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CONFERENCE PROCEEDINGS ON THE WEB 12

Adapting Freight Models and Traditional Freight Data Programs for Performance Measurement

Summary of a Workshop

April 30–May 1, 2013
Washington, D.C.

TRANSPORTATION RESEARCH BOARD
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Katherine F. Turnbull, *Rapporteur*
Texas A&M Transportation Institute
Texas A&M University System

April 30–May 1, 2013
Keck Center of the National Academies
Washington, D.C.

Sponsored by
Transportation Research Board
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This report has been reviewed by a group other than the authors according to the procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

This project was sponsored by the Federal Highway Administration Office of Freight Management and Operations and the Transportation Research Board.

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Preface

The freight transportation system is key to the global competitiveness of the United States. The Moving Ahead for Progress in the 21st Century Act (MAP-21) emphasizes the freight transportation system, performance-based planning, and freight performance measures. The Transportation Research Board (TRB), in collaboration with the Federal Highway Administration's Office of Freight Management and Operations, hosted a workshop to consider the adequacy of freight data and modeling to support performance measurement in public- and private-sector decision making. The Adapting Freight Models and Traditional Freight Data Programs for Performance Measurement Workshop was held April 30–May 1, 2013, in Washington, D.C.

The workshop had four objectives: (*a*) identify the data and models necessary for estimating key performance measures of freight system condition, efficiency, and safety and the economic and environmental impacts that support public and private decision making; (*b*) consider the adequacy of existing data programs and models, including the Freight Analysis Framework, for meeting performance measurement needs; (*c*) define critical gaps in data programs and modeling tools and identify essential actions needed to close them; and (*d*) explore a focused research framework, with supporting research needs statements, that could lead to improvements in data and models for estimating freight transportation performance measures.

To accomplish these objectives, the workshop included general sessions, breakout sessions, and an electronic poster session. Speakers in the general sessions provided public- and private-sector perspectives on freight performance measures, data needs, and opportunities and challenges. The freight-related elements of MAP-21 were also highlighted. The breakout sessions focused on defining needs and opportunities to adapt freight data and models to support performance measurement and identifying research needs.

TRB assembled a planning committee, appointed by the National Research Council (NRC), to help organize and develop the workshop program. The planning committee was chaired by Joseph L. Schofer of Northwestern University. Committee members provided expertise in freight data and analysis, planning and modeling, performance measures, and policies.

The planning committee was responsible solely for organizing the workshop, identifying speakers, and developing breakout session topics. Katherine F. Turnbull of Texas A&M Transportation Institute prepared this report as a factual

summary of what occurred at the workshop. The conference PowerPoint presentations are available at http://onlinepubs.trb.org/onlinepubs/conferences/2013/Freight/FinalProgram.pdf.

The workshop attracted 107 participants, including representatives of state departments of transportation, metropolitan planning organizations, universities, federal agencies, consulting firms, and other groups. This document presents the proceedings of the workshop. The major topics addressed in the general sessions and the breakout sessions are presented in these proceedings. A list of attendees is provided at the end of this document. The abstracts prepared by the authors of the electronic posters are provided in the Appendix.

The views expressed in the proceedings are those of the individual workshop participants, as attributed to them, and do not necessarily represent the views of all workshop participants, the workshop planning committee, TRB, or NRC. This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise in accordance with procedures approved by NRC's Report Review Committee. The purposes of this independent review are to provide candid and critical comments that will assist the institution in making the published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the project charge. The review comments and draft manuscript remain confidential to protect the integrity of the process.

TRB thanks the following individuals for their review of this report: Alison Conway, City College of New York; Richard Curry, San Diego Association of Governments, California; Rebekah L. Karasko, North Central Texas Council of Governments, Arlington; and Rebecca Knudson, Oregon Department of Transportation, Salem.

Although the reviewers listed above provided many constructive comments and suggestions, they did not see the final draft of the conference summary before its release. The review of this report was overseen by Susan Hanson, Distinguished University Professor Emerita, School of Geography, Clark University, Worcester, Massachusetts. Appointed by the NRC, she was responsible for making certain that an independent examination of this summary was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this proceedings rests entirely with the rapporteur and the institution. Karen S. Febey, Senior Report Review Officer, TRB, managed the report review process.

The workshop planning team thanks Katherine Turnbull for her work in preparing the workshop proceedings and extends special thanks to the Federal Highway Administration for providing the funding support that made the workshop possible.

Workshop Introduction, Objectives, and Organization

Joseph L. Schofer, *Northwestern University, Chair, Workshop Planning Committee, Presiding*

The opening session featured Joseph Schofer, Northwestern University, Chair of the Workshop Planning Committee. Schofer summarized the objectives of the workshop, Adapting Freight Models and Traditional Freight Data Programs for Performance Measurement; recognized the workshop planning committee and Transportation Research Board staff; and reviewed the workshop schedule. The following topics were covered:

- The workshop has four objectives. The first is to identify the data and models necessary for estimating key performance measures of freight system condition, efficiency, and safety and the economic and environmental impacts that support public and private decision making. The second is to consider the adequacy of existing data programs and models, including the Freight Analysis Framework, for meeting performance measurement needs. The third is to define critical gaps in data programs and modeling tools and to identify the essential actions needed to close them. The fourth is to explore a focused research framework, with supporting research needs statements, that could lead to improvements in data and models for estimating freight transportation performance measures.
- The first general session features the customers for performance measurement—network managers and users. The focus will be on the needs of decision makers and on delivering products that can be used to meet the requirements of the Moving Ahead for Progress in the 21st Century Act (MAP-21) and to enhance freight transportation planning and investment decisions. Speakers will provide perspectives from the federal, state, and metropolitan levels and those of shippers and carriers. The second general session features speakers from the data and modeling community who will highlight current and emerging practices. The afternoon begins with a summary of key themes from the first two general sessions, a summary of the electronic posters, and a charge to the working groups.
- The four parallel breakout discussion groups have the same assignment of considering how freight data and modeling support performance measurement in public-sector decision making and of identifying gaps, research needs, and action items to address them. The final general session on the first day highlights the topics discussed in the breakout sessions. The electronic poster session and reception conclude the first day.

- The breakout groups resume the morning of the second day, with a focus on research priorities. The closing session highlights the results of the breakout sessions and includes a final open discussion. The research priorities should be practical, feasible, and effective in supporting advanced freight performance measurement and decision making.
- Performance measurement is really about making transportation management and investment decisions that are data driven—decisions that are based on measures of the condition and performance of the transportation system. Performance measurement and management are good practices even without the requirements of MAP-21. The right data and the right tools are needed to make effective use of performance measurement. The workshop focuses on these targets.

Performance Measurement for Freight Planning and Management

Views from Network Managers and Users

Caitlin Hughes Rayman, *Federal Highway Administration, Office of Freight Management and Operations*
Barbara Ivanov, *Freight Systems Division, Washington State Department of Transportation*
Randy Deshazo, *Chicago Metropolitan Agency for Planning*
Ken Allen, Supply Chain and Logistics, H-E-B (retired)
Steven S. Grabell, *NFI Industries*
Charles E. Howard, *Puget Sound Regional Council, Presiding*

Speakers in this session provided public- and private-sector perspectives on freight performance measures, data needs, and opportunities and challenges. Caitlin Rayman, Federal Highway Administration, summarized key freight-related elements of the Moving Ahead for Progress in the 21st Century Act (MAP-21). Barbara Ivanov, Washington State Department of Transportation (DOT), discussed freight performance measures at the national and state levels. Randy Deshazo, Chicago (Illinois) Metropolitan Agency for Planning (CMAP), described the role of metropolitan planning organizations (MPOs) in freight planning and performance measurement and the development and use of freight performance measures in the Chicago area. Ken Allen, retired from H-E-B, provided a perspective from a major grocery store chain. Steve Grabell, NFI Industries, discussed freight performance measures from an industry perspective.

MAP-21 ERA: CHANGING THE FREIGHT TRANSPORTATION LANDSCAPE

Caitlin Hughes Rayman

Caitlin Hughes Rayman discussed the freight transportation components of MAP-21. She reviewed the sections addressing performance-based planning, national goals and performance management measures, the National Freight Policy, the Freight Transportation Conditions and Performance Report, and state freight plans. Rayman covered the following topics:

- A number of factors influence the freight transportation landscape. Among them are the increasing orientation toward a performance-based transportation system and the focus on government transparency and accountability. Other factors are the emergence of corridor-level thinking and the Transportation Investment Generating Economic Recovery (TIGER) discretionary grant program. Freight and multimodal projects are eligible under the TIGER program.
- There are many reasons for using performance measures. In decision making, performance measures provide a guide for resource allocation decisions. In planning, performance measures provide a link between goals and specific actions, as well as a mechanism for understanding system performance. In forecasting and modeling, performance measures track system performance over time. Performance measures in performance management improve the management and delivery of products and services and evaluate the impacts of policies, plans, programs, and projects. Performance measurement is mandated for federal agencies by the Government Performance and Results Act (GPRA) of 1993 and the GPRA Modernization Act of 2010. Performance measures are used to communicate results to policy makers, stakeholders, and the public and to strengthen accountability. Performance measures demonstrate integrity in the use of taxpayer resources and help justify programs and their costs in an era of limited budgets.
- MAP-21 was signed into law by President Obama on July 6, 2012. The effective date was October 1, 2012. MAP-21 established a performance- and outcome-based program. The objective is to invest resources in projects that will make progress toward achievement of national goals. That objective is not currently tied to specific programs, however. The U.S. DOT is working to ensure that connections are made between the various sections of MAP-21 that call for performance measurement. MAP-21 addresses performance-based planning in Sections 1201 through 1203. In metropolitan planning, MPOs must establish performance targets, and the long-range plan incorporates other performance plans. In statewide and nonmetropolitan planning, there is a transition to a performance-based, outcome-driven planning process, with the state setting performance targets. Most states have or are organizing statewide freight advisory committees. Long-range plans should include reports on conditions and performance of the system relative to established performance measures. The long-range plans incorporate other performance plans. MAP-21 also addresses national goals and performance management measures. It has goals for focusing the federal-aid highway program on freight movement and economic vitality by designating and improving the national freight network, strengthening access by rural communities to national and international trading markets, and supporting regional economic development.
- MAP-21 includes national goals and performance management measures in Section 1203. Freight movement and economic vitality are established as national performance goals. The section requires the U.S. DOT to establish performance

measures to assess freight movement on the Interstate system. The U.S. DOT is developing a proposed rule. The American Association of State Highway and Transportation Officials (AASHTO) has provided suggested freight performance measures, which has helped inform the process. The law further requires states to establish performance targets within 1 year of the establishment of measures by the U.S. DOT. States are required to report on performance targets 4 years after the targets are set.

- The National Freight Policy in Section 167 includes new language on improving the conditions and performance of the national freight network to provide a foundation for the United States to compete in the global economy. The section sets goals related to investments in infrastructure and operational improvements that strengthen U.S. economic competitiveness, reduce congestion, and increase productivity—especially in domestic industry high-value jobs. Goals are set for improving safety, security, resilience, and the state of good repair; for using advanced technology to improve safety and efficiency; and for incorporating concepts of performance, innovation, competition, and accountability into operation and maintenance. Still other goals are improving economic efficiency and reducing environmental impacts of freight movement.
- Section 1115 of MAP-21 requires the U.S. DOT to develop a Freight Transportation Conditions and Performance Report by October 1, 2014, and to revise the report every 2 years after that date. The U.S. DOT will produce a multimodal report that provides a comprehensive examination of the U.S. freight system. It will consider economic efficiency, productivity, and competitiveness; congestion reduction; safety, security, and resilience; state of good repair; use of innovative technology, competition, performance management, and accountability; and the reduction of adverse environmental and community impacts. The data and findings in this report will be used as a key input for the National Freight Strategic Plan, which is required in Section 1115 and is due within 3 years of enactment.
- State freight plans are addressed in Section 1118 of MAP-21. Although state freight plans are not required, the U.S. DOT must encourage each state to develop a comprehensive state freight plan. As outlined in MAP-21, the state freight plans shall include a number of elements identifying significant freight system trends, needs, and issues. The plans shall include a description of freight policies, strategies, and performance measures to guide freight-related transportation investment decisions for the state. The plans should also describe how they will improve the ability of a state to meet the national freight goals established under the MAP-21 National Freight Policy in Section 167. Finally, the plans should consider innovative technologies and operational strategies to improve the safety and efficiency of freight movement, a description of improvements to reduce or impede deterioration of routes that are traveled by heavy vehicles, and an inventory of facilities with freight issues and strategies to address bottlenecks and other issues. The U.S. DOT recommends that state freight plans include those measures of freight conditions and performance that are estab-

lished by the U.S. DOT in the National Freight Strategic Plan and Freight Conditions and Performance Report. The freight plan should comply with the MAP-21 requirement to ensure eligibility for federal-aid matching funds for freight projects.

