

The Role of Freight Transportation in Economic Competitiveness

DETAILS

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The Role of Freight Transportation in Economic Competitiveness

*Summary of the 8th University Transportation Centers
Spotlight Conference*

Katherine F. Turnbull, *Rapporteur*

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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 University Transportation Centers Program, Office of the Assistant Secretary for Research and Technology, U.S. Department of Transportation; and the Transportation Research Board.

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Preface

The highly developed transportation system in the United States is a key factor in the nation's economic competitiveness. Roads, railroads, the inland waterway system, seaports, and airports all contribute to connecting agricultural and natural resource areas, population and employment centers, and international gateways. Maintaining and improving an effective and efficient transportation infrastructure for the movement of people and freight continue to be important in today's global marketplace, especially given projected population growth and increased domestic oil, gas, and agricultural production. Urban goods movement, international supply chains, and logistics are also key to the future economic competitiveness of the country.

The Transportation Research Board (TRB) hosted a conference entitled *The Role of Freight Transportation in Economic Competitiveness* at the Keck Center of The National Academies in Washington, D.C., in December 2014. This meeting was the eighth in a series of Spotlight Conferences funded by the U.S. Department of Transportation's Office of the Assistant Secretary for Research and Technology, University Transportation Centers (UTC) Program. The UTC Program awards grants to universities across the country to advance state-of-the-art transportation research, conduct technology transfer activities, and educate the next generation of transportation professionals.

TRB assembled a planning committee, appointed by the National Research Council (NRC), to organize and develop the conference program. The planning committee was chaired by Denver Tolliver of North Dakota State University. Committee members provided expertise in freight supply chains, transportation system resiliency, and energy sector developments.

The planning committee was responsible solely for organizing the conference, identifying speakers, reviewing submitted poster abstracts, and developing topics for the breakout group discussions. Katherine Turnbull of the Texas A&M Transportation Institute served as the conference rapporteur and prepared this document as a factual summary of what occurred at the conference. Responsibility for the published conference summary rests with the rapporteur and Texas A&M Transportation Institute.

The conference attracted 84 participants. Agency personnel responsible for freight transportation, system resiliency, responding to disasters and extreme weather events, and addressing energy sector developments joined faculty, students, and researchers from UTCs and other universities to explore the role of freight in economic competitiveness. Representatives from industries and trade associations also participated in the conference. The conference, which was characterized by broad and active participation and discussion, considered potential research to help improve

PREFACE

supply chain operations, enhance transportation system resiliency, and address energy sector transportation needs.

The conference began with an overview of trends in global trade and a national perspective on transportation and economic competitiveness. Plenary sessions highlighted modal perspectives on freight supply chains and economic competitiveness, transportation system resiliency, energy sector developments and economic competitiveness, and global freight supply-chain issues. Conference participants also had the opportunity to interact with poster authors and to discuss issues and areas for further research in breakout groups. Speakers in the closing plenary session highlighted the key issues, opportunities, and research needs discussed in the breakout sessions.

These proceedings consist of presentation summaries from the plenary sessions and the poster abstracts provided by the authors. The views expressed in this summary are those of the individual speakers and discussants, as attributed to them, and do not necessarily represent the consensus views of the conference participants, the conference planning committee members, TRB, or NRC. The conference PowerPoint presentations and the poster abstracts provided by the authors are available at <http://onlinepubs.trb.org/onlinepubs/conferences/2014/UTCSpotlight/Program.pdf>.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise in accordance with procedures approved by the NRC 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 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 the conference summary: Paul Bingham of Hackett Associates, Anne Goodchild of the University of Washington, Pasi Lautala of Michigan Technological University, and Reginald Souleyrette of the University of Kentucky.

Although these four reviewers provided many constructive comments and suggestions, they did not see the final draft of the summary. The review of this summary was overseen by Susan Hanson of Clark University (emerita). Karen Febey, TRB Senior Report Review Officer, managed the review process.

The conference planning committee thanks Katherine Turnbull for her work in preparing this conference summary report and extends a special thanks to the Office of the Assistant Secretary for Research and Technology of the U.S. Department of Transportation for providing the funding support that made the conference possible.

List of Acronyms and Abbreviations

| | |
|------------|--|
| APEC | Asia–Pacific Economic Cooperation |
| ARRA | American Recovery and Reinvestment Act |
| ASC | average social cost |
| ATA | American Trucking Associations |
| AV/CV | autonomous vehicles and connected vehicles |
| CEA | Consumer Energy Alliance |
| Commerce | U.S. Department of Commerce |
| DOT | Department of Transportation, department of transportation |
| FAF | Freight Analysis Framework |
| LNG | liquefied natural gas |
| MAP-21 | Moving Ahead for Progress in the 21st Century Act |
| NCFRP | National Cooperative Freight Research Program |
| NCHRP | National Cooperative Highway Research Program |
| NFAC | National Freight Advisory Committee |
| NOx | oxides of nitrogen |
| NRC | National Research Council |
| NS | Norfolk Southern |
| ORNL | Oak Ridge National Laboratory |
| P3 | public–private partnership |
| RET | research experience for teachers |
| REU | research experience for undergraduates |
| SAFETEA-LU | Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users |
| SHRP 2 | Strategic Highway Research Program 2 |
| STEM | science, technology, engineering, and mathematics |
| STIP | statewide transportation improvement program |
| TIGER | Transportation Investment Generating Economic Recovery Program |
| TRB | Transportation Research Board |
| TVA | Tennessee Valley Authority |
| U.S. DOT | U.S. Department of Transportation |
| UTC | University Transportation Centers |
| VMT | vehicle miles traveled |

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Conference Overview

Denver Tolliver, *North Dakota State University and Conference Planning Committee*
Chair, presiding

David Long, *U.S. Department of Commerce*

Mortimer Downey, *Mort Downey Consulting, LLC*

The opening session featured welcoming comments by Denver Tolliver of North Dakota State University and chair of the conference planning committee. David Long of the U.S. Department of Commerce discussed global business models and trends in global trade. Mortimer Downey provided a national perspective on transportation and economic competitiveness.

CONFERENCE WELCOME AND OVERVIEW

Denver Tolliver

Denver Tolliver welcomed participants to the 8th University Transportation Centers (UTC) Spotlight Conference, *The Role of Freight Transportation in Economic Competitiveness*. He recognized the Office of the Assistant Secretary for Research and Technology of the U.S. Department of Transportation (U.S. DOT) for sponsoring the conference. He also thanked the conference planning committee and Transportation Research Board (TRB) staff for their hard work in organizing the conference. He described the conference focus, topic areas, and format. Tolliver covered the following topics in his presentation:

- He observed that the U.S. transportation system has been a key factor in the nation's economic competitiveness, connecting agricultural areas, population and employment centers, and international gateways. Tolliver suggested that an effective and efficient transportation system is increasingly important in today's global marketplace. In response to this need, this UTC Spotlight Conference would address three key areas in which freight transportation contributes to economic competitiveness: freight supply-chain operations, transportation system resiliency, and meeting the demands of changing energy markets.

- Tolliver thanked the U.S. DOT's Office of the Assistant Secretary for Research and Technology for sponsoring the conference and gave special acknowledgment to Robin Kline and Thomas Bolle for their assistance. He recognized the work of

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the conference planning committee listed in the program and noted the extra efforts of Caroline Mays, Anne Strauss-Wieder, and Melissa Tooley in coordinating the three topic area sessions. The hard work and assistance of TRB staff members Scott Babcock, Tom Palmerlee, and Mai Q. Le were also recognized.

- Tolliver reviewed the conference program. The opening plenary session would provide a national perspective on freight transportation and economic competitiveness, as well as global business models and supply chains. Speakers in four plenary sessions would address modal perspectives on supply chains, transportation system resiliency, transportation and energy sector developments, and global freight supply-chain issues. Posters on a wide range of research projects addressing these topics would be presented during the conference reception. Participants would have opportunities to discuss common issues, share experiences, and identify research needs during the breakout group discussions. The closing session would highlight the key themes from the breakout discussion groups and identify potential follow-up activities and research.

FREIGHT TRANSPORTATION IN ECONOMIC COMPETITIVENESS: TRADE AND INVESTMENT ASPECTS

David Long

David Long discussed supply chains in relation to global business models, trends in global trade and investment, emerging trends influencing views of those two topics, and activities under way at the U.S. Department of Commerce and across other government agencies. Long noted the need to consider these four themes against the background of potentially doubled freight volumes over the next 15 years and of unresolved questions about funding supply chain and transportation infrastructure. Long covered the following topics in his presentation:

- He described some of the underlying assumptions about the role of supply chains in global business today. Supply chains allow the growth of business models based on global sourcing for services and manufacturing alike, with companies taking proximity to markets, selection of products and services on the basis of best prices and quality, and other commercial factors into account in their investment and operational decisions. This approach requires integrated relationships at every level, from raw materials, to production, to the point of sale. It is a value-chain view, focused on the end-to-end supply chains and the total landed cost of products.
- Long suggested that the efficiency of the global supply chain affects the cost of every product in the United States, determines whether U.S. firms meet global prices, and influences where firms invest and where people are hired. He also suggested that rather than companies competing against each other, entire supply

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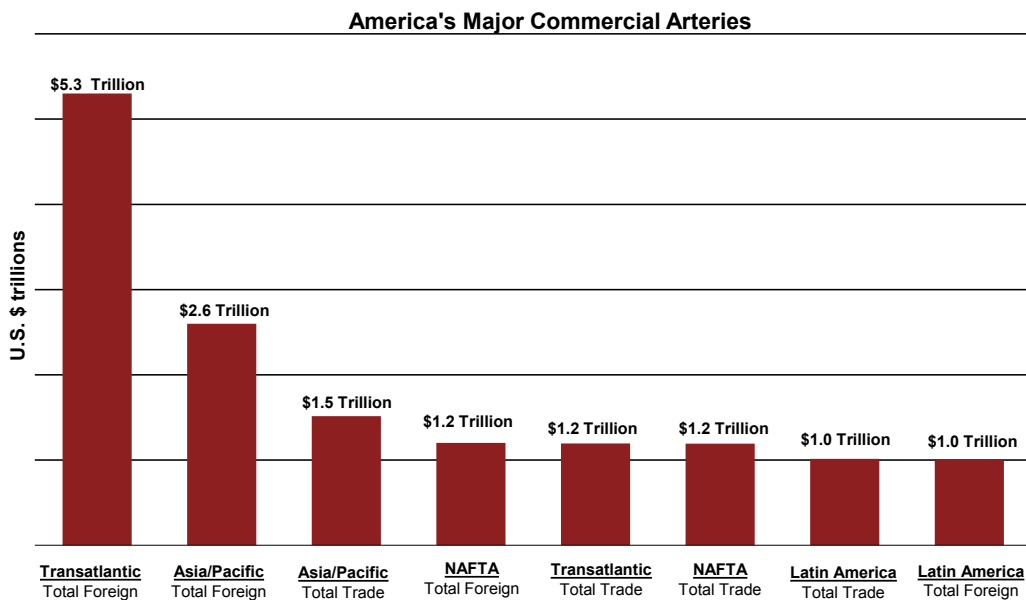
chains now compete against other entire supply chains. He observed that this new role for supply chains is essential in today's investment-driven competition, a major change from previous approaches. He noted that global supply chains operating under these conditions depend on low-cost telecommunications, information technology, and transportation. Long suggested all the major trading countries in the world are considering these issues, supply chains, and supply chain infrastructure as strategic priorities in their approaches to economic competitiveness.

