas; and Sanjeev Bhurtyal, University of Arkansas. Special thanks to Stacey Bricka, Monique Stinson, and Akiko Yamagami for serving as peer reviewers of this workshop summary.

This document presents the discussions and presentations from the workshop. The views expressed in the circular 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, or TRB. A copy of the program with links to the presentations is available at https://trb.secure-platform.com/a/page/InnovationsFreightData.

Contents

In Memory of Tom Palmerlee

Thomas "Tom" M. Palmerlee was born on July 21, 1941, in Lawrence, Kansas, and passed away on April 7, 2023, in Washington, DC, after serving as staff director for this workshop. He was an Associate Director of the Technical Activities Division at the TRB. Prior to joining TRB, Tom was executive director for the University Consortium for Geographic Information Science and for the Urban and Regional Information Systems Association. He served as a legislative assistant and legislative director for US Senator Malcolm Wallop of Wyoming. Tom was a Captain in the United States Marine Corps in Vietnam. He joined TRB in 1998 as a Senior Program Officer (SPO) in the Technical Activities Division, eventually supporting 31 groups, sections, committees, task forces, and many conferences and workshops. He also served as TRB staff liaison to 23 Cooperative Research Projects.

As a TRB SPO, Tom Palmerlee was a connector, linking people and ideas to advance data applications in transportation and to bring diversity to the field. He was a mentor, coach, partner, and friend to hundreds of TRB volunteers and transportation leaders across the nation. His efforts made TRB volunteers work hard, work well, deliver, and enjoy their experience. It was Tom Palmerlee who made their contributions to TRB and transportation worthwhile. He is missed.

Introduction and Welcome

ALISON CONWAY
City College of New York, Chair

Freight data sources and data fusion methods are frequently adapting to the changing needs of transportation stakeholders. The purpose of this workshop is to bring together freight data users to discuss and learn about recent innovations in the acquisition, integration/fusion, analysis, modeling, and visualization of freight data.

Conway welcomed participants to the 2023 Innovations in Freight Data Workshop. Conway covered the following topics in her opening remarks:

- Conway recognized the planning committee members and TRB staff, including Katherine Kortum, Scott Babcock, Gary Jenkins, and James Manning, for helping to organize the workshop.
- Conway also expressed appreciation for Tom Palmerlee's previous efforts in planning the workshop and helping to advance numerous careers. Tom was passionate about and obtained a wealth of knowledge about transportation data. He was a dedicated mentor and leader who was able to get volunteers to strive in TRB efforts, including this workshop. Tom Palmerlee passed away on April 7, 2023.
- Conway welcomed the keynote speaker, Patricia Hu, from the US Department of Transportation's (USDOT's) Bureau of Transportation Statistics (BTS) to discuss recent advances and emerging data needs at BTS.

KEYNOTE PRESENTATION

Recent Advances and Emerging Data Needs at the Bureau of Transportation Statistics

PATRICIA HU

Bureau of Transportation Statistics

Patricia Hu, Director of BTS, provided an overview of the BTS Freight Program, including the different data sources that the program produces. Hu's keynote presentation, detailed below, provides insights into the freight data BTS provides and what the agency hopes to accomplish in the short and long term. Her remarks are as follows:

BUREAU OF TRANSPORTATION STATISTICS' ROLE IN PROTECTING DATA

BTS was created by the Intermodal Surface Transportation Efficiency Act in 1991 and serves as the USDOT principal statistical agency. BTS is completely independent of non-statistical influence, which allows them to produce objective and trustworthy data. Freight transportation is complex and the trustworthiness of the data—from both those who produce it and those who use it—is critical. Understanding the availability of equipment *and* freight assets is needed. Much work has been conducted to understand infrastructure capacity and demand, but little has been done to understand the availability of equipment and other supplies. The BTS Freight Program is extensive and continues to be shaped by recommendations from this and previous TRB Freight Data Workshops. It is also shaped by key takeaways from the "Section 25003" effort [i.e., the section of the Infrastructure Investment and Jobs Act (IIJA) requiring BTS to determine the data and tools necessary for local decision-making] and by lessons learned from recent events, such as the pandemic and supply chain disruptions. As the world continues to change, the BTS Freight Program must adapt and be shaped to meet the industry's needs.

Vehicle Inventory and Use Survey

The Vehicle Inventory and Use Survey (VIUS) is the principal data source on physical and operational attributes of trucks in the United States. The last VIUS was conducted in 2002. The 20-year wait for the next set of results is nearly over; the 2021 VIUS key tables was released on September 28, 2023, and the public use file on December 29, 2023. BTS is currently looking to address what the next VIUS will look like, and they hope to reduce respondent burden. One consideration is how frequently the data is collected, so BTS may consider more frequent smaller surveys. Another consideration is including different vehicle types—BTS may add government-owned vehicles and buses. A separate survey, eVIUS, will focus specifically on electric passenger vehicles and light-duty trucks.

Commodity Flow Survey

The Commodity Flow Survey (CFS) collects data on commodities, origins, destinations, value, weight, and mode of transportation and acts as the main input for the Freight Analysis Framework (FAF). The 2022 CFS collected data from more than 100 million shipments, a 15-fold increase from the 2017 CFS. As a result, there are now twice as many origin–destination (OD) pairs and twice as many destination zip codes per origin zip code. The 2022 CFS is scheduled to be released in Spring 2025.

Freight Analysis Framework

The FAF brings together data from multiple sources to estimate freight movements by origins, destinations, and modes. BTS expedited the data release schedule and has already released the 2022 preliminary annual estimates. BTS also improved the imputation processes that it uses in foreign trade flow estimation. The next steps to improve FAF will include county-to-county disaggregation and the development of a multimodal network assignment. The maps BTS creates (Figure 1 for an example) take a lot of data to produce and they are continually looking to improve the multimodal aspect.

Freight Logistics Optimization Works

The Freight Logistics Optimization Works (FLOW) was initiated by the Biden–Harris Administration because of supply chain disruptions during and after the COVID-19 pandemic. As a government–industry partnership, FLOW is a voluntary data exchange program that began in August 2022 and currently has 49 industry partners that submit data daily. It seeks to use data exchange to reduce delivery times and increase delivery efficiencies while reducing consumer costs. The industry indicated that they wanted to share data, but they were concerned with whom to share it with due to data protection needs. FLOW is only possible due to industry buy-in and BTS' ability to protect the data

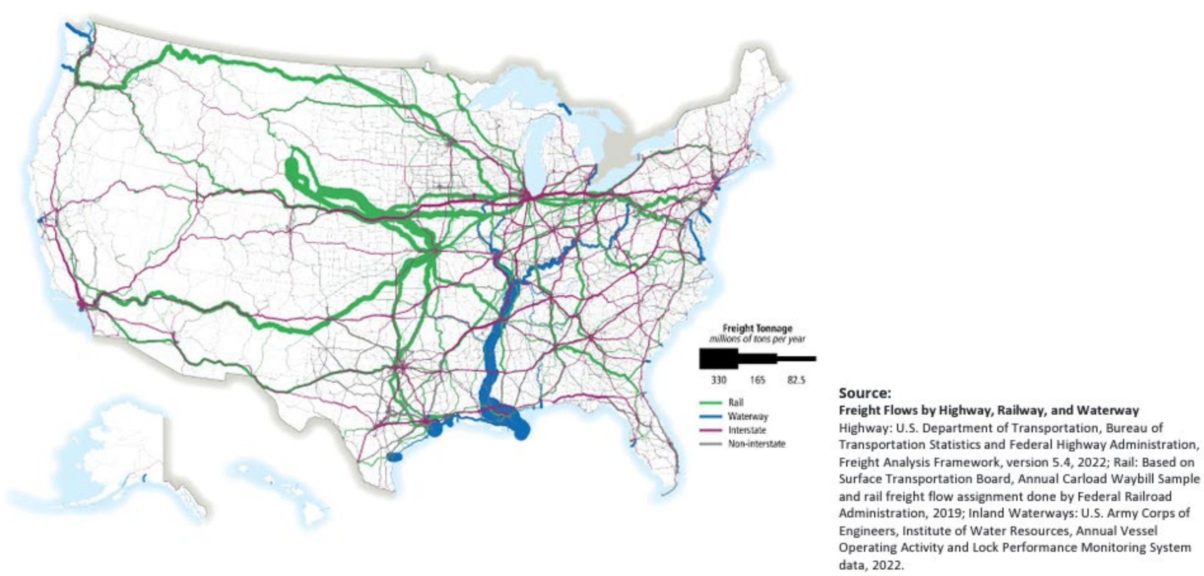

FIGURE 1 Multimodal freight flow map.

through its Confidential Information Protection and Statistical Efficiency Act (CIPSEA) authority. Data is currently only available to industry partners that submit data. As the program matures, BTS may consider sharing aggregated information, but currently, protection of the data is critical in sustaining the buy-in and benefit to the industry partners.

PRINCIPLES TO SHAPE THE FUTURE FREIGHT PROGRAM

BTS wants the Freight Program to be relevant and timely, so they are asking questions of and listening to transportation stakeholders, which was an unprecedented opportunity through IIJA Section 25003. IIJA Section 25003 seeks to develop local decision-making authority by focusing on and addressing what is missing by

- Creating economic development through infrastructure development.
- Rebuilding infrastructure to a state of good repair.
- Establishing freight plans and infrastructure that connect communities to supply chains.
- Reducing congestion.
- Improving maintenance of existing assets.
- Improving community resilience to extreme weather events.
- Increasing options for communities that lack access to affordable transportation.
- Including other subjects.

BTS wants to hear about what decisions cannot be made because the data is not available to fulfill needs. Beyond just data, the industry also faces issues with limited workforce and many needs for technical assistance. BTS is continuing to tackle old challenges while preparing for new ones. For example, BTS is conducting pilot experiments focused on innovation, such as using artificial intelligence (AI) on imagery data. BTS also wants to expand upon recent successes. For example, if they can successfully share data within the private sector, can they leverage CIPSEA authority to use it in other beneficial ways?

KEY TAKEAWAYS AND PATH FORWARD TO IMPLEMENTATION

BTS has identified six key takeaways posing challenges for local decision-makers that they hope to address in the short to long term.

- There is a lack of adequate data.
- Data often exists in silos and is incompatible between the public and private sectors.
- There is a lack of capacity and understanding of data and tools.
- There is a lack of multimodal data.
- Data is inequitable, as data exist to address the nation's transportation challenges, but local decision-makers can be left behind.
- The work plan needs to be implemented (i.e., cannot just make it for the sake of making it, but implementation takes resources).

As a result, BTS is focused on the following recommendations relevant to freight from IIJA Section 25003.

- Inform freight infrastructure investment and planning.
- Improve asset management, maintenance, and resilience.
- Create economic development through infrastructure development.

Short-Term Strategies

In the short term, BTS plans to implement some of the low-hanging recommendations from IIJA Section 25003, including the implementation of the Transportation Vulnerability and Resilience Data Program. FAF mode share forecasts and small area commodity flow estimates will be improved. BTS will collaborate with the US Department of Agriculture and the Federal Maritime Commission to obtain information on the availability of empty containers. BTS is also looking at real-time port performance and branching into rail by extending current efforts by Transport Canada using cameras, imagery, and AI to better understand rail performance.

Long-Term Strategies

In the long term, BTS plans to modernize FAF and move to model-based estimates, to include the availability of equipment, and to develop a National Energy Modeling System-like policy scenario tool to estimate freight transportation supply and demand. BTS also plans to evaluate the implications of various manufacturing policies and executive orders on the freight system.

There is a need for the transportation industry to better understand chassis and container availability. The labor workforce also needs to be considered and included in the conversation. BTS would prefer that job information from the warehousing and utilities sectors not be lumped in with the transportation sector and they will work with the Bureau of Labor Statistics (BLS) to address this issue.

DISCUSSION

After Hu’s keynote address, three attendees posed comments and/or questions to her:

- *Smaller regions and metropolitan planning organizations (MPOs) may have modeling capabilities, but they may not have the staff capacity to deal with grant applications, which is a challenge. There is also a plea for BTS to consider including inland waterways, which represent 16% of the missing infrastructure in FAF and other freight data, which is a huge gap. Incorporating this information would help inland waterways communities immensely.*

BTS is looking to add the inland waterway network in upcoming iterations of freight data tools.

- *The issues related to the labor workforce and the technical capacity of staff were mentioned, but what potential solutions (e.g., better tools, training) is BTS considering to address these challenges?*

BTS is looking to develop training videos and is considering classroom-type training to educate users on how to use the data and tools.

- *Where do public agencies fit into the FLOW program?*

The FLOW program is just 1 year old, so at this point BTS is keeping the data only available to those that submit data. The agency is aware that the public sector wants to take advantage of the data to make decisions, but BTS must make sure that they are protecting the data for the sustainability of the program and buy-in from industry partners. BTS may eventually make the data available to the general public.

How the Commodity Flow Survey Made Its First 100 Million … Shipments

Roundtable Discussion

Berin Linfors
Christian Moscardi
US Census Bureau

This panel discussed the joint efforts of BTS and the Census Bureau to accommodate more detailed data, such as key dimensions of geography, commodities, and modes of transportation, in the CFS. As a result of these efforts, the 2022 CFS collected 15-times the amount of data in the previous cycle. It also used machine learning techniques and modernized data editing, imputation, and review. This roundtable discussion shared more on these efforts and current progress and discussed the ultimate benefits of these data for data users.

COMMODITY FLOW SURVEY BACKGROUND

The Census Bureau conducts the CFS for BTS as a mandatory, shipper-based (not carrier-based) survey of establishments that ship commodities from the mining, manufacturing, wholesale trade, auxiliaries (i.e., warehouses and distribution centers), and select retail and service trade industries. The survey collects data on the movement of goods within the United States every 5 years, on years ending in 2 or 7. Data is collected quarterly within the survey year and annual estimates are produced.

The CFS uses the North American Industry Classification System (NAICS) to select the sample frame, which includes mining (except for oil and gas extraction);

manufacturing; wholesale; select retail (electronic shopping, mail-order, and fuel); newspaper, periodicals, books, and directory publishing; and selected auxiliary establishments of multi-establishment companies. Out-of-scope NAICS industries include agriculture; oil and gas extraction; construction; most of the retail sector; most of the transportation sector; and the government sector. Additional areas that are out of CFS scope include businesses located in US territories; shipments traversing the United States (e.g., a shipment going from Mexico to Canada, passing through the United States); crude petroleum by pipeline; imports (unless they move through an in-scope establishment); promotional items; waste; and items not intended for commercial activity.

The survey questionnaire includes shipment information on the value, weight, type of commodity, domestic destination, domestic mode of transportation, export destination, and export mode of transportation. The questionnaire also includes whether the shipment was temperature-controlled or hazardous.

The publicly available data shows shipments by origin–destination–commodity–mode, highlighting value, tons, ton-miles, and average miles per shipment. Additional information on the type of industry, temperature-controlled and hazardous materials (hazmat) shipments, and exports are also available. The public CFS data is available at https://www.census.gov/programs-surveys/cfs.html and www.bts.gov/cfs.

IMPETUS FOR CHANGE—2017 COMMODITY FLOW SURVEY

User feedback about the 2017 CFS was the impetus for change. BTS and the Census Bureau heard from data users who were requesting more localized geography estimates and more detail on commodities. To produce more detailed estimates, more detailed information needed to be collected, yet that can cause more respondent burden. Making surveys take more time means fewer will respond, even if it is mandatory.

Since 2017, the Census Bureau has received feedback from respondents on the survey burden that highlighted what information was unnecessary or painful to respond to. In response, the Census Bureau developed several strategies to mitigate these concerns. For example, the Census Bureau evaluated the median burden versus the number of shipments (see Figure 2) and found that the highest burden occurred when respondents were extracting shipment data from their databases.

Since the respondents are not statisticians, the survey instructions can be complex and confusing, adding additional respondent burden. The 2017 CFS used a spreadsheet option that looked similar to the original paper survey form, but it was not as easy to use. Some companies have multiple locations, which meant they would have to fill out the spreadsheet or form for each location. The Census Bureau developed a streamlined alternative option, thus consolidating the reporting and reducing response time.

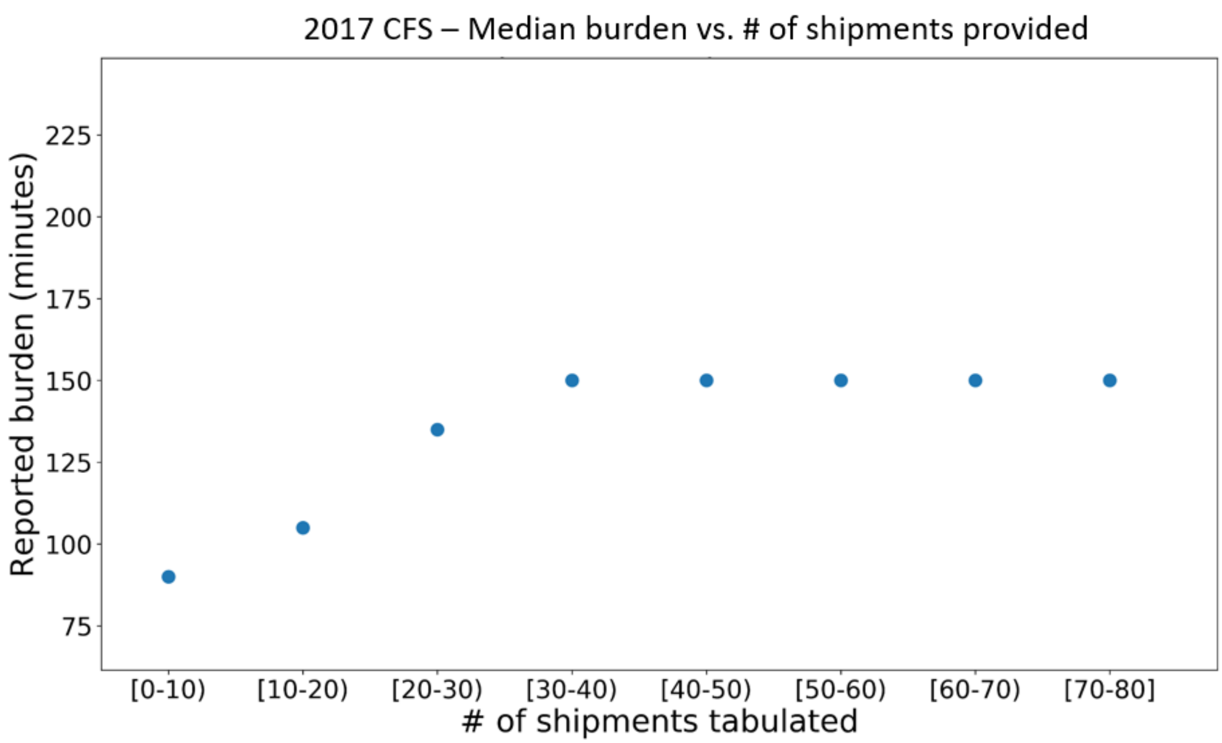

FIGURE 2 Census Bureau analysis of median respondent burden versus number of shipments.