- The freight-related requirements of MAP-21 raise a number of research challenges. Examples cited by Rayman focus on adapting and enhancing existing data, models, and tools to support performance measures; examining the need for creating new data models; and identifying the need and sources for new data. New data may be needed in economic, environmental, and travel areas. Among the types of data that may be needed are administrative records, survey and probe data, and modeled data. Potential data sources include federal agencies, state agencies, and the private sector.

PERFORMANCE MEASURES DRIVING STATE FREIGHT PLANNING

Barbara Ivanov

Barbara Ivanov discussed freight performance measures at the national and state levels. She summarized the freight policy goals and the freight movement and economic vitality goals contained in MAP-21, the truck freight performance measures developed by AASHTO, and the development of freight performance measures at Washington State DOT. Ivanov covered the following topics in her presentation:

- Performance-based freight system management is being pursued at the national and state levels for a number of reasons. MAP-21 provides a strong policy framework for performance-based freight transportation systems. States, regions, and ports wishing to keep existing businesses and to attract businesses and jobs, while meeting residents' demands for healthy communities, have adopted similar policy goals. There is and will continue to be tension between, on the one hand, improving the services provided to freight-dependent businesses, freight carriers, and residents and, on the other, political and organizational resistance to change. Freight data programs and models can be powerful tools in supporting customer-focused results by tracking current corridor-level performance to identify deficiencies, in predicting performance outcomes of various investments, and in tracking postinvestment performance to evaluate progress and apply lessons learned. It is important that data and analytical methodologies be transparent, sound, and defensible.
- The freight policy goals in MAP-21, which are contained in Section 1115, are focused on the national freight network. The goals are to strengthen the contribution of the national freight network to the economic competitiveness of the United States; to reduce congestion; to increase productivity; and to improve safety, security, and resilience. Other goals are to improve the state of good repair; to use advanced technology to improve safety and efficiency; to improve economic efficiency; to reduce environmental impacts; and to incorporate concepts of performance, inno-

vation, competition, and accountability into the operation and maintenance of the network. Different agencies may interpret these goals slightly differently. Some goals may require changes in agency cultures, including a change from inward-focused to outward-focused goals.

- The freight movement and economic vitality performance goals of MAP-21, which are contained in Section 1203, are to improve the national freight network, to strengthen the ability of rural communities to access national and international trade markets, and to support regional economic development. While it is envisioned that the national freight network will focus on high-volume corridors meeting national needs, states will also be able to address critical rural corridors.
- Many state and regional policy goals for freight systems mirror the national goals. A focus by states on keeping existing businesses and attracting new businesses and jobs, while meeting residents' demands for healthy communities, will allow customers to set customer freight performance goals within the state policy framework. Freight system customers typically include freight-dependent industry sectors such as manufacturing, agribusiness, retail and wholesale trade, construction, timber and wood products, and transportation. Other customers are freight carriers and residents. To drive performance improvement, Ivanov observed that freight performance measures should focus on a short list of performance goals that matter most to these customers. Performance measures should also be specific and measurable. As a result, data must be available for measuring progress.
- AASHTO recently developed two truck freight performance measures for the Interstate system, as directed by MAP-21, Section 1203, 150(c)(6). AASHTO further recommended that the U.S. Secretary of Transportation adopt these performance measures. The first performance measure is annual hours of truck delay, which is defined as travel time above the congestion threshold in units of vehicle hours for trucks on the Interstate highway system. The second performance measure is the truck reliability index, which is defined as the ratio of the total truck travel time needed to ensure an on-time arrival to the agency-determined threshold travel time. These two performance measures were selected because they align with MAP-21 and state freight policy goals, drive progress toward freight customers' prioritized performance goals, focus resources on key priorities, and are measurable. States have the data needed to calculate both measures on the Interstate system as required by MAP-21.
- The Washington State DOT worked with three state freight plan technical teams to identify and prioritize the state's truck freight performance goals. More than 60 representatives from the state's key freight-dependent industry sectors, carriers, local governments and ports, air quality associations, labor groups, and academic experts served on the technical teams. The technical teams identified six performance goals that are strongly aligned with both state and federal freight policies and that are most important to shippers, freight carriers, and residents in Washington State. The

six performance goals relate to reducing truck travel time, truck operating costs, and truck engine emissions and to improving economic output, network resiliency, and reliability. These metrics will be used to measure the performance of the state's truck freight economic corridors.

- To develop the Washington State Freight Plan, the Washington State DOT worked with technical teams, MPOs, and regional transportation planning organizations to develop criteria for use in defining the state's truck, rail, and waterway freight economic corridors. The criteria used included volume; connectivity to freight-intensive land use such as industrial-zoned land, agricultural processing centers, and intermodal and military facilities; and resiliency. The Washington State DOT systematically and quantitatively analyzes the performance of state truck freight economic corridors to locate areas of severe truck collisions; poor state of repair; and slow-speed, resiliency, and legal-load truck bottlenecks.
- The Washington State DOT has developed a methodology for modeling changes in truck travel times, economic impacts, and emissions for highway project proposals to assist in predicting how investments will affect truck freight transportation. Figure 1 shows the draft truck freight highway benefit evaluation framework. The inputs rely on changes in truck travel times produced by the regional travel demand models. The output from the travel demand models is an input to the economic impact models and the latest version of the Motor Vehicle Emissions Simulator, which is used to model truck emissions characteristics.

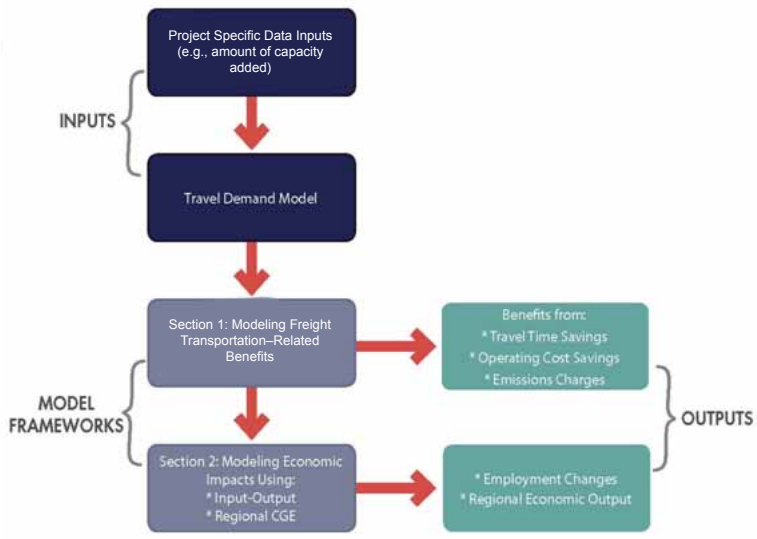

FIGURE 1 Predicting performance improvements: draft Washington State DOT truck freight highway benefit evaluation methodology (CGE = computable general equilibrium). (Source: Washington State DOT.)

- A number of elements can be identified to help advance freight system performance management. According to Ivanov, states and federal agencies may need better tools for analyzing the reliability of truck freight corridors from goods origin to destination as well as that of highway segments. Better tools may be needed for analyzing truck slow-speed bottlenecks on short highway segments, such as on- and off-ramps. Improved tools can be used to analyze zone-to-zone truck freight performance in urban areas, to predict the impacts of investment strategies on truck freight reliability, and to analyze and compare the performance of national and regional intermodal freight corridors with each other in terms of cost and service. Agencies may consider benchmarking and publishing results as a way to improve performance. Finally, Ivanov noted, agencies would benefit if research and funding are focused on improving overall corridor performance.

FREIGHT PERFORMANCE MEASURES IN THE CHICAGO REGION

Randy Deshazo

Randy Deshazo discussed the development and use of freight performance measures in the Chicago region and the role of MPOs in the freight planning and performance measurement processes. He described the freight system in the Chicago area, the GO TO 2040 regional plan, freight performance measures, and links to performance-based programming. Deshazo covered the following points in his presentation:

- The Chicago metropolitan area is the third largest metropolitan region in the country. The population of the seven-county Chicago metropolitan area within the CMAP jurisdiction is approximately 8.5 million. If the region were a separate country, it would be the 20th largest economy in the world. Freight transportation is a key part of the region's economy. The region includes 24,000 miles of roadways, with more than 58 billion annual vehicle miles of travel.
- CMAP was established in 2005 by the state of Illinois with support from the region's mayors. CMAP's central purpose is to improve integration of planning for land use and transportation. CMAP's staff was created by merging the Northeastern Illinois Planning Commission and the Chicago Area Transportation Study. The seven-county region covered by CMAP includes 284 municipalities.
- Chicago is one of the country's key freight hubs. Freight moves into, out of, and through the region by air, rail, truck, and water. Intermodal service is important in the region. The rail system in the Chicago area is extensive. The rail industry continues to consolidate lines, focusing on modernization and productivity. The majority of freight moves by truck and rail, with higher-value commodities moving by truck. Congestion on both the highway system and the rail network is an issue in

the area. The road and rail infrastructure has been entangled for more than a century. CMAP is taking a more innovative approach to capital investments and policies to address these long-standing issues.

- The Chicago metropolitan area is the economic engine for the state, accounting for approximately 66 percent of the state's population, 61 percent of collected motor vehicle fees, 66 percent of taxable sales, and 71 percent of taxable individual income. There has been a historic imbalance in statewide transportation investments, however. A long-standing agreement within the state's General Assembly directs 45 percent of transportation funds to District 1 in northeastern Illinois and the remaining 55 percent to the eight downstate districts.
- The public and private sectors use different freight performance measures and have different expectations and needs. It is important to keep these differences in mind in developing freight performance measures and in communicating with stakeholders.
- The CMAP GO TO 2040 is the long-range transportation plan for the region. GO TO 2040 includes a number of performance measures for the various goal areas. The performance measures are all measurable, and a majority are quantitative. Different planning efforts have tied performance measures to the GO TO 2040 goals. Some goals, such as gross regional product, are more difficult to relate to a specific set of investments.
- Performance measures do not always reflect the full story of what is occurring in the transportation system. Working with the city of Chicago and other partners, CMAP has mapped truck restrictions in the metropolitan area to identify connectivity issues, off-hour delivery restrictions, truck routing problems, and parking restrictions. These variables influence performance measures and influence the ability of infrastructure and operational investments to address key issues.
- CMAP is examining how funding from the Congestion Mitigation and Air Quality (CMAQ) program is allocated across the region. Currently, CMAP uses four modal groups to review proposals from local partners. Each group has developed its own ranking criteria for making recommendations. Each group makes its recommendations to the CMAQ Project Selection Committee, which uses air quality rankings, modal recommendations, and its own information and judgment to compile the recommended program. This approach is a step in the direction of performance management.
- There is a high correlation between freight performance measure rankings and GO TO 2040 major capital recommendations. The freight performance measures are validated by the broader decision-making process. The approach also provides insight into goods movement issues.
- CMAP hosted a 2-day peer exchange in 2012 to explore how other regions approach performance-based transportation funding. Representatives from other

MPOs and state DOTs participated. Some of the key points emerging from the peer exchange were the importance of depoliticizing the process, ensuring transparency, and using measures and qualitatively driven targets in the project selection process.

- At CMAP, performance-based funding uses a variety of performance measures to assist in prioritizing and selecting projects for funding. These measures are used as part of a transparent, public process that also relies on the professional judgment of transportation stakeholders and, in some cases, the general public. Project scores built from quantitative and qualitative input must be reconciled against available funds. Deshazo noted, however, that not all performance measures can be immediately applied to the programming process.
- To examine further how Illinois distributes transportation funding, CMAP has requested that the Illinois DOT form a technical advisory group to advance performance-based programming. Legislation was introduced to require the Illinois DOT to use performance-based programming, but the legislation has not moved forward. CMAP is developing a freight component of the travel demand model that will include capabilities for scenario development on changes in cost, pricing, and capacity and other improvements.
- CMAP maintains the following websites devoted to freight data, regional indicators, and performance measurement for the Chicago metropolitan area: http://www.cmap.illinois.gov/freight-snapshot, http://www.metropulsechicago.org, and http://www.cmap.illinois.gov/cmp/measurement.

SHIPPER PERSPECTIVE

Ken Allen

Ken Allen discussed freight performance measures from the perspective of a major grocery store chain. He provided an overview of H-E-B and described the major elements of the grocery store freight transportation system. He highlighted examples of transportation challenges in the Texas market. Allen covered the following points:

- H-E-B is a privately held grocery retail company with approximately 300 stores in Texas and 50 stores in Mexico. H-E-B has approximately 80,000 employees, $20 billion in annual revenues, and 40 warehouses and seven manufacturing plants in eight cities across Texas and Mexico. H-E-B trucks travel more than 100 million miles a year, not including inbound freight movement.
- The H-E-B supply chain and logistics group monitors the movement of items in every store on a daily basis. The information is used to predict future inventory needs at each store. The group writes the purchase orders to initiate the delivery of inventory into the system and manages the movement of products from suppliers to H-E-B warehouses and then into each store.