- With regard to the idea of investment-driven competition—a central feature of the global economy—Long discussed Figure 1, which presents regional trade and investment data on major U.S. trading routes. The central point is that sales from foreign affiliates operating abroad outpace total trade flows in most markets. He noted that where mutual investment (i.e., globalization) is most advanced, the flows from foreign affiliates far outpace trade volumes and are where economic competition and profitability lie today. The figure contrasts data for foreign affiliate sales and total trade figures for the transatlantic region, the Asia–Pacific region, North America Free Trade Agreement countries, and Latin America. He noted that foreign affiliate sales are not included in the trade figures because foreign affiliate sales are counted separately from total trade by the Bureau of Economic Analysis. For the Asia–Pacific region, the total foreign investment is greater than the total trade. The difference in the transatlantic region is even greater, with foreign affiliate sales almost five times as great as total trade. He suggested that having a presence in another market is much more complicated than just exporting a product. Local laws, licensing issues, real estate, zoning, taxes, and other factors need to be considered; these factors change the nature of the business relationship and the nature of the trade agenda.

- Against that positive view of global business models, Long discussed some of the tensions in the global sourcing business model. One issue he noted is the length and complexity of supply chains, which add risk. Some of these risks can include cost issues, especially exposure to fluctuating fuel prices; the concentration of key operational elements; and sourcing risks, which represent other potential exposures. Long suggested that the rise in resiliency planning represents another response to tensions in the model. He noted that issues related to flexible responses to interruptions, security issues in operations, and sensitivity to disturbances are all important in supply chain design and operations. Long noted that supply chains present endless trade-offs for a company with international operations.

- Long discussed long-term drivers of global growth. He noted that some estimates place freight growth at 100% by 2030, with the growth of the freight share of total transportation at 70% by 2030. He suggested the rising international middle class and the focus on modernizing supply chain systems were two key factors in the growth in global freight.

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Foreign Affiliate Sales: Estimates for 2011. Total Trade: Data for goods & services, 2011.

FIGURE 1 2011 foreign affiliate sales estimates.

(Source: International Trade Administration, U.S. Department of Commerce.)

- Long described spending on supply chain transportation and logistics, focusing on the cost of different components as a percentage of gross domestic product for selected countries. He noted that in China, approximately 20% of the gross domestic product is spent on supply chains; this figure is approximately 17% in India, 8% to 9% in the United States, and 7% to 8% in European countries. He noted the importance of transportation costs in supply chains, citing the example that by undertaking transportation and logistics management improvements, China could be even more competitive in the global marketplace. He suggested that maintaining and improving the U.S. supply chain system was critical to continuing global economic competitiveness.

- Long highlighted the importance of considering policies to improve freight movement in the United States. He suggested that improving freight corridor planning, including integration across and between modes and taking a holistic view of freight planning, would improve U.S. competitiveness and the attractiveness of the United States as a place to do business. He also discussed performance measures and elements to monitor for speed, reliability, safety, and security; the availability of and costs associated with these measures; safety concerns; and environmental issues. He indicated that other trading countries, especially Canada and Europe, have gone further than the United States in freight corridor planning and view it as a strategic

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economic priority. He noted that freight transportation and infrastructure to support global competitiveness is a major focus in countries throughout the world.

- Long discussed supply chains in the trade policy arena. He reviewed the range of trade agreements and trade negotiations that are under way. He suggested the theme to watch for in a world of investment-driven, globally sourced supply chains is the need to align policy with business reality by producing the conditions in trade agreements that allow for modern global sourcing business models to operate efficiently. He suggested the format of existing trade agreements is very complex in order to reflect this new reality, as the agreements require provisions across a series of chapters and appendices touching investment, cross-border services, competition, telecommunications and information technology, trade facilitation and customs agreements, and, more recently, regulatory issues. He suggested the current trade agenda focuses on identifying the service issues that are enablers for other parts of the economy, such as financial and investment services, distribution services, information technology and computer services, express delivery and logistics services, and environmental services. Issues associated with the electronic economy (data privacy, cross-border data flows, and server placement) are also essential in modern business.

- Long described the global supply chain for the iPhone 6 as an example of the new global business model and associated trade issues. He noted that the supply chain includes the flow of intellectual property from the United States to other countries, shipments of goods and services, and cross-border services. These elements are far beyond what a trade negotiator would have considered 10 to 20 years ago. In applying a value-chain view of trade policy, elements of trade agreements touch virtually every international transaction in the supply chain. He suggested cross-border flows and border management issues are a complex but critically important new issue offering great opportunities to reduce costs and processing delays in international trade around the world. For example, at present as many as 47 agencies in the United States are involved in processing elements of the \$4.2 trillion in annual two-way trade flows.

- Long described the World Trade Organization Trade Facilitation Agreement, which provides a link to a broader agenda of transforming border management processes. Some of the elements in the agreement are a statement of principle to guide larger policies, and specific sections address transparency, preapprovals, de minimis values, and points of contact and other elements of border processes. He also commented that the coming agenda in supply chain development and management addresses new issues affecting trade, including border management, the energy revolution, 3-D printing, the consequences of using ever-larger container ships, and applications of data flows and big data.

- Long described the activities under way at Commerce to improve border management, including those focused on reducing transaction costs and processing time. He noted that a Presidential Executive Order issued in February 2014 directed all federal departments led by the U.S. Department of Homeland Security and

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U.S. Customs and Border Protection to install the new Single Window system (the international trade data system) by the end of 2016, not only to automate current operations but to transform border operations. He noted that developments in the energy sector are also placing increasing demands on global supply chains. He suggested there may be environmental justice concerns with increasing freight flows.

- Long reported that supply chain and infrastructure are now a strategic objective for Commerce. The objective is to reduce transaction costs and processing time for exporters. The focus is on practical measures that make it easier to do business in the United States. He noted that Commerce has an Advisory Committee on Supply Chain Competitiveness that has provided expert recommendations on Single Window and freight movement issues; this group also collaborates with the U.S. DOT and its National Freight Advisory Committee (NFAC). In support of the Moving Ahead for Progress in the 21st Century Act (MAP-21), Commerce has provided materials for strategic planning activities based on the application of commercial supply-chain management techniques to freight policy. Other Commerce efforts focus on implementing the Single Window system and developing supply chain-based freight policy recommendations and supply chain performance measures linked to North American trade and investment objectives.

- Long stressed the importance of the Single Window system in addressing cross-border issues to enhance the \$4.2 trillion in trade flows to and from the United States each year. Commerce is playing a major role in the Border Interagency Executive Committee. He also noted that Secretary of Commerce Penny Pritzker is committed to making North America a more competitive region. The North American Leadership Summit included various commitments focusing on regional supply chains and promoting North America as an export platform. He noted that Commerce's new SelectUSA program is focused on attracting foreign investment to the United States. The second SelectUSA conference is scheduled for early 2015. Long noted that data flows and big data are also key elements of Commerce's agenda, and he suggested information technology is key in current trade negotiations and in supply chain operations.

- In concluding, Long stressed the importance of matching domestic and international policies to commercial realities, noting that everything flows from markets and technology. He identified areas for further research, including exploring the role of transportation in the global supply chain. He noted that complex and interrelated problems require holistic solutions that focus on the needs of users. He stressed that transportation is critical to global economic and trade performance.

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**A NATIONAL PERSPECTIVE ON TRANSPORTATION
AND ECONOMIC COMPETITIVENESS***Mortimer Downey*

Mortimer Downey provided a national perspective on freight transportation, goods movement, and supply chains. Drawing on his experience as the U.S. Deputy Secretary of Transportation and as a transportation consultant, he discussed the importance of freight transportation to the global competitiveness of the United States, projections for population and freight growth, current issues facing different freight modes, funding needs and federal legislation, and possible research topics. Downey covered the following topics in his presentation:

- He observed that transportation policy and planning has traditionally focused on the movement of people by motor vehicles, transit, bicycle, or on foot. As a result, Downey suggested that the country had lost its focus on the movement of freight, which is crucial to economic growth and to national competitiveness. Although the U.S. economy ranks third overall based largely on strong laws and transparency, the U.S. transportation system ranks 16th in the world. Downey further suggested that with the investments under way in European Union countries and in Asia, it could be only a matter of time before the U.S. ranking falls even further, which is not good for the global competitiveness of the country. He noted that a strong transportation system supports manufacturing, lowers distribution costs, and offsets lower wages in other countries as the United States competes to increase exports.

- Downey remarked that more attention should be given to goods movement in planning transportation investments and in the reauthorization of the national Surface Transportation Assistance Act. He suggested greater support for additional transportation funding is needed given the lack of progress over the past decade. He noted that the Grow America Act put forward by the Obama Administration includes a focus on freight. In describing the act, Secretary of Transportation Anthony Foxx always leads off with the idea that expanded national attention to freight is key to achieving the objectives for the program and for the nation.