2021 COMMODITY FLOW SURVEY PILOT

The 2021 CFS Pilot sought to evaluate the streamlined response approach. This approach removed the extra work of sampling and looking up NAICS codes. As a result, respondents extract shipment data from their databases and put it in the collection instrument. Based on feedback in a previous TRB Freight Data Workshop, the Census Bureau provided a free text description box for respondents to describe the product being shipped. The Census Bureau also implemented machine learning validation to automatically determine the commodity codes of products, showing respondents the top five probable categories. This process was used to develop confidence levels and ultimately helped to streamline the collection instrument.

The 2021 CFS Pilot was mailed to 500 mid- to large-sized businesses and the Census Bureau received 30 voluntary responses, with 106 average shipments per location. The 2017 CFS only had 80 average shipments per location. The results indicated that the respondent burden appeared to be reduced—an 80% reduction in response time—and the machine learning process showed the correct classification within the top five probable categories for 95% of the shipments. Limitations to the pilot study were that it was voluntary, and the survey was only sent to mid- to large-sized businesses, which likely had electronic databases, making it easier for businesses to respond.

2022 COMMODITY FLOW SURVEY

As a result of the 2021 CFS Pilot, the Census Bureau adjusted for the 2022 CFS. They included sampling as an option instead of a requirement, enabled multi-establishment and single establishment reporting options, and tuned the machine learning to look for more respondent validation. Respondents were also given the option to provide all shipment data in 2022, instead of extracting samples of shipment data from the shipment database.

The 2022 CFS resulted in a sample size of 165,000 establishments compared to 104,000 establishments in 2017. The survey was completely electronic for the first time and was sent at the end of each quarter instead of weekly. Hazardous shipments were also included for the first time, including information from both 2021 and 2022.

Currently, the 2022 CFS has collected 106 million shipments, compared to only 6.5 million shipments in 2017. Approximately 60,000 establishments responded to the survey in both 2017 and 2022. However, because of the growth in shipments, the number of unique OD pairs has doubled from 2.4 million in 2017 to 5.1 million in 2022. The number of unique origin–destination–commodity–mode combinations has quadrupled, from 3.1 million in 2017 to 13 million in 2022.

Results from the 2022 CFS indicate that there was no increase in burden for establishments with one location, with an average response time of 2.5 h. However, establishments reporting at least one shipment from multiple locations saw a 15% reduction in response burden, dropping the response time to 2.1 h. The 2022 CFS resulted in 16 times more data to use in estimates, with over 100 million shipments. This expanded dataset will result in a more robust public use file and more publishable aggregate data cells. Respondents provided feedback that they liked the consolidated reporting option.

The next steps for the Census Bureau include continuing to review the data through 2024 and releasing the data in 2025. The Census Bureau is also working to get more data users to access the raw data through the Federal Statistical Research Data Centers (FSRDC). More information about the FSRDC can be found at https://census.gov/fsrdc. Gaining access to the FSRDC can be a long process but provides more meaningful data for researchers.

DISCUSSION

After the CFS presentation, several attendees posed comments and/or questions to Linfors and Moscardi along with other federal government officials.

- *A recent webinar indicated that the US government was one of the single largest customers when it comes to purchasing products, so why is the government sector not included in the CFS. Are we missing a huge area?*

Linfors responded that the CFS is based on what is sampled and the Census Bureau is not sampling any government agencies. If a government agency is purchasing a product and it is shipped to them, then that would be covered in the CFS. The CFS will not capture any products being shipped from a government facility.

Moscardi indicated that he would be interested to hear BTS' perspective on government shipments as they relate to FAF. Monique Stinson, Freight Estimation, Forecasting and Analysis Manager at BTS, responded that BTS is looking into military household move shipments and whether they can be included in future iterations of FAF.

- *Is the CFS based on sampling or is the Census Bureau receiving full data?*

Linfors stated that the current goal is to tabulate everything, but the Census Bureau is still processing the data. Currently, the goal is to take all the data, weight it appropriately, and see what comes out of that process.

- *Please talk about the process of identifying commodity codes and stitching together different commodity codes (e.g., Standard Classification of Transported Goods (SCTG), Harmonized System) and how they compare. Different agencies use different codes, with BTS using one type and TransBorder another. There is a lot of interest for industry-specific information. The total numbers are consistent, but when breaking the numbers into commodities, they become inconsistent, so agencies using different coding systems is a challenge. Is there a way to provide a lookup table and publish what the different code definitions include?*

Linfors acknowledged that at the aggregate level, it can be a bit complicated. The Census Bureau does have internal lookup tables, but he was unsure if those were publicly available. Users who gain access to the raw data through the FSRDC would have access to the product descriptions.

Rolf Schmitt, Deputy Director of BTS, indicated that users can crosswalk industry codes to commodity codes using NAICS. The SCTG does not have a crosswalk with the NAICS-related North American Product Classification System; they attempted to create one several years ago, but it did not work. However, the SCTG is built on the Harmonized System (the standardized numerical method for classifying commodities that are traded internationally), so that crosswalk is straightforward.

Moscardi indicated that he could discuss the SCTG crosswalk after the session, as it should not be classified and should be publicly available. He also announced that the Census Bureau is developing a tool for data dissemination access, including crosswalk processes, and is piloting it now.

- *Can you expand on the statistical representativeness, including the sample size, of the CFS?*

Linfors said that the frame size is 750,000 and the sample is approximately 165,000 businesses. The CFS sampling methodology is all publicly available on the Census Bureau website, and they attempt to make the methodology as representative as possible.

According to Moscardi, the Census Bureau is confident on the sampling size and methodology. The frame size is built on Internal Revenue Service filings for businesses in the represented sectors and the Census Bureau draws the sample from that frame.

Schmitt reminded the attendees that FAF was developed to fill in the freight not covered by the CFS. The CFS covers about three-fourths of value and two-thirds of tonnage in FAF. The CFS is the core of the FAF, but the FAF data include many out-of-scope estimation methods for dealing with missing shipments. Governments are considered more of a consumer than a shipper. As a consequence, the CFS measures what goes out the door, not what comes in the door. CFS cannot require overseas establishments to report data, so imports also must be estimated using other methods.

- *It is exciting to see that the 2022 CFS resulted in 16 times the amount of data compared to 2017. Where have the increases been located? When will we see the next iteration in FAF?*

Linfors indicated that the Census Bureau is still reviewing the data and is unsure of an exact timeframe.

Stinson stated that the current CFS data should be included in FAF by late 2025.

- *What validation has been done and how reasonable is the CFS data?*

Linfors stated that after respondents submit the data, Census Bureau staff sift through it to make sure that the estimates look reasonable. The Census Bureau looks at the data at a macro level and compares it to previous results to make sure that the results make sense. They are looking into machine learning methods but still have humans validate those outputs through various techniques. Census Bureau staff also impute data and look for any new patterns within the data that may need additional improvements.

- *Are any other data used in calculating CFS results?*

Moscardi responded that the Census Bureau uses foreign trade export data and works with Customs and Border Patrol (CBP) to look at declarations for imports and exports. On the export side, for US-originating shipments they can cross-check against CBP data and perform quality checks. Domestic shipments, those staying within the United States, are harder to find additional data to reconcile.

Linfors stated that the Census Bureau also uses energy and gross domestic product data to cross-reference results.

Panel 1: Freight Decision-Making

Telling Compelling Stories with Freight Data

AKIKO YAMAGAMI
LA Metro, Moderator

This panel discussed current federal, state, and local practices for using freight data to tell compelling stories and to highlight freight's importance. The panelists discussed how they use the freight data to change narratives, as well as what changes are still needed to tell a more compelling narrative.

Caitlin Hughes, *Federal Highway Administration*

Caitlin Hughes began by highlighting how telling stories is what gets things done, including helping Congress pass laws. In retrospect, she finds that compelling stories mean the most and stick with people.

Based on FAF data, the freight tonnage by all modes is projected to increase 43%, from 20.2 billion tons in 2019 to 28.9 billion tons in 2050. Trucks carry most of the tonnage and value of goods being transported across the country. Truck travel is expected to increase 66% between 2019 and 2050, which is why addressing the truck parking crisis is a critical need, as more trucks will be driving across the country and need to park in safe, authorized locations.

The public needs to understand the issue of bottlenecks and all parts of the supply chain. The pandemic helped explain to the public what supply chains are, but most people still do not understand the concept of nodes and all that goes into moving goods throughout the supply chain.

As previously discussed, FAF shows freight movements by commodity type between metropolitan areas, states, and the United States and foreign countries. These freight flow scenarios are shown as base-year estimates and 30-year forecasts. The newest version, FAF5, includes improved modeling capabilities, truck flow maps, and summary tables (Figure 3). It can also project total freight flows for 2050 based on the baseline, as well as low- and high-growth scenarios. FAF can illuminate freight movements and inform decision-making. FAF can be a resource to help agencies and decision-makers apply for grants and deal with state and local matches. It has also proven useful in state freight plans.

USDOT's Conditions and Performance reports (https://www.transit.dot.gov/research-innovation/status-nations-highways-bridges-and-transit-condition-and-performance) include indicators of conditions, performance, and safety of the nation's

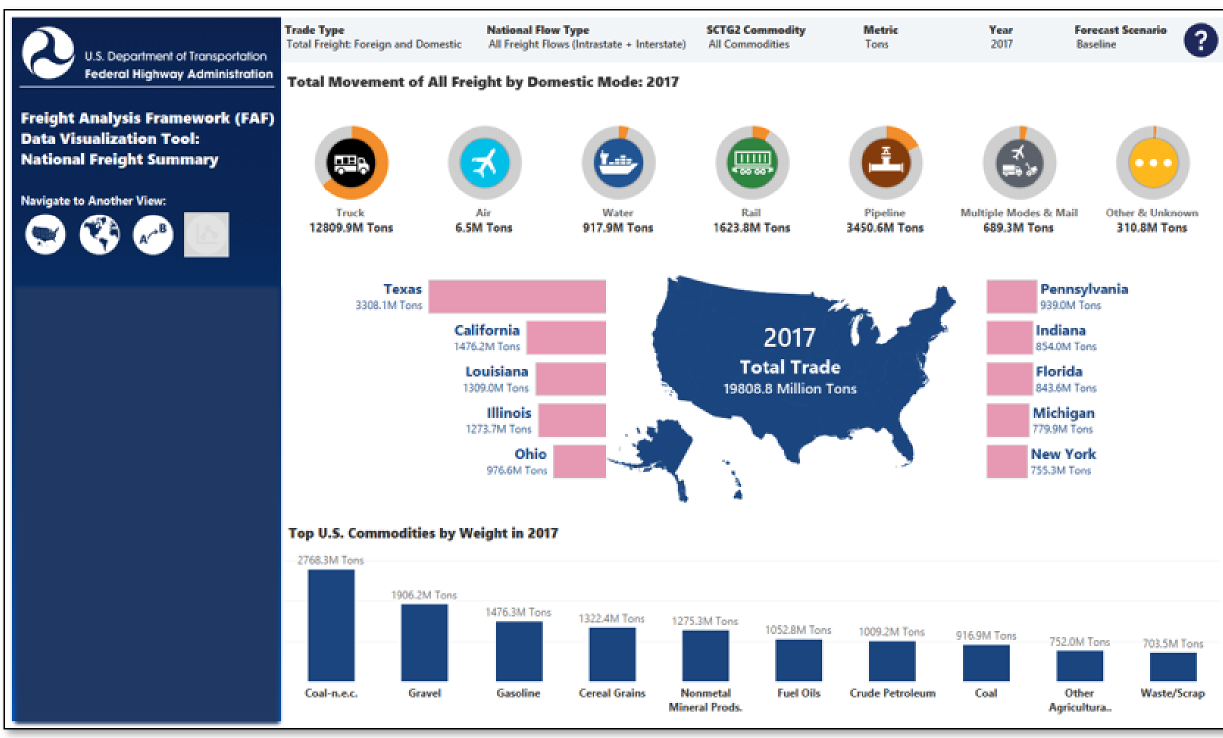

FIGURE 3 New FAF5 Web Tool Visualization Dashboard. (Source: USDOT, FHWA, Office of Freight Management and Operations, using FAF, version 5.2.[1])

[1] USDOT, BTS, Federal Highway Administration (FHWA). (2017) Freight Analysis Framework, FAF5 [datasets]. https://doi.org/10.21949/1529116

highways, bridges, and transit systems. The most recent edition (24th edition), completed in 2021, added information related to the National Highway Freight Network, including trends and data improvements.

Some state freight plans have used the freight performance measurement dataset; however, states use the freight performance measurement dataset more widely in freight performance reporting. National Performance Management Research Data Set (NPMRDS) collects vehicle probe-based data, such as speed and travel times, which can evaluate congestion and performance.

The Freight Mobility Trends (FMT) tool has recently added MOtor Vehicle Emission Simulator (MOVES) data, which is provided by the Environmental Protection Agency (EPA), to provide truck carbon dioxide emissions. The FMT tool showcases freight mobility at national, state, regional, and corridor levels and around major ports, intermodal facilities, cargo airports, and border crossings to indicate freight mobility performance indexes. The tool also includes information on the delay and cost related to bottlenecks.

Ultimately, there is significant opportunity to invest in freight. Telling the freight story is critical so that everyone understands its importance and becomes more willing to invest in improvements in freight flow.

After Hughes' presentation, one attendee posed the following comment:

- *Transport Canada realized that it was important to not just look at loaded freight flows, but also empty freight flows, since these can still have an impact on infrastructure. Transport Canada has done this for rail, and they are beginning to do so with trucks. Also, trucks may take one route when loaded and another when empty, so the impacts on the infrastructure may be different and need consideration.*

Hughes responded that was an important consideration. It is similar to the issues faced with cruise ships coming into port because trash has to come off of the boat. New supply chains will need to be analyzed.

Hughes also indicated that there are deficiencies in the freight networks and Congress requires maintenance of these networks. But freight goes where it wants to go, not where we tell it to go, which can create challenges in addressing inefficiencies and overall maintenance. She posed the question to attendees on whether the current networks are working or are they are impeding processes. She also questioned attendees if the current freight network designations are a valuable tool.

One attendee responded that because freight moves across the country, these freight network designations are needed to be able to tell the story about the importance of freight. It is also helpful for MPOs and cities to visualize these vital networks in their areas. It can be obvious for Interstates, but the designations and visualization tools for smaller roads can be critical for helping to tell the importance of freight.

Another attendee agreed that was a good statewide perspective but reiterated the value at the MPO level for these types of designations. MPOs have many competing needs for their attention (e.g., transit and other roads not used for freight). The designations and visualization tools help to communicate the importance of freight locally and show the economic importance. Having the USDOT brand on them also helps. It would be beneficial to have a conversation with MPOs about the significance of being on the freight network and the requirements for funding related to being on the freight network.

David Gray, *South Carolina Department of Transportation*

David Gray began with asking the attendees about the next step after a state has completed its state freight plan. How can the state use the document and convey its findings to the public, as well as to state and local leaders? In an effort to address these questions, the South Carolina DOT developed the South Carolina Commodity Flow Dashboard using Transearch and FAF5 data and based on the 2022 update of South Carolina's statewide freight plan. The dashboard allows users to analyze and disseminate commodity flow data and to visualize freight movements. Users can choose to highlight the commodity flow profile, trends, or costs. The dashboard also includes filters (see Figure 4) to further explore the data and show trends for inbound and

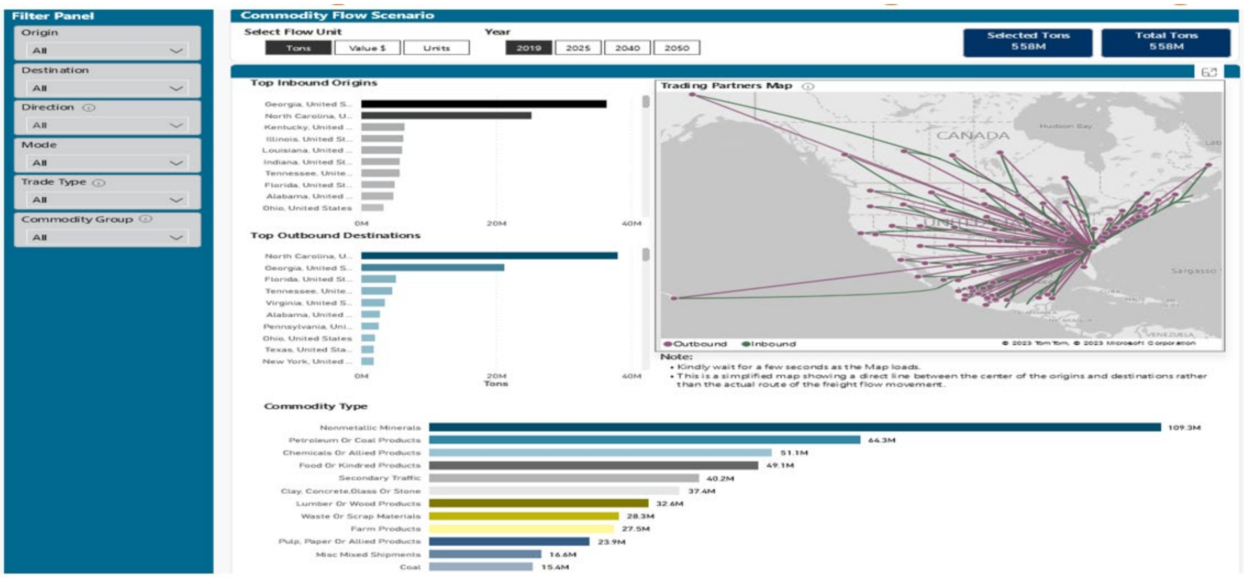

FIGURE 4 Example of South Carolina Commodity Flow Dashboard.

outbound movements. The commodity flow cost page shows the average rates for freight movements.

South Carolina first created its statewide freight network map in 2018, using the state's Department of Commerce data to highlight how different industries affect the roadway network. The original map was incomplete, so in 2020, South Carolina DOT updated the statewide freight network map using Transearch 2016 base-year data and evaluated truck tonnage growth out to 2040. The updated map included oversize/overweight routes, routes deemed important by councils of governments and MPOs. It also included those routes recommended by the freight planning offices at the Georgia and North Carolina DOTs to ensure interstate connectivity. South Carolina DOT continues to add map layers, including airports, waterways, rest areas, and other relevant layers. South Carolina DOT is also incorporating data about crashes, economic development, jobs, and other contributing factors. All layers can be turned on and off by the user. South Carolina DOT plans to use these tools to help make investment decisions by identifying where the needs are and how the state can adequately allocate resources and educate the public on freight movements.

After Gray's presentation, one attendee asked the following question:

- *During your acknowledgments, you identified many people that you coordinate with to develop these visualization tools. Was that coordination one-on-one or more collaborative?*

Gray responded that the coordination occurred on an as-needed basis. South Carolina DOT had some existing partner relationships. However, they had to build others, such as with the Department of Commerce, from scratch for all parties to understand the needs and importance of the data.