- The most vital performance measure for the group is every store being in stock every hour of every day. The reliability of freight movement is critical in meeting this performance measure. The top value H-E-B stores have approximately $4 million in weekly sales and 60 to 70 deliveries a week by H-E-B trucks, as well as direct store deliveries of major name brand goods. Most grocery stores follow similar delivery schedules. At H-E-B, direct store deliveries arrive between 6:00 and 9:00 a.m. H-E-B trucks deliver produce, bread, and frozen food products at designated times throughout the day to allow day crews to stock the products on the shelves as customers purchase them. Dry freight is delivered mostly in the evening and overnight hours.
- The second most important performance measure cited by Allen is managing costs. The cost of products is measured on the store shelves. At that point, a product is the responsibility of the retail division. In some cases, the logistics costs exceed the cost initially paid for a product. Logistics costs include more than trucking costs. For example, most of the seasonal general merchandise is sourced in Asia. These goods are carried by truck from the production location to the Asian port, loaded on oceangoing vessels, transported to a U.S. port, unloaded, taken by rail and truck or just truck to an H-E-B warehouse, and then taken by truck from the warehouse to the store. Costs are associated with each step. In addition, many of the food products in grocery stores today come from China, Thailand, Mexico, and other countries throughout the world.
- Key performance goals involve a reliability index and annual hours of delay measurement. Meeting these goals is critical in maintaining products on the shelves of grocery stores. The reliability of trucking, ports, rail, oceangoing vessels, air travel, and U.S. border crossings is important. With produce coming from Mexico into Texas, travel times and trip time reliability at the border crossings at Laredo and other ports of entry are critical.
- H-E-B is examining the impacts on reliability and cost of the Panama Canal expansion for goods sourced from Asia and South America. The all-water route through the Panama Canal to Texas ports is longer than the water route to the Los Angeles–Long Beach, California, ports and rail to Texas. Depending on cost and reliability, the all-water route may be viable for some products. Many elements, such as fees for use of the expanded canal, may not be known until completion in 2015.
- Highway congestion was the key issue for H-E-B's truck freight transportation. Traffic congestion results in delays in deliveries, increased fuel costs, decreased safety, and increased driver frustration. Pay for H-E-B truck drivers is activity-based—drivers are paid per mile driven and per delivery made. Being stuck in traffic reduces a driver's pay. The truck driver bid process might provide an approximate measure of the performance of the transportation infrastructure. For example, one H-E-B terminal in San Antonio, Texas, has 400 truck drivers who bid on the routes they will drive on the basis of seniority. The most senior drivers pick routes going

south to the Rio Grande Valley to pick up produce. Drivers on these routes leave San Antonio between midnight and 2:00 a.m. and return between 9:30 and 10:00 a.m. Drivers on these routes avoid traffic congestion in the San Antonio area on both ends of the trip. The lowest 100 drivers on the bid schedule take whatever routes are left. Examples of these routes are the delivery of dry goods north to Austin, Waco, and the Dallas–Fort Worth area in Texas. These drivers typically depart San Antonio at 2:30 to 3:00 p.m. and arrive in Austin between 4:00 and 4:30 p.m.—one of the most congested times of day. Drivers are not paid for the extra time it takes to get through Austin. Many other companies use similar activity-pay processes. Examination of the routes that are selected last by truck drivers at different companies would provide a good idea of congested roadway segments and congested times on the freight transportation network.

- I-35 through Austin is one of the most congested freeway segments in the state. The SH-130 toll road was constructed to help relieve traffic congestion on I-35. The SH-130 route is 17 miles longer and, with the tolls and the increased mileage, costs approximately $110 more for trucks to use than I-35. As a result, H-E-B uses the toll roadway only when there are major incidents on I-35 or when special events in the area make I-35 impossible to use. Overall, only about 2 percent of H-E-B trucks use the toll road.
- Freight movement is key to the economic vitality of the nation, states, and local areas. Business owners consider traffic congestion in locating new offices, warehouses, and other facilities. Enhancing freight modeling capabilities will assist in making better infrastructure investment decisions and in better operation of existing facilities.

FREIGHT PERFORMANCE MEASURES: AN INDUSTRY PERSPECTIVE

Steven S. Grabell

Steve Grabell provided a freight industry perspective on performance measures. He described NFI Industries, some of the differences between public-sector and industry freight performance measures, and possible approaches for synthesizing industry and public-sector performance measures. Grabell covered the following topics:

- NFI is a leading supply chain solutions provider. NFI has approximately 6,500 employees and owns approximately 7,000 trailers and 2,000 trucks. NFI provides a full suite of logistics services, including dedicated fleets, warehousing, brokerage, and intermodal. A major focus of NFI is on the multimodal movement of temperature-controlled goods. NFI has a Fortune 1000 customer base and generates more than $1 billion in annual revenue. The company owns and operates more than 20 million square feet of facilities in the United States and Canada.

- NFI serves a diverse mix of customers and carries a wide range of products, with a focus on grocery and food items, which require temperature-controlled trucks and storage facilities. Reliability is key in serving grocery stores. In addition, many stores are reducing on-site storage and display space and thus require more frequent deliveries. NFI has been focusing on providing dedicated fleet service to major companies. NFI has also been migrating to shorter-haul routes and services.
- Industry freight performance measures focus on enhancing operational performance, including provision of reliable, cost-efficient, and safe performance for customers. Grabell noted that performance measures need to be granular and to use real-world data-based measures. Reliability is typically measured by bottleneck avoidance through routing or time-of-day scheduling, planning for worst-case delays, and on-time performance. Cost-efficiency is measured by out-of-route miles, activity per truck per day, driver turnover, and miles per gallon of fuel. Safety is measured by the accident frequency rate; truck parking availability; and adherence to compliance, safety, and accountability and hours of service regulations.
- In contrast, public-sector freight performance measures are typically monitored at a corridor, network, or regional level. They are also often aggregated and annualized. Public-sector freight performance measures are frequently more focused on monitoring rather than on prompting change. Some areas of the country have not begun to develop and use freight performance measures.
- There are a number of differences between freight performance measures used in the public sector and those used in industry. Public-sector performance measures tend to focus on a macro scale, while private-sector measures focus on a micro scale. Public-sector measures are typically targeted at a region or at the state level and use aggregated data, while private-sector measures address specific points and unitize actual data at a granular level. The public sector focuses on multiple modes and examines measures in terms of months, years, and decades; industry focuses on the singular mode of truck transportation and examines measures by minutes, hours, and days.
- One method for synthesizing industry and public-sector freight performance measures is to calculate and monitor metrics by using real-world truck data. This approach focuses on objective operational costs, such as the hourly cost of operating a vehicle, rather than a less objective measure, such as the value of time. Furthermore, this approach would utilize truck data, such as the average number of hours with 20 percent of truck vehicle miles congested or a truck travel time index, without passenger car or other mode data. It would disaggregate data wherever possible by time of day, roadway, discrete bottlenecks, and other variables. The disaggregated data could be distributed to the industry to promote responses and obtain feedback.
- On the basis of the feedback, the freight performance measures could be adjusted to reflect private-sector needs. Reliability and travel time measures should account for urban and rural areas, large urban and small urban areas, peak and

nonpeak periods, and limited access highways and surface roads. No one measure will match the needs of all groups. Greater attention could be given to the most important freight corridors. The levels of data specificity could also be examined.

- Consideration could be given to how trucks use the network. Identifying the locations and network segments most critical to truck freight mobility, including concentrations of access to shippers and receivers and access to rail and ports, would be one step. Consideration could be given to enhancing safe and efficient access to these areas or to providing viable detours. Policy and infrastructure impediments could be identified and mitigated. Avoidance of unintended consequences and sensitivity to supply chain and marketplace decisions are important.
- Understanding the role that trucks play in local, regional, and state economies could be helpful. For example, the percentage of gross regional product moved by truck could be calculated for different areas. Consideration could be given to growing and declining industry sectors and to the need for just-in-time deliveries. For example, I-290 at I-90–I-94 in Chicago is ranked first by the congestion index. The segment has an average speed of 29 mph, a peak average speed of 22 mph, a nonpeak average speed of 32 mph, and a nonpeak–peak ratio of 1.43. This type of information is granular and actionable and is of use to the private sector.

State of Freight Data and Models
What Can We Do Now? What Are Future Opportunities and Limitations?

Rolf R. Schmitt, *Bureau of Transportation Statistics*
José Holguín-Veras, *Rensselaer Polytechnic Institute*
Alain L. Kornhauser, *Princeton University*
Matt Roorda, *University of Toronto*
Edward D. McCormack, *University of Washington, Presiding*

Speakers in this session focused on the status and trends in freight data and freight modeling. Rolf Schmitt, Bureau of Transportation Statistics, provided a historical perspective on freight data collection and model development and highlighted current applications. José Holguín-Veras, Rensselaer Polytechnic Institute, discussed urban freight tour models. Alain Kornhauser, Princeton University, reviewed available freight supply and demand data for railroads and trucks. Matt Roorda, University of Toronto, described an urban goods movement study in the Toronto metropolitan area.

STATE OF FREIGHT DATA AND MODELS FOR PERFORMANCE MEASUREMENT: A PUBLIC-SECTOR PERSPECTIVE

Rolf R. Schmitt

Rolf Schmitt provided a public agency perspective on freight data and models for freight performance measurement. He discussed the history of freight data collection and model development and current applications. The following topics were covered:

- Most freight data in the public sector were collected initially to support regulation, planning, and policy analysis. As economic regulation receded, some of the data sources disappeared. Data that could also serve planning and policy analysis had a better chance of being maintained. Usefulness for planning and policy analysis was not a guarantee of continuation, however. The Truck Inventory and Use Survey became the Vehicle Inventory and Use Survey, then was discontinued a decade ago. The renewed emphasis on freight national transportation policy and the growth of freight planning in state and metropolitan transportation agencies have brought new life to long-standing freight data programs such as the Commodity Flow Survey and the Freight Analysis Framework (FAF).
- There are a number of questions. Will today's emphasis on performance measurement become a new outlet for traditional freight data and the models that the data

were collected to support? Or does performance measurement require types of data and modeling different from those developed for policy and planning?

- The use of models for predicting or evaluating performance is not new in the public sector. Urban travel demand models have been used to forecast traffic flows and predict changes in levels of congestion for decades. A "special area analysis" module was added to the standard four-step urban travel forecasting package to summarize predicted traffic and travel times for individual links into regional isochrones and other evaluation measures. Four decades of models for the analysis of highway cost allocation and truck size and weight policies converted forecasts of freight activity and truck volumes into pavement and bridge condition, economic productivity, and other impacts that are now labeled as performance.
- Direct measures have replaced some applications of planning data and models for performance measurement, such as in the popular urban mobility reports that rank cities by congestion. The Texas A&M Transportation Institute used traffic volume data and a model based conceptually on the *Highway Capacity Manual* to estimate speeds and delay until direct measures of speed from loop detectors, cell phones, and other technologies became available. The Federal Highway Administration used a similar approach to estimate trucking bottlenecks with the FAF until bottlenecks could be identified from direct observations of truck speeds by using Global Positioning System (GPS) data.
- While direct observation of performance tends to be more accurate than model-based performance measures, not everything can be measured directly. Topics such as national freight ton-miles and gross domestic product require integration of data from multiple sources with models. Measures such as resilience are often based on conceptual models of what may happen rather than observations of what is happening.
- Models can serve as a basis for setting performance targets. The private sector uses models to identify ways of optimizing the efficiency of supply chains, and the level of performance identified in the model's optimal solution can become the target against which real-world operations are evaluated. Similarly, predicted responses to a policy change or public investment can become the target against which actual responses are measured and the policy change or investment evaluated. If an investment is justified by a predicted change, Schmitt asked, why not judge the subsequent performance of the investment by whether the predicted change was achieved?
- The utility of freight models and their necessary adaptations for performance measurement depend on whether performance is being measured for ensuring accountability, for improving performance through incentives (both rewards and penalties), or for improving performance through learning from experience. Accountability and incentives based on outputs of freight policies and projects require precision and credibility that are typically better achieved by direct observations than by using mod-

els. Learning, as well as accountability and incentives based on outcomes, requires evidence that conditions before and after implementation of an attempted freight improvement are caused by the improvement and are not merely a coincidence. Unless the attempted improvement is implemented under carefully controlled conditions, evidence of causality typically requires an explanatory model to make sense of available data.

- Freight models and data developed for planning appear to be most relevant for performance measurement when the subject cannot be observed directly, when predicted outcomes make good performance targets, and when models can help establish causality between actions taken and presumed outcomes. If others agree, the remaining tasks would be to identify (*a*) what aspects of freight performance can only be measured by models rather than by direct observation, (*b*) what targets are best defined by models, (*c*) what modifications or additions to models are necessary to summarize model outputs in terms of performance, and (*d*) whether freight models developed for prediction and planning can be adapted to serve explanation and learning.
- The central challenge is to find ways to use models and data collection to encourage feedback and learning about the world transportation professionals are trying to improve, the policies and projects that are proposed to improve the world, and the planning methods used to propose those policies and projects.