- Downey observed that freight is embodied in the U.S. Constitution, which singles out “commerce with foreign nations and among the several states” as one of the primary responsibilities of the national government. He suggested that unlike many other governmental activities, goods movement is properly addressed at the national level. Moving raw materials and finished products efficiently requires end-to-end movement unconstrained by state or metropolitan boundaries. It also requires the total transportation network, not just individual modes, with the benefits of geographic investments spread to all shippers and all consumers across wide areas.

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Downey further suggested that if the national government does not focus on the freight transportation network, it is unlikely that states and local governments will be able to provide needed resources.

- Downey remarked that now, as the country continues to recover from the recession that began in 2008, is the time to address these issues. He indicated that as the economy picks up over the next few years, there will be a very thin margin of capacity to handle the volumes of freight that will begin to move. The system has been fluid in recent years only because economic activity was depressed and demand was low. He suggested the recent issues in the railroad industry highlight this need. Despite record levels of private-sector investment in rebuilding rail infrastructure, service levels in recent months have sharply deteriorated, reflecting the new demand for shipment of crude oil by rail and the capacity absorbed by that movement.

- Downey indicated that although opportunities exist in all the freight modes to operate more efficiently and to use technology more effectively, there are limits to what the existing system can be expected to handle. He suggested that now, while volumes are depressed and the financial system is offering record low interest rates, is the time for investments in freight infrastructure. He noted that the International Monetary Fund recently made that case as a key to economic recovery, with findings that the economic growth inherent in immediate construction and long-term efficiency would rapidly offset the debt issued to pay for investments in freight infrastructure.

- Downey discussed the demographic projections that the U.S. population will grow by upward of 100 million people by the middle of the century. These forecasts are well above the modest growth predicted in most European Union countries and Japan. He observed that the prospect of more people and their need for food, shelter, and goods means an increase in freight in the United States. He noted that one individual accounts for 40 tons of freight a year, and the projections are that total freight demand by the midcentury could be double today's volumes.

- If existing highway choke points are not addressed, Downey suggested they will become major bottlenecks. He noted that trucks contribute to congestion at major highway bottlenecks, and although it is in the interest of truckers to avoid traveling in congested periods, some conflict is inescapable. He indicated U.S. railroads have become very efficient at moving goods across long distances, including bulk commodities such as coal or grain as well as higher-value cargo that moves largely in double-stack container rail cars. He noted that the Achilles' heel of the railroad system is points where trains make connections, especially between railroads. Chicago, which has been called the mixing bowl for Class 1 railroads, provides a prime example of this congestion. Downey said no matter how fast freight might move across the docks at the Ports of Los Angeles and Long Beach and onto rail for the transcontinental move, it may take two or three days to travel across Chicago. Increasing freight volumes will only make that situation worse.

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- Downey observed that U.S. ports are playing catch-up as the world's shipping patterns change. He noted that the super tankers of today and the new post-Panamax vessels will be able to use newly expanded capacity in both the Panama and Suez canals. He remarked that East Coast ports have yet to complete the basic needs of deepening channels, let alone constructing the terminal facilities and connections needed to move additional cargo inland.

- Downey mentioned that the inland waterways are perhaps the least visible, but arguably among the most important elements of the U.S. transportation system. He noted that setting aggressive goals for increasing exports as a means of stimulating economic growth can only be met if the transportation system is able to move the goods. He observed that reliable barge service on the Mississippi River and its tributaries is key to meeting the growing demand for U.S. agricultural exports. He suggested the inland waterway system can move impressive volumes of grain and other agriculture products, but key locks on the system will soon pass into their second century of service, with a few locks still operating with wooden gates. He noted that the traffic backup that occurs when a lock fails or when water levels fall is monumental and frightening.

- Downey stressed the importance of focusing more attention on U.S. freight assets, what is being done to improve those assets, and how research can support good decisions relating to freight infrastructure and operations. He described three trends that have been developing over the past decade to argue that progress in these areas can be made. These trends focus on freight legislation, innovative projects, and industry support for appropriate investments.

- Downey remarked that freight policies and programs have been one of the bright spots in an otherwise depressing decade and a half of federal transportation legislation. He noted that two presidents and multiple Congresses have yet to enact legislation that would measure up to the Intermodal Surface Transportation Efficiency Act and the Transportation Equity Act for the 21st Century, largely because of inadequate revenues to support existing and new surface transportation programs. He observed that these two transportation acts benefitted from increases in the gasoline tax. He suggested the political will to lower the deficit or to increase transportation revenues seems to have disappeared soon after the turn of the century as a victim of no-tax pledges and decreasing trust in government decision making. He described the only two bills passed since the Transportation Equity Act for the 21st Century was enacted in 1998: the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), which was passed in 2005, and MAP-21, which passed in 2012. He suggested the new practice of "patching" the holes in the trust fund has become the hallmark of numerous short-term extensions with both bills. He noted that between these two pieces of legislation, the American Recovery and

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Reinvestment Act (ARRA) of 2009 provided some temporary investment levels in transportation as part of its goal of stimulating the economy.

- Downey highlighted the freight components in the various acts. SAFETEA-LU included the Projects of National and Regional Significance Program, the Borders and Corridors Program, the Freight Intermodal Demonstration Program, freight capacity building, the National Cooperative Freight Research Program (NCFRP), and multimodal commissions. ARRA included the Transportation Investment Generating Economic Recovery (TIGER) program, with some freight projects selected for funding. MAP-21 consolidated the Borders and Corridors Program, unfunded the Projects of National and Regional Significance Program, and abolished the NCFRP. Some freight provisions were more positive, he observed, including the requirements for a national freight policy, a freight strategic plan, freight transportation condition and performance reports, designation of a national freight (highways only) network, and data and planning tools and encouragement to establish state freight plans and freight advisory committees. Downey reviewed recent administration initiatives, including the appointment of the National Freight Advisory Committee (NFAC) to support MAP-21 freight provision implementation, particularly the freight strategic plan; identifying delays on the national freight network; and calling for Projects of National and Regional Significance projects. He also reviewed key provisions of the Obama Administration's proposed Grow America Act, which includes a four-year, \$10 billion multimodal freight program that would be allocated on a 50% discretionary and 50% incentive basis. Other elements include a national freight network, freight eligibility in a new TIGER program, and restoration of the NCFRP.

- Downey reviewed recent Congressional activities that will need to be reintroduced in 2015 with the new Congress. The Senate Energy and Public Works bill included six years at current funding levels, with the expectation that the Senate Finance Committee would find the needed funding. It also included a formula-driven, highway-oriented Special Freight Investment Program funded at \$6 billion for six years and mandatory state freight plans and advisory committees. The Senate Commerce Committee was examining multimodal approaches, and the House Transportation and Infrastructure Committee had a special working group examining freight, which included bipartisan membership from all relevant subcommittees. The House Transportation and Infrastructure Committee also issued a unanimous report calling for federal leadership and funding for freight. The Water Resources Reform and Development Act was enacted by near unanimous margins in both the Senate and the House of Representatives in June 2014. He suggested that based on the achievements of the past few years, goods movement will be a key component of the next transportation bill.

- In reviewing recent innovative freight projects, Downey observed that the high quality of limited projects illustrates what can be done to meet freight needs through

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partnerships between industry and government. He commented that the pattern for these partnerships was established in the 1990s through the development of the Alameda Corridor project, which provided direct rail access for container movements from the Ports of Los Angeles and Long Beach. The project was authorized in federal legislation, with notable leadership from local entities. The Alameda Corridor project provided a balance of national benefits in terms of better goods movement and local interest in reducing congestion by removing trucks from local streets. It was funded through a mix of sources, with a key federal role facilitating project financing through guarantees and access to federal sources. The project was delivered in a relatively short time and continues to provide benefits even though the industry has undergone economic and technological change. Downey noted that the project's financial projections have been met, and the federal financing was paid off early.

- Downey observed that subsequent innovative projects were implemented under the TIGER program, which was authorized as a one-time effort under the 2009 ARRA, but has been continued through annual appropriations. He noted that because TIGER funding is totally discretionary and unencumbered as to transportation mode or project type, the U.S. DOT has been able to work with new partners to support key investments. He indicated that over several rounds of project selection, freight projects have typically received approximately 25% of the available grants. Most projects have involved a mix of funding sources, with the TIGER funds serving as a catalyst and a gap filler to make projects work. He remarked that long-term investments have brought better intermodal access to ports from Duluth to Houston and from Bayonne to Oakland. Congested highway corridors, key to the movement of freight, have also been improved. Further, projects have addressed the needs of several smaller railroads feeding freight into the Class 1 system.

- Downey highlighted a few major projects funded by ARRA, including \$100 million to the Chicago Region Environmental and Transportation Efficiency project to continue work on streamlining freight movement through the Chicago area and approximately \$100 million each to freight corridors developed by the Norfolk Southern and CSX railroads to improve access between East Coast ports and Midwest markets. He also cited the Colton Crossing project in California, which had been stalled for decades, as a classic example of a local improvement with national implications. Built in 1883 as a ground-level crossing where today's Burlington Northern Santa Fe and Union Pacific railroads meet, Colton Crossing had a long history of dispute, resulting in delays to both railroads and roadway traffic. The project to provide grade separation of the railroads and eliminate the bottleneck was completed with \$34 million in TIGER funding. The TIGER funding brought about a plan to produce what was thought to be an unaffordable \$200 million investment, but turned out to cost less than \$100 million and is now generating the predicted national and local benefits to highway users that gave it a strong benefit–cost ratio.