Hughes added that each state should have a state freight advisory committee which includes several key groups that DOTs can collaborate with to evaluate the freight network. Hughes also recommended to Gray to add truck parking as a data layer; Gray responded that South Carolina DOT intends to add additional data layers.

Brian Hamlin, *Seattle Department of Transportation*

Localized freight data is a niche area which primarily focuses on curb management. Seattle has more than 90,000 curb sign records in its asset management system and over 2,700 block faces in its digital linear curb inventory. Seattle has developed a great internal tool to manage curbs, but it is challenging to communicate to the public that the tool exists.

The curb management data management system (see Figure 5) supports performance-based parking efforts, including setting the parking rates around Seattle. This has been a great long-standing program, but it only includes paid parking management for passenger vehicles, not commercial vehicles.

There has been a drastic increase in the demand for curb space by commercial vehicles over the last decade, especially since the pandemic. At the local level, this increase is merely anecdotal, and they cannot manage what they cannot measure. However, local decision-makers want changes to curb management policies for freight because they are seeing the challenges. To address this, Seattle DOT needed data to help inform local decision-making. Seattle DOT conducted research and determined

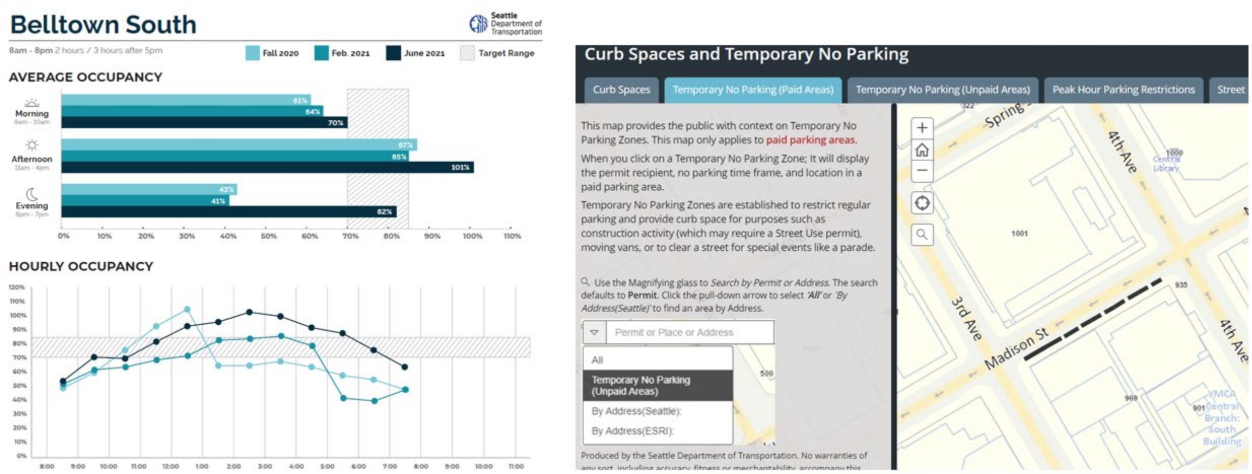

FIGURE 5 Example of Seattle DOT's curb management system.

that 80% of the commercial buildings in the region rely on curb space for deliveries. However, most of the city was designed before cars, which makes it challenging to manage freight deliveries along the curb. As a result, Seattle DOT needs modern tools to manage these modern problems.

Seattle DOT implemented the Commercial Vehicle Loading Zone Program, which allows commercial vehicles to apply for an annual permit ($250 per year), to pay by phone ($1.00 for 30 minutes), or to pay at a station ($1.00 for 30 minutes). Figure 6 shows an image of the Commercial Vehicle Loading Program sign and a commercial vehicle in the commercial vehicle loading zone. As a result, Seattle DOT is able to charge users for the highly coveted curb space. The program has faced challenges, such as permit applications decreasing regardless of increased curb demand, questions about which delivery types are considered commercial (passenger sedans delivering Amazon deliveries, etc.), and the program not being data driven.

Seattle DOT received a SMART grant, which is a USDOT-led initiative to use technology to address a specific problem. In this case, Seattle DOT will work with the University of Washington (UW) to address delivery and logistics challenges in Seattle using real data. The objective of the grant is to address three problems: the inability to meet curb space demand, a lack of ongoing data collection, and the political desire to proactively manage commercial vehicles along the curb. Seattle DOT is collaborating

FIGURE 6 Seattle DOT commercial vehicle loading zone and signage. (Source: Mary Catherine Snyder, Seattle DOT.)

with the Open Mobility Foundation (OMF) using curb data specifications.

The plan for the grant project is to work with local businesses to build a model with baseline conditions. Next the Seattle DOT will prototype and assess vehicle-to-curb (V2I) infrastructure and ultimately evaluate different commercial vehicle loading zone scenarios. “Freight’s gonna freight,” meaning that freight is going to go where freight wants and needs to go to make deliveries, so it is important to understand the needs and what is happening to adequately make decisions. The UW Urban Freight Lab (UFL) is leading the research and evaluation of the grant project; the lab will analyze the baseline and scenarios, assess the technology, and develop policy and permit recommendations.

The next steps for the SMART grant include beginning the baseline data collection effort and procuring the V2I technology in late 2023. In 2024, UW UFL plans to test the V2I prototype, develop scenarios, and work with other OMF cities. By early 2025, the project should have the evaluation and recommendations prepared for the second phase of the grant.

After Hamlin's presentation, several attendees posed questions:

- *In dense urban areas, curb space is a hot commodity. For example, people need their coffee but need their car to get to the coffee shop, and the coffee shop also needs curb space for deliveries of the coffee. How are you dealing with all of these competing needs?*

Hamlin responded that Seattle DOT is using the curb prioritization program and referenced the curb model when asked. They are also looking at the local political situation to identify where the support will come from so that they can make an informed decision. They are working with local decision-makers to explain the competing needs and why the current situation exists, along with the need to move to a data-driven program so that decision-makers can have the data to back up decisions.

- *How do you tell the freight story and are you successful?*

Hamlin responded that the Seattle DOT has changed how they tell the story over time to appeal more to the general audience and people are beginning to see the need for the curb management program. Using data helps tell the story of where needs are and how the city can weigh alternatives. Having a data-driven program makes the story more transparent.

- *What is the dream dataset that you would like to have for the program?*

Hamlin responded that it would be a dream to be able to understand the number of deliveries occurring block-by-block, including all deliveries from different types of services. The data must be based on the street and to be granular or it will not be able to fully meet the needs.

- *How were the prices determined for commercial vehicle parking?*

Hamlin responded that the $250 annual permit price is to recognize that the curb has value, and that price has increased over time. Everyone wants their goods delivered and how the prices are determined and changed can be political. To be successful, there has to be a way to manage the pricing, which can be challenging. Seattle DOT hopes to better address these challenges in the coming year.

- *When discussing the SMART grant, you said that collaborating with UW was a factor in winning. What was the relationship between the city and university?*

Hamlin responded that prior to this grant it was generally challenging to work with universities due to all the bureaucratic challenges. However, Seattle has a memorandum of understanding with UW, which is different than in many places. Both organizations benefit because the city gets the grant, and the university gets the research opportunity. UW also has the UFL that partners with local small businesses, providing a safe space where stakeholders can communicate and collaborate. It is extremely beneficial to create a relationship between a city and university.

- *As demand grows, how can we become more flexible in how data is used?*

Hamlin responded that a big component of the grant is to implement an application programming interface (API) to have a digital curb inventory to show curbs and be able to communicate with the curb signs digitally. The API could then update the curb use type throughout the day (e.g., commercial in periods of low passenger vehicle demand). The flexibility of curb use types can be very confusing, and Seattle DOT does not want to add unnecessary and confusing signs, so the digital efforts can make the signs more meaningful and user friendly. The program will also produce micro- and macro level data for making decisions.

- *With new emissions regulations, electrification will add challenges. Charging infrastructure will be needed and the Department of Energy (DOE), USDOT, and EPA are putting a lot of money into supporting charging and alternative fueling infrastructure.*

It would be beneficial to remain aware that this new technology and potential new data needs are coming.

Hughes responded that a location in the Netherlands moved all charging to outside of the city. This allowed users to leave their vehicles at a charging hub and use buses to get downtown, reducing the number of vehicles in the downtown area.

Panel 2:
Electronic Logging Device Data
Opportunities and Challenges

SAL HERNANDEZ
Oregon State University, Moderator

Electronic logging devices (ELDs) provide new opportunities to obtain freight data that can inform decision-making. The panelists discussed potential applications of ELD data and their experiences working with this emerging data source.

Gareth Robins, *robinsight*

The freight industry has faced several challenges using data. These include data capabilities that do not match the scope of the work, data costs that are too high, data that are difficult to integrate, data that are too aggregated, data with unclear biases, and privacy constraints on the data. Privacy constraints are one of the top challenges for researchers in using freight data. The raw data include a lot of information, which data providers must handle and manage very carefully to keep it secure. As a result, no single data source fully addresses a given problem; however, most datasets can address various problems simultaneously.

EROAD is a regulatory telematics company that specializes in fleet solutions and has 226,000 vehicles worldwide, with approximately 90,000 in the US EROAD formed a data trust with robinsight to provide data to researchers. To share raw data with the research community, the data need to be manipulated in several ways to be meaningful. For example, data collected every 250 m indicates when the vehicle is turned on and off, when it is moving, when it has stopped, when harsh braking occurs, and other indicators. Because every problem is unique, the raw data can be combined in ways that will tell stories about what is happening on a trip while protecting the integrity of the privacy of the data. At times this requires being creative with the data (Figure 7). One example of how robinsight used the data in creative ways was during the Kaikoura (a town in the South Island, New Zealand) earthquake analysis to evaluate what trucks were doing following the event. The results highlighted that, because of the earthquake, trucks were using roads that were not designed for them.

Additional research efforts have used EROAD data to analyze when trucks were stopping compared to how many available hours of service (HOS) remained. The results indicated that many trucks faced challenges reaching a safe truck parking facility within the remaining HOS. The data can provide a nationwide index of state-by-state parking for additional intelligence on where to locate new truck parking facilities.

robinsight produces data based on the unique requirements of each customer. There may be data parameters that need to change, and different customers may have different research needs. Data can be geolocated, but robinsight removes data with

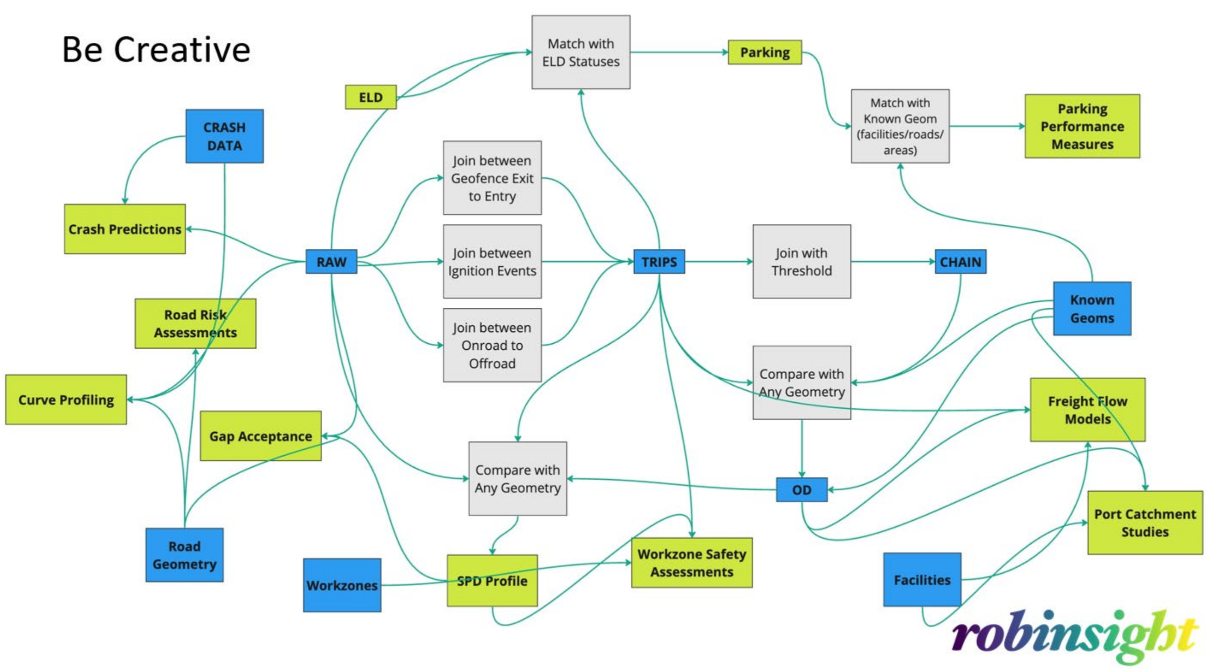

FIGURE 7 Example of creative methods to analyze and manipulate raw freight data.

fewer than three trucks because it can be too easy to identify the exact trucks. Again, data privacy is a critical component, and the company notifies researchers if data is removed. There are several situations where data cannot be provided, including using the data to determine:

- An individual's location,
- Where individuals are speeding,
- Competitor activity, and
- A purpose that is not aligned with the electronic service providers.

Protecting data privacy is critical for data providers; however, the providers understand the data's importance in decision-making so they work with partners to develop solutions that can allow researchers to use the data. Ultimately, it is important to be creative with the data while ensuring privacy to make the transportation network better.

Rodolfo Souza, *Texas A&M Transportation Institute*

Rodolfo Souza presented research results from a case study using ELD data. The case study incorporated results from three research categories: 1) how to use emerging datasets to analyze truck parking; 2) harsh braking events; and 3) work zone speed profiling.

The first study originated because many states report inadequate truck parking; however, most studies rely on stakeholder surveys and supply and demand analyses, which may not tell the full story on why there is inadequate truck parking and could be improved with adequate data. Insufficient truck parking can lead both to safety hazards for all roadway users and to trucks parking in unauthorized areas. The study used ELD data to analyze when trucks are coming and going and to understand truck parking needs.

The study provided a needs assessment for two major freight corridors: I-35 in Texas, Oklahoma, and Kansas and I-90 in Washington, Idaho, and Montana. The study produced a data visualization dashboard, which shows truck hourly distributions and clusters by month. The dashboard also shows the average distance to the next available truck parking facility. Figure 8 shows that, for arrivals at parking clusters along the I-35 corridor, most stops averaged about 1 h, so only required short rest periods. March and April were peak months for arrivals at the parking clusters along the I-35 corridor.

The second study focused on harsh braking events to understand driver behavior. Harsh braking event data can be used to understand truck driving behavior and improve safety. Importantly, ELD tracks the machine, not the driver, so inferences cannot be made about individuals. Researchers can use harsh braking events to learn what is happening in the transportation system. However, speed is not a good indicator that a harsh braking event will occur, as most harsh braking events in the study

FIGURE 8 Example data visualization for arrivals at I-35 truck parking clusters.

occurred at speeds less than the posted speed limit. The research also found that weather conditions are not a good indicator that harsh braking events will occur.

The third study focused on profiling trucks in work zones. Work zones have proven to be a common disruption to the flow of traffic. In Texas, work zones account for 4.6% of all roadway fatalities. The goal of the study was to analyze whether ELD data could analyze speed reductions in work zones. As a result, the study showed that ELD data can capture speed reductions in the work zones, producing similar speed reduction results as in previous studies.

Sal Hernandez, *Oregon State University*

Sal Hernandez presented an academic perspective of using ELD data to understand behaviors at roundabouts, rest areas, and throughout supply chains. The presentation highlighted results from the Idaho Statewide Freight Data and Commodity Supply Chain Analysis Study, the preliminary investigation of heavy vehicle parking design in Oregon rest areas, and truck access at roundabouts.

The Idaho Statewide Freight Data and Commodity Supply Chain Analysis Study sought to understand freight movements within and through the state and to analyze how these movements can impact economic development. The project used publicly available data in combination with EROAD data to look at freight ODs among trucks that bypassed, originated in, or were destined for Idaho. The project included the conduct of shipper and establishment (businesses that ship commodities) surveys. The data were useful in filling gaps, and the results provided valuable insights on individual trip chains for several commodity sectors and were able to show the origin–destination pairs by industry. The final report can be found at https://rosap.ntl.bts.gov/view/dot/55847.

The preliminary investigation of heavy vehicle parking design in Oregon rest areas sought to answer how lane striping of heavy vehicle parking in rest areas can be improved to increase the utility of the parking area. It also sought to understand why trucks would park in unauthorized areas when parking was available. The study surveyed drivers and used EROAD data to analyze truck activity. The truck drivers indicated that rest areas were designed with smaller vehicles in mind, increasing the risk for property damage incidents. Because of insurance issues related to these incidents, drivers were instructed to park alongside the road instead of in the rest area. As a result, the study sought to analyze how DOTs can improve the rest area design without the need for heavy investment, such as improved lane striping.

Trucks parked on roadways can have major safety implications, such as decreased sight distance for other vehicles, stationary roadside objects located close to high-speed traffic, and additional obstacles for emergency vehicle operations. Additionally, cars sometimes park in spaces designed for trucks. The project created different scenarios and used a truck simulator at Oregon State University to model the base case and potential solutions. The project team then brought in truck drivers to determine which scenario worked best. This project was a good example of using data to improve conditions. As a result, Oregon DOT increased the width of the rest area parking spaces, removed passenger vehicle parking, and relocated the truck parking to allow for more entry space. The paper can be found at https://ascelibrary.org/doi/abs/10.1061/9780784484340.007.

The third example highlighted issues with trucks navigating roundabouts; it used telematics data along with video-based field data to identify gap lengths and driver behavior. The study observed 724 heavy vehicles over a 39-h period, in which the observations peaked between 9 and 11 a.m. The EROAD GPS data provided the circulating speed and direction of the trucks (Figure 9) and were consistent with ground-truthing observations. The estimated heavy vehicle circulating speed was approximately 12.6 mph.

Two upcoming studies will use freight telematics data. The first will look at ways to handle weather events that cause heavy traffic or slowdowns. The second will analyze hard braking events using unobserved heterogeneity and spatial correlation. A growing field of research is on using telematics data to improve the transportation system.