FREIGHT DEMAND MODELING: STATE OF THE ART AND PRACTICE

José Holguín-Veras

José Holguín-Veras described urban freight tours and the characteristics of various urban freight tour models. He discussed the need for ongoing basic and applied research in developing and testing new models. The following topics were covered:

- Approximately 80 percent of manufacturers in the United States are in urban metropolitan areas. It is important to describe and develop models that replicate freight tour behavior. The number of stops per urban tour depends on numerous variables, including the size of the urban area, the type of truck, the number of trip chains, the type of carrier, the service time, and the commodity transported. In general, the average number of stops per tour increases as the population and the size of an urban area increase. Models are needed that reflect this complexity.
- Data from Denver, Colorado, and the New York–New Jersey metropolitan area provide an indication of the complexity of urban freight tours. In Denver, the number of stops per tour is higher for trucks making one tour a day and lower for trucks making three tours a day. An examination of truck data conducted for the Port Authority of New York and New Jersey indicated differences in the number of trucks per tour related to the type of company and the origin of the tour. Common carriers

made 15.7 stops per tour, while private carriers made 7.1 stops per tour. Trucks with origins and deliveries in New Jersey made 13.7 stops per tour, while trucks with origins and deliveries in New York made 6.0 stops per tour. The commodity being transported also influences the number of stops per tour. For example, trucks transporting beverages make more stops than trucks carrying furniture.

- Holguín-Veras described three general types of urban freight tour models: simulation models, hybrid models, and analytical models. Simulation models attempt to create the needed isomorphic relation between the model and reality by imitating observed behaviors in a computer program. Simulation models are used in many areas. There are conditions and behaviors that cannot easily be captured by simulation models, however. Hybrid models incorporate features of both simulation and analytical models. Hybrid models use a gravity model to estimate commodity flows and a simulation model to estimate urban freight tours and logistical patterns. Analytical models attempt to achieve isomorphism by using formal mathematical representations based on behavioral, economic, or statistical axioms. The two main types of analytical models are spatial price equilibrium or disaggregate models and entropy maximization or aggregate models.
- Entropy maximization tour flow models are based on entropy maximization theory. The key concepts of these models are tour sequence (an ordered listing of nodes visited) and tour flow (the flow of vehicle trips that follow a sequence). The problem is decomposed into two processes—a tour choice generation process and a tour flow model. The tour choice generation process estimates sensible node sequences, and the tour flow model estimates the number of trips traveling along a particular node sequence. The optimal tour flows are found under the objective of maximizing the entropy of the system. The tour flows are a function of tour impedance and Lagrange multipliers associated with the trip productions and attractions along that tour.
- Spatial price equilibrium tour models estimate commodity flows and vehicle trips that arise under competitive market equilibrium. This approach accounts for tours and provides a coherent framework for modeling the joint formation of commodity flows and vehicle trips. It seeks to maximize the economic welfare associated with the consumption and transportation of the cargo, taking into account the formation of urban freight tours.
- Knowledge, models, and data were discussed. Data do not necessarily lead to knowledge, and models cannot be developed without knowledge. Furthermore, knowledge and models inform data collection, and the integrative developments of knowledge, models, and data are needed.
- The allure and traps of low-hanging fruit were discussed and compared to freight data collection and models. People love low-hanging fruit, although they may not realize that they are benefiting from trees planted by others. Rather than just taking the low-hanging fruit, there is a need to plant trees. Holguín-Veras suggested

the need to plant trees of different varieties to determine which ones provide the best fruit, which is basic research. The trees can be considered models—there is a need to develop different models to determine which produce the best results. Evaluating the trees or models to determine which ones are better is applied research. Finally, there is a need to take the best trees and their fruit or the best models and their results to the market. This step is development. These steps are needed to ensure that adequate models are available to examine the critical freight issues facing the country.

STATE OF FREIGHT DATA AND MODELS: RAIL, TRUCKLOAD, AND PICKUP AND DELIVERY

Alain L. Kornhauser

Alain Kornhauser discussed the availability of freight supply-side and demand-side data for railroads and trucks. He described positive attributes and challenges with regard to various data sources. The following topics were covered:

- The discussion framework presented in Figure 2 examines supply and demand data for the intermodal components of rail, truckload, and pickup and delivery freight services. The supply data include the underlying infrastructure. The public sector is largely responsible for the roadway infrastructure where trucks operate, while the private sector provides the railroad infrastructure. Demand generated by freight consumers is met by the private sector. Almost all freight movement today requires multiple modes. Supply and demand can be examined from a strategic or a policy perspective, a tactical or operations planning perspective, and an operational or real-time perspective.
- Digital map databases are frequently used to document the roadway supply. The databases are well developed and contain substantial detail. They are developed, maintained, and distributed by the private sector. They include all the attributes—distance, lanes, speed limits, historical volumes, address ranges, and tolls—for all roads. Current travel times are essentially available everywhere from INRIX and other providers. Historical statistical distributions are also available. Paths and tours can be readily calculated, including time windows and other constraints.
- However, challenges exist with regard to roadway digital map databases. First, digital map databases with truck-specific attributes must be used. Kornhauser cited the PC*Miler network as the standard. Second, travel time forecasts remain a challenge. Incidents are difficult to predict. Stochastic route choice remains a challenge, with a nontrivial risk and reward trade-off.
- Railway digital map databases are also available, with fairly detailed networks. These databases are developed, maintained, and distributed by the private sector. ALK Technology's PC*Miler–Rail is the standard. All major and most minor

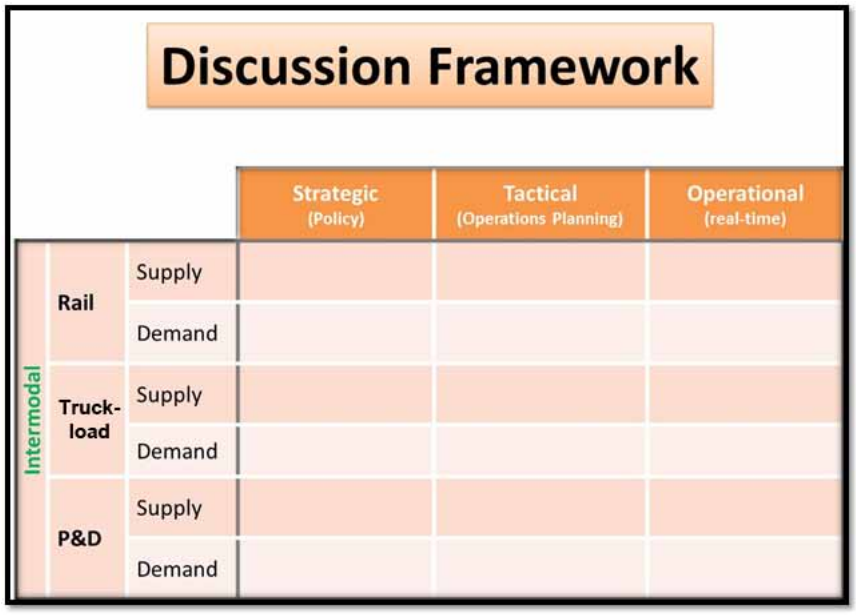

FIGURE 2 Discussion framework (P&D = pickup and delivery).

railroads in the country are included in this database. Available attributes include distance, ownership, trackage rights, interchange points, freight stations, grade, and track quality. Paths or flow traffic, competitive and cooperative routes, and Uniform Rail Costing System–type costs can be calculated. Trucks, rather than another railroad, are often the major competitor for rail freight. Multimodal analysis techniques are needed in assessing the potential impact of the Panama Canal expansion and other infrastructure investments. Challenges with regard to rail digital map databases include proprietary detailed operations-oriented network databases at each railroad. Travel time forecasts remain a challenge; each railroad has the data but holds them closely.

- Vehicle performance and cost models are fairly good for both rail and trucks. Fuel consumption, pollution, environmental, speed, accident propensity, and other variables can all be calculated. The Uniform Rail Costing System can be used to estimate variable and total unit costs for Class I railroads. Data on pavement and track infrastructure performance and maintenance are also good.
- On the demand side, the Carload Waybill Sample has been an excellent source of annual data since 1979. The stratified sample, called the "1 percent sample" though it is closer to a 2 percent sample, includes unit trains and provides data on car type, commodity, weight, and revenue. The regulatory framework and legislation have language that provides directions to railroads on how to sample their database at specific times and how to deliver the results of the sampling. The sample with all of its individual carload detailed data is accessible with permission for appropriate legal or

legislative purposes. A "public use" waybill file (sanitized version), which is a spatial aggregation, is available online. Each railroad has proprietary "100 percent" waybill files. Permission to sample these waybills may be requested.

- Comparable demand data for trucks are not readily available. Commodity surveys continue to be challenging. Essentially, every trucking company has detailed movement data similar to the Carload Waybill Sample. Most of these data are now maintained electronically. Many trucking firms have GPS tracking data and activity monitored by stops. Some firms have data every 45 minutes, while others monitor every 5 minutes, every 2 minutes, or even every 3 seconds. The challenge is that these data are all proprietary and, in contrast to the railroads, there are many trucking companies. A possible option would be for one aggregator, such as freight payment companies who receive the electronic bill of lading, to consolidate the data from the many trucking companies that they serve. The issue then would be to determine how well such a sampling mirrors freight movement throughout the motor carrier industry.
- Supply-side freight data appear to be relatively good. On the demand side, legislation comparable with the Carload Waybill Sample requirements would be beneficial but does not appear likely. Crowdsourced data for demand has limitations but provide an option. A key issue with learning algorithms is that data to calibrate the algorithms are missing.
- Finally, automation of the road driving function for trucks may hold benefits for obtaining demand data. More important, the biggest impact of automation of the driving function on the motor carrier industry is likely to be improved freight mobility. Improved mobility may result in shorter and more reliable travel times, opportunities for point-to-point deliveries of smaller units, and reduced costs. Such changes may substantially affect the logistics of manufacturing and the distribution of finished goods.

DEVELOPING URBAN GOODS MOVEMENT DATA IN THE GREATER TORONTO, CANADA, METROPOLITAN AREA: A FRAMEWORK

Matt Roorda

Matt Roorda discussed a project conducted for Metrolinx, which is a regional agency similar to a metropolitan planning organization in the Greater Toronto, Canada, area. He described the project objectives, the role of data in modeling and performance measurement, and the data collected and analyzed for the project. The following topics were covered:

- The project had three major objectives. The first was to develop a coordinated urban goods movement data collection and data management plan for the Toronto

metropolitan area. The second was to obtain data to support the performance measurement and modeling processes. The third objective, and the ultimate purpose of the project, was to inform urban goods movement–related public policy.

- The urban goods movement data framework had three pillars. The first was a plan for performance measurement and modeling. The second was a plan for data collection. The third was a plan for data management, which included data privacy protection, data sharing and dissemination, and data documentation.
- One of the first challenges of the project was identifying freight data needs and data sources. Freight data collection is often thought of as putting pieces of a puzzle together, with each puzzle piece representing a freight data source and the result being a complete picture. The project took a different approach of considering data as windows that allow users to see parts of the freight system. Each window is based on a different data source, including small sample surveys. Some of the freight system is left unmeasured or unobserved with this approach. Modeling is used to help fill in the gaps between the windows.
- Freight data in the Toronto area come from a variety of sources. Approximately 10 roadside interview sites in the Toronto area are used by the province of Ontario to collect data on an ongoing basis. Before this project, small establishment surveys were conducted in two of the six regions in the Toronto area. There is an ongoing program of purchasing truck GPS data from a third-party provider. A mixture of business registries and employer surveys provide data on business locations and business attributes. In addition, there are several traffic counting systems, which sometimes produce conflicting results. National data sources include the Trucking Commodity Origin and Destination Survey and the Canadian Vehicle Use Survey.
- Freight performance measurement is important for a number of reasons. Monitoring of the freight system can identify impacts due to changes in background conditions, such as urban growth, the economy, business practices, and technology, as well as those due to changes in public policy and infrastructure. Six classes of performance indicators were developed for the project: the economy and productivity, commodity and service flow, commercial vehicle movements, road network performance, intermodal performance, and environmental and social impacts. Specific measures were identified for each indicator.
- The data framework performance measurement recommendations included continuing existing data collection programs and undertaking new data collection activities. Existing data collection programs included the road performance counting systems, GPS data from third-party providers, and roadside truck intercept surveys. Recommended new data collection activities included consolidating the tracking of all establishments, conducting a commercial travel survey of establishments, conducting a cordon count program, and conducting additional roadside truck intercept surveys at intermodal terminals and airports.