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- Downey viewed freight improvements as an area in which new financing ideas can be made to work, even as the debate continues on how to raise the funds needed for a robust surface transportation program in an era of declining gas tax revenues. Due to the private-sector nature of the U.S. freight industry, there is a willingness to invest when opportunities for more profitable operations exist. For example, he noted that the Class 1 railroad industry provides as much as \$25 billion a year to upgrade track, structures, facilities, and equipment. In addition to these self-generated funds supporting their right-of-ways, the railroads have entered into public-private partnerships on projects that produce major public benefits. Downey noted that the trucking industry has expressed a willingness through their trade associations to support a 10- to 15-cent increase in the diesel fuel tax if doing so would reduce traffic congestion and result in improved conditions. He also observed that the port industry advocated successfully for the full allocation of the already-collected harbor maintenance tax to fund port improvements, which was authorized in the Water Resources Reform and Development Act. In addition, he noted that the barge industry recently successfully implemented a nine-cent increase in their diesel fuel tax as a means of increasing investment in inland waterway projects.

- Downey identified several research opportunities for UTCs to address key issues in freight transportation. He noted that the NCFRP has excelled in producing targeted and useful products for policy makers and practitioners. Downey's first suggested research topic would focus on freight and the economy. He noted that freight movement is essential to a strong economy and that additional information on both trends in the United States and comparisons with other countries would be beneficial.

- Project-level analysis represented a second research area highlighted by Downey. Transitioning from the macro to the micro, he noted that he expected a significant element in future federal support would come through competitive discretionary funding, with a focus on the costs and benefits of specific projects. A better understanding of approaches to quantify the benefits of different types of freight projects would be beneficial.

- A third research topic addressed by Downey was a better understanding of freight dynamics. He commented that NFAC pointed out in its recommendations that better data are needed on what freight is moving and on how decision making occurs in supply chains. He suggested there is a mismatch between the time horizons of public-sector decision makers, who build things, and the managers of goods movement, who can alter their business models overnight. He suggested new planning tools and metrics are needed to better plan public investments that will last for decades and through many cycles of supply chain changes.

- Workforce development represents a fourth research topic highlighted by Downey. The NFAC report raised a concern about the state of the transportation workforce. He noted that this sector, with more than 4 million jobs ranging from airline pilots and bridge engineers to truck drivers and longshoremen, is facing a

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potential crisis. Research sponsored by the U.S. DOT, the U.S. Department of Labor, and the Veterans Administration shows an expectation of a net 100% turnover in sector employment over the next decade, with only 10% of that number coming out of recognized employment pipelines. For example, a recent survey showed that the average truck driver is now 52 years old. Downey indicated a retooling of the educational and career planning models is needed. NFAC is now examining the implications of these findings on the industry's future, as well as the barriers created by regulations and other impediments. He suggested additional research on these topics would be beneficial.

PLENARY SESSION

Modal Perspectives on Freight Supply Chains and Economic Competitiveness

Heather Nachtmann, *University of Arkansas*

John Gray, *Association of American Railroads*

Bob Costello, *American Trucking Associations*

Melissa Tooley, *Texas A&M Transportation Institute, presiding*

Speakers in this session provided perspectives from different modes on freight and economic competitiveness. Heather Nachtmann of the University of Arkansas discussed the inland waterway system, John Gray of the Association of American Railroads described the freight rail system, and Bob Costello of the American Trucking Associations summarized major issues facing the trucking industry.

THE INLAND WATERWAY SYSTEM AND WATERBORNE FREIGHT

Heather Nachtmann

Heather Nachtmann discussed the U.S. maritime system and waterborne freight. She highlighted the maritime challenges affecting U.S. competitiveness and policy, legislative, and system changes that could enhance economic competitiveness. She also described future maritime challenges and identified opportunities to engage the research community to help address these challenges. Nachtmann covered the following topics in her presentation:

- She suggested that waterborne freight directly and indirectly supports U.S. economic growth by contributing to economic value, earnings, and employment. Nachtmann noted there are approximately 25,000 miles of navigable waterways in the country. Inland waterways represent a major portion of these miles. Key commodities transported on the inland waterways include coal, petroleum, and agricultural commodities. She noted that the maritime infrastructure is in critical need of repair and maintenance. She reported the most recent annual report card issued by the American Society of Civil Engineers on the state of infrastructure in the United States includes the following grades for maritime infrastructure: ports, C; dams, D; levees, D-; and inland waterways, D-. These grades reflect the poor condition of much of the system, raising concerns about the reliability of the waterborne freight mode.

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- Nachtmann suggested one of the opportunities in the maritime arena is multiagency engagement in projects and programs. The Maritime Administration in the U.S. DOT, the U.S. Army Corps of Engineers, the U.S. Department of Homeland Security, and the U.S. Coast Guard are all involved in keeping the waterways operating. She noted that ongoing multiagency coordination and cooperation, such as the Cabinet-level Committee on Marine Transportation System, is needed. Multiagency collaboration at the tactical level is also needed to help ensure the system operates to its full potential.

- Nachtmann noted that individualized agency budgets may hinder funding needed for system performance. She also noted that the maritime system has a relatively low profile and is not visible to most of the public. As a result, a clear economic case needs to be made for investments in the waterway system. She suggested dredging restrictions may limit the U.S. Army Corps of Engineers and ports, but that intermodal transload facilities may provide opportunities for public–private partnerships.

- Nachtmann suggested the Panama Canal expansion presents opportunities for coastal and inland ports. The expanded canal will accommodate larger ships, including post-Panamax vessels. She noted that numerous studies have been conducted on the potential impacts of the Panama Canal expansion on U.S. ports and trade flows. Many East and East Coast ports are undertaking harbor-deepening projects and improvements in landside transportation access to take advantage of the expanded canal. She noted that numerous ports and communities are exploring opportunities associated with the expansion of the Panama Canal (including cold storage facilities in Arkansas) and that research is still needed to examine possible options and monitoring changes once the expanded canal is open.

- Nachtmann discussed some of the economic impacts of the inland waterway system. For example, one barge can carry as much freight as 70 semitrucks. A typical barge tow includes nine to 15 barges. She noted that the excess capacity in the inland waterway system could accommodate numerous types of commodities. She highlighted an innovative example about equipment manufactured at a plant within the Plaquemines Port, located along the Mississippi River in Louisiana, which is then transported by barge to the Port of New Orleans, where it is shipped throughout the world.

- Nachtmann suggested UTCs have numerous research opportunities for examining issues associated with maritime freight transportation. She encouraged researchers to better understand the intricacies of the maritime transportation system and to consider new approaches to maximizing its uses and benefits. She provided a recent example of a study examining ports along the upper Mississippi River and opportunities for additional off-loading by rail. The study examined the total number

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of ports, the number of ports with rail-access terminals, the number of rail-access terminals with off-loading capabilities, and the commodities handled. Thus, the study was more complex than originally envisioned. She suggested it was important for researchers to remember that if you have seen one port, you have only seen one port. Ports have different business models, commodities, capacities, and landside transportation options.

- Nachtmann concluded by suggesting the navigation system can benefit from research on a variety of topics, including state-of-good-repair practices, system-level performance measurement, operations analysis, and strategic planning. She noted that thinking of the inland waterway system as a tree may be useful: there may be opportunities to trim a little, but if you trim too much, the tree and the system will die. Research can help ensure effective improvements are made to maximize the use of the inland waterway system.

RAIL TRANSPORTATION AND ECONOMIC COMPETITIVENESS

John Gray

John Gray discussed the role of railroads in promoting and supporting the economic competitiveness of the United States. Focusing on the export marketplace, he discussed commodity prices and railroad costs, services, capacity, and flexibility. He also highlighted future issues and research needs. Gray covered the following topics in his presentation:

- He noted that serving domestic markets comprises approximately 70% of railroad business. In serving the domestic economy, railroads ensure that basic, intermediate, and end-use goods have maximum space utility. The remaining 30% of railroad business focuses on international business. Railroads help maximize the number of international markets that can be accessed by domestic production. In rail export movements, these markets are primarily commodity markets such as coal, grain, chemicals, minerals, metals, ores, bulk foods, and forest products. Gray observed that a growing portion of rail exports involve intermodal freight (containers), although this share does not yet come close to the level of intermodal imports.

- Gray reported that in 2012, approximately 30% of U.S. exports were transported by rail to ports or destinations in Canada and Mexico. He noted that railroads focus on bulk exports, but that intermodal freight or containers, which to date are primarily transported to the Ports of Los Angeles and Long Beach and other West Coast ports, are a growing market segment. He mentioned that all tons are not created equal in

rail, with more trains required to transport intermodal tons. The bulk tonnage carried by four trains to a port is equivalent to what would be carried on 14 intermodal trains. He suggested railroad investment strategies will change depending on the future mix of bulk and intermodal traffic.

- Gray noted that commodity price is the critical element in determining all aspects of the transaction and logistics chain. Movements in price will determine both the timing and the physical quantities of commodities transported to market. He remarked that most players in the supply chain are price takers, who react to events they cannot control. The net result is a tendency for commodities to want to move to market in surges. For example, he indicated that rail capacity was only part of the problem with the recent grain shipments in the Upper Great Plains; another part of the problem was that large amounts of the 2013 harvest were being held in storage by farmers because of price fluctuations. Farmers waiting for higher prices began to release residual portions of the 2013 crops at the same time the 2014 harvest began.

- Gray reviewed the key elements of a competitive logistics system. These elements include cost, service, capacity, and flexibility for specific markets. He noted that these elements are especially important for exports.

- Gray reported the average U.S. export rail move is 935 miles, with many moves over 2,000 miles and some over 3,000 miles. He noted that the largest export rail moves are coal going to the Chesapeake Bay ports, which only move about 300 miles. The average length of haul to market for traffic moving to Canada and Mexico is 1,601 miles. He observed that many offshore competitors are much closer to their ports, which provides better access to the land portion of the transportation market. Producers can only compete where costs permit carriers to help their customers participate within market price constraints. He noted that the only way to stay competitive is to drive down the costs on the rail side, which requires keeping operating costs under control and maintaining productivity and efficiency during all stages of a supply chain.

- In the context of export markets, Gray indicated it was important to remember that service has both a physical and a financial component. The physical component of service focuses on ensuring the chain of events comprising the movement process occurs without undue delay. Ensuring that an export product is in place to permit a ship to depart on schedule is an example of a physical component. The financial component of services recognizes that various points in the movement process will trigger financial events for parties related to the transaction. As an example, the owner of grain is typically paid at the prevailing market price when the grain is loaded onto rail cars or into a vessel. Thus, how quickly a destination can be reached is not as important as ensuring that all parts of the system operate smoothly. The timing of the transportation events has financial implications. Both these service components put a premium on communication and performance for all stages of the movement.