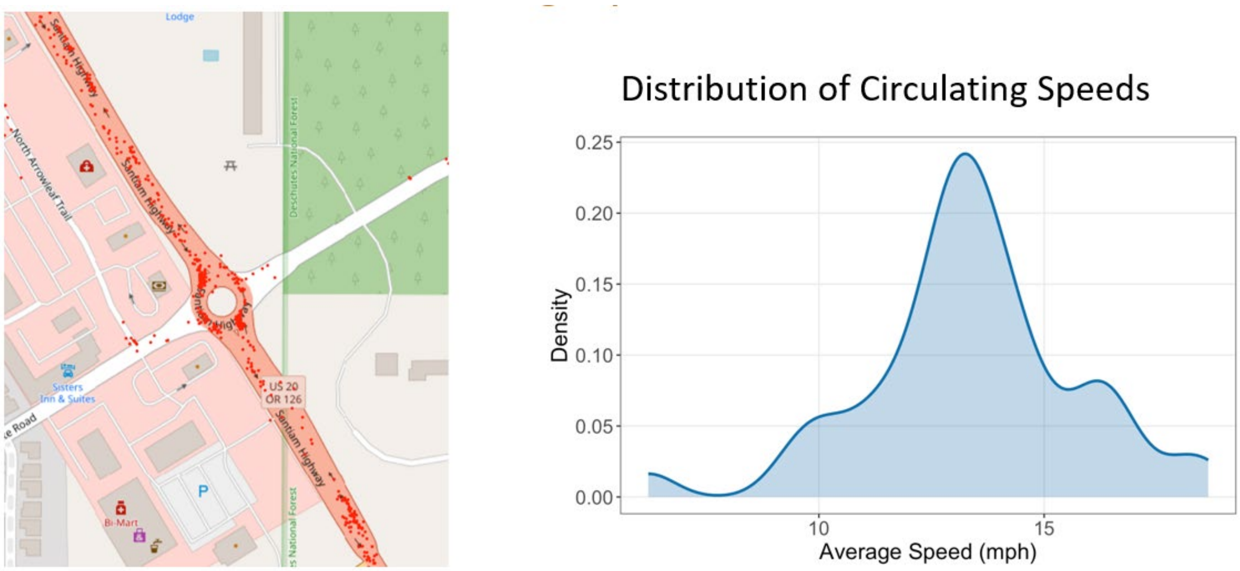

FIGURE 9 EROAD GPS data for 477 heavy truck events.

DISCUSSION

Hernandez facilitated a Q&A session during which attendees posed questions to Robins, Souza, and Hernandez.

- *Regarding the heavy vehicles in roundabouts study, did the project team verify that the truck drivers' concerns about roundabouts were justified?*

Hernandez responded that the truck drivers stated that they did not like the roundabouts and the Oregon Trucking Association (OTA) was trying to block all roundabouts due to the driver concerns. As a result, OTA asked Oregon State University to evaluate if the concerns had merit or if they were only the view of a handful of drivers. The Oregon DOT's concern was that OTA was threatening to lobby to block the implementation of roundabouts. The project ultimately led to improved design standards. Oregon DOT continues to look at different designs and use a truck simulator to test scenarios.

- *Is there a difference between ELD data and telematics data? Have either of these had an impact on HOS?*

Robins responded that ELD data are a subset of telematics data. The terms are often used interchangeably, but when you start getting into the details, there is a need to be more specific. There has not been a change to the HOS mandate.

- *Are ELD data and truck probe data complementary? If not, what are the challenges with making them complementary? Can ELD data evaluate empty trucks, such as looking at tire pressure?*

Robins responded that ELD data and truck probe data are complementary and robinsight combines the two. The challenge occurs in trying to understand what drivers are really doing compared to what we think they are doing. It can be a messy process to analyze the data and things do not always happen with vehicles like we think they do in a live environment. A lot depends on research, and it is up to the researcher to set the data parameters. Measuring empty trucks can be difficult and no mandate exists to measure them. Some researchers will implement sensors or tire monitoring systems, but doing so can be expensive and complex. Combining data sources can help fill gaps.

Hernandez responded that researchers at Oregon State University have been inputting data into a statewide model and matching timestamps. By doing so, they have been able to match many trips and verify them with weigh-in-motion (WIM) data, which has helped develop their understanding of truck movements.

Robins added that WIM station data are a good data source and can complete some crosswalks to verify data. Patching the data together can help tell a compelling story.

- *Can we fuse the ELD data with other data?*

Robins responded that ELD data can be fused with other data; in fact, completing research is not possible without data fusion. Many datasets need to be combined to tell the full story.

- *Looking at the data, has it been considered to overlay hard braking events with traffic light data? For example, Esri has a 3D model with the ability to add grades. Has road infrastructure, such as traffic lights, been considered as a layer?*

Robins responded that staff at robinsight have used different layers and have looked at traffic signal timing. In one case, many hard braking events were occurring at night. They were able to match the signal timing with the use case, such as having freight priority signals in the overnight hours to reduce hard braking events.

- *Even in long-haul trucking, it is difficult to manage how drivers use the device. How applicable and how easy would it be to use ELDs on smaller trucks and other modes in urban scenarios?*

Robins responded that he does not see a distinction between long-haul and smaller urban trucks, but they have not looked at a scenario with smaller trucks and other modes. Staff at robinsight have spent quite a bit of time explaining the devices' attributes and benefits to drivers, but it is a challenge because the data is never clean. The data must be cleaned before it can be used.

Hernandez added that researchers at Oregon State University are doing research in urban areas, including about safety implications related to parking. This research is ongoing and will investigate this topic.

Panel 3:
Freight Data for E-Commerce Planning and Regulation

KERI ROBINSON

California Department of Transportation, Moderator

The final panel proposed ways to use freight data for e-commerce planning and regulations. Panelists discussed topics including e-commerce trends and their implications for urban and regional planning, California's warehouse indirect source rule, and data for e-commerce decision-making.

Veiko Parming, *CPCS*

The first presentation shared perspectives from the ongoing Urban Freight Distribution Study conducted for the Metropolitan Council, the MPO for the Twin Cities of Minneapolis and St. Paul, Minnesota. The study had three pillars. The first focused on traffic and how to quantify e-commerce impacts on regional vehicle miles traveled (VMT). The second pillar addressed land use and how to understand facility siting trends and needs. The third pillar focused on the curb and how to accommodate deliveries. Because the study is underway at the time of this presentation, final results are not yet available.

A major consideration in the study is to understand what affects regional VMT and greenhouse gas (GHG) emission growth. For example, there are sales-related impacts (e.g., population, income, digitization of goods), order fulfillment-related impacts (e.g., order sizes and frequency, carrier splits), delivery-related impacts (e.g., parcel size, vehicle type and capacity, returns), and shopping-related impacts (e.g., shopping trip length, trip chaining, frequency). It is important to evaluate how each of these play a role in VMT and GHG growth.

The statistics on e-commerce are constantly evolving (Figure 10). The pandemic may have added a percentage point increase to the ratio of e-commerce sales compared to retail sales in the long run, as online sales increased, but then it dropped and stabilized, so it will be interesting to see how the changes play out. The MPO conducts an app-based household travel survey in the Twin Cities every 2 years, collecting a large amount of data that are helpful in evaluating e-commerce trends. The parcel delivery market is comprised of four major players: United Parcel Service (UPS), US Postal Service (USPS), FedEx, and Amazon Logistics. Amazon Logistics does utilize other parcel delivery providers to deliver Amazon orders; however, Amazon Logistics has also started delivering orders for third-party merchants, which is unique, as they are now making non-Amazon deliveries and taking on more of the delivery market.

When estimating the impacts of e-commerce on regional VMT, the MPO is concerned with the overall regional impacts, not corridor-based or OD-based impacts. The study uses a NielsonIQ dataset to link orders and deliveries, and then

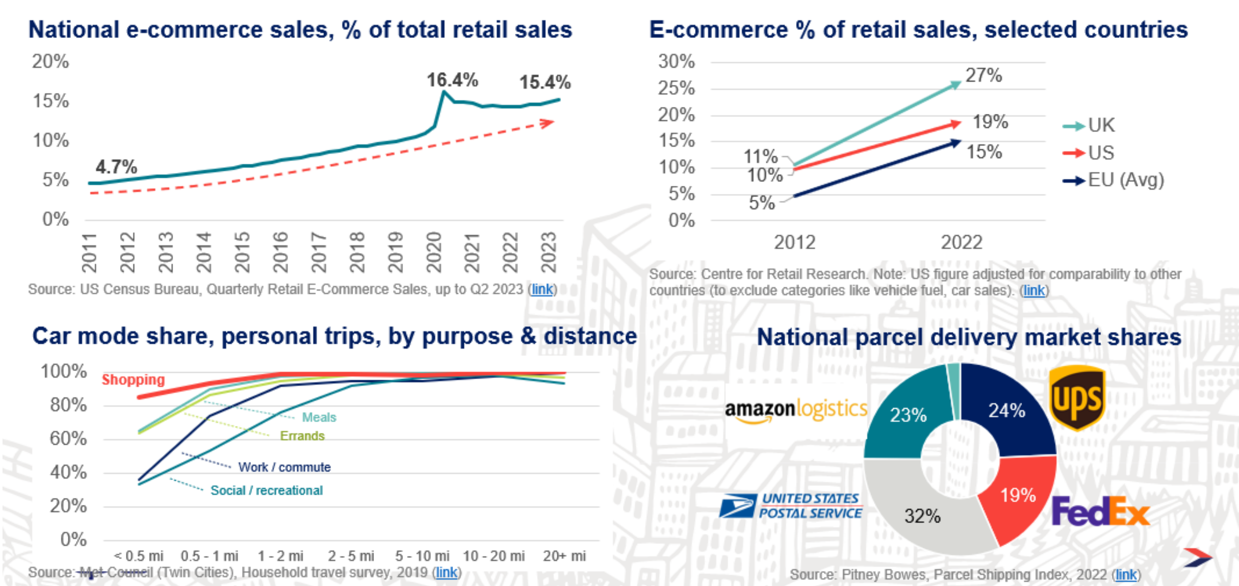

FIGURE 10 E-commerce statistics.

supplements the data with additional sources, such as Census data sources. The MPO then maps key facilities where deliveries begin and uses a routing algorithm to simulate deliveries. As a result, the MPO can map VMT and GHG impacts.

The study has highlighted several land use and curbside considerations. Demand for industrial space is resilient, in line with national trends. Preferred sites are those located near major roadways, which are easier for trucks to access. The MPO is beginning to see more consideration for new land use types, such as repurposing vacant retail stores for delivery pick-up points. There is a need to prioritize curb space in urban areas and the MPO has looked to Seattle as a leader.

The City of Minneapolis was selected for a SMART grant to collect, analyze, and share data on curb use. Big cities are not alone in dealing with curb management and demand challenges; smaller and non-urban locations are also being impacted.

The study highlights data gaps and raises three research questions:

- How does online shopping complement versus substitute for traditional shopping trips?
- What is the nature of these curbside pick up, failed delivery, and product return delivery trips?
- How do people combine shopping trips with other trip-making activities?

Nicole Silva, *South Coast Air Quality Management District*

In California, air quality is regulated at the federal, state, and local levels. At the federal level, the EPA sets and enforces national air quality standards and regulates interstate transportation. At the state level, the California Air Resources Board (CARB) regulates mobile sources (such as cars, trucks, and buses) of air pollution, GHGs, and consumer products. At the local level, air districts, such as the South Coast Air Quality Management District, regulate stationary and local sources of air pollution.

The South Coast Air Quality Management District is a four-county area (Los Angeles, Orange, San Bernadino, and Riverside counties) with a population of 17 million people (44% of California's population). The South Coast area is also home to 67% of California's environmental justice (EJ) population. It is a critical area for freight transportation, with one-third of the United States' total containerized cargo coming through the Port of Los Angeles and the Port of Long Beach.

While air quality in the area has improved in recent years, it still has a long way to go. The area remains in National Ambient Air Quality Standards nonattainment status for criteria pollutants, meaning negative air quality impacts must be mitigated. The Air Quality Management District's Rule 2305 was developed to focus on emissions reductions near warehouses and improve air quality for local communities severely impacted by these emissions. Several data sources were used to develop the rule (Table 1).

The goal of the warehouse indirect source rule is to reduce NO_x (nitric oxide and nitrogen dioxide) emissions by 10% to 15%. The rule affects approximately 3,300 facilities; 400 only need to report and 2,900 are or will be required to take mitigation actions to reduce emissions. Some sites have multiple tenants, but the rule is only applicable to owners and operators of warehouses with more than 100,000 ft^2 of indoor floor space. The rule is being implemented in three phases based on warehouse size:

- Phase 1 – Warehouses larger than 250,000 ft^2:
  - Initial Report Date: July 5, 2022.
    - Initial Annual Report Due: March 2, 2023.
- Phase 2 – Warehouses between 150,000 and 250,000 ft^2:
    - Initial Report Date: July 5, 2023.
    - Initial Annual Report Due: January 31, 2024.
- Phase 3 – Warehouses between 100,000 and 150,000 ft^2:
    - Initial Report Date: July 1, 2024.
  - Initial Annual Report Due: January 31, 2025.

TABLE 1 Data Sources Used for Rule 2305 Development

Parameters	Data Sources	Data Availability
Warehouse Populations and Square Footage	CoStar, Dun & Bradstreet, InfoUSA, Leonard's Guide, Google Earth	www.costar.com, www.dnb.com www.dataaxleusa.com www.leonardsguide.com www.google.com/earth
Truck Emission Rates	EMission FACtor (EMFAC) 2017, CARB META Tool	https://arb.ca.gov/emfac/2017/ ww2.arb.ca.gov/resources/documents/2020-mobile-source-strategy
Truck and Car Trip Rates	Institute of Transportation Engineers, 2016. High-Cube Warehouse Vehicle Trip Generation Analysis	www.ite.org/pub/?id=a3e6679a%2De3a8%2Dbf38%2D7f29%2D2961becdd498
Truck and Car Trip Lengths	Southern California Association of Governments 2016 Regional Transportation Plan	https://scag.ca.gov/resourcesprior-plans
Transport Refrigeration Units (TRU) Populations and Emissions Rates	CARB TRU rulemaking analysis	https://ww2.arb.ca.gov/ourwork/programs/transportrefrigeration-unit/tru-meetingsworkshops
Yard Truck Populations	Power Systems Research	www.powersys.com
Yard Truck Emission Rates	CARB Carl Moyer Guidelines, CARB Low NO_x Omnibus rulemaking analysis	https://ww2.arb.ca.gov/guidelinescarl-moyer https://ww2.arb.ca.gov/rulemaking/2020/hdomnibuslownox

Overall, there has been a big learning curve for warehouse owners and operators to understand the reporting requirements. The South Coast Air Quality Management District is seeing differences in what was anticipated compared to what was reported related to Warehouse Actions and Investments to Reduce Emissions (WAIRE) Points (Figure 11). They are continuing to analyze the data and are the first location in the nation to have this type of data at such a granular level. In time, they hope to be able to estimate weighted annual truck trips, which are a key metric used to determine compliance obligation in Rule 2305.

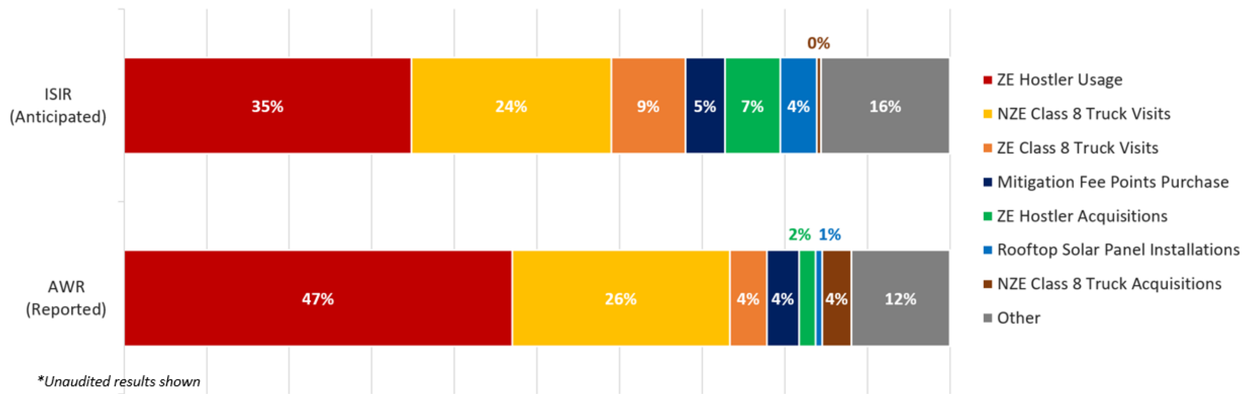

FIGURE 11 Anticipated versus earned operator-reported WAIRE menu items (compliance year 2022).

Alison Conway, *City College of New York*

Conway's presentation explained how e-commerce data can be used in decision-making by highlighting the use of publicly available data. The results were based on experiences at middle-mile facilities in Berks County, Pennsylvania, and New York City. Berks County houses the warehouses that serve New York City and is located directly to the west of Lehigh Valley, one of the fastest growing warehouse markets in the country.

The study team pulled 100 articles to piece together the decision-making process in Berks County and to understand community concerns. These brand-new warehouses generate extensive economic development advantages and tax revenue benefits. However, the community has expressed concerns about traffic and collision risks, air and noise pollution, infrastructure damage, resource demand on transit and utilities, loss of community character, and more.

Some of the critical decisions in bringing warehouses to the community-involved development approvals, zoning related to land use changes and height restrictions, transportation access, environmental permitting, and tax abatements. In Berks County, many decision-makers are involved in the process.

The project did not have any budget to procure data, so it used publicly available data (Table 2) to analyze e-commerce trends. It is critical to also know what is

TABLE 2 Berks County, Pennsylvania, Data Sources

Metrics	Data	Data Challenges
• Trip generation – Freight trips – Worker commutes ▪ Car trips/parking ▪ Transit demand • Collision risk • Job creation • Job characteristics • Land values	• Cell-phone records – Temporal patterns – ODs • Pennsylvania DOT collision records • Pennsylvania DOT traffic counts • Longitudinal Employer-Household Dynamics OD Employment Statistics (LODES) • Quarterly workforce indicators • County land value records	• Data suppression • Aggregation – By sector – By geography • Time lag • Coverage • Decoupling effects • “On-spec” development

happening within the warehouse itself and who is using the warehouse. The project team faced challenges with large amounts of noise in the data sources.

The second study area was New York City, the most populous city in the United States, with 8 million residents in the city and 20 million in the metro area. The region supports a diverse economy and contains extreme vertical density within the central business district. As a baseline, it is important to understand what is considered a warehouse in New York City, as they can appear nontraditional (e.g., quasi-dark stores, on sidewalks, out of the back of trucks, vertical warehouses, etc.). Figure 12 shows some of the types of nontraditional warehousing efforts being used for e-commerce deliveries in New York City.

Related to warehouses, the community expressed concern with traffic and related emissions, collision risks, street activation, jobs, parking, roadway and sidewalk obstructions, e-bike safety, and package theft.