- The model development activities focused on investing in a program of model improvement over time. There is a three-stage aggregate truck trip–based model for the region. Model improvements were recommended, with upgrading of the existing three-stage truck trip–based model as the first step and development of a tour-based microsimulation model as the next. An agent-based microsimulation model was recommended in a future phase. The approach was to invest now in the data and the research needed to develop the next-generation models.
- The data recommendations addressed both data needed for performance measurement and data needed for model development. Data needs for model development included tracking business establishments over time to monitor locations, attributes, numbers of employees, commodities produced and transported, and other variables. Conducting commercial travel surveys of establishments and roadside intercept surveys at gateways and intermodal terminals was recommended, as was obtaining records of major fleets with scheduled deliveries. Enhanced data collection for light commercial vehicles and enhanced cordon count programs were identified as needs for model calibration and validation. Investment in knowledge of the freight system and supply chains was identified as a longer-term need. Partnering with large firms to improve understanding of logistics and investing in research to improve understanding of behavior were suggested.
- Data management is the third pillar. Data management principles focus on data security, data availability, mutual benefit, ease of use, access control, flexibility, and documentation of use. Ensuring that private data are not compromised is a key principle. Nonprivate information should be widely shared and used. Data sharing should be reciprocated. Data sharing should be convenient, timely, and inexpensive. Differential access control can be provided for different data users. Flexibility is important for meeting the needs of various users. Documentation of use is also critical to articulate the benefits of data collection and the return on investment in data collection.
- A number of activities were conducted to implement the framework. A commercial travel survey of 1,000 small and medium-sized firms was conducted. The results were used to develop a modeling database that links commercial vehicle activity to establishment attributes. The survey also captured key aspects of performance measurement, including truck and commodity flows. Online, mail, and telephone methods were used to conduct the survey, which achieved a 22 percent response rate. The survey included three components: questions about the establishment, documentation of shipments for 1 day, and documentation of private fleet truck activity for 1 day.
- Extensive interviews with 12 large firms in the retail, wholesale, and food sectors were conducted. Information on each establishment was obtained during the interviews, and electronic shipment databases and driver logs were obtained for 1 day. Interviews focusing on supply chain information were conducted with representatives

from each firm. Information obtained during the interviews included the number and location of vendors and customers, vendor selection procedures, green supply chain management practices, transportation practices, and inventory practices. This information will be used in developing supply chain models.

- The interview results indicate that large retail supply chains have many attributes in common. Among them are global supply chains and selection of vendors primarily on the basis of price and quality. The interviews indicated that global sourcing can be cost-effective but can bring about challenges in inventory management and quality control. Additional common attributes were an emphasis on larger shipments—full truckloads and containers—to economize and movement of most products through distribution centers. Demand forecasting 6 to 18 months ahead, with quarterly or monthly updates, was a commonly reported practice.
- The interview results identified major differences in retail supply chains. Complexity was one. Some firms had relatively simple supply chains, with five vendors, while others had complex supply chains with hundreds of vendors. Resiliency was another difference, with some firms having multiple vendors for all products and some only one source for all their products. Inventory turnover ranged from two to 32 turns per year, depending on the product. A question on environmental initiatives elicited three general views from respondents. Some indicated that environmental initiatives were vital to the firm's successful operation. Others suggested that they were a necessary public relations exercise. Still others indicated that they were a nonissue. Two views were expressed on outsourcing logistics to a third-party logistics firm. Some respondents found it beneficial in reducing cost and allowing the company to focus on core competencies, while other respondents reported that it led to poor service and less customer satisfaction.
- This project points out the importance of simultaneously planning for data collection, modeling, performance measurement, and data management. Another concluding message is that data sources do not always fit together well, but similar data can be used to support both modeling and performance measurement. Data collection that supports an ongoing program of model improvement is helpful. Developing behavioral knowledge of the system is crucial, as is learning by listening to logistics managers.

Integration

What Did We Hear? What Did We Learn? What Are the Implications for Freight Data and Models?

Leo Penne, *American Association of State Highway and Transportation Officials*
Joseph L. Schofer, *Northwestern University*
Michael D. Meyer, *Parsons Brinckerhoff, Presiding*

Speakers in this session summarized key themes from the morning presentations, outlined a framework for considering the electronic posters, and provided a charge to the breakout groups. Michael Meyer, Parsons Brinckerhoff, expanded on information presented in the morning sessions and suggested initial research needs. Leo Penne, American Association of State Highway and Transportation Officials (AASHTO), described a framework for reviewing the electronic posters. Joseph Schofer described the format and topics for the breakout groups.

INITIAL THOUGHTS

Michael D. Meyer

Michael Meyer summarized key points from the speakers in the morning sessions and provided related information from previous conferences. He identified potential research needs from the presentations for further discussion during the breakout groups. The following topics were covered:

- Joe Schofer set the stage for the workshop in the opening session. He noted that the effective use of performance measures and performance-oriented decision making requires good tools and good data. He emphasized that performance measures focus on enhancing decision making and improving outcomes. This theme was echoed by other speakers.
- Meyer summarized the discussion from a previous freight workshop on the relationships between modeling, analysis data, and decision making. As Figure 3 illustrates, participants at that workshop identified different levels in the decision-making context. The data and the analysis techniques for examining freight at the global level are much different from those needed to assess freight at a local, site-specific level. It is easy to discuss these relationships, but implementation is more complex, with decisions occurring at different scales.

FIGURE 3 Geographic levels for decision making (NAFTA = North American Free Trade Agreement).

- Meyer discussed Figure 4, which is also from a previous conference. It illustrates different types of decisions—from systems operations to strategic investments—and examples of analysis tools appropriate at each level. Every level of decision making can be an important focus for development of models and tools and for data analysis.
- Caitlin Hughes Rayman summarized the key freight sections of the Moving Ahead for Progress in the 21st Century Act (MAP-21). She highlighted the new emphasis on freight and the inclusion of freight in the transportation planning process; discussed the multitask use of freight data for decision making, planning, forecasting and modeling, performance management, and communications; described the various levels for freight performance measures, including metropolitan, statewide, and national scales; highlighted the importance of demonstrating a need for investments that will benefit freight and multimodal transportation; and noted the link between national freight policies and state freight plans. Meyer commented that the development of national freight policies and the linking of national policies to those at the state and local levels were recommended in a report of a previous international scan. He suggested that the eligibility of freight projects for a higher federal match influences much of the increased interest in freight data and freight modeling at the state and metropolitan planning organization (MPO) levels.

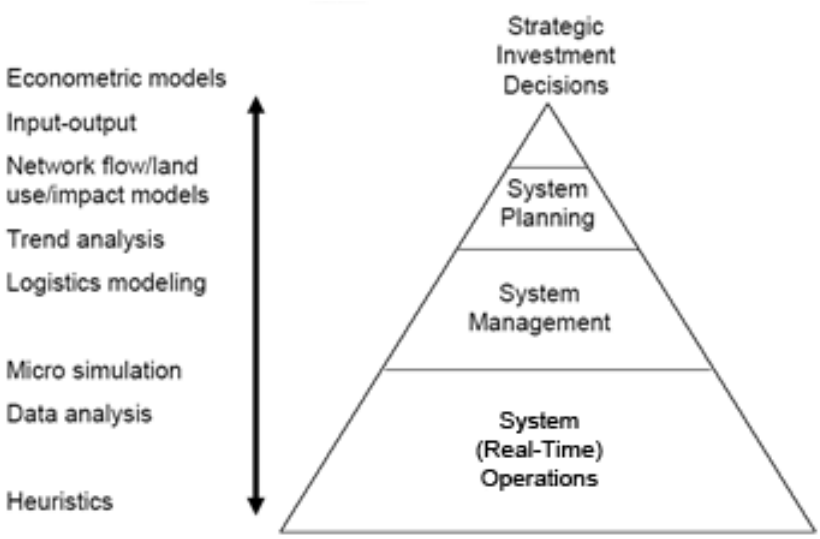

FIGURE 4 Decision levels and analysis tools.

- Barbara Ivanov also discussed MAP-21, with a focus on the economic impetus for freight performance measures from a customer perspective. She described the potential for tension between the managers of the freight system and the political structure; discussed the use of freight data and models as tools in promoting organizational change; noted that resiliency is becoming more critical in light of the recent extreme weather events; discussed defining the freight network from the state, metropolitan, and national perspectives, as well as the perspective of freight-dependent firms; and discussed the performance measures developed by AASHTO, which can also be applied to freight transportation systems under state control.
- Randy Deshazo described the use of performance measures in the Chicago, Illinois, metropolitan area related to information dissemination, long-range planning, benchmarking, and performance-based programs; discussed performance-based funding (which enhances transparency), the relationship between state departments of transportation and MPOs, depoliticization of the planning process, and implementation; and noted the relationship between freight performance measures and investment decisions.
- Ken Allen provided a perspective from the private sector, noting the importance of reliability in ensuring that grocery stores are well stocked at all times. He described managing the cost of products on the shelf and indicated that in some cases the logistics cost is more than the cost of a product itself. He discussed the potential impact of the Panama Canal expansion on the cost of products on the shelf; voiced concerns similar to those of public agency personnel related to safety, fuel use, the environment, and congestion; noted that supply chain delay is an important measure in

the private sector; and described the driver bid process for routes and suggested that it provides a good indication of congested roadway segments.

- Steve Grabell provided the perspective of a private-sector carrier. He described the granular location-, time-, and scale-specific data used by carriers for action-oriented decisions and noted the importance of avoiding unintended consequences by being sensitive to supply chain and marketplace decisions.
- Rolf Schmitt discussed the history of using tools in the context of performance measurement and suggested that models are best used when subjects cannot be observed directly and when causality can be inferred. He highlighted the importance of conducting before-and-after analyses to identify causality and noted the importance of models for learning and understanding the underlying economic principles, concepts, and behavioral issues.
- José Holguín-Veras discussed the dynamic nature of freight movement; the behavioral decisions made by companies, shippers, customers, and drivers; and how to represent these characteristics in a model. He described three levels of models—simulation, hybrid, and analytical—and identified advantages and disadvantages of each. He emphasized the need for models to account for economic competition and the importance of knowledge and noted that data by itself do not equal knowledge. He challenged workshop participants to think beyond the "low-hanging fruit" in discussing research needs.
- Alain Kornhauser assessed the strengths and weaknesses of various freight data sources. On the supply side, he noted that roadway data are well developed, especially data related to infrastructure, current travel time, and path and tour calculations. Challenges included data on truck-specific attributes, travel time forecasting, assessment of the impact of incidents, and the concept of stochastic route choice. He noted that railway data are well developed and that paths can be calculated reliably. Challenges include large detailed operations network databases and travel time forecasting. Kornhauser suggested that vehicle performance and cost models are good for trains and trucks and that pavement and track data are good. On the demand side, data on historic rail flows and current data from the Waybill Sample are good, but the railroad databases are proprietary. Obtaining trucking demand data is a challenge, since the Global Positioning System tracking data and detailed movement data are proprietary and there are numerous trucking companies.
- Key points from Matt Roorda's presentation on freight planning in the Toronto, Canada, area included modeling to fill data gaps and simultaneously planning for data collection, modeling, performance measurement, and data management. He described the variety of public and private data sources at various scales and the use of diverse data sets in support of performance measurement; provided the perspective of not merely developing models but continually improving modeling approaches and progressing from trip-based to tour-based to agent-based modeling; and emphasized

that investment in knowledge is important, as is investment in data management.

- Meyer noted that many speakers described research needs during their presentations, with additional ideas emerging during the questions and discussions. He summarized these research topics for further consideration in the breakout groups. Among them were the following: developing and applying methods for assessing the reliability of truck freight corridors from origin to destination; examining freight bottlenecks and zone-to-zone freight performance; developing tools for estimating the investment impacts of freight-related projects; conducting before-and-after assessments of projects; examining the performance of national and regional intermodal freight corridors and interconnections in a global economy; developing credible methods for benchmarking; addressing the potential for disconnects between aggregate system performance measures; and supporting more location-specific and granular decisions.
- Other research needs were mentioned by speakers: examining the potential for adapting models for learning and understanding and developing and calibrating learning algorithms; increasing knowledge of the freight system through basic and applied research; examining the impact of driving automation on truck drivers and trucking operations; examining the usefulness of alternative data sources, such as truck enforcement and safety data; developing real-time data management strategies; improving data-cleaning methodologies; and developing a phased approach to tour-based and agent-based modeling.

FRAMEWORK FOR CONSIDERING THE ELECTRONIC POSTERS

Leo Penne

Leo Penne described a framework for considering the electronic posters to be presented at the workshop reception. The abstracts provided by the poster authors are presented in Appendix A. The framework focused on the institutional and geographic coverage of the posters. He highlighted the interrelationships of the MAP-21 freight elements. The following topics were covered:

- The workshop represented progress related to freight data, freight modeling, and freight performance measures. The progress is reflected in the presentations and posters and in the activities under way in states and MPOs throughout the country. Policy makers are benefiting from improved freight data and modeling techniques.
- The electronic posters provide a useful framework of institutional and geographic interest in freight data and freight modeling. The posters represent work at the federal level (the Federal Highway Administration and the U.S. Army Corps of Engineers) and at the state level (Florida, Minnesota, and Washington). There are also posters from multistate organizations—the Appalachian Regional Commission (ARC) and the Institute of Trade and Transportation Studies (ITTS)—and metropolitan agencies in Chicago and Toronto.