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- Gray reported volume must be carefully managed to maintain a fluid rail network. As volume on a rail network approaches 100% of theoretical capacity, the fluidity of the network and service deteriorate. Further, if volume exceeds 100% of theoretical capacity, maximum throughput capability actually declines. He noted that the comfortable range for rail capacity is generally about 70% to 80% of the maximum theoretical capacity. Both the total cost and the average unit cost increase rapidly and service declines after this comfortable capacity is exceeded.
- Gray indicated that capacity relates to being able to provide predictable delivery of goods in export markets for commodities. He noted that export volumes and markets tend to be less predictable than domestic movements, which places a premium on capacity to handle surge movements in export corridors. As a result, capacity for export markets has to be slightly overbuilt. He observed that there are numerous factors in the export process chain, including loading facilities, railroad equipment and crews, port facilities and personnel, and vessel availability. The capacity of an export movement process chain is dictated by the most constrained element. All elements need to be managed together for a successful export process. He stressed that a long-term commitment to investment in assets is critical to successful participation in exports markets.
- Gray reported that U.S. freight railroads continue to make major investments in infrastructure and equipment. In 2013, the Class 1 railroads invested approximately \$25 billion in infrastructure and equipment. He noted that railroads rarely make major investments for just one commodity. Rather, investments are made to accommodate multiple commodities.
- Gray stressed the importance of timing in serving export markets. He noted that timing and location of export markets may change frequently, often on short notice. Changes may occur due to fluctuations in exchange rates and commodity price, weather, vessel availability and pricing, and congestion in the logistic chain elements. Such fluctuations place a premium on the ability to use assets flexibly. They also imply that some surplus assets are usually necessary to participate effectively in these markets and that adaptability is key to effective market participation and survival.
- Gray discussed some of the ongoing issues with serving the export and import markets, which represent approximately 25% to 30% of freight rail business in the United States. The issues in these business lines reflect the basic issues of the industry. One issue is the ability to invest in and construct new infrastructure, which can take time due to the permitting process and other requirements. A second issue relates to regulatory initiatives that may endanger the ability to invest in growth and new initiatives and to reinvest in existing assets. A third issue highlighted by Gray was the availability of high-quality people to operate and maintain the railroad industry. He indicated that similar to other modes, railroads are experiencing high levels of retirement among long-term employees. Attracting and retaining a quality workforce, even with relatively high salary levels, represents an ongoing challenge

for the railroad industry. A final issue noted by Gray was regulatory threats to railroad customers' businesses, which can be as critical as regulatory concerns to railroads.

- In concluding, Gray identified research opportunities to help address these issues. He suggested the development of advanced capacity-measuring and modeling techniques would be beneficial, as would research to better understand future market directions and drivers for commodities in railroad portfolios. He also identified the need for research examining technology applications for safety and productivity improvements and real-time network and capacity management. A final research area suggested by Gray focused on examining labor markets, labor availability, and training processes to meet the future needs of the rail industry.

TRUCKING PERSPECTIVE

Bob Costello

Bob Costello discussed three major challenges facing the trucking industry that affect the competitiveness of the United States. These issues include the lack of recent investments in highway infrastructure, labor availability, and limited productivity gains in vehicle size and weight. He described each issue and suggested potential research that could help address these concerns. Costello covered the following points in his presentation:

- Citing information from the recent American Transportation Research Institute report, *Cost of Congestion to the Trucking Industry 2014*, Costello suggested that the lack of investment in highway infrastructure has led to an increase in congestion, resulting in significant costs to the trucking industry and the economy. According to the report, trucks were delayed in traffic for approximately 141 million hours in 2013, corresponding to over 50,000 drivers sitting idle for a working year. The direct cost of these delays to the industry was over \$9.2 billion in 2013. Approximately 89% of these costs were experienced on 12% of the Interstate highway system mileage.

- Costello noted that a cumulative shortfall of \$92 billion in the highway account and \$34 billion in the transit account of the Highway Trust Fund is projected by 2023. He suggested there is a need to invest \$10 billion to \$16 billion over the next six years to address maintenance and congestion on the highway system. He noted that the passenger vehicle corporate average fuel economy standard increases to 54.5 mpg by 2025, which is projected to result in a 21% erosion of fuel tax revenue by 2040. He also noted that inflation has reduced the buying power of the federal fuel tax, which was last increased in 1993. Buying power was reduced by approximately 38% by 2013 and is projected to be reduced by 52% by 2024.

- Costello described the historical growth in vehicle miles traveled (VMT) and its recent leveling off. He noted that VMT increased from 1971 through 2006, when

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it declined slightly and then remained relatively flat through 2011. He also noted the improved fuel economy of automobiles, trucks, and other vehicles. Although these improvements are good for drivers and the environment, they mean lower revenues in the Highway Trust Fund.

- Costello suggested that research was needed to develop a better understanding of the impacts of congestion on supply chains, including the total cost of transporting different goods. He noted that studies have examined the impacts of congestion on the traveling public and on commercial vehicles, but analyses of the impact of congestion on different supply chains and economic competitiveness have not been undertaken. He suggested this type of analysis would be beneficial and of interest to the public and private sectors.

- The second issue Costello discussed was the difficulty in attracting new employees to the trucking industry. As illustrated in Figure 2, this situation is resulting in a shortage of truck drivers. He noted that the American Trucking Associations (ATA) has estimated that approximately 96,000 new commercial vehicle drivers will be needed on an annual basis for the next 10 years. This need is being fueled primarily by industry growth and by the retirement of current drivers, but he also suggested that some drivers are leaving the industry or being pushed out of the industry owing to hours of service restrictions and other regulations. He noted that the median age of truck drivers is well above the median age of all U.S. workers.

- Costello described driver needs, compensation levels, and the types of base pay packages offered by the different sectors of the trucking industry. Private fleets are operated by companies that have in-house truck fleets to support their primary business. The for-hire sector, which provides service to a wide range of businesses, is subdivided into truckload carriers and less-than-truckload carriers. He noted that although all sectors face challenges in recruiting and retaining drivers, the major shortage is in the over-the-road truckload sector. The ATA estimates there are 750,000 to 800,000 trucks in that sector.

- Costello noted that compensation varies by sector, vehicle type, and company. The ATA 2014 compensation study found that private van-only and private nonvan drivers were the highest paid, followed by less-than-truckload over-the-road drivers. At the other end of the wage spectrum, national truckload irregular route drivers have the lowest median pay. He noted that many drivers enter the industry in this sector, and that drivers in this sector are on the road and away from home the longest.

- He suggested many people in the industry understand driver pay is an issue and are beginning to explore ways to increase salaries. The ATA study found that 76% of companies use multiple base-pay packages, paying drivers in two or more ways. Guaranteed minimum daily pay is a new approach being used by some companies. The study also found that carriers offer many benefits to employee drivers, including paid holidays, paid time off, life insurance, health insurance, and retirement plans. In general, private fleets appear to offer the best benefit packages.

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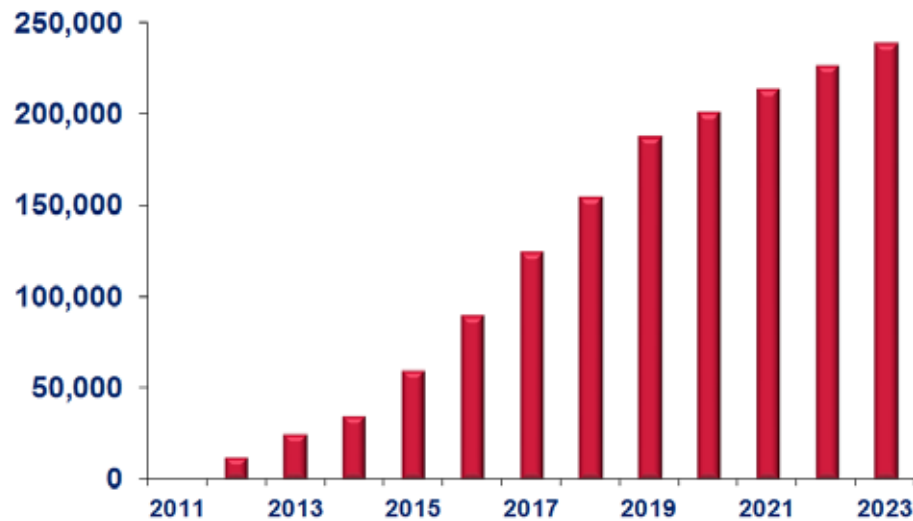


FIGURE 2 Projected truck driver shortage.

(Source: Economics Department, American Trucking Associations.)

- Costello noted that a judicial or legislative effort to reclassify independent contractors as employees is an issue for the trucking industry. He suggested one of the best examples of a small business in the United States is a person who owns or leases and operates a truck. He also described regulations and potential regulations that decrease productivity or constrain driver supply, including sleep apnea testing, mandatory electronic logging device use, and hours of service restrictions. He noted that some drivers may be unwilling to submit to sleep apnea testing or to follow prescribed treatment. Drivers may also be unwilling to use electronic logging devices, and the hours of service restriction may result in a decrease in driver productivity.

- To address these issues, Costello suggested that research examining the potential of allowing drivers under the age of 21 to operate in Interstate commerce with proper training, monitoring, and restrictions would be beneficial. Exploring other methods to attract new drivers to the industry and to retain existing drivers would also be beneficial.

- The third major issue discussed by Costello was the lack of an increase in truck size and weight nationally since 1982. He suggested that the current regulations limit the industry's productivity. As illustrated in Figure 3, he noted that many other developed countries allow heavier commercial vehicles. He suggested that increasing the allowable truck size and weight would have environmental benefits from lower fuel use and lower emissions and economic benefits to shippers.