Critical decisions about warehouses in New York City include the city having little control over development, construction approvals determined by the Department of Buildings, curb cut approvals and loading zone allocations determined by the city’s DOT, building management, and the design and implementation of city logistics solutions. A growing area of concern is that

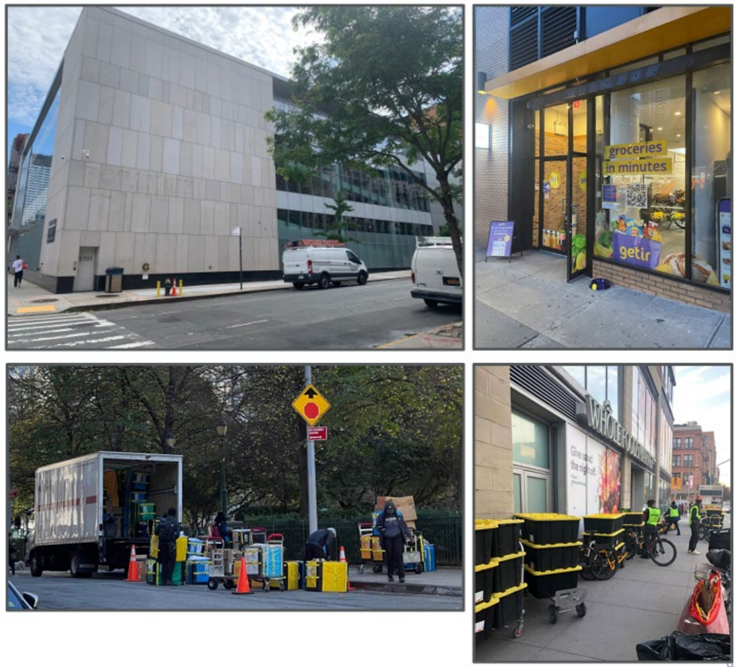

FIGURE 12 Different types of warehouses (e-commerce distribution sites) in New York City. [Source: Alison Conway, City College of New York (top two photos and bottom left photo) and Tom O'Brien, California State University, Long Beach (bottom right photo).]

planners are trying to reduce truck operations in urban areas or ban trucks in certain areas; however, "freight's gonna freight," meaning that freight is going to go where freight wants and needs to go, so more should be done to make it easier.

Ongoing research efforts are addressing truck-bike conflicts, residential delivery activity, social effects of proximity logistics (the development of logistics facilities in urban or high-demand areas), and micro-distribution pilots. E-commerce needs to be considered as a service provider to fulfill consumer and business demand for goods. E-commerce impacts should be evaluated for both freight and commuting trips, as carriers have indicated that micro-distribution hubs need to be located near transit so that individuals can pick up their packages at parcel hubs. Shopping behavior is different based on commodity type, individual characteristics, built environment characteristics, and cultural characteristics.

DISCUSSION

Robinson as the moderator facilitated a Q&A session, during which participants posed questions to Parming, Silva, and Conway:

- *Specifically related to Silva's presentation, in the old warehouse facility design, products came in bulk, nothing was added or changed, and then it was shipped out. Now there are more value-add warehouses where changes occur to the product before it ships out. So, what exactly is considered to be a warehouse under Rule 2305?*

Silva responded that a warehouse is defined as a facility that deals with the distribution of goods. They are not looking at manufacturing sites; however, if a location has both warehousing and manufacturing, it falls under Rule 2305. The South Coast Air Quality Management District fields many questions about what is required for warehouse operations and generally answers these questions on a case-by-case basis. Currently, they are trying to identify what warehouses exist and who needs to report.

- *Specifically related to warehousing in rural areas (e.g., Berks County), the "built as spec" moniker lets the private sector off the hook in a lot of ways and puts the onus on the public sector to demonstrate that there will not be a significant level of impact, such as increased truck traffic, based on the square footage of facilities. What research is needed to help rural communities better understand the impact of large footprint warehouses and how they should think about the development and transportation infrastructure?*

Conway responded that this point is well taken and acknowledged that a spectrum should be considered in the analysis. Many of these projects result in legal action and many angry public meetings occurred in Berks County. In one example, a warehouse was not approved, and the developer sued the city, claiming exclusionary zoning. The city won the case, but it cost them heavily to fund it and as a result taxes were increased to pay for the lawsuit. The goal is to make communities aware of the impacts of warehouses. Local planners currently use the Institute of Transportation Engineers trip generation rates, which are not accurate for the warehousing sector. It is a complex issue and local control is needed.

- *[To Parming and Conway] Are there any insights on how local decision-makers view "dark stores" (a brick-and-mortar retail facility that has been converted into a center for fulfillment operations)?*

Parming responded that in the Twin Cities, dark stores are still a nascent concept. He added that he has heard of some European cities banning them, which is causing trepidation elsewhere.

Conway added that in New York City these sites are more "quasi-dark" stores because they are required to have some retail function. Overall, these stores are not desirable because they deactivate that area and create traffic, such as from e-cargo bikes, which contributes to e-bike safety concerns.

- *Lehigh Valley has become a truck staging area because the industry determined that it was a feasible location for that type of activity. How can we make sure that truck handling is done correctly?*

Conway responded that she has not seen a comprehensive effort to address this issue, but there is a general understanding across the industry that it is a concern. In Berks County, the community did not want warehousing because they were concerned that it would bring in crime.

- *[To Parming] Considering VMT for e-commerce and then hearing about experiences in New York City that will bring in different types of delivery sources, what other metric can be substituted for VMT for these additional modes?*

Parming responded that VMT is key to evaluating emissions reductions, making it an important metric. In the Twin Cities, cargo bikes are not a common delivery vehicle outside of food delivery. Whatever the metric, the type of trips needs to be evaluated.

- *We know that whenever trucks are moving, many externalities exist. As a result, some want to move to cargo bike deliveries. How should e-cargo bikes be used and measured?*

Conway responded that New York City is trying to design a micro-hub network. The initial report is out (https://www.nyc.gov/html/dot/downloads /pdf/microhubs-pilot-report.pdf) on how the city will manage the pilot project. The city is considering curbside and other public spaces, while also looking to the private sector. Since the pandemic, fewer people are going into offices, so parking garages are underused, and opportunities may exist to repurpose them.

Parming added that Toronto has set up shipping-container-as-micro-distribution sites in some underused locations, which is another opportunity.

Session 1A: Innovative Uses of Public Data

JEFF PURDY
Federal Highway Administration, Moderator

CARLA TEJADA LOPEZ
University of Illinois Chicago, Recorder

Session 1A presented different approaches for using existing public datasets in several applications that included: (1) simulation of corridor performance, (2) analysis of truck travel trends, (3) prediction of waterborne commerce, and (4) disaggregation efforts of freight data for public planning decision-making. Many of these presentations also showed applications of how to use these datasets and how they work together to inform public planning.

SIMULATING MULTI-STATE CORRIDOR PERFORMANCE FROM ORIGIN TO DESTINATION

Alex Marach and Kamol Roy, *CPCS*

The first presentation presented a regional bottleneck assessment for member states of the Institute for Trade and Transportation Studies, which are mostly located in the southeastern United States. The study's main goal was to create a geographic information system (GIS) planning tool that would enable collaboration among states through an information sharing platform about the freight network and existing bottlenecks at the OD levels.

To achieve this goal, the primary data inputs were NPMRDS 2019 and Highway Performance Monitoring System (HPMS) 2019, along with road network data and top OD pairings from several sources including USDOT, BTS, and FHWA.[2] Outputs consisted of performance metrics that included: (1) average truck speed, (2) truck travel time reliability index, (3) truck delay per mile, (4) annual hours truck delay, and (5) annual cost truck delay. Furthermore, having an OD-level analysis permitted the researchers to analyze the behavior of traffic and bottlenecks in every state and how each portion of the network would affect the following steps.

Thirty-six OD pairs were identified in the area of study, representing the top trade lanes, routes with high volumes of freight movements based on multi-state commodity flows and state consultations. The final network was adjusted manually. With this network and the input data, the study developed a simulation of truck trips by time of day, resulting in a GIS-based platform that would allow researchers to study segments of the roads to identify bottlenecks. In addition, this application is also expected to inform where truck parking is needed, to facilitate regional collaboration to solve bottleneck problems, and to define an area of project prioritization.

TRENDS IN TRUCK TRAVEL FROM THE NEXTGEN NHTS OD DATA

Mitchell Fisher, *MacroSys Research and Technology*

The second presentation discussed a new data source called NextGen NHTS Truck OD. This source (1) provides annualized truck trip volumes and distances between 583 FHWA zones; (2) is based on GPS data and is supported by American Transportation Research Institute (ATRI) and INRIX; (3) covers vehicle classes from 5 to 13; and (4) is

[2] U.S. Department of Transportation, Bureau of Transportation Statistics (BTS), Federal Highway Administration (FHWA). (2017) Freight Analysis Framework, FAF5 [datasets]. https://doi.org/10.21949/1529116

validated against other common sources such as FAF data. Importantly, it also contains ODs.

The presented applications of this tool show that most truck trips between 2020 to 2022 are intrastate (91.7% on average for the 3 years) and that the percent of annual trips (annualized truck trip volumes) by distance usually range from 0 to 10 mi. The tool provides several visualizations that can be found at https://nhts.ornl.gov/od/, including one of truck flows for 2020 and 2021 departing the Miami area, which can show actual changes in truck trip flows from year to year.

PREDICTING WATERBORNE COMMERCE STATISTICS WITH AUTOMATIC IDENTIFICATION SYSTEM DATA AND MACHINE LEARNING

Sanjeev Bhurtyal, *University of Arkansas*

The third presentation discussed the potential of predicting waterborne commerce statistics (WCS) using Automatic Identification System (AIS) data and machine learning. The presenter showed that in general, waterborne commerce presents several benefits over other types of commerce. First, it is a more environmentally friendly mode as measured by ton-miles per gallon of fuel. Second, it is also a more cost-efficient mode, as it costs $4.38 less per ton-mile than moving goods by truck. Finally, waterborne commerce represents a vital economic contribution as 42% of all US international freight value is traded via waterways.

To be able to predict WCS, the researchers had to use several data sources due to the limited amount of existing data. Their sources included both commodity tonnage and trips data and publicly available AIS data (i.e., vessel characteristics, international and local waterway data) to study 10 US port statistical areas from 2016 to 2020. The commodity data used in the study was based on the 1-digit NAICS code and a clustering algorithm was used to group vessels based on their size. Next, a long short-term memory network model was used to train the dataset, validate the model, and sort the predictions generated into four models of uncategorized and categorized data (combined-uncategorized, combined categorized, port statistical area-uncategorized, and port statistical area-categorized).

One of the main findings of this model is that movements of coal presented a higher degree of error than other commodities. In the future, the researchers plan to include additional port terminals and improve the predictive model.

UNLOCKING GRANULAR INSIGHTS: DISAGGREGATION OF THE FREIGHT ANALYSIS FRAMEWORK COMMODITY FLOW DATABASE FOR REGIONAL AND MULTI-JURISDICTIONAL USE

Daniel Forbush, *Cambridge Systematics*

The final study presented in this session showed an example leveraging publicly available data for decision-making for a project undertaken by The Eastern Transportation Coalition (TETC). The research group showed the need to disaggregate existing data, specifically the FAF, to a more granular level that will enable further understanding of freight movements. The group stated that disaggregated data is of high value to understand the specifics of freight movements within FAF regions and, most importantly, in smaller regions within states.

Although disaggregation is necessary, the research group showed that it also presents a challenge in terms of methods and capacity, as the FAF can present over 1.5 billion unique freight flows. Besides the FAF, the group also used the County Business Patterns, the Bureau of Economic Analysis (BEA) input-output accounts data, the TransBorder Freight Data from BTS, and the WCS from the US Army Corps of Engineers (USACE). To process all of it, they developed two methodologies: one for domestic flows and the second for import–export flows. This methodology proved valid to evaluate a specific freight problem in the TETC region.

In the TETC region, the chosen problem was related to the Marine Highway Program. In the past, the Ohio River had been a primary gateway for moving coal (50 million tons moved during World War II); however, coal's decline has reduced the current river traffic. As a result, maintaining this important waterway has become incredibly expensive. Nonetheless, it remains a vital option for transportation, and the river causes fewer negative impacts on the surrounding communities than does carrying freight by road or rail. Representatives of the area sought to justify the need for investment to maintain the river transportation because the USACE wanted to put the cost burden on the region. This would have been harder to accomplish without the disaggregation, mainly due to the limitations on the data that were not available, flexible, and representative of freight's multimodal characteristics. Using the project methodology and being able to analyze the area in more detail proved of great use to explain the need for this waterway.

DISCUSSION

Several questions in this session resulted in a more detailed discussion of the methodology to use data at each disaggregation level, the definition of trips, the area of the study, and the sample considered to develop models and visualizations. The session's general conclusions were that disaggregation and the use of existing and novel data can be useful to inform several talking points. However, it should be done very carefully and with consideration of its limitations. The data were not created to be disaggregated and results can be either inconsistent or invalid.

SUMMARY

This session discussed innovative uses of existing public data to inform important decisions on the movement of freight. The data used included that informing the use of the network (NPMRDS, HPMS, etc.), GIS, ATRI, INRIX, CFS, FAF, waterways use, County Business Patterns, and BTS data. Using several methods, the researchers generated informative visualizations, developed machine learning models, and served as an input for explaining the importance of the movement of goods in several diverse regions across the United States.

The presented studies and results made clear the importance of public data. Even if public data are imperfect, the case could still be made that public data are important in informing decision-makers about the movement of goods and need for investment.

Session 1B: Data for Modeling

DIANA RAMIREZ-RIOS
University at Buffalo, Moderator

SUBHADIPTO PODDAR
University of Arkansas, Recorder

The Data for Modeling session at the Innovations in Freight Data workshop featured presentations from national laboratories and the USDOT on applying transportation demand models and simulations to identify and understand various aspects of freight transportation. Many participants in this session expressed the importance of having information regarding the freight's size, weight, and commodity type by mode. Four presentations encompassed various aspects of freight transportation.

DEPOT DETECTION FOR FREIGHT TOUR DEVELOPMENT

Monique Stinson, *Bureau of Transportation Statistics*

The first presenter described a method for identifying freight vehicle depots based on GPS data. The presenter explained that the raw GPS data did not include information on when and where the trucks stopped, so they developed an algorithm to identify these places. They were able to identify the truck depots based on stop locations using a method that they developed which is not found anywhere in the literature. The presentation also used a US business database, the Census Tiger database, and

Google Images to identify stops (e.g., temporary stops to comply with HOS regulations) and filter out depots (where the truck tour starts and ends). The number and duration of stops at a place were key factors in filtering depots from stops. Key findings were that depots were generally visited by many individual trucks, and most depots were located at logistics-related locations. The presenter expressed interest in future work to look at the various stop activities and classify these stops.

A HEURISTIC METHOD TO SEQUENTIALLY IMPUTE VEHICLE CLASS AND WEIGHT FOR US HIGHWAY NETWORK TRUCK FLOWS

Diyi Liu, *University of Tennessee, Knoxville*

The next presentation reconstructed truck flows over time and space using the Travel Monitoring and Analysis System (TMAS) and the FAF. The presentation addressed the main drawbacks of these data sources: GPS trajectories and OD surveys often do not have information on vehicle class and weight and represent a very biased sample of the whole population of trucks, as not all trucks participate in GPS tracking or OD surveys. The researchers imputed the class and weight data to describe the statewide distribution of freight (trucks) at different locations based on time of day, day of week, and season of the year. They also described a case study on first- and last-mile trips near the Port of Savannah, Georgia. As a result of the study, the project team developed a method to impute TMAS records over the network to produce an outlook of where the trucks were located based on class and weight distributions.

DEVELOPING A FREIGHT ASSET CHOICE MODEL FOR AGENT-BASED SIMULATION MODELS

Natalia Zuniga-Garcia, *Argonne National Laboratory*

The third presentation established behavioral models that jointly predict fleet ownership (number of medium- and heavy-duty trucks) and distribution center control (defined as ownership or leasing of distribution centers by the firm). This presentation covered a notable gap: agent-based models were usually developed for passenger car vehicles. Models that involved freight vehicles missed key strategic asset decisions, such as fleet ownership, fleet distribution, and distribution center ownership and size. The simulation-based models described in the presentation analyzed the behavioral models of different firms. Key findings were that firms with higher revenue tended to own their fleets and had larger distribution centers, that the transportation sector (for-hire carriers) had the strongest preference for heavy-duty truck fleets, and that private fleets dominated among medium-duty trucks. Transportation researchers can use this model to understand freight-related operations, and policymakers can use simulation scenarios to better understand freight operations' impact on VMT and GHGs. Future work will incorporate a national-level multimodal scenario involving both rail and waterways.

FUTURE FREIGHT POPULATION GENERATION FOR AGENT-BASED MODELING

Abdelrahman Ismael, *Argonne National Laboratory*

The last presentation used a microsimulation model to represent entire supply chains by synthesizing current freight agents (e.g., carriers, private fleets, and firms and their establishments) and predicting future national freight transportation movements and employment in various industry sectors. The presentation discussed applying the model to predict future employment growth by freight-intensive sector (using 3-digit NAICS codes) at every 5-year interval until 2040, thus predicting freight traffic movement.

Based on the model, the metropolitan area of Austin, Texas, is expected grow about 50% in fleet size and nearly double its employment. Future studies would be more dynamic, using the data to predict further in the future and tracking individual establishments differently based on their technological advancements.

The session concluded with presenters and participants discussing the importance of understanding empty freight trips to track the movement of commodities and the need for connected vehicle data, such as trajectory data, for better freight transportation modeling.

Session 1C: Data for Supply Chain Analysis and Decision-Making

TYLER GRAHAM
Texas Department of Transportation, Moderator

This session focused on using data for supply chain analysis and decision-making. The presentations discussed enhanced commodity flow data, data merging, multiship mode choices, data fusion, and the GIS analysis of hazmats.

QFIT—A NEW SOURCE FOR COMMODITY FLOW DATA

Benjamin Zietlow, *Quetica*

The private sector's goals in assessing supply chain performance are to lower costs, improve service, and outperform the competition. The public sector's goals in assessing supply chain performance are to understand supply chain operations and performance and to support economic growth through freight transportation investment. However, both sectors face limitations in accessing data to adequately evaluate supply chain performance.

The presenter stated that Quetica's Freight Intelligence Tracker (QFIT) addresses data challenges: QFIT disaggregates FAF data and is enhanced with private-sector shipping records and mode-specific data. It details commodity flows for county-to-county ODs using a proprietary regression tool for disaggregated flows of 42 commodity groups.

Using integrated data requires seeing both the forest and the trees. If you are only talking with one shipper, then you are only going to understand one supply chain, which is inadequate. Quetica uses a regression analysis method to disaggregate FAF data to the county level, resulting in an analysis of supply chain performance. Notably, FAF underestimates agriculture exports from midwestern states because exports are entered based on the port location, not the actual originating location.

Three key shipment benchmark data points are needed from the private sector. First, length of haul by commodity, mode, and region helps facilitate the trade lane analysis for heavy haul industries and provides an understanding of the trends in last-mile delivery. Second, equipment type is used to understand equipment needs and availability, which are helpful in analyzing infrastructure investments to the multimodal freight network. Third, modal cost benchmarks are used to analyze costs of modal operations for shippers and to estimate the financial resources required to move freight.

QFIT has several freight planning applications. It can help develop statewide, regional, urban, or corridor freight plans. It can analyze economic development and support private-sector investment, and in be used in adaptive freight network optimization modeling and analytics. QFIT can also analyze freight infrastructure cost–benefit scenarios for grants and other funding opportunities.

DATA MERGING AND DATA ANALYSIS TO ESTIMATE SUPPLY CHAIN FLUIDITY

Mario Monsreal, *Texas A&M Transportation Institute*

Monsreal presented results of data merging and analysis to estimate supply chain fluidity. The purpose of the project was to develop a methodology to measure supply chain performance and to develop a supply chain fluidity index. The supply chain includes everything from the creation of the raw product to the delivery of the final product to the consumer.