Florida, Minnesota, and Washington represent a diversity of economies, institutional arrangements, and transportation system components. They are more advanced than many other states in developing and using freight performance measures, freight data, and freight models. The information from these three states should be beneficial in assembling a national freight strategy.

- The posters from ARC and ITTS reflect the perspectives of multistate organizations. ARC has promoted the development of the Appalachian Highway System, which is important for freight movement in the region. ARC focuses on identifying the economic potential of the region and developing a transportation system to support that potential. ITTS grew out of a study examining the potential for trade between the southeastern states and South America and the implications for the transportation infrastructure and operations in the southeastern states. The ITTS poster presents a systematic approach for examining data on transportation infrastructure and on business development. There are posters presenting freight data, performance measures, and planning components in the Chicago and Toronto metropolitan areas.

Penne discussed Figure 5, which presents the interrelationships of the MAP-21 freight program. Implicit in the figure is the role of freight data, analysis, and

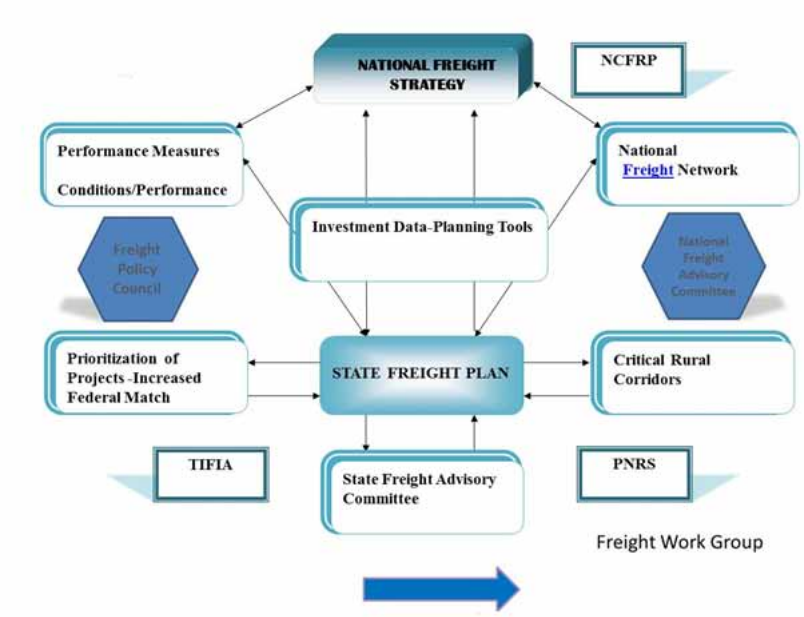

FIGURE 5 Interrelationships of the MAP-21 freight program (NCFRP = National Cooperative Freight Research Program; PNRS = Projects of National and Regional Significance; TIFIA = Transportation Infrastructure Finance and Innovation Act).

modeling at different levels and in different spheres. Consistency is needed between the levels, as is coordination in moving the elements forward. The posters can help in developing a coordinated approach among agencies and groups at the metropolitan, state, multistate, and federal levels.

CHARGE TO BREAKOUT GROUPS

Joseph L. Schofer

Joseph Schofer provided the charge to the breakout groups. He noted that the speakers have discussed freight data and modeling to support performance measurement in the public and private sectors. The breakout sessions focus on discussing needs and opportunities for adapting freight data and models to enhance freight performance measurement and to identify research needs to fill existing gaps. Participants were asked to discuss the adequacy of existing freight data programs and models in supporting performance-oriented freight system planning and decision making, to outline issues and opportunities with regard to current data and models, and to identify research topics that would help advance the use of freight performance measures and enhance freight transportation decision making.

Breakout Reports and Town Hall Discussion of Needs for Freight Data and Models

Paul H. Bingham, *CDM Smith*
Michael Sprung, *Bureau of Transportation Statistics*
Edward D. McCormack, *University of Washington*
Rolf R. Schmitt, *Bureau of Transportation Statistics*
José Holguín-Veras, *Rensselaer Polytechnic Institute*
Charles E. Howard, *Puget Sound Regional Council*
Michael D. Meyer, *Parsons Brinckerhoff*
Juan Carlos Villa, *Texas A&M Transportation Institute*
Joseph L. Schofer, *Northwestern University, Presiding*

This session featured the final reports from the breakout groups. The leaders of the four breakout groups presented research topics identified by participants. Some of the groups used a common format that included the research title and descriptions of the issue, research steps, likely outcomes, and who could benefit from the research. An open discussion at the end of the session allowed participants to voice their thoughts and ideas on the research topics, the discussions at the workshop, and other activities to promote the development and use of freight performance measures.

GROUP 1

Paul H. Bingham and Michael Sprung, Leaders

Paul Bingham summarized the three research problem statements developed by participants in this breakout group. The three topics resulted from discussions concerning issues and opportunities related to public and private freight data and models. The problem statements focus on developing a freight fluidity index or transportation time and reliability performance measures for multimodal shipments, developing local network travel time and reliability performance measures for last mile delivery and pickup, and examining the adequacy of truck parking supply and demand for regional logistics.

Freight Transportation Time and Reliability Performance Measurement Development

Why an Issue?

There are data gaps between international and domestic activity in the freight system and data gaps at the last mile or local delivery portion of the freight network. This research project would address the full supply chain. There are differences in multimodal supply chain characteristics. There is a need to examine cargo-specific corridors, to make improvements across a variety of supply chains, and to evaluate system shocks and the resiliency of the system. The President's National Export Initiative and the Department of Commerce National Supply Chain Advisory Council have initiated efforts to examine the transportation aspect of supply chain performance. The research project would focus on these issues and develop freight transportation time and reliability performance measures. The freight fluidity measures used in Canada would be examined as part of the analysis.

Research Steps?

A number of activities would need to be conducted if this project were undertaken. Examples are identifying data from freight security–related processes, determining the ability to access the data, addressing the trucking origin–destination data gap to map commodity movements to trucking movement through the Global Positioning System (GPS), identifying private supply chain data, developing a framework for data sharing with the private sector while respecting confidentiality, and researching technology applications for data collection and data mining related to freight transportation travel time and reliability. Other activities would build on the National Cooperative Freight Research Program's Project 42, Development of Multimodal Linkages. A final research area would be to investigate how to group commodities and shipment types for performance measurement, given the differences between commodities and the need for simplification to develop a useful process.

Likely Outcomes?

Potential outcomes include improved competitiveness and reliability of supply chains, better decisions by national and state planners for facilities, and better outreach and communications by local and metropolitan area planners. Participants noted the differences between decision making at the state and national levels and decisions at a metropolitan or local level. It was suggested that performance measures may be useful in advocating for specific freight improvement projects.

Who Benefits?

High-level policy makers, local planners and decision makers, and private-sector operators may benefit from this research.

Last Mile–Local Network Travel Time and Reliability Performance Measures

Why an Issue?

Last mile freight transportation, which typically consists of trucks operating on the local roadway system, is a key part of the supply chain. This research would develop travel time and reliability performance measures for the last mile of the supply chain. The research would address the data gap that exists on the local network for the last mile of delivery or the first stop of origination of shipments. There is a lag in data collection of last mile usage that is a challenge. The impacts on the system from major changes in last mile deliveries can be significant. The results could contribute to improved urban goods movement decision making and help to address asset management and environmental issues.

Research Steps?

Possible research activities include exploring sensor technology applications for collecting data on use of the last mile road network. Research to identify commodity mix shifts or business establishment locations would be needed, along with a better understanding of changes within small area geographies. A synthesis of models that work at the local level for public–private collaboration could be helpful.

Likely Outcomes?

Anticipated outcomes are improved small area planning and performance, with environmental conditions and environmental justice benefiting, and improved capabilities for before-and-after project performance evaluation.

Who Benefits?

Local transportation planners and decision makers would likely benefit from this research.

Truck Parking Supply and Demand Adequacy for Regional Logistics

Why an Issue?

The third research topic is also related to the last mile but is more narrowly focused. It would examine truck parking needs for freight and logistics. Data on the availability and use of truck parking in many urban areas are currently unavailable, as are data on out-of-service truck travel patterns and data on trucks waiting for their delivery or pickup window to open.

Research Steps?

One possible research activity is to identify existing parking supply characteristics in various urban areas, including number of parking spaces, land use interfaces, and parking regulations. Another is to identify system usage, which would involve application of GPS data on the location and time of current parking activity.

Likely Outcomes?

Potential outcomes from the research include improved system performance for carriers (since they will spend less time searching for parking), improved safety from reduced conflicts between parked trucks and other vehicles, improved safety for drivers, reduced emissions, lower energy consumption, and reduced congestion from lower levels of parking search activity.

Who Benefits?

A number of groups would benefit from this research: planners responsible for parking facility zoning and locations, parking and enforcement personnel, truck drivers, and carriers and receivers. Policy makers responsible for investments decisions would benefit from having better information on parking supply and demand. One possible disbenefit identified by participants was reduced revenue to local jurisdictions from parking fines for illegally parked trucks.

GROUP 2

Edward D. McCormack and Rolf R. Schmitt, Leaders

Ed McCormack summarized the four research topics from Group 2. Participants identified a number of research needs, which were consolidated into the four topic areas. Participants indicated that activities in these four areas could be undertaken quickly by building on existing research efforts. He also summarized two higher-level overarching research needs identified by participants. McCormack highlighted the following potential research needs from Group 2:

- Adapt the Canadian Gateway Program freight fluidity measures for application in the United States. The focus of the fluidity measures is on access and travel time, and they require the ability to track freight from the point of origin to the destination. Information is also needed on the freight mode and the type of commodity being transported. The freight fluidity measures, which were developed by Texas A&M Transportation Institute (TTI) for Transport Canada, could be adapted for use in the United States. Incorporating resiliency into the U.S. application was suggested by participants. Some participants suggested that leveraging the work of Transport Canada and TTI promotes good use of resources and would assist in developing freight performance measures.

- Quantify the cost of delay. Information on the nature and the extent of delay and the commodities being transported is needed to translate delay into costs. Commodity information is critical, since different commodities have different delay costs, but this information is difficult to obtain. The research would explore levels of delay for various commodities and the impacts of delay in one commodity on other products. For example, a delay in a shipment of sheet metal may delay production on an automobile assembly line. The research would develop a methodology for estimating the cost of delay for various commodities.
- Explore the performance of the last mile in the supply chain. The last mile, which is typically in urban areas, is often the location with the most delay. Combining micro and macro analyses and forecasting approaches represents a viable alternative for assessing the potential for delay in the last mile. The U.S. Department of Transportation's intermodal connector assessment tool provides an approach that would be examined in the research. The potential for revising and updating this tool to examine the last mile would be considered, as well as development of a new tool.
- Explore the use of data from third-party logistics firms (3PLs) for freight performance measures. These firms have a variety of freight performance data. The research would assess how the data could be used in freight performance measures while protecting confidentiality. Selected firms could be approached to determine their interest in sharing data, and a pilot test could be conducted with a few firms. The results of the pilot test would be used to assess the benefits of using 3PL data for freight performance measures, and the approach could be expanded as appropriate.
- Participants also discussed two higher-level, overarching potential research needs. The first focuses on developing methods for fusing national and local freight data. The second examines a national customer satisfaction survey to identify problem-specific areas and bottlenecks in the freight transportation system.

GROUP 3

José Holguín-Veras and Charles E. Howard, Leaders

Participants in Group 3 discussed a number of potential research needs. The four research topics that emerged from the discussions were presented by the group members who helped develop the problem statements: Barbara Ivanov, Washington State Department of Transportation; Maren Outwater, Resource Systems Group; José Holguín-Veras, Rensselaer Polytechnic Institute; and Teresa Brewer, Municipality of Anchorage, Alaska.

Improving the Use of Truck GPS Data to Track Truck Freight Performance

Why an Issue?

On the basis of the Moving Ahead for Progress in the 21st Century Act (MAP-21), as well as state and local initiatives, state departments of transportation and metropolitan

planning organizations (MPOs) are motivated to track truck freight performance on the national freight network and on state and regional corridors. The analysis of truck GPS data could provide low-cost, high-value information on truck freight performance. The use of GPS data is still new. As a result, it may not be widely accepted by transportation professionals unless research is conducted into obtaining, analyzing, and applying GPS data.

Research Steps?

Two major research steps were suggested by participants. The first was to define the characteristics of the truck GPS data sets in terms of sample bias and data integrity to establish credibility with regard to their use. The second was to develop a national methodology for tracking truck travel time and reliability on truck freight corridors by using the GPS data sets.