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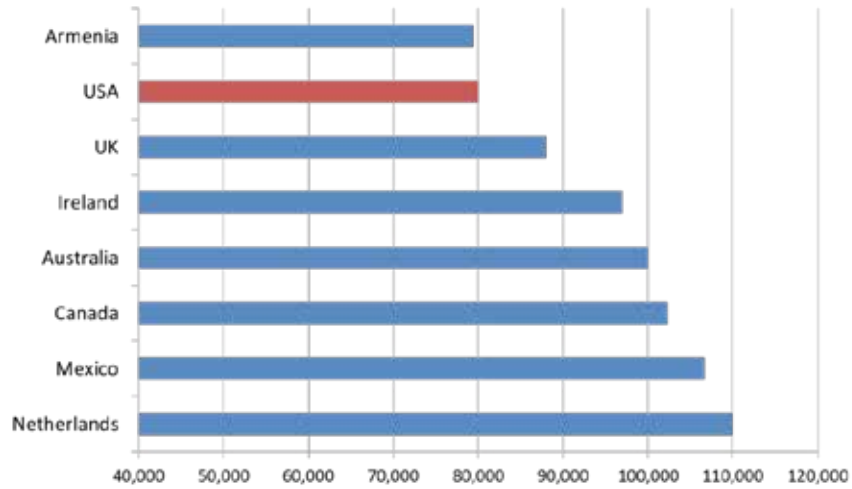


FIGURE 3 Maximum commercial vehicle weight comparisons by country.
(Source: International Transport Forum, University of Michigan Transportation Research Institute.)

- Costello suggested that examining the potential impacts of increasing commercial vehicle size and weight on bridges and pavements would be beneficial. He also suggested that ongoing research collecting and analyzing crash and VMT data by truck configuration is needed.

PLENARY SESSION

Transportation System Resiliency

Janet Benini, *U.S. Department of Transportation*

Christopher Luebbers, *Norfolk Southern Corporation*

Anne Strauss-Wieder, *A. Strauss-Wieder, Inc., presiding*

Speakers in this session addressed transportation system resiliency. Ann Strauss-Wieder of A. Strauss-Wieder, Inc. provided a framework for discussing supply chain disruptions. Janet Benini of the U.S. DOT discussed an international project focusing on improving supply chain resilience during disasters. Chris Luebbers of Norfolk Southern (NS) described the railroad's recovery from Hurricane Katrina.

FRAMING THE DISCUSSION OF SUPPLY CHAIN DISRUPTIONS

Anne Strauss-Wieder

Anne Strauss-Wieder's opening comments framed the topic of supply chain disruptions. She described the benefits of examining responses to supply chain disruptions and presented a disruption spectrum. She also discussed characteristics of disruptions, commented on Superstorm Sandy, and outlined freight movement activities affected by disruptions. Strauss-Wieder covered the following topics in her presentation:

- She explained the importance of examining the responses to supply chain disruptions. She suggested that understanding how agencies and organizations worked together, the roles and responsibilities of various groups, and the results of different approaches was beneficial. Strauss-Wieder noted it was important to differentiate between shorter- and longer-term impacts from supply chain disruptions. Short-term impacts and recovery affect immediate capital needs and operations; longer-term impacts affect economic outlooks and long-term business positions.
- Strauss-Wieder provided a disruption spectrum with examples of the range of disruption types. The spectrum includes planned, predictable, rapid, and abrupt disruptions. She noted that a defining variable with the different levels of disruption is the amount of advanced warning and time to plan and implement a response. She used the Columbia River lock closures as an example of a planned disruption. In that case, needed maintenance was scheduled well in advance, providing companies,

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shippers, and carriers with time to plan alternate routes, modify shipping schedules, or make other needed changes. She noted that the recent snowstorms in Buffalo, New York, provided an example of a more predictable disruption, as snow and ice are expected in the winter. Examples of rapid disruptions provided by Strauss-Wieder included Hurricane Katrina and Superstorm Sandy. In these cases, most people had 24 hours or less for planning responses and taking action. In abrupt disruptions, such as the terrorists attacks of 9/11 or the Howard Street Tunnel fire, there is no time available to plan.

- Strauss-Wieder noted that one way to describe supply chain disruptions is by a set of characteristics developed in a recent National Cooperative Highway Research Program (NCHRP) project, Methodologies to Estimate the Economic Impacts of Disruptions to the Goods Movement System (reported in NCHRP Report 732). She reviewed the information in Table 1 and discussed the use of these categories to explain the impacts of Superstorm Sandy. She noted that the storm affected all freight modes and facilities along the East Coast and that the storm occurred during the peak delivery week for holiday goods. The Port of New York and New Jersey, the largest port on the East Coast, was closed for nearly a week, with more than 50 vessels diverted to other ports. The surge in vessels and container shipments to alternate ports overwhelmed some ports, most notable the Norfolk International Terminals, which received the bulk of the diverted containers.

- Strauss-Wieder presented a second approach from the NCHRP study for examining supply chain preparation and response. This approach focuses on the three layers of activities necessary for freight movement. These layers are physical flows, communication and information, and regulatory considerations. Physical flows include any physical activity directly needed for freight movement, including vessels, terminals, railroads, trucks, pipelines, aircraft, and warehouses and distribution centers. Communication and information flows include any information and transactional exchanges needed for freight movement. She noted that communication was a key element of responding to Superstorm Sandy, because communication among transportation providers, agencies, shippers, customers, financial institutions, and many other groups was essential to the swift recovery from a supply chain standpoint. Regulatory considerations represent the third set of activities. This category includes any government regulations, rules, and agency activities. Examples provided by Strauss-Wieder include the Jones Act, truck driver credentials, and Customs and Border Protection screening.

- Strauss-Wieder discussed NCFRP Report 30, which examines disruptions at ports. She reviewed a graphic from the report outlining all the steps that need to be considered when an inbound container ship is diverted to a different port. Elements

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TABLE 1 Defining Superstorm Sandy as a Supply Chain Disruption

| Characteristics | Superstorm Sandy |
|------------------------------------|--|
| Geographical Scope Affected | <ul style="list-style-type: none"> • Extensive – the entire East Coast • At landfall – the New York-New Jersey Region |
| Freight Facilities Affected | <ul style="list-style-type: none"> • All • Ports closed along the East Coast in the storm’s path • Railroads, trucking lines, airports and air cargo, pipelines (power outages, flooding, damage) |
| Commodities and Shipments Affected | <ul style="list-style-type: none"> • Occurred during peak delivery week • Multiple commodities and shipments affected |
| Recovery Time from Disruption | <ul style="list-style-type: none"> • Port of New York-New Jersey closed for nearly a week • Physical repairs to facilities still occurring |

Source: A Strauss-Wieder, Inc., with categories from *NCHRP Report 732: Methodologies to Estimate the Economic Impacts of Disruptions to the Goods Movement System*. Transportation Research Board of the National Academies, Washington, D.C., 2012.

to consider focus on waterside considerations, original port terminal considerations, original region inland-movement considerations, local facility delivery considerations, and delivery to customers considerations, along with diverted ports and freight modes available. She noted that an important lesson from Superstorm Sandy was that a disruption may have ramifications far beyond the immediate area, as was the case with the Norfolk International Terminals. This example also highlighted the importance of “modal flexing,” which enabled diverted containers to move through alternative gateways and modes to their end users.

- In concluding, Strauss-Wieder suggested it was important to learn from and improve after every disruption. Preparations and responses in the United States have improved with the lessons learned from various events. However, she stressed the equal importance of expecting the unexpected. For example, Superstorm Sandy highlighted power, communications, and surge issues. She also suggested focusing on common-sense solutions and noted a strong working relationship among agencies, organizations, and individuals is key to recovery. She commented that the Marine Transportation System Recovery Unit, which is a public-private community, played a key role in coordinating the response during Superstorm Sandy. This recovery unit was required after Hurricanes Ike and Katrina. In the case of the New York-New Jersey region, the cooperation that began during Superstorm Sandy has continued with the Council on Port Performance, which is now focused on other port issues in the region.

IMPROVING THE RESILIENCE OF SUPPLY CHAINS DURING DISASTERS

Janet Benini

Janet Benini discussed a project focusing on improving supply chain resilience during disasters. The project represents the joint efforts of the U.S. DOT, Asia–Pacific Economic Cooperation (APEC), the U.S. Agency on International Development, and other groups. Benini covered the following topics in her presentation:

- She reported that according to the U.S. Department of Labor, 43% of U.S. companies experiencing disasters never reopen. Further, approximately 29% of businesses that are able to reopen after a disaster go out of business within two years. As a result, she noted that business resumption is a major issue in disaster management. She suggested the focus historically has been on examining the business infrastructure rather than the complete picture of all the factors that keep a business in operation.

- In focusing on the complete picture, Benini summarized a quotation from Albert Einstein about two ways to view the universe. One way is to think of the universe as particles, and the other way is to think of the universe as a set of energy waves. She observed that transportation professionals tend to focus on particles, as reflected in the infrastructure elements of bridges, tunnels, roads, ports, and airports. She suggested that transportation professionals should focus on the total system, which reflects supply chains.

- Benini summarized the widespread impacts of the 2010 volcanic eruption in Iceland. She noted that the relatively modest eruption had local impacts affecting the ponies near the volcano as well as global impacts affecting European air passengers; automobile assembly plants in the United States, Germany, and Japan; rose growers in Kenya; and manufacturers worldwide.

- Benini presented a second example of how a major disruption of computer hard drive production in Thailand affected global supply chains. She noted that Thailand is the second-largest producer of hard drives in the world. The major floods in Thailand in 2011 resulted in a 30% drop in global hard-drive production. She indicated that numerous major corporations experienced significant losses as a result of the disruption, including \$162 million for Sony, \$603 million for Canon, and \$199 million for Western Digital.

- Japan's experience after the 2011 earthquake and tsunami represented the third example of a major disruption highlighted by Benini. According to the Asian Disaster Reduction Center in Kobe, Japan, 90% of the businesses that closed as a result of the disaster went bankrupt due to secondary or indirect losses and damage. The lack of functioning supply chains to bring in needed production materials and to ship out finished products was a major factor in these closings.