Supply chain fluidity is defined as the movement performance of services, goods, money, and information flows throughout different supply chain activities. The public sector has an influence on supply chain performance and flow, as policies, planning, and investments can all have impacts. Fulfillment and reverse flows are likely to have the most public-sector impact.

The project considered two case studies: aluminum to automobiles and chips to computers. These case studies considered the entire product transformation from raw product to finished good. The data used in the analysis and methodology included AIS, port dwell time, NPMRDS, BEA inventory-sales ratio, Google travel time and distance, Border Crossing Information System, and Union Pacific performance metrics. The case studies evaluated multiple route options to analyze the supply chain fluidity index and evaluate the time spent both in transportation and at each relevant node.

The supply chain fluidity index has several applications for future work. First, it can help explain and compare supply chains and can estimate traffic value and economic impacts. Second, public-sector agencies can better understand commodity transportation and node intensity. The supply chain fluidity index can identify the contribution of individual transportation modes to the total supply chain flow time, leading to a better understanding of infrastructure productivity and capacity. Third, the private sector can use the supply chain fluidity index to better understand inventory planning, network design, customer service levels, and postponement of deliveries.

INVESTIGATING THE FACTORS AFFECTING MULTI-SHIP MODE CHOICES USING DATA FUSION TECHNIQUE

Md Sami Hasnine, *Virginia Tech*

Hasnine presented results of a data fusion technique to investigate factors that affect multi-ship mode choices. The objective of the project was to create a model that used historical shipper demands and generate capacity plans for full truckload (FTL), less-than-truckload (LTL), and small parcel (SP) in Seattle.

The project had a small dataset compiled from an Amazon middle-mile team that delivers to hubs. The data were aggregated for three destinations and the project team developed a tool, using Google API to generate specific routes. The project team also added inputs from the Council on Environmental Quality's Climate and Economic Justice Screening Tool (https://screeningtool.geoplatform.gov/en/).

The results were analyzed using regression analysis and nonparametric (kernel density) regression. Results indicated that the method was appropriate for short-term forecasting. Future work would incorporate additional datasets and test which routes could be quickest for deliveries.

GIS ANALYSIS METHODOLOGY OF DANGEROUS GOODS MOVING THROUGH METRO VANCOUVER, BRITISH COLUMBIA

Monica Blaney, *Transport Canada*

Blaney presented a GIS analysis of dangerous goods movements through metro Vancouver, British Columbia, that can describe trends and patterns in the movements. The study split the freight market for Vancouver into four sectors:

- Gateway Marine/Air: all freight movements through Port Metro Vancouver, Gateway facilities, and related infrastructure.
- Cascade Border: all freight movements through land ports-of-entry by commercial vehicles and by rail across the Cascade Gateway.
- Inter-Regional: all domestic freight movements with one trip end in metro Vancouver/Lower Mainland and the other outside of metro Vancouver.
- Regional: all freight movements with both trip ends within metro Vancouver/Lower Mainland.

The methodology combined transportation and trade data, site volume estimates, and Dangerous Goods Accident Information System with freight-related GIS data (based on a 2014 truck classification/dangerous goods study). It then developed truck volume models using the aforementioned data along with elements of TransLink's

Regional Transportation Model. Canada has an advantage over the United States in that the hazardous trucks are placarded and the country tracks empty trucks, which can help to better capture what is being moved and where it is moving to and from. The project also used business directory information, industrial land maps, and NAICS commodity information.

Trucks carrying dangerous goods make up approximately 2% of all trucks in the Lower Mainland; 75% of these trucks contain flammable liquids and gases. The largest truck trip volumes are generated by petroleum terminals near Burnaby. The most reported dangerous goods moving by air are lithium-ion batteries and dry ice. Airports are also a major consumer of aviation fuel, another dangerous good that requires transport.

Between 2008 and 2017, approximately 75 reported incidents in the Lower Mainland involved dangerous goods. More than 90% of these incidents involved four dangerous goods classes: gases, oxidizing substances, flammable liquids, and corrosives. Most incidents occurred at terminals, as opposed to between them, which is not necessarily the case outside of the Lower Mainland.

The project team conducted a hot spot analysis but did not see significant clustering of the incidents. The project results indicate that the most significant hazmat flows are Class 3 flammable liquids to and from petroleum terminals in and around Barnaby. There is significance in the dangerous goods clustering at rail interchanges with the United States. The clustering of dangerous goods terminals was highest along Burrard Inlet, which includes chemical plants and terminals in North Vancouver. Future efforts include working with other industries to obtain data and better understand where dangerous goods movements are occurring.

DISCUSSION

Graham facilitated a Q&A session during which participants posed questions to Zietlow, Monsreal, Hasnine, and Blaney.

- *Is QFIT able to capture placards to analyze whether containers are hazardous and whether they are empty or loaded?*

Zietlow responded that QFIT can capture hazardous trucks, but they are not currently able to capture empty trucks. The company is also working to add emissions analysis to the tool.

- *Can you explain more about the private data sources used in QFIT?*

Zietlow responded that the company gathers private-sector data in two ways. First, they meet individually with companies, which requires relationship-building, history, and trust. As a result, they sign nondisclosure agreements and do not share access to the underlying shipment records; clients only have access to the aggregated results. Second, the company purchases shipment records.

- *Is Transearch data used in QFIT?*

Zietlow responded that QFIT does use Transearch data. Transearch data was enhanced with private-sector shipment records in Illinois, Missouri, South Carolina, and Texas.

- *How does QFIT work for counties that are small?*

Zietlow responded that they have conducted analysis at the transportation analysis zone (TAZ) level, but it depends on the disaggregation.

- *Does QFIT look at engine type or just the commodity?*

Zietlow responded that they have information on equipment type but not engine type.

Caitlin Hughes, FHWA, added that the new VIUS will be able to provide information on engine type.

- *In the supply chain fluidity index, did you use the average for port dwell times? How did you create the free flow measure?*

Monsreal responded that the supply chain fluidity index uses the average port dwell time based on information available from the port. The free flow measurement is the shortest travel time over the time period.

- *What are nodes in the supply chain fluidity index? Does the index calculate bottlenecks?*

Monsreal responded that nodes are the points in the supply chain where some other activity is being performed, such as the transformation of the raw product. The supply chain fluidity index does not calculate bottlenecks.

Graham added that the Texas A&M Transportation Institute conducted this study for the Texas DOT. The study has helped to visualize the supply chain process and how much happens on Texas networks, which can be important for decision-makers.

- *Can dangerous goods movements be understood based on the season? Can you pinpoint peaks of travel?*

Blaney responded that it was possible to understand seasonality for one commodity—anhydrous ammonia (a source of nitrogen fertilizer)—as it is transported during a 3-week period. Other commodities are more spread out across seasons, making it difficult to see any seasonality trends.

- *Is the dangerous goods movement data obtained from the shipper in weekly increments?*

Blaney responded that they do not receive that level of data from the shipper; they only have OD data.

- *If you could track dangerous goods by season and see the hotspots, that could lead to analysis of plumes and catastrophic events. This could help determine what cross-disciplinary efforts might be needed to mitigate climate change efforts.*

Blaney responded that the methodology does incorporate a climate change component and that they provide their data and results to other departments, as there are many cross-disciplinary impacts from their results.

Session 2A: Emerging Data Analytics Approaches for Decision-Making

ALISON CONWAY
City College of New York, Moderator

SANJEEV BHURTYAL
University of Arkansas, Recorder

This session discussed emerging data analytics approaches for decision-making. Presentations covered the use of digital twins, machine learning, generative AI, and Automated License Plate Reader (ALPR) systems. The session addressed these approaches in the context of freight transportation.

THE RISE OF PLANIMETRIC DIGITAL TWINS: IMPLICATIONS FOR FREIGHT MODEL CALIBRATION AND TRIP GENERATION RATE STABILIZATION IN WAREHOUSING

Troy Simpson, *Ecopia*

Simpson presented research findings using digital twins to conduct a freight model calibration based on inventory land parcels and building geometry factors. Regional-level land use and warehousing inventory data are not as detailed as they need to be and are out of date. The project used geospatial methods to create a uni-temporal digital twin of 3D buildings using 3.1 million land use parcels in the Southern California

Association of Governments (SCAG) region. Building geometry factors were calculated using the Kernel Density Estimation Model and were aggregated by land use type. Future efforts will include partnering with other organizations to expand the analysis capacity and 3D modeling of multi-level structures and to incorporate more discrete land type variables.

A MACHINE LEARNING METHOD FOR STRATEGY DATA DEVELOPMENT WITH AN EMPIRICAL FREIGHT ASSET MODEL APPLICATION

Monique Stinson, *Bureau of Transportation Statistics*

Stinson reported research findings for a new machine learning methodology for strategy data development. Personal attitudes and perceptions can impact transportation decisions and are used widely in behavioral models. However, attitudes and preferences are not easily observable or quantifiable. Personal attitudes and preferences are typically collected in surveys, but these surveys are generally subjective, expensive, and burdensome. As a result, there is a gap in strategy data for shippers and receivers. The purpose of this research was to develop a method to measure attitudes using existing text; the method could then be used to evaluate real-world strategies and their impacts. The results indicated that companies use keywords differently and the use of keywords is dependent on transportation functions. The research resulted in a proof-of-concept that demonstrates the link between company strategies and freight asset decisions.

RESPONSIBLY TELLING THE FREIGHT STORY USING GENERATIVE ARTIFICIAL INTELLIGENCE

Dan Seedah, ***Jacobs***

Seedah presented on how freight stakeholders can responsibly discuss freight using generative AI. Word choice matters in how we use AI and its results. The machines learn based on the information that we input into them. As a result, researchers need to be responsible. Context is important and responsible use of AI is ethical, safe, transparent, accountable, and comprehensive. Researchers need to decide if we want AI to tell the story because there will be impacts based on this choice. Researchers should also consider context, availability, accuracy, and usefulness when using AI in freight planning. AI will continue to improve and be able to help freight stakeholders make informed decisions.

HEAVY-DUTY TRUCK OPERATIONAL INSIGHTS USING ALPR SYSTEMS

Koti Reddy Allu, ***University of California, Irvine***

Allu presented operational insights for identifying heavy-duty trucks using ALPR systems at the San Pedro Bay Port Complex. There is a limited understanding of jurisdiction-wide spatiotemporal truck activities. The project ground-truthed 12,300 ALPR observations and converted ALPR readings into vectors to develop a fully connected neural net model with an accuracy rate of more than 90%. The research team manually classified 10 truck body types in the data. The results found that out-of-state tanker trucks have a high frequency of trips on I-710. They also found that container trucks have license plates from far away states, which may indicate that these are long-haul trucks. The research analyzed port truck activity patterns and found that 70% of single trips to the port in one 24-h period occurred between the hours of 6:00 a.m. and 7:00 p.m., while multiple trips within one 24-h period were completed in two continuous segments. This research conducted a performance assessment of ALPR systems on freeways leading to port complex gateways and was able to preliminarily identify intrastate freight operations. Future work could consider data fusion techniques to improve the model and sensing technologies.

SUMMARY

The session highlighted the following key findings, gaps, and next steps:

Key Findings

- Geospatial methods can relate a uni-temporal digital twin of 3D buildings to land use inventory parcels.
- Methods to measure attitudes using existing text are relatively more objective than surveys. These methods use readily available text and hence no surveys are required. In addition, measurements from these methods are continuous and unbounded and can link company strategy to freight asset decisions.
- With the increase in AI applications, discussion on responsible AI use is needed. AI can be used for decision-making; however, the scenarios for its application must be carefully analyzed before implementation.
- ALPR, paired with neural networks, can identify intrastate operations of out-of-state trucks.

Gaps

- Trucks from Mexico have two plates; however, ALPR can only capture one plate.

Next Steps

- Geospatial methods to relate a uni-temporal digital twin of 3D buildings to land use inventory parcels can be expanded to other infrastructure features like loading bays.
- Attention needs to be given to the inputs that train machine learning models.
- ALPR can be paired with inductive loop detectors and lidar for insights on disaggregated freight operational characteristics.

Session 2B: Planning for Future Freight Infrastructure

CARLA TEJADA LOPEZ
University of Illinois Chicago, Moderator

This session discussed planning efforts for future freight infrastructure. Presenters shared research results on freight optimization system deployment, charging infrastructure needs, analysis, modeling, simulation (AMS) framework development, and planning for truck electrification infrastructure using telematics data.

NORTH CENTRAL TEXAS COUNCIL OF GOVERNMENTS FREIGHT OPTIMIZATION SYSTEM DEPLOYMENT

Douglas Gettman, *Kimley Horn*
Collin Moffett, *North Central Texas Council of Governments*

Moffett shared that the Dallas–Fort Worth (DFW) is the largest inland port and distribution ecosystem in the United States and has more than 40 freight-oriented developments. As a result, there is a need for truck signal priority. The vision for the project was to collect real-time information, retain active control of the traffic signals, track benefit-costs of truck priority signals (without burdening local agencies and truck drivers with the costs), and to create a self-sustaining program after 5 years of operation. The project resulted in the implementation of 500 freight priority traffic signals in the region. Studies have shown that transit signal priority has reduced bus travel time approximately 10% to 20% without negatively impacting side streets. Freight signal priority is expected to provide similar benefits for trucks. The Traction Priority system uses truck GPS trajectory data and second-by-second signal phase and timing data from the controller. Together, these data sources allowed the researchers to estimate what both the truck and the controller would have done without signal priority. The system also used MOVES data to evaluate fuel savings and emissions reductions.

CHARGING INFRASTRUCTURE NEEDS OF ADVANCED CLEAN TRUCK RULE STATES

Lynn Daniels, *Rocky Mountain Institute*

Daniels presented research results highlighting the level of charging infrastructure needed for advanced clean truck (ACT) rule states. The research project used real-world telematics data from Geotab to assess the potential of truck electrification and to determine the trucks' VMT, energy and infrastructure needs, load profiles, and community health impacts. Currently, electric trucks' range is 300 mi. The research resulted in a better understanding of the daily driving distances and energy needs of trucks. The energy needs were also mapped for ACT rule states (California, Colorado, Connecticut, the District of Columbia, Hawaii, Maine, Maryland, Massachusetts, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Rhode Island, Vermont, Virginia, and Washington). The research evaluated the median time spent driving and parking for both medium- and heavy-duty trucks. It also used a Monte Carlo simulation to determine the percentage of trucks at the depot at any given hour to develop load profiles. The data dashboard and additional information is available at https://rmi.org/early-trucking-electrification-in-act-states/.

DEVELOP AN ANALYSIS, MODELING, AND SIMULATION FRAMEWORK FOR CONNECTED AND AUTOMATED TRUCKS

Zhitong Huang, ***Leidos, Inc.***

Huang reported research results from the development of an AMS framework for automated trucks. This research was motivated by agencies needing a low-cost approach to quantify the effects of connected and automated vehicle (CAV) deployments to make investment decisions. Current AMS tools were developed to model human driving behavior; this work updates these tools for CAVs. The research team conducted an assessment to understand the gaps in existing CAV AMS capabilities. As a result of those findings, the research team developed an AMS framework specifically for connected and automated trucks (CATs). The final research report is available at https://rosap.ntl.bts.gov/view/dot/39965.

PLANNING OF TRUCK ELECTRIFICATION INFRASTRUCTURE USING EMERGING TELEMATICS DATA

Sebastian Guerrero, ***WSP***

Guerrero presented research findings on using truck telematics data to plan for electrification infrastructure needs. Between 1990 and 2021, 60% of the growth in GHGs can be attributed to trucks. The US trucking sector emits more GHGs than all of the United Kingdom. As a result, there is a growing desire to accelerate the electrification of trucks. For example, the IIJA designated national electric vehicle charging corridors and the Inflation Reduction Act provided funding for truck and clean freight technologies. This study used Geotab telematics and GPS data to identify fleet segments that could be electrified and to identify freight routes and optimal charging locations. For a truck to be considered electrifiable, it must be able to return to the home base for at least 95% of its trips and have the ability to stop for longer than the recharge threshold. Detailed data and analyses are needed to plan for electric charging infrastructure, making truck telematics data will be critically important.

DISCUSSION

Tejada Lopez facilitated a Q&A session, during which participants posed questions to Gettman, Moffett, Daniels, Huang, and Guerrero.

- *[To Gettman and Moffett] The hardest part of freight signal optimization will likely be getting the fleet operators to provide the data. What is your approach to working with fleet operators in DFW?*

Moffett responded that public involvement helps, and the North Central Texas Council of Governments (NCTCOG) is actively engaged with several partners and private-sector freight stakeholders in the region. It is critical to have good relationships, which can help all parties understand that there are opportunities to engage with and improve the transportation system. NCTCOG also gets involvement from the cities and buy-in from its policy board and technical committee. Kimley Horn helps on the private-sector side and works with the Texas Trucking Association to access trucking fleet operators.

- *[To Daniels] Does the COBRA tool account for upstream emissions?*

Daniels responded that the COBRA tool only calculates $PM_{2.5}$ from trucking.

- *[To Guerrero] How did Rhode Island respond or react to the research results?*

Guerrero responded that there has been limited guidance on freight electrification, but the guidance is coming from FHWA. The focus has been on light-duty and passenger vehicles in the National Electric Vehicle Infrastructure program. Freight electrification conversations must start with states and industry partners, which hopefully will lead to future investments.

- *[To Guerrero] Did the study ask whether truck drivers are paid for the lost time due to charging? Charging requires 4 to 6 h and drivers are paid by the mile or delivery, not by charging time.*

Guerrero responded that they are still figuring out electrification potential and only evaluated trucks that were stopping anyway. Charging time would not have affected their operations. The 4 h metric is an assumption that can be changed.

- *[To Moffett] How were the critical corridors determined? Have you worked with the DOT to prioritize critical corridors?*

Moffett responded that they focus on performance metrics that are not captured in the current federal measure of truck travel time reliability because that measure is limited to Interstates. Critical corridor identification requires coordination and discussion with the DOT. The MPO's priorities are different because its data and experience are at the local level, and they have industry partners who are facing issues. First- and last-mile movements and connectivity to intermodal facilities are important.

Session 2C: Using Data for Emissions Estimation

STACEY BRICKA
MacroSys Research and Technology, Moderator

This session discussed how data can estimate emissions by addressing freight flows, data gaps, and planning needs.