Likely Outcomes?

The outcome of the research would be a systematic, objective, widely adopted, and relatively inexpensive methodology for tracking truck freight performance, especially travel reliability, by using GPS data.

Who Benefits?

Numerous public- and private-sector groups would benefit from the research. State, MPO, regional, and federal transportation professionals would benefit from a relatively inexpensive method of accurately evaluating truck freight performance. Decision makers would benefit from information that would enable them to understand current system performance, prioritize investment for improvements, and assess the results of public investments in truck freight corridors. The private sector would benefit from improved infrastructure and operations.

Moving Toward a Multimodal Freight Modeling and Data Collection Framework

Why an Issue?

The second research topic was viewed as a long-term project. Current freight forecasting models do not typically address behavioral, economic, and multimodal issues well. In addition, data collection needed to support multimodal freight models is costly, and proprietary issues associated with obtaining value sample sizes need to be addressed. Developing a multimodal freight modeling framework and a data collection process to support the model would be beneficial. The research would build on the few existing multimodal models and data collection programs.

Research Steps?

A multimodal freight framework would need to address resiliency, supply chains, pickup and delivery systems, exports, industry shifts (e.g., ethanol), and regulatory changes. It would need to address the supply side for all modes—air, water, pipeline, rail, truck, and transfer facilities. The research would develop an affordable and practical data collection program. Elements to be included in the data collection program are truck counting programs by truck type, time of day, and speeds; vehicle tours; and supply chains. Other research activities could include a review of existing multimodal frameworks, development of a phased approach to implementation, integration of this framework into the planning process, and development of performance metrics.

Likely Outcomes?

Anticipated outcomes include an implementable modeling framework and data collection program that recognizes the different freight transportation requirements for states and regions. A migration path or a phased approach to implement this framework could be identified, beginning from different points on the spectrum. Guidance on integrating freight forecasting models into the planning process could be provided.

Who Benefits?

State departments of transportation and MPOs would be the major beneficiaries of this research. Industry would also benefit.

Behavioral Determinants of Freight Demand: The Role of Manufacturers, Shippers, Carriers, and Receivers in the Generation of Freight Demand

Why an Issue?

The behavior of participants in the freight system is not well understood. Freight demand is the result of interactions between shippers, carriers, and receivers. Carriers have to deliver supplies and must respect the constraints imposed by shippers and receivers. Influencing the behavior of shippers and receivers could improve system performance in dramatic ways. Research is needed to determine the best ways of representing the behavior of participants in the freight system in freight demand models (e.g., delivery time decisions, routing, tour formation). The enhanced knowledge will likely improve the predictive capabilities of models and the definition of policies and programs that increase the sustainability of the freight system and its contributions to quality of life, livability, and environmental justice.

Research Steps?

In-depth interviews, focus groups, and behavioral surveys could be conducted to identify and prioritize the behavioral processes and gain insight into the freight transpor-

tation decision-making process. The results of these efforts could be synthesized for input into models and the public-sector transportation decision-making process.

Likely Outcomes?

Anticipated outcomes from this research include an understanding of the behavior of participants in the freight system; how to incorporate their behavior into freight demand models; and how to induce behavior changes leading to increasing the sustainability of the freight system and its contributions to quality of life, livability, and environmental justice.

Who Benefits?

State departments of transportation, MPOs, and policy makers would benefit from the research through a better understanding of how to improve various elements of the freight system.

Applying Performance Management Science to Transportation

Why an Issue?

Transportation experts need to understand the process and decision models for performance management for the successful deployment of projects. Application of performance management science to the freight transportation system and the use of freight performance measures would be beneficial.

Research Steps?

Suggested research activities included conducting a background and literature review of industries outside and inside transportation, casting the results, and packaging and adapting the results to freight transportation.

Likely Outcomes?

The anticipated outcomes would be a primer for use by all levels of the freight transportation system and lessons learned to inform decision makers, transportation managers, and local governments.

Who Benefits?

Decision makers and stakeholders would be the major beneficiaries of this research.

GROUP 4

Michael D. Meyer and Juan Carlos Villa, Leaders

Juan Villa summarized the three research topics prepared by participants in this breakout group. Participants had discussed the importance of travel time reliability, the fluidity index, a better understanding of the complete supply chain, and other issues. Participants identified three research topics focusing on developing economic performance metrics for multimodal freight transportation, identifying end-to-end supply chain transparency to understand economic linkages, and establishing performance measure model calibration methods and data sources for freight modeling.

Development and Assessment of Economic Performance Metrics for Multimodal Freight Transportation

Why an Issue?

Currently, methodologies for conducting economic analysis of multimodal freight transportation are lacking. It is difficult to link the decision-making process for multimodal freight transportation investments to measures of effectiveness and performance measures. This research project would develop economic performance metrics for multimodal freight transportation. The information developed may be of interest to freight transportation system users and decision makers at the local, state, and national levels.

Research Steps?

Suggested elements of the research include completing a synthesis of theories and current practices, developing case studies by economic sector, and developing an analytical framework for education and understanding of freight transportation. The major activity would be developing and testing economic performance metrics for multimodal freight transportation that would be appropriate for use by public agencies and the private sector. It is envisioned that the metrics would be tested at selected MPOs and states throughout the country. A final activity would be preparation of a road map of the data sources needed for the metrics.

Likely Outcomes?

Anticipated outcomes of the research include development of economic performance metrics that would provide relevant information to decision makers, best practices for presenting the metrics to policy makers, and approaches for incorporating the results into planning and programming processes for multimodal freight transportation infrastructure investments and operations funding.

Who Benefits?

The major beneficiaries of this research would be state departments of transportation, MPOs, federal agencies, and other public-sector groups. Shippers, carriers, industries, and other private-sector groups would benefit from the economic performance metrics and the resulting improvements in the freight transportation system.

Identifying End-to-End Supply Chain Transparency to Understand Economic Linkages

Why an Issue?

A better understanding of the complete supply chain is needed for different types of commodities and for various geographic areas. Data are not available for all supply chain segments. Information on the full end-to-end supply chain, including on-land intermediate points and the last mile, is needed to assess the impacts of investment decisions, operational strategies, and policies. Information on empty backhauls would be beneficial in understanding the full impact of freight movement on the transportation system. A better understanding of supply chains would assist states, MPOs, and other jurisdictions in ensuring resiliency in the transportation system.

Research Steps?

The initial research activities would be reviewing available information on supply chains for various commodities and geographic areas. The results of this review would be used to develop a tool or methodology for assessing end-to-end supply chains. The methodology would consider the level of detail or resolution on supply chains needed by decision makers in the public and private sectors. The project would investigate potential and actual unintended consequences of transportation investment decisions, operating guidelines, and policies for supply chains. Performance measures for monitoring supply chains would be developed. A final task is identification of the benefits to data providers and other stakeholders of using the methodology and performance measures.

Likely Outcomes?

The methodology for identifying the full supply chain for various commodities and the performance measures would be the main product of the research. The methodology could allow users to develop and analyze different supply chain scenarios and their economic linkages. The performance measures could also be used by public- and private-sector decision makers. The results would be of benefit in defining the multimodal national primary and rural transportation networks.

Who Benefits?

State departments of transportation, MPOs, federal agencies, shippers, carriers, and developers and ports would all likely benefit from the research.

Establishing Performance Measure Model Calibration Methods and Data Sources for Freight Modeling

Why an Issue?

To benefit transportation professionals and policy makers, freight models need to reflect reality. Freight performance models need to have independent and direct values that ensure that results are properly grounded. Furthermore, data used in the models must be valid. The calibration process helps ensure that models reflect reality and that the input data are valid. This research project would identify data sources and performance measure model calibration methods for freight models.

Research Steps?

Suggested research activities include identifying data sources needed for freight models and freight performance measures. Both public- and private-sector data, including weigh station data, would be examined. Factors to consider in selecting the model input data might include availability, cost, accuracy, granularity, and geographic coverage. Calibration methods typically used in the modeling process would be reviewed and applied to freight performance measure models to identify the best approach.

Likely Outcomes?

Anticipated outcomes would be more realistic models, transparent data, and improved performance measures. The research may provide better freight modeling capabilities.

Who Benefits?

The beneficiaries of the research may include modelers working at or for state departments of transportation, MPOs, and other public agencies. Private-sector groups may use the results in their modeling activities. The public and private sectors could both benefit from using better models.

OPEN DISCUSSION

Joseph Schofer, Workshop Planning Team Chair, provided closing comments to begin the open discussion. Workshop participants then had the opportunity to provide additional thoughts, ideas, and comments on the research topics identified in the breakout groups, other needs associated with freight data and models, and additional activities to support the development and use of freight performance measures. This section highlights the general topics discussed by workshop participants.

- Schofer noted that the transportation profession has had at least 60 years of experience in modeling passenger travel. Modeling freight transportation is a relatively new undertaking. Many participants suggested that while progress has been made in freight data and freight modeling over the past few years, there is more to be done in understanding the complexities of the freight transportation system. Schofer noted that the need for understanding the last mile of the freight transportation system and adaptation of the Canadian fluidity index for use in the United States were discussed in many of the breakout groups. He suggested that the discussion of freight performance measures was robust, even without the requirements of MAP-21, and that some of the research topics presented could be combined to provide fewer, more comprehensive projects.
- A number of participants discussed comparing performance across freight modes. They noted that conducting modal comparisons is not easy. Comparing supply chains rather than modes was suggested as a more beneficial approach by some participants. Participants noted that truck size and weight and modal diversions were not discussed extensively in the breakout groups.
- Some participants suggested that transportation time and reliability were important freight performance measures. The use of the fluidity index or other measures to address time and reliability were further discussed. The need for adding resiliency as a measure was noted.
- Most participants expressed a need to develop a deeper understanding of freight supply chains. Some suggested that obtaining more information on the behavior of shippers and carriers would be beneficial.
- Participants noted the complexity of the freight transportation system. Freight transportation is multifaceted, and it is difficult to capture all the diverse dimensions of the freight system. International supply chains are more complex than local supply chains. Focusing first on data availability and modeling tools for analyzing local supply chains was suggested as a good approach.
- Many participants discussed the need for ongoing capacity-building activities, including training, peer-to-peer exchanges, web seminars, and other efforts. It was suggested that sharing the information presented at the workshop would be beneficial and that using different venues, agencies, and groups—such as the Transportation Research Board, the National Cooperative Highway Research Program, the Federal Highway Administration, the American Association of State Highway and Transportation Officials, and pooled-fund studies—would help in outreach to diverse stakeholders involved in freight transportation. Training and outreach could build the expertise of technical staff at state departments of transportation, MPOs, and other groups. Providing information on available tools, resources, data, and models was suggested. The importance of continued outreach to the private sector was noted.

Moving Forward

Katherine F. Turnbull, *Texas A&M Transportation Institute, Rapporteur*

As part of the conference proceedings, Katherine Turnbull, conference rapporteur, prepared a summary of the overarching themes, capacity-building needs, and research needs discussed by the participants. This section includes Turnbull's summary.

The Adapting Freight Models and Traditional Freight Data Programs for Performance Measurement workshop represents one of an ongoing series of conferences and workshops organized by the Transportation Research Board to advance freight transportation planning, data collection and analysis, and performance measurement. These efforts focus on providing better information on all aspects of the freight transportation system to enhance decision making related to infrastructure investments, operations, and policies.

A number of overarching themes and capacity-building opportunities emerged from the presentations, electronic posters, and breakout group discussions. There were similarities in the research needs identified in the four breakout groups. These overarching themes, capacity building opportunities, and research projects provide a robust set of follow-up activities to continue improvements in freight data, models, and performance measurement. The activities can capitalize on opportunities presented by the Moving Ahead for Progress in the 21st Century Act and meet its requirements.

OVERARCHING THEMES

The following overarching themes and cross-cutting topics emerged from the workshop presentations, electronic posters, and breakout group discussions.

- *Freight transportation is complex and involves diverse stakeholders*. The complexity of the freight transportation system was noted by speakers and participants. The freight transportation system includes diverse commodities, multiple modes, far-ranging origins and destinations, and a variety of supply chains at different levels. The private sector is key to the freight transportation system. The private sector makes decisions on supply chains and modes, owns and operates many of the modes, and maintains key data on the movement of diverse commodities, which are often proprietary. Private-sector freight groups have not traditionally participated in the transportation planning and project selection process conducted by state departments of transportation, federal agencies, metropolitan planning organizations (MPOs), and other public agencies.