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- Linking back to the quotation from Einstein, Benini suggested that transportation professionals need to focus on both particles and waves, that is, on both infrastructure and supply chains. She noted that supply chains depend on infrastructure to operate and function. Considering how the infrastructure is used for different supply chains opens up new possibilities for disaster response and recovery. Focusing on how the infrastructure is used in a supply chain, rather than just focusing on fixing the infrastructure, might result in establishing better priorities. She suggested that this approach might help companies stay in business and assist in local economies recovering faster, but it requires public agencies and businesses to work more closely together.

- Benini described APEC and the collaborative supply chain project. She noted that APEC comprises 21 member economies or countries that represent 40% of the world's population and 56% of the world's gross domestic product. Approximately 70% of the world's natural disasters occur in APEC countries.

- Benini reviewed seven principles (presented in Table 2) that have been developed working with APEC and business industry councils. The first principle is to share information and knowledge to promote supply chain resilience. She noted that extensive promotions are under way in the 21 APEC countries. The second principle is to promote disaster risk management and hazard mapping to better understand potential risks to supply chain resilience. She indicated that the California DOT is a leader in mapping earthquake hazards and their impact on transportation, which helps with risk management for supply chains. The third principle is supporting planning and business continuity management to improve global supply chain resilience. Benini observed that although government agencies and large businesses have continuity management plans, medium-size and small businesses often do not, especially in developing countries. As a result, assistance is being provided to businesses in developing countries as part of the project. The fourth principle is promoting best-practice policy, regulations, and flexibility to enable global supply chain resilience. She suggested that sometimes government policies and regulations can inhibit business recovery. Activities are under way working with companies to identify and address these types of policies and regulations. The fifth principle is leveraging regional cooperation to support the supply chain, including coordination with other multinational organizations working on supply chain resilience inside and outside the APEC region. The sixth principle is promoting critical infrastructure protection and intermodalism as a key component of supply chain resilience. Benini noted this principle should be of interest to conference participants. The final principle is to recognize and promote best practices in human resource and capacity management in the context of supply chain resilience. She reported that much has been learned on this topic from the recovery activities associated with the earthquake in Christchurch, New Zealand.

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TABLE 2 Seven Principles of Supply Chain Resilience

| |
|---|
| 1. Share information and knowledge to promote supply chain resilience. |
| 2. Promote disaster risk management and hazard mapping to better understand potential risks to supply chain resilience. |
| 3. Support planning and business continuity management to improve global supply-chain resilience. |
| 4. Promote best-practice policy, regulations, and flexibility to enable global supply-chain resilience. |
| 5. Leverage regional cooperation to support the supply chain, including coordination with other multinational organizations working on supply chain resilience inside and outside the Asia–Pacific Economic Cooperation region. |
| 6. Promote critical infrastructure protection and intermodalism as a key component of supply-chain resilience. |
| 7. Recognize and promote best practices in human resource and capacity management in the context of supply chain resilience. |

- Benini suggested that supply chain resilience is multifaceted and involves government, businesses, disaster preparedness, and infrastructure planning. She also noted that research is important in supply chain resilience.

- Benini summarized the APEC five-year action plan for improved supply chain resilience. She indicated that funding from the U.S. Agency on International Development has been secured for the next five years. In addition to the U.S. Agency on International Development, other partners include the World Bank, the United Nations, and numerous companies. An action plan for supply chain resilience will be developed each year for one of the APEC economies. With this funding, other annual activity will include conducting a workshop, facilitating discussions, jointly developing an action plan, and implementing the action plan. The initial effort in 2015 will focus on the Philippines.

- Benini reported that one principle will be promoted each year through the ongoing program. Planned activities each year include identifying and publicizing best practices, hosting an intensive workshop with multiple participants from each participating economy, and promoting cooperation between governments, businesses, nongovernment organizations, and international organizations. The principle for 2015 is promoting disaster risk management and hazard mapping to improve global supply chains. She mentioned that the work under way at the California DOT and the University of Singapore are examples, but other case studies are being examined. A seminar will be held in Peru in the spring of 2015 on these activities.

- In concluding, Benini said that by working together, numerous agencies and organizations can improve supply chain resilience. She noted that the most recent

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partner is the American Society of International Security, which is the largest security industry group. She also noted that TRB has been a key participant since the beginning of the process and will continue to be an important partner.

RESILIENCY IN THE RAIL NETWORK: NORFOLK SOUTHERN RESPONDS TO HURRICANE KATRINA

Christopher Luebbers

Chris Luebbers described how NS responded to Hurricane Katrina. He discussed the NS system, the rail network in the New Orleans area, the damage caused by Hurricane Katrina, and the recovery process. Luebbers covered the following topics in his presentation:

- He noted that NS and other railroads experience minor disruptions on a regular basis and major disasters periodically. Derailments, which are typically small scale, are day-to-day occurrences. Landslides and washouts from localized flooding occur on a periodic basis. He reported that maintenance crews are usually able to respond to derailments and localized landslides and flooding quickly, with no major impacts on service. Prolonged unique events like Superstorm Sandy and Hurricane Katrina, however, have major disruptive impacts on railroads. He noted that prolonged winter weather, such as that experienced during the winter of 2013 to 2014, also causes major disruptions to railroads, as recovery from long periods of bad weather is difficult.

- Luebbers described the NS network, which covers the eastern half of the United States. The system includes approximately 36,302 miles of track, including 65% in mainline track and 35% in yards and other areas. The 20,000 route miles include almost 67,000 bridges and culverts and serve 55 intermodal terminals. NS has approximately 3,900 locomotives and operates an average of 1,000 trains per day. The company has approximately 30,330 employees. Luebbers stressed that the NS system is an extensive, highly capital intensive, and very active network. NS has a major capital investment program to address ongoing infrastructure needs.

- Luebbers reviewed the rail system serving New Orleans before Hurricane Katrina. He noted that New Orleans is a dynamic city for railroads, with service from the NS, Burlington Northern Santa Fe, Union Pacific, Kansas City Southern, Canadian National, and CSX railroads. NS serves local businesses and the Port of New Orleans and has interchanges with the other railroads. Cargo is interchanged with these railroads on a daily basis, providing connections to the West Coast, Chicago and the Midwest, and Canada. Traffic to the Port of New Orleans focuses on grains, agricultural produce, and other products for export. With all this activity, Luebbers noted that New Orleans is an important part of the NS network.

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- Luebbers indicated that NS began response planning based on the forecasts for Hurricane Katrina. He described the preparation for Hurricane Katrina, which included evacuating all rail equipment and redirecting en route traffic to other gateways or holding it on line on Friday, August 26, 2005. He noted that NS was able to divert traffic to Memphis and other areas due to some system redundancy, but capacity constraints and employee availability provided some limitations. NS employees were also encouraged to evacuate on August 26. A command center was established in Atlanta, which is the location of the NS transportation group, on Saturday, August 27. Hurricane Katrina made landfall on Monday, August 29. Luebbers noted that the first lesson learned from Katrina was the importance of redundancy in the system and the ability to redirect traffic.

- Luebbers reviewed the damage from Hurricane Katrina to the NS system, which included 14.8 miles of damaged track, 3.4 miles of roadbed washed out or destroyed, and 6.3 miles of track under water. In addition, two switching yards, as well as intermodal and auto terminals, were under water, and three drawbridges were not operational. Hurricane Katrina destroyed most of the NS communication and signal equipment in the area, including 14 grade-crossing warning devices, two hotbox detection systems, and five automatic equipment identification systems. Three microwave communication sites, six control points, and 18 intermediate signals were also destroyed.

- The track restoration efforts described by Luebbers included emergency inspection of 1,400 miles of track in the New Orleans area, Mississippi, and Alabama, as well as removal of 5,500 trees and installation of 11,000 railroad ties. Other activities were replenishing 65,000 tons of ballast and 2,400 tons of riprap and laying 27 track panels. Luebbers suggested a second lesson learned from Hurricane Katrina was the importance of having replenishment supplies and replacement parts available and in position to respond quickly. The Lake Pontchartrain railroad bridge suffered heavy damage during the hurricane, with the track washed into the lake. Luebbers described the reconstruction of the bridge, illustrated in Figure 4, which included recovering the washed-out track from the lake by using nine floating cranes.

- Luebbers noted that safety is NS's top priority. Ensuring that NS employees and contractors were safe during and after the hurricane was a major focus of the company's efforts. He reported that no employees or contractors sustained any injuries. NS provided \$4,000 grants and \$15,000 interest-free loans to employees affected by Hurricane Katrina. NS also donated \$500,000 to communities affected by Katrina and matched employee donations up to an additional \$500,000.

- Luebbers described some of the challenges NS and other businesses faced during the recovery. With the devastation of New Orleans, NS had to bring in everything—electric power, diesel fuel, food, water, shelters, and rail replacement equipment—needed for response and recovery. NS had a tire replacement team with

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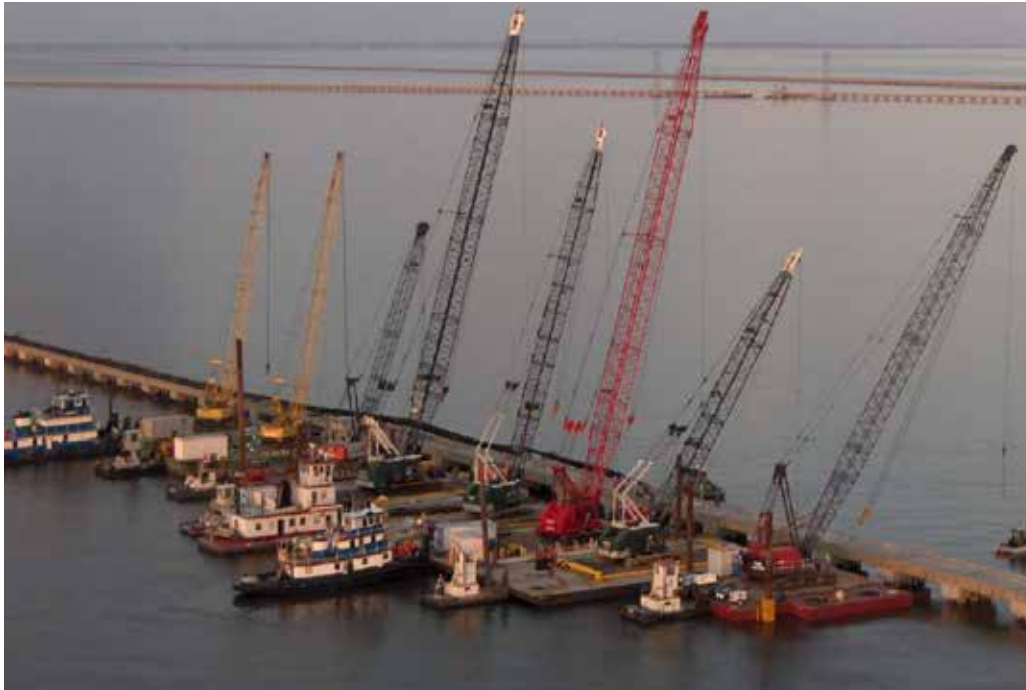


FIGURE 4 Repairing damage to the Lake Pontchartrain Bridge from Hurricane Katrina. (Source: Norfolk Southern.)

on-duty mechanics because company vehicles continued to experience flat tires due to all the debris in the streets. NS also provided security to employees and contractors during the recovery operations.