US MODAL FREIGHT FLOWS EMISSIONS ESTIMATIONS AND FORECASTS

Mitra Salehiesfanda, ***S&P Global***

Salehiesfanda presented research results for US modal freight flow emissions estimates using Transearch data. Freight transportation, a major source of air pollution, is expected to increase from 20.2 billion tons currently to 28.9 billion tons by 2050. Additionally, 29% of GHG emissions come from the transportation sector. The study reviewed almost 100 papers on truck emissions. The existing literature highlights two models: Argonne National Lab's Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies Model (GREET) and EPA's MOVES. Both estimate emissions based on distance traveled, weight, and/or fuel consumption. The models are limited for several reasons: (1) nonroad emissions can only be estimated using the inventory option; (2) there is a lack of data, such as temperature data; (3) the models require using default inputs; and (4) forecast freight flow data is unavailable. Additionally, vehicle loads affect emissions, but the MOVES model does not adequately address the vehicle load. Transearch data can estimate weight and distance simultaneously. The

S&P Global methodology includes inputs on truck weight by axle, commodity weight, OD distance, fuel type, and idling time. The emissions factor is added based on information found in the literature and from the EPA. Idling time is added based on information found in the literature and from Geotab data. The research team conducted two case studies, one in Michigan and another in Rhode Island, to evaluate the methodology. Both studies showed the significance of the methodology to evaluate emissions.

DIESEL TRUCK EMISSIONS FROM FREIGHT TRIP GENERATION IMPACTS ON AIR QUALITY

Diana Ramirez-Rios, ***University at Buffalo***

Ramirez-Rios presented project results from a case study evaluating diesel truck emissions in Oakland, California. The objective was to quantify the air quality impacts in highly industrialized areas to better understand the impacts of freight congestion and to evaluate whether neighborhoods see disparate impacts. The study used freight generation models, based on NAICS codes, developed by Rensselaer Polytechnic in the *NCHRP Research Report 37: Using Commodity Flow Survey Microdata and Other Establishment Data to Estimate the Generation of Freight, Freight Trips, and Service Trips: Guidebook* (https://dx.doi.org/10.17226/24602). Using business data at the zip code level, the project team used freight order generation linear models and CARB's EMFAC database, which provides onroad and offroad mobile sources in California, to apply pollutant rates by distance traveled. In the city of Oakland, 5,479 businesses with a reported 49,772 employees are located in freight-intensive sectors.

The results indicated that a concentration of trucks arrives to and leaves the port; other zip codes, such as those near the airport, also have many truck trips. The project team used a stratified sampling approach and coded results in Python to extrapolate the number of trips to see locations with high levels of exposure to pollutants. The methodology can show the differences in exposure by sector type. High pollutant exposure is correlated with higher mortality rates and lower life expectancy and disproportionately impacts African Americans. The results of this work may have policy implications, such as minimizing industry in neighborhoods and transitioning to cleaner logistics operations. Future research efforts will expand modeling efforts by using multiple data sources to improve accuracy, estimate hourly concentrations, and incorporate scenario planning.

ADDRESSING DATA GAPS IN TRANSPORTATION EMISSIONS ANALYSIS: A SIMULATION FRAMEWORK FOR METROPOLITAN PLANNING ORGANIZATIONS AND LOGISTICS COMPANIES

Olcay Sahin, *Argonne National Laboratory*

Sahin presented a simulation framework for addressing the data gaps in emissions analysis. In 2021, the transportation sector produced 29% of GHGs in the United States, and MPOs need high-quality emissions data to support their planning efforts. Logistics companies and fleet owners also need better emissions data.

As a result of these data gaps, the project team proposes a simulation framework that allows local agencies to use a chain of tools to analyze truck behavior and the impacts of advanced truck technologies. The project team conducted a comparative analysis of consumption, emissions, and costs using real truck trips in California. While future vehicles designs are uncertain, vehicle manufacturers will certainly seek to maximize benefits. A National Renewable Energy Laboratory survey looked at 23 powertrain classifications for medium- and heavy-duty trucks; these classifications covered 62% of the population, 82% of the distance traveled, and 90% of the fuel consumed.

Many tools developed by Argonne National Laboratory help to fill the emission and energy data gaps. For example, SVTrip uses route information to generate stochastic vehicle trip prediction to generate the naturalistic speed profile. Polaris is an agent- and activity-based framework used to simulate travel demand at scale.

Autonomie analyzes vehicle energy consumption, performance, and cost. It is the DOE-preferred tool for vehicle-level simulations and is licensed to more than 275 organizations. Techscape analyzes and visualizes data to answer questions about cost, energy, emissions, materials, and electric vehicle supply equipment. The results emphasize the limitations of electric powertrain technologies. The proposed framework, comprised of chaining these tools together, provides MPOs with high-quality data to support their planning efforts.

CHANGING GEARS TO ZERO-EMISSION TRUCKS

Andreas Breiter, *McKinsey & Company*

Breiter presented research results from a multi-step methodology using OD pairs by commodity type for medium- and heavy-duty trucks to simulate different trip ranges and to evaluate the need for charging infrastructure. Truck trips vary depending on the type of commodity being transported. Battery electric vehicles will likely work best for shorter trips and lighter commodities, whereas fuel cell electric vehicles make sense for longer and heavier trips. California, Texas, and the Midwest will likely have some of the highest charging infrastructure demand. As a result, the public and private sectors will need to work together to prepare for charging infrastructure needs. Additional impacts may result from near-shoring, autonomous trucks, changes in the value chain, cargo drones, and clean fuels. The quantity and locations of charging infrastructure need to be considered now because making decisions will not be easy.

DISCUSSION

Bricka facilitated a Q&A session, during which participants posed questions to Salehiesfanda, Ramirez-Rios, Sahin, and Breiter.

- *[To Salehiesfanda] What data is used for empty trucks and how was the methodology validated?*

Salehiesfanda responded that Transearch data provides information on empty trucks. The methodology was validated by comparing the results with information available from the Energy Information Administration and other publicly available data.

- *[To Salehiesfanda] Can you expand on the different emissions factors for empty and full trucks?*

Salehiesfanda responded that the emissions factors are based on weight and distance, so the model uses ton-mileage.

- *[To Ramirez-Rios] In the heatmap graphic, what is in the area in red with the highest concentration of pollutants (Figure 13)?*

Ramirez-Rios responded that the area in red represents the downtown area where a lot of retail is located.

- *[To Sahin] Where did the Techscape's input data come from?*

Sahin responded that the Autonomie outputs become Techscape's inputs.

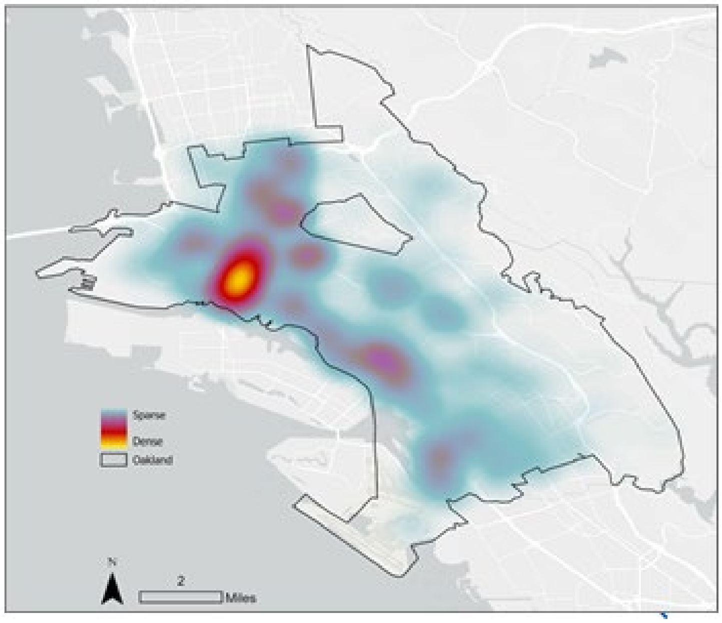

FIGURE 13 Average daily emissions in Oakland.

- *[To Sahin] Is Autonomie publicly available?*

Autonomie is publicly available with a license request.

- *[To Sahin] How did you get data for empty trucks and how was it validated?*

Sahin responded that the empty truck data comes from Geofleet, which records every trip; however, the data are confidential.

- *[To Breiter] How can we have hydrogen power generators that are sustainable?*

Breiter responded that hydrogen can be generated in different ways, including from fossil sources, which is not necessarily clean. Even if we could generate hydrogen at scale in a cleaner way, it would still need to be transported.

- *[To Breiter] Do you have any guidance for local governments regarding technology that is going obsolete? What advice do you have on how to support development without investing too much in something that could become obsolete?*

Breiter responded that there needs to be alignment on charging infrastructure, which is getting better. We want to avoid incompatible infrastructure. We also want to prevent trucks from needing to stop too early due to charging needs. In addition to battery electric trucks, hydrogen is another alternative to fuel clean air trucks; it will take time to determine how much hydrogen will be available.

RESEARCH PRIORITIES

- There is a need for a standardized, coordinated *approach* for state and local governments to best work with utility companies to forecast and prepare for electric vehicles, build out the grid, and manage charging infrastructure. Oftentimes, state and local governments should be working with the utility companies more than 4 years in advance of identifying charging infrastructure locations.
- There is a need to better understand life-cycle emission analysis, which includes emissions beyond just tailpipe emissions. Reducing GHG emissions and improving health impacts on local residents are two different but important topics to be analyzed. The research community needs to be considerate of the problem to be solved. As we begin to understand tailpipe emissions, tire emission analysis is becoming a research need.

Breakout Speed Round 1: Truck Telematics and Probe Data Applications

Nikola Ivanov
CATT Lab, University of Maryland, Moderator

During this breakout speed round, presenters provided high-level overviews of research within 6 min. Presenters then showcased their project results at an interactive poster session immediately following the session. Presenters discussed truck telematics and probe data applications.

THE USE OF TELEMATICS TRUCK DATA TO ENRICH COMMODITY FLOWS

Shweta Shah, *Geotab*

State freight plans need to include recent data, including accurate commodity data. Shah presented results of work using Geotab and Transearch commodity data to analyze post-pandemic freight flows. The Geotab data includes information that other data sources do not have, such as vehicle class, vocation, and industry type. Using this in combination with Transearch data, the project team modeled freight flows for Rhode Island using telematics data, based on county-to-county and intra-county flows. As a result of the project, Rhode Island now has a more accurate and updated freight model. The combined data set showed a 35% increase in the number of truck trips over the Transearch data alone; 55% of this increase is attributed to the model's payload adjustment (the split between medium- and heavy-duty trucks). The results of this work could lead to a better understanding of what exactly the freight and infrastructure needs are in specific areas and can also analyze e-charging planning and carbon emission modeling.

ELECTRIC HIGHWAYS: ACCELERATING AND OPTIMIZING FAST-CHARGING DEPLOYMENT FOR CARBON-FREE TRANSPORTATION

Lynn Daniels, *Rocky Mountain Institute*

There are concerns about whether the electric grid will be able to meet the demand of electric vehicle charging. Daniels presented on project results to characterize site-specific impacts of mid- to heavy-size trucks at highway charging stations at 71 sites in New York and Massachusetts. These sites needed to be along a major corridor, within 1 mi of a highway exit, and a maximum of 50 mi apart. Existing sites and those with proximity to the national grid transmission and substation infrastructure were prioritized. The project used Geotab telematics data for aggregated OD information and New York DOT traffic count data for scaling. The study assumed that electric trucks will operate under the same characteristics as traditional trucks and only considered two charger types—350 kW and 1 MW chargers. The study developed forecasts for power demand at each site and determined grid capacity needs. The results indicated that capacity can currently accommodate the charging needs, but more grid capacity will be needed after 2030.

INSIGHTS FOR THE PRESENT TIME: ENHANCING VIUS WITH TELEMATICS DATA

Aleksandra Maguire, *S&P Global*

Maguire presented on enhancing VIUS data with telematics data, such as that from Geotab and S&P Global Mobility. Geotab captures nearly 2 million trucks in the United States, whereas S&P Global Mobility captures more than 8.5 million medium- and heavy-duty trucks. Enhancements of the current VIUS elements can produce annual, quarterly, or monthly updates, and can also address seasonality and orientation by area of operation, such as state, MPO, or county, and forecasting. It can accomplish these while not incurring additional respondent burden. As a result of the enhancements, the model can visualize where the trucks are being used, which goes beyond seeing only where they are registered. The enhancements can also evaluate truck parking and emissions impacts.

UNDERSTANDING ORIGIN–DESTINATION TRAVEL PATTERNS USING HIGH-FIDELITY PROBE DATA

Gregory Jordan, ***CATT Lab, University of Maryland***

Jordan presented on the analysis of high-fidelity pathways of real-world truck trips using INRIX truck probe data in Philadelphia. The data can evaluate many scenarios, such as what routes are used in the event of crashes, work zones, or road closures. The data can also be used to improve mainline travel times and to analyze cross-streets for impacts of road closures or slowdowns. The project used a case study related to a bridge closure on I-95 in Philadelphia to evaluate if trucks took the designated detour or used alternate routes. The results indicated that most trucks in the sample used the road closest to the detour site instead of the designated detour route.

USE OF PROBE DATA FOR FREIGHT PLANNING AND OPERATIONS

Shuake Wuzhati, ***CPCS***

Wuzhati presented preliminary findings from NCHRP Project 53-14, Use of Probe Data for Freight Planning and Operation. The project team surveyed all state DOTs and conducted interviews on specific use cases to better understand how transportation agencies use probe data in freight planning. There are three primary types of truck probe data: truck trip trajectory, truck trip OD, and real-time or historic speed data. Truck probe data is primarily used by state DOTs in federal performance measure reporting. The survey results indicate that data coverage is a significant challenge for state DOTs. The project team conducted case studies in California, Michigan, and the District of Columbia. Each of these three state agencies formed significant partnerships with the data providers. Survey results also indicated that 43% of state DOTs procure data on an ad hoc basis for state freight plans or special studies. Only 27% of state DOTs procure data at regular intervals and 21% of state DOTs have continuous subscriptions to data sources. The results also indicate that state DOTs are regularly fusing data sources to analyze freight operations.

CASE STUDY EVALUATIONS OF TRADITIONAL AND EMERGING TRAVEL PATTERN DATA SOURCES

Makarand Gawade, *HDR*

Gawade presented the findings from a Florida case study evaluating traditional and emerging travel pattern data sources. For state DOTs, the key performance indicators are congestion [e.g., bottlenecks and levels of service (LOS)], activity patterns (e.g., OD patterns, tonnage, and volume), and safety (e.g., crashes and unsafe parking events). This evaluation is designed to help state DOTs identify which freight projects should receive funding. States can use NPMRDS data to develop a list of bottlenecks in the state based on recurring and nonrecurring congestion patterns. FAF and Transearch can provide information on truck volumes and truck tonnage, both important factors to consider, and WIM data can evaluate fully loaded and empty trucks. Data from ATRI have also been used to evaluate truck parking and use rates. Several emerging areas, such as e-commerce, electrification, and resilience, will need data to evaluate and understand patterns.

LEVERAGING PROBE DATA FOR FREIGHT MODELING

Md Rauful Islam, *Maks Inc.*

Islam presented project findings on leveraging probe data for freight modeling. FAF has long been the primary source of data for modeling freight transportation. However, the lack of ground-truthing data sources has hindered the development of an adequate freight model. Models could be much improved by adding OD information, truck counts, travel times, travel time reliability, commodity-specific load factors, and route preferences. This project analyzed ATRI truck trajectory data by segments to analyze speed, flow, reliability, and LOS. The results indicated that it is challenging to process large-scale data and to match the tracking points to the actual road network. The project identified two limitations. First, map-matching accuracy is highly dependent on the positional accuracy of the trajectory data. Second, the map-matching algorithm is unable to consider vertical separation. Future work would include improving travel time accuracy, trip-level estimation, and congestion and bottleneck identification. Ultimately, the project concluded that probe data can be leveraged for sourcing operational data for freight modeling.

SIGNIFICANCE OF NON-FREIGHT TRUCKS IN FREIGHT PLANNING AND MODELING

Kaveh Shabani, *Cambridge Systematics*

Shabani presented on the significance of non-freight (i.e., non-FAF) truck trips in freight planning and modeling. Non-freight refers to truck trips that are not currently included in FAF. It is believed that FAF mostly includes medium and heavy truck flows [i.e., likely, trucks with a gross vehicle weight rating (GVWR) over 14,000 lb] pertaining to long-haul truck movements. Currently, FAF does not cover light-duty trucks and empty back-haul truck trips. Truck GPS data and classification counts coupled with FAF data can provide a better picture of all truck activity in a region. The project team conducted a pilot case study for the SCAG region to disaggregate FAF5 data to 97 freight analysis zones in California (which will also be used in the update of the statewide freight model), process truck GPS data into OD truck trips, expand OD truck trips to classification counts, and compare the results. FAF data is reported in value and tonnage, so it needed to be converted to trucks in order to be comparable with the expanded truck trips from truck GPS data. It should be noted that FAF truck trips have been calculated applying average payload factors by commodity to annual tons.

FAF estimates economic activity between regions (usually in dollars or tons), which must be translated to number of trucks on the roadways. For the purposes of this analysis, a reasonable assumption is that all trucks (light-, medium-, and heavy-duty) have a GVWR over 10,000 lb. In general, truck GPS data is only a sample, so it needs to be expanded (e.g., to classification counts) and researchers assume that the expanded truck GPS data covers all truck activity (i.e., trucks with GVWR over 10,000 lb). The results (considering all the assumptions and details specified above) determined that FAF covers less than 10% of all OD truck trips in the SCAG region. This shows both the importance of combining different complementary data sources and the importance of light-duty trucks, which are becoming more significant for last-mile and e-commerce deliveries.

DISCUSSION

Ivanov facilitated the Q&A session.

Stinson, BTS, addressed Shabani's point about what is and what is not in FAF. BTS plans to integrate both e-commerce and household logistics data programs into FAF. The CFS is much richer now, with around 100 million shipments compared to 6 million shipments in the past, and it will include more information on e-commerce and household logistics. Historically, it has been hard to acquire localized delivery information. The FAF also does not include empty truck trips, does not model service trucks, and currently does not model truck movements that are part of a multimodal move, although this last limitation is changing soon.

- *How has sample bias been studied and/or addressed? Specifically, if the data is being expanded with other data sources, how can the sample size issue be addressed?*

Jordan responded that all data sources will have some level of sample bias, but it needs to be reasonable. CATT Lab has conducted ground-truthing exercises, and the data have been fairly accurate. Ground-truthing methods need to be in place.

Wuzhati added that state DOTs are examining ways to evaluate sample bias, to remove overrepresentation in the data, and to handle other challenges within the data sources. State DOTs recognize the sample bias present in their work.

Breakout Speed Round 2: Freight Data for Policy Analysis

ALISON CONWAY
City College of New York, Moderator

CARLA TEJADA LOPEZ
University of Illinois Chicago, Recorder

Breakout Speed Round Session 2 presented a summary of several projects using freight data for policy analysis. Projects and case studies included (1) warehouse locations in urban areas, (2) truck lanes in support of freight mobility, (3) new data approaches to measure bridge use and infrastructure, and (4) capturing the impacts of supply chain disruption.

THE MYTH OF A WAREHOUSE: WHAT DOES IT MEAN WHEN A NEW ONE IS BUILT IN YOUR NEIGHBORHOOD?

Fatemeh Ranaiefar, *Fehr & Peers*

The first presentation discussed benefits and problems of warehouse development. As logistics operations have evolved, the need for warehouse space has shifted and construction of new warehouses has increased dramatically in urban areas. Some urban areas are skeptical about the economic benefits and other more problematic externalities that these developments may have for the community.