- *Progress is being made in freight transportation data, models, and performance measures*. Workshop participants noted that progress has been made over the past few years in obtaining and analyzing both public and private freight data. Public-sector data, including the Commodity Flow Survey and the Freight Analysis Framework, as well as locally collected data, have been used to analyze elements of the freight transportation system. States, the Federal Highway Administration, MPOs, universities, and other groups have worked with private industry to obtain and analyze trucking Global Positioning System data, as well as other private data sets. The information presented at the conference highlighted examples of freight data, models, and performance measures being developed and used by some state departments of transportation, MPOs, regional agencies, federal agencies, and other groups.
- *More research, outreach, and training are needed to further the understanding of the complex elements of the freight transportation system*. Such efforts are needed to incorporate freight into the transportation planning process and to provide policy makers with data for making informed decisions on freight transportation investments and operations.

CAPACITY BUILDING

Many participants discussed the need for sharing available information and for building capacity among transportation professionals, policy makers, shippers and carriers, and other groups. Ensuring that all groups are aware of the progress that has been made over the past few years can promote and leverage the use of existing resources.

- *Continue outreach to engage diverse freight stakeholders, including the private sector*. Participants noted that much progress has been made in outreach to shippers, carriers, industries, associations, and other private-sector groups. Transportation professionals and policy makers have a greater appreciation of the freight system, shippers, carriers, and third-party logistics firms. These private-sector entities also have a better understanding of the transportation planning process and the transportation decision-making processes involving state departments of transportation, MPOs, federal agencies, and local governments. Participants suggested that existing activities with diverse public- and private-sector freight stakeholders be continued and that new initiatives be undertaken. The U.S. Department of Commerce Advisory Committee on Supply Chain Competitiveness and the U.S. Department of Transportation National Freight Advisory Committee were cited. Outreach to local freight stakeholders and sharing of best practices on ways to engage the freight sector were suggested.
- *Share available information with all stakeholders*. Much information has been developed over the past few years on freight planning, data, models, and performance measures. Reports, guidebooks, and other materials have been developed

by federal agencies, the cooperative research programs—especially National Cooperative Freight Research Program and National Cooperative Highway Research Program projects—states and MPOs, university research institutions, consultants, and other groups. Some participants suggested that sharing information on supply chains, freight transportation, and logistics as widely as possible and reviewing the state of knowledge in related fields and adapting available information for use with states, MPOs, and other groups would be beneficial. Such information could assist in improving available tools and models and help build the theory of knowledge by leveraging the experiences from the public- and private-sector professionals responsible for freight transportation. Participants suggested a wide range of methods—conferences, workshops, web seminars, electronic media, and one-on-one meetings—for sharing information.

RESEARCH NEEDS

Sixteen potential research needs identified by participants in the breakout groups were presented in the closing session. Common topics included obtaining a better understanding of supply chains; better defining the issues associated with last mile delivery; adapting the fluidity index used in Canada for application in the United States; and incorporating transportation time, reliability, and resiliency into freight performance measures.

- *Deep dive research into supply chains*: A number of participants discussed the need for a better understanding of supply chains. While progress has been made on this topic, support was voiced for additional research to improve understanding of the complexity of supply chains. Suggested elements to be included in a research project were examination of enterprise-to-enterprise supply chains in addition to geography-to-geography supply chains, which is the focus today, and the various supply chain layers or levels. Enterprise-to-enterprise supply chains focus on the movement of products from one business to another as part of the product development process. The downstream cost impacts of delay would be examined. Participants noted the need to define the data and the data sources for examining supply chains and developing a typology for presenting different supply chain layers and suggested that developing performance measures related to supply chain components could be beneficial. Examining multimodal freight analysis methods was suggested as an element of this project or as a separate project.
- *Research to improve understanding of last mile freight delivery*: Many participants suggested that a more detailed assessment of the last mile, which is part of the overall supply chain, would be appropriate given its importance in most metropolitan areas. The last mile typically involves trucks operating on local roadways. Among the

research elements suggested were identifying data, data sources, and data gaps associated with the last mile and developing analysis techniques for examining alternative strategies to address local issues. Other activities would focus on developing performance measures associated with the last mile. Information on truck parking supply and demand, truck routes, and local regulations could also be examined.

- *Adapting the freight fluidity index for application in the United States*: Many participants believed that adapting the freight fluidity index would be beneficial and would leverage available resources. The freight fluidity index compares the average travel time in the period of interest with travel time during free-flow or unconstrained conditions. It addresses trip time reliability by comparing the 95th percentile travel time with travel time during free-flow or unconstrained conditions. Participants suggested that adding resiliency to the index could be beneficial.

APPENDIX A

Electronic Poster Summaries

The summaries of the electronic posters presented at the workshop contained in this appendix were provided by the authors. They appear in the order listed in the workshop program.

WATERWAY MOVEMENTS LOCK AND DAM

Marin M. Kress, *U.S. Army Corps of Engineers*, and Ned Mitchell, *Engineer Research and Development Center*

The marine transportation system relies on safe and reliable navigation through coastal and inland waterways. The U.S. Army Corps of Engineers (USACE) supports this need by operating and maintaining physical infrastructure such as locks, dams, and jetties, along with thousands of miles of dredged navigation channels. Annual maintenance dredging decisions historically have been made on a project-by-project basis, without the ability to optimize resource allocation across the system as a whole. However, the USACE Channel Portfolio Tool now allows authorized users to conduct system-level optimization based on the detailed origin–destination cargo database maintained by the Waterborne Commerce Statistics Center (WCSC). Integration of landside freight data and WCSC data will allow for more extensive analysis of inter-modal freight flows.

IMPACTS OF COMPLETING THE APPALACHIAN DEVELOPMENT HIGHWAY SYSTEM

Julie Marshall, *Appalachian Regional Commission*

Completion of the Appalachian Development Highway System (ADHS) will yield significant economic benefits for the Appalachian region and for the nation. The first highway system authorized by Congress for the purpose of stimulating economic development, the ADHS is a 3,090-mile highway system composed of 32 corridors located in the 13 Appalachian states. The ADHS is 86 percent open to traffic and, when completed, will link to an integrated network of national markets and trade flows. By facilitating national freight flows, reducing travel times, improving safety, and enhancing access to markets, completion of the ADHS will create new jobs and greater value-added activity.

FEDERAL HIGHWAY ADMINISTRATION FREIGHT ANALYSIS FRAMEWORK AND FREIGHT PERFORMANCE MEASURES PROGRAM

Edward L. Strocko, *Federal Highway Administration*

The Federal Highway Administration's Freight Analysis Framework, Version 3 (FAF3), data and Freight Performance Measurement Program (FPM) are tools to help decision makers, planners, and the public in understanding the magnitude and importance of freight transportation to the economy. FAF3 integrates data from many sources to provide a snapshot of the volume and value of freight flows, which provides insight to states and regions about their major trading partners and the volumes and sources of through traffic at the corridor level. The FAF3 Data Tabulation Tool allows users to create and download summary tables directly from the FAF3 regional database. This ability will help inform discussions of goods movement; economic conditions; and the safety, energy, and environmental implications of freight transportation. The FPM uses truck probe data to identify average speeds and reliability on significant corridors and border crossings. With the FPM web tool, decision makers can evaluate the performance of key freight corridors and determine opportunities for operational or physical improvements. This capacity provides data-based decision-making support to target investments strategically and to improve the freight network where the need is greatest.

FREIGHT PERFORMANCE MEASURES IN METROPOLITAN CHICAGO, ILLINOIS: A METROPOLITAN PLANNING ORGANIZATION PERSPECTIVE

Randy Deshazo, *Chicago Metropolitan Agency for Planning*

"Hog Butcher for the World, / Tool Maker, Stacker of Wheat, / Player with Railroads and the Nation's Freight Handler; / Stormy, husky, brawling, / City of the Big Shoulders." Carl Sandburg had it right in his 1914 poem describing Chicago as the busy center of North American freight. Today this means more than 1 billion tons per year, $3 trillion of goods, and hundreds of thousands of jobs in the Chicago metropolitan area. This freight activity begets substantial investment needs—more than current investment resources can meet. With a customary minority share of state and federal transportation dollars for the nation's third largest metropolitan region, the Chicago metropolitan area has a particular interest in ensuring that performance measures prevail as a central tool in investment decision making. Since its formation in 2005, the Chicago Metropolitan Agency for Planning has collaborated with local governments to define a vision of future transportation investments, in GO TO 2040, that strengthens the role of performance measures in capital investments. This poster highlights the impacts of freight on the metropolitan regions and recent actions to strengthen the role of performance-based programming in Illinois.

STRATEGIC INTERMODAL SYSTEM ANALYSIS: FLORIDA DEPARTMENT OF TRANSPORTATION

Richard Biter, *Florida Department of Transportation*

Florida's Strategic Intermodal System (SIS) is a network of high-priority transportation facilities. The SIS carries virtually all waterborne freight, rail freight, and cruise passengers; more than 99 percent of all commercial air passengers and cargo; 89 percent of all interregional rail and bus passengers; and more than 70 percent of truck traffic and 55 percent of total traffic on the state highway system. Projects on the SIS are evaluated on the basis of measures such as reliability, operational performance, and economic impacts. The Florida Department of Transportation is moving forward by creating the new Office of Freight, Logistics, and Passenger Operations and developing the Florida Freight Mobility and Trade Plan Policy Element with significant stakeholder input.

FREIGHT TRANSPORTATION AT THE MINNESOTA DEPARTMENT OF TRANSPORTATION

William D. Gardner, *Minnesota Department of Transportation*

The Minnesota Department of Transportation and the Minnesota Department of Employment and Economic Development have initiated several transportation economic analyses that use cluster analysis, as well as transportation data and analysis, to identify and profile key industries and their characteristics. The intent is to identify opportunities to optimize supply chain productivity for individual industry clusters. Opportunities include correlation analysis to establish the suitability of alternative transportation modes—freight rail in particular—as well as needed transportation infrastructure improvements that could be achieved through coordinated public–private investments.

iCORRIDOR ANALYSIS TOOL, ONTARIO, CANADA

Jason Z. Li, *Ontario Ministry of Transportation*

The Systems Analysis and Forecasting Office of the Ministry of Transportation of Ontario, Canada (MTO), has a mandate to provide evidence-based analysis at the state level to support policy and program development. Evidence-based analysis requires collection of large amounts of systemwide data, with Global Positioning System data playing an innovative role in modernizing the suite of near real-time investment decision-making tools. MTO has used Google Maps and Google Cloud to transform a transactional, request-based delivery model into a user-defined exploration model to advance open data concepts, unlock the potential of valuable individual data streams, and integrate multimodal travel demand data and operations and land use data layers. For information, visit http://www.mto.gov.on.ca/iCorridor/.

BUILDING FREIGHT PERFORMANCE MEASURES FOR WASHINGTON STATE BY USING GLOBAL POSITIONING SYSTEM DATA FROM TRUCKS

Edward D. McCormack, *University of Washington*

The Washington State Department of Transportation and the University of Washington have partnered on a program to collect and analyze Global Positioning System data from commercial, in-vehicle truck fleet management systems. Initiated in 2007, this truck performance measurement program uses spot speed and location data collected daily from more than 7,000 trucks to analyze the entire freight roadway network and to identify truck freight bottlenecks in Washington State. This enables the state to identify and develop solutions to key truck freight problems and to meet the performance requirements of the Moving Ahead for Progress in the 21st Century Act.

FREIGHT 2050: THE USE OF SCENARIO MODELING TO EXPLORE FUTURE FREIGHT TRANSPORTATION ENERGY USE

Daniel F. Beagan, *Cambridge Systematics, Inc.*

A freight scenario planning tool was developed for the National Renewable Energy Laboratory. Scenario planning can test the implications of various futures—such as changes in freight transportation demand—for a desired outcome, such as energy consumption. Scenario planning is applied when changes in demand are difficult to estimate because the changes might follow complex, nonlinear feedback loops or the actual degree to which demand might change is not known. By testing different factors on elements of the demand—percentage changes in flows by origin or by commodity—the implications of a variety of those changes can be estimated and compared. For example, the implications of changes of Panamax ships on the total energy consumed by domestic freight might be desired, but the changes in demand cannot be determined precisely. It is anticipated, however, that the change will be a shift in certain commodities from West Coast ports to East Coast ports and that those shifts might be as much as 20 percent or as little as 5 percent of demand. In this case, scenario planning can apply factors representing those changes to tables of base year and official freight demand forecasts, such as tons by commodity by mode between zones. The changes in freight flows can be transformed into total domestic ton-miles by mode, and rates of energy consumption by ton-mile by mode can transform this transportation demand into energy demand. By testing reasonable ranges of changes in West Coast zones and corresponding changes in East Coast zones, how each change in demand affects total domestic energy consumption can be estimated.

LINKING INTERSTATE AND BUSINESS PATTERN DATA

Bruce Lambert, *Institute for Trade and Transportation Studies*

With a focus on economic competitiveness, Interstates serve local, regional, and national flows and support many supply chains. By linking transportation geography—business and economic activity—to broad supply chain trends, performance measures could be developed that suggest where multiagency corridor planning may provide broad improvements. In combination with existing freight flows, these metrics could be extended to include a framework for estimating the value of a corridor to the regional or the national economy.

APPENDIX B

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