In general, data sources informing these impacts remain at a high level. Limited information exists about what is in the warehouses, what operations are undertaken, or the rotation of warehouse lessees. As a result, researchers need to physically visit the warehouses to make an inventory and to identify these nuances. Measuring the destinations of trips originating in the warehouse is important in knowing what is in the warehouses. Carrier operations are dynamic and can change greatly over a year.

Key findings include (1) that understanding the entire supply chain is key to predicting transportation demand and the number of drivers and warehouse workers; (2) based on facility observations conducted over a 3-day period in two separate years, daily truck traffic generated by a facility can vary to up to 40% compared to the previous observation period, meaning that an average may not be the best metric; (3) based on truck probe data, the VMT generated by trucks using the facilities can vary up to 75% compared to the previous year, although cyclical patterns emerge throughout the year; (4) the BEA estimates that, for every 10 new warehouse jobs, 14 jobs are created in other industries; (5) for every $1.00 that warehouse workers earn, an additional $1.50 is generated in the economy; and (6) information sharing is important to implement “good neighbor” policies and coordinate all stakeholders in warehouse development.

CAN DEDICATED TRUCK LANES IMPROVE FREIGHT MOBILITY? A CASE STUDY WITH OPERATIONAL AND SAFETY ANALYSIS

Sushant Sharma, *Texas A&M Transportation Institute*

This case study discussed the implications of truck-only lanes in a major 32-mi corridor in Dallas, Texas. In general, truck-only lanes reduce the number of car-truck interactions, leading to increased safety and mobility. The general problems in this corridor included roadway grade issues, weaving, and reduced capacity. The project’s motivation was to build something in the area that will reduce traffic problems.

To study this problem, researchers used a multi-resolution mesoscopic simulation model as a combination of dynamic traffic assignment and microsimulation models, allowing the researchers to record changes according to the size and area of the analysis. Researchers took several steps in applying the model: calibration, identifying all modes travelling in the corridor, analyzing the climbing lane, comparing LOS, and conducting a crash analysis.

The study results showed that truck-only lanes can result in travel time and crash cost savings, but overall savings can vary by study site and infrastructure costs may be significantly high. In general, truck-only side lanes may not be practical for longer lengths with many interchanges, but autonomous trucks/vehicles could benefit from these lanes. Moreover, existing tools and methodologies to examine the car-truck interactions and predicting crash reduction fall short in evaluating the advantages of truck-only lanes.

FREIGHT OPERATIONS EXCHANGE

Erik Zuker, *HNTB*

This presentation discussed an approach to leveraging WIM for bridge design and evaluation. Three major data-related changes have occurred in the industry: (1) the ubiquity of WIM data, (2) the democratization of data tools, and (3) the accelerating growth in freight. Furthermore, data are more approachable and new tools can process existing data in faster and cheaper ways, create compelling visualizations, and present data to stakeholders for decision-making.

The existing data was used to confirm design fatigue details on highways based on actual trucks using the highways, to compare the highway data with bridge fatigue, and to determine the linear correlations between increasing gas prices with illegal behavior on bridges (e.g., overweight vehicles using bridges not designed for that load level). The study found that truck drivers must make decisions when they exit the highway based on bridges along that route and that robust networks need to focus not only in supporting freight weight but also on other conditions (i.e., vehicles, weather).

CAPTURING THE IMPACT OF SUPPLY CHAIN DISRUPTIONS, APPLICATIONS IN FREIGHT DATA

Derek Cutler and Temple Anyasi, *EBP*

This presentation discussed creating a framework to quantify freight's impact on different industries and how disruptions play a role. Knowing the commodities inside the trucks is important to understanding how critical the commodities are to the economy and the resulting supply chain performance. In general, change may be linked with risks, especially the risk of an operational disruption, which can affect the supply chain and the movement of goods. However, the effects of and solution for a disruption vary depending on the area and the commodity.

To exemplify this, the presenter showed an example of a freight disruption at the US/Canada border affecting supply chains of cars, car parts, and medical and chemical supplies. This example made clear that freight exists only because industries exist.

The presenter highlighted the need to identify the real cost of businesses and to create a framework that measures the impact of goods movement by commodity.

FREIGHT DATA INTEROPERABILITY FRAMEWORK UPDATE

Dan Seedah, *Jacobs*

In the final presentation of this speed round session, Seedah provided an update of NCHRP Project 08-119, Data Integration, Sharing, and Management for Transportation Planning and Traffic Operations, focusing on freight data interoperability. Overall, today's freight decision challenges are the same as 10 or 15 years ago. Some advances try to address differences in freight data sources, data collection, querying, and fusion methodologies; the presenter highlighted several specific cases using different data. Developing a consolidated and comprehensive freight database is challenging. This project seeks to develop a generic but robust data-querying methodology for multiple freight datasets to encourage the implementation of an interoperable freight data architecture. The tool is intended for transportation planners.

The tool will provide common base parameters to query most freight data sources. It can be used for OD analysis, congestion analysis, safety analysis, bridge condition and vertical clearance analysis, pavement analysis, and socio-economic analysis. Some of the most interesting use cases are origin/destination analysis, congestion studies, and freight parking research.

Although this tool has already proven useful, many gaps still need to be filled and additional funding is required to continue its development, testing, and deployment.

DISCUSSION

A primary discussion topic in this session was the need for constant information sharing among stakeholders. Many participants agreed that data sharing and collaboration is necessary to make decisions, measure infrastructure performance and fatigue, create programs, and ensure the smooth functioning of supply chains. Furthermore, people in the decision and planning sectors need to be aware of existing freight operations to make the correct decisions. All planning agencies should coordinate in their efforts towards freight solutions.

Further discussion considered the lack of models that include car/truck interactions and limited evaluation of actual, real-world safety implications for truck transportation. Finally, there was discussion about needing more disaggregated data.

SUMMARY

This session concluded that, although similar issues about data needs have been discussed over decades, major efforts are still needed to acquire high-quality disaggregated data to plan for better freight movement. This is only possible with collaboration among stakeholders and a correct understanding of all freight and supply chain operations.

Closing Session

DONALD LUDLOW
CPCS, Moderator

The closing session highlighted key takeaways and research needs identified throughout the workshop, focusing on lessons learned, best practices, directions for the future, and attendee-generated research and data needs. The workshop addressed the challenges and opportunities impacting freight data.

Workshop panelists and attendees provided a great deal of information over 2 days. Ludlow stated that attendees learned about advances in federal data products, visualizations and storytelling, emissions and electrification, applications and data fusion, granularity, and modeling. The following section summarizes Ludlow's comments on the emerging workshop themes, followed by additional comments from planning committee members and workshop participants.

FEDERAL DATA PRODUCTS

Several advances in federal data products have occurred. VIUS is back, CFS is different, FAF is adapting, and FLOW is new. All are important data products for freight transportation research and are envied by those outside of the United States without equivalent tools. Based on results of a recent NCHRP study, NPMRDS data is one of the most commonly used probe data sources, likely because it is free to so many agencies. There has been a burst in federal investment and increased interest and attention on supply chain performance.

VISUALIZATIONS AND STORYTELLING

Visualizations and compelling stories are critical in helping the public and decision-makers to understand freight needs and challenges. Without proper storytelling, decision-makers will not understand the issues and the problems will not be adequately addressed.

EMISSIONS AND ELECTRIFICATION

Emissions and electrification are growing topics of research in the freight community. Vehicle probe data is a powerful data source to evaluate these impacts. Telematics data can further enhance evaluation of emissions and electrification.

APPLICATIONS AND DATA FUSION

Data applications and data fusion techniques are expanding and improving. The development of AI and machine learning tools are benefitting the freight industry. Digital twins are also starting to help analyze freight movements. Data fusion techniques have been used for a long time, but fusion work is expanding and improving.

GRANULARITY

Disaggregation is a core tool used in freight data analysis, routinely used in practice. More work needs to be done to determine the best current disaggregation approaches and how they can be improved. Researchers are somewhat comfortable disaggregating to the county level, less comfortable disaggregating to the municipal level, and not comfortable at all disaggregating to the block group or zip code level.

ADVANCED MODELING

This workshop has historically looked at freight data but is beginning to discuss more advanced modeling techniques, a growing area in the freight research community. We need to continue focusing on observed data streams.

PLANNING COMMITTEE AND PARTICIPANT KEY TAKEAWAYS AND ADDITIONAL THEMES

- Purdy added that FHWA continues to monitor electrification and automation of freight vehicles to see how they will evolve and be implemented. FHWA will update the *Freight and Land Use Handbook*, last updated in 2012. He added that the final workshop session gave him several ideas on the impacts of e-commerce and urban deliveries. Truck parking needs to be integrated into local development. FHWA will also evaluate and standardize the disaggregation methodology.
- Conway suggested that, when considering disaggregation, the freight research community may need to start from the decision end and think about the problem based on the data being used to make decisions. The reality is that we use available data, whatever its quality, to make decisions. AI and its potential impacts also keep coming up.
- Yamagami highlighted a need to build local-level capacity and generate local-level data. Amazing products exist, but we need to cultivate local capacity to better understand how to use these tools.
- A workshop participant added that FAF measures how much stuff goes between point A and point B and tries to map that to the network, which is quite different than actual truck movements. Transportation is often a good indicator of supply chain activity. However, during the pandemic, headlines were not about transportation but about manufacturing. Disaggregation raises concerns about data quality and its fitness for use. An order of magnitude estimate is enough in some cases, but others need more precision. How precise does data need to be in freight analysis? Researchers will have

to be careful when comparing disaggregated numbers and avoid making county-to-county comparisons.

- Another workshop participant was excited to hear about the work to evaluate FAF disaggregation methods, but more needs to be done. Safety data still contains granularity gaps, such as being able to identify and differentiate the type of driver. Some data, such as inland waterway data, is not well represented. Entire commodity types are missing.
- Another workshop participant added that the freight industry and research community are beginning to understand the importance of tracking equipment availability. Recent experiences, especially during the pandemic, highlighted that doing so is critical.
- Another workshop participant agreed that standardizing terminology would be helpful; before the workshop, he did not understand the difference between probe, telematics, and ELD data.

FUTURE RESEARCH NEEDS

- The research community needs to further evaluate how electrification and automation of freight vehicles will be implemented.
- The research community needs to do more to evaluate the impacts of e-commerce and manage urban deliveries.
- How can truck parking be managed and developed in areas of high development and warehouse growth?
- The research community needs to standardize terminology. For example, to freight practitioners, a cargo bike is a bike with a trailer; in the bike community, a cargo bike is a bike with a cart on the front for hauling children.
- What data is needed to understand community needs to better manage freight movements and build local-level capacity to manage freight impacts?
- How can we improve the timeliness of freight shipments and create new measures to capture different transportation elements?

- How can the research community expand to bring in more data and information?
- The research community needs to continue developing validation methods to improve freight models.

APPENDIX A

Agenda

Tuesday, September 19, 2023

12:30 p.m. – 4:00 p.m.	Registration
1:00 p.m. – 4:00 p.m.	Standing Committee on Freight Transportation Data (AED70) Committee Meeting

Wednesday, September 20, 2023

7:00 a.m. – 6:00 p.m.	Registration
7:30 a.m. – 8:30 a.m.	Breakfast
8:30 a.m. – 9:15 a.m.	Welcome and Keynote Presentation: Patricia Hu
9:15 a.m. – 10:00 a.m.	Roundtable Discussion on How the Commodity Flow Survey Made Its First 100 Million … Shipments
10:00 a.m. – 10:30 a.m.	Break
10:30 a.m. – 12:00 p.m.	Panel 1 – Freight Decision-Making: Telling Compelling Stories with Freight Data
12:00 p.m. – 1:30 p.m.	Lunch
1:00 p.m. – 2:30 p.m.	Breakout/Concurrent Sessions (3)
2:30 p.m. – 3:00 p.m.	Break
3:00 p.m. – 4:15 p.m.	Breakout Speed Rounds (2)
4:30 p.m. – 6:00 p.m.	Interactive Poster Session and Reception

Thursday, September 21, 2023

7:00 a.m. – 4:00 p.m.	Registration
7:30 a.m. – 8:30 a.m.	Breakfast

8:30 a.m. – 10:00 a.m.	Panel 2 – Electronic Logging Device Data: Opportunities and Challenges
10:00 a.m. – 10:30 a.m.	Break
10:30 a.m. – 12:00 p.m.	Breakout/Concurrent Sessions (3)
12:00 p.m. – 1:00 p.m.	Lunch
1:00 p.m. – 2:30 p.m.	Panel 3 – Freight Data for E-Commerce Planning and Regulation
2:30 p.m. – 3:00 p.m.	Break
3:00 p.m. – 4:00 p.m.	Closing Session

APPENDIX B

List of Abbreviations and Acronyms

ACT	Advanced Clean Truck
AI	Artificial Intelligence
AIS	Automatic Identification System
ALPR	Automated License Plate Reader
AMS	Analysis, Modeling, and Simulation
API	Application Programming Interface
ATRI	American Transportation Research Institute
BEA	Bureau of Economic Analysis
BLS	Bureau of Labor Statistics
BTS	Bureau of Transportation Statistics
CARB	California Air Resources Board
CAT	Connected and Automated Trucks
CAV	Connected and Automated Vehicles
CBP	Customs and Border Patrol
CFS	Commodity Flow Survey
CIPSEA	Confidential Information Protection and Statistical Efficiency Act
DFW	Dallas/Fort Worth
DOE	Department of Energy
DOT	Department of Transportation
EJ	Environmental Justice
ELD	Electronic Logging Device
EMFAC	EMission FACtor
EPA	Environmental Protection Agency
FAF	Freight Analysis Framework
FHWA	Federal Highway Administration

FLOW	Freight Logistics Optimization Works
FMT	Freight Mobility Trends
FSRDC	Federal Statistical Research Data Centers
FTL	Full Truckload
GHG	Greenhouse Gas
GPS	Global Positioning System
GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies
GVWR	Gross Vehicle Weight Rating
HOS	Hours of Service
HPMS	Highway Performance Monitoring System
IIJA	Infrastructure Investment and Jobs Act
LOS	Level of Service
MOVES	MOtor Vehicle Emission Simulator
MPO	Metropolitan Planning Organization
NAICS	North American Industry Classification System
NCHRP	National Cooperative Highway Research Program
NCTCOG	North Central Texas Council of Governments
NPMRDS	National Performance Management Research Data Set
OD	Origin-Destination
OMF	Open Mobility Foundation
OTA	Oregon Trucking Association
QFIT	Quetica’s Freight Intelligence Tracker
SCAG	Southern California Association of Governments
SCDOT	South Carolina Department of Transportation
SCTG	Standard Classification of Transported Goods
SP	Small Parcel
SPO	Senior Program Officer
TAZ	Transportation Analysis Zone
TETC	The Eastern Transportation Coalition
TMAS	Travel Monitoring and Analysis System

TRB	Transportation Research Board
TRU	Transport Refrigeration Units
UFL	Urban Freight Lab
UPS	United Parcel Service
USACE	United States Army Corps of Engineers
USDOT	United States Department of Transportation
USPS	United States Postal Service
V2I	Vehicle-to-Infrastructure
VIUS	Vehicle Inventory and Use Survey
VMT	Vehicle Miles Traveled
WAIRE	Warehouse Actions and Investments to Reduce Emissions
WCS	Waterborne Commerce Statistics
WIM	Weigh-in-Motion

APPENDIX C

Data Sources Discussed at Workshop

The following list includes information on data sources discussed at the workshop. TRB does not endorse any data source. This is not an exhaustive list of all available data sources or all data sources discussed at the workshop.

Argonne National Lab’s Autonomie. https://vms.taps.anl.gov/tools/autonomie/

Argonne National Lab’s SVTrip. https://vms.taps.anl.gov/tools/svtrip/

Argonne National Lab’s TechScape. https://vms.taps.anl.gov/tools/techscape/

Automatic Identification System. https://marinecadastre.gov/ais/

BEA’s Input-Output Accounts. https://www.bea.gov/industry/input-output-accounts-data

Border Crossing Information System. https://bcis.tti.tamu.edu/

CARB’s EMFAC Database. https://arb.ca.gov/emfac/2017/

CARB’s META Tool. ww2.arb.ca.gov/resources/documents/2020-mobile-source-strategy

Climate and Economic Justice Screening Tool. https://screeningtool.geoplatform.gov/

Commodity Flow Survey. https://www.census.gov/cfs

CoStar. www.costar.com

County Business Patterns. https://www.census.gov/programs-surveys/cbp.html

Dangerous Goods Accident Information System. https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=7503#:~:text=The%20Dangerous%20Goods%20Accident%20Information,the%20transportation%20of%20dangerous%20goods.

Dun & Bradstreet. www.dnb.com

EROAD. https://www.eroad.com/

FleetSeek. http://www.fleetseek.com.au/

Freight Analysis Framework. https://www.bts.gov/faf

Freight Logistics Optimization Works. https://www.bts.gov/flow

Freight Mobility Trends.
https://ops.fhwa.dot.gov/freight/freight_analysis/mobility_trends/index.htm
Geotab. https://www.geotab.com/
Google Earth. www.google.com/earth
Highway Performance Monitoring System.
https://www.fhwa.dot.gov/policyinformation/hpms.cfm
InfoUSA. www.dataaxleusa.com
INRIX. https://inrix.com/
LEHD Origin-Destination Employment Statistics (LODES).
https://lehd.ces.census.gov/data/
Leonard's Guide. https://www.leonardsguide.com/
National Performance Management Research Data Set.
https://npmrds.ritis.org/analytics/
FHWA's NextGen NHTS Truck OD. https://nhts.ornl.gov/od/
NielsonIQ. https://nielseniq.com/global/en/
Quetica's Freight Intelligence Tracker. https://quetica.com/freight-commodity-flow-data/
S&P Global's Transearch Data.
https://www.spglobal.com/marketintelligence/en/mi/products/transearch-freight-transportation-research.html
TransBorder Freight Data. https://www.bts.gov/transborder
Union Pacific's Key Performance Metrics. https://www.up.com/investor/key-metrics/
Vehicle Inventory and Use Survey. https://www.census.gov/programs-surveys/vius.html

NATIONAL ACADEMIES *Sciences Engineering Medicine*

The **National Academy of Sciences** was established in 1863 by an Act of Congress, signed by President Lincoln, as a private, non-governmental institution to advise the nation on issues related to science and technology. Members are elected by their peers for outstanding contributions to research. Dr. Marcia McNutt is president.

The **National Academy of Engineering** was established in 1964 under the charter of the National Academy of Sciences to bring the practices of engineering to advising the nation. Members are elected by their peers for extraordinary contributions to engineering. Dr. John L. Anderson is president.

The **National Academy of Medicine** (formerly the Institute of Medicine) was established in 1970 under the charter of the National Academy of Sciences to advise the nation on medical and health issues. Members are elected by their peers for distinguished contributions to medicine and health. Dr. Victor J. Dzau is president.

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500 Fifth Street, NW
Washington, DC 20001