- Luebbers reported that NS service to New Orleans was restored on September 13, roughly two weeks after Hurricane Katrina's landfall. The preplanning activities in the transportation and engineering departments, including modeling two traffic rerouting options, proved to be very beneficial. The innovative thinking and dedicated personnel of NS were a real strength. He also noted the importance of strong business and government partnerships, including links with contractors and NS police having good working relationships with the state police. Access to immediate funding, resources, materials, and experience were other keys. Luebbers noted again there were no accidents, injuries, or fatalities among NS employees or contractors during the hurricane and recovery.

PLENARY SESSION

Energy Sector Development and Economic Competitiveness

Helen Currie, *ConocoPhillips*

John LaRue, *Port Corpus Christi*

Michael Zehr, *Consumer Energy Alliance*

French Thompson, *Burlington Northern Santa Fe Corporation Railway, presiding*

This session featured three speakers discussing recent developments in the energy sector and economic competitiveness. Helen Currie of ConocoPhillips described potential benefits from allowing U.S. crude oil to be exported. John LaRue of Port Corpus Christi reviewed impacts of the recent shale oil production in Texas on the port. Michael Zehr of Consumer Energy Alliance provided a consumer perspective on recent shale oil developments and transportation.

THE BENEFITS OF U.S. CRUDE OIL EXPORTS

Helen Currie

Helen Currie provided a perspective from an upstream oil company on the potential benefits of exporting crude oil from the United States. She described recent trends in U.S. crude oil production, changes in crude oil imports, and the potential economic benefits of lifting the ban on oil and gas exports. Currie covered the following topics in her presentation:

- She reviewed a 2014 study by IHS Global, Inc. assessing the impact of the ban on crude oil exports. The study used a global model to estimate the impact of lifting the export ban at various levels of production. The study found that U.S. exports would lower consumer motor fuel costs by approximately \$18 billion annually, or 8 to 10 cents per gallon of gasoline, and that the U.S. economy could gain \$135 billion and almost 1 million jobs at its peak. Further, the analysis indicated that eliminating the export ban would reduce the nation's oil import bill by \$67 billion annually, increase government revenues by \$1.3 trillion between 2016 and 2030, and strengthen the U.S. geopolitical position.
- Currie discussed global economic growth. She noted that the economic recovery is still under way, as China's growth rate is slowing and Europe and Japan continue

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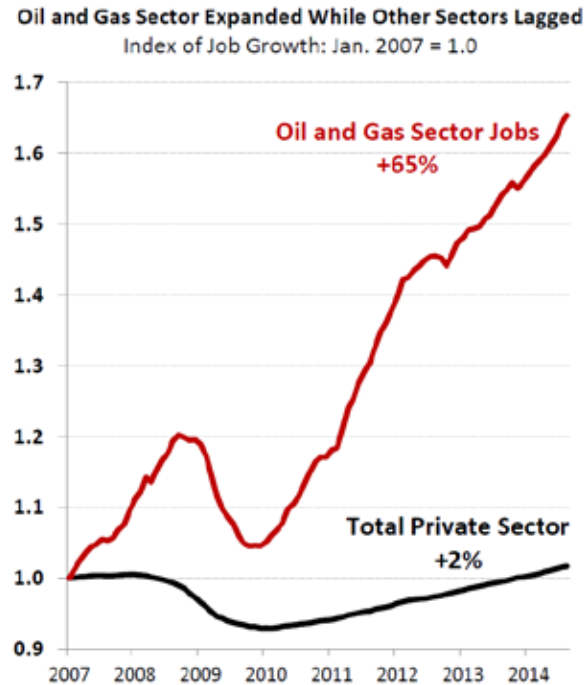


FIGURE 5 Growth in oil and gas sector jobs.

(Source: U.S. Bureau of Labor Statistics, total private-sector jobs, NAICS 211000 and 213112.)

to stagnate. She suggested that the United States, with increasingly solid economic growth, is one of the bright spots. She further suggested that the energy industry and postrecession oil production have been major contributors to this economic growth.

- Currie noted that the oil and gas industry has spurred a broader U.S. economy, that energy production prevented a worse economic downturn, and that this production is speeding the economic recovery. She described Figure 5, which highlights the 65% increase in direct oil- and gas-sector jobs from 2007 to 2014. She further noted that the increase in shale oil production has helped reinvigorate chemical production and other types of manufacturing. In 2011, manufacturing employment reversed a 12-year decline. This employment growth has continued into 2014. The U.S. employment rate has also been declining from a high of approximately 10% in 2010.

- Currie noted that North Dakota has experienced substantial economic growth as a result of the Bakken oil play. As illustrated in Figure 6, according to the U.S. Bureau of Labor Statistics, employment in North Dakota increased by approximately 40% from 2003 to 2014 as the Bakken oil play developed. In addition, based on information from the U.S. Bureau of Economic Analysis, the state economy more than doubled in a decade, from a little over \$20 billion in 2003 to approximately \$55 billion in 2013.

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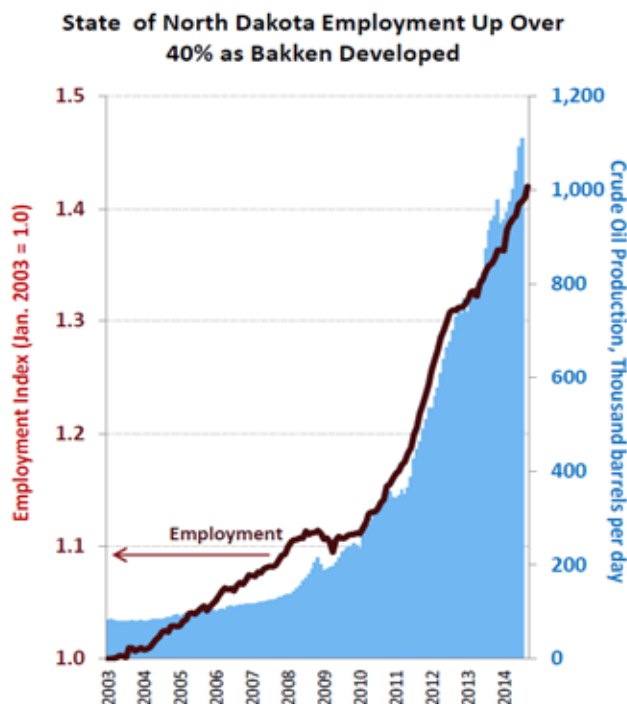


FIGURE 6 Employment in North Dakota and development of the Bakken oil play.
(Source: U.S. Bureau of Labor Statistics.)

- Currie discussed how tight shale oil is the biggest driver behind the oil renaissance in the United States. She noted that the United States is estimated to be producing 4.2 million barrels of tight oil a day. This volume of tight oil production is greater than the production of all OPEC members except Saudi Arabia, highlighting the global significance of U.S. production.

- Currie described the increase in global oil supply disruptions and the growth in U.S. tight oil production. Global supply disruptions, measured by the number of barrels of oil that do not make it to market due to civil wars or other events, have increased since 2009. She noted that the growth in U.S. tight oil production over the same period has offset most of the global supply disruptions, which has provided market stability over the past five years.

- Currie discussed a 2014 study conducted by ICF International for the American Petroleum Institute estimating crude oil prices without U.S. production. The study found that Brent crude oil prices would have been \$12 to \$40 per barrel higher in 2013 without U.S. production. Further, the study found that consumer gasoline prices would have been 30 to 94 cents per gallon higher in 2013 without U.S. production.

- Currie reviewed the Energy Information Administration's *Annual Energy Outlook 2014* (Figure 7), which focused on expanding U.S. oil production. She noted

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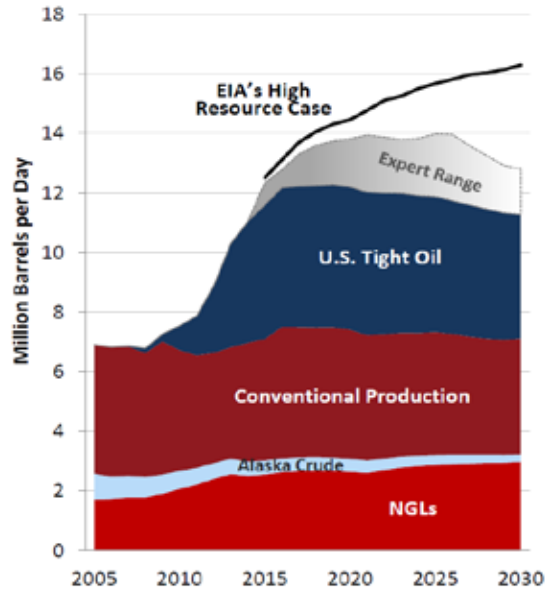


FIGURE 7 U.S. crude, condensate, and natural gas liquids forecasts.

(Source: *Annual Energy Outlook 2014*, various forecasts. Energy Information Administration, U.S. Department of Energy.)

that liquids production has returned to levels not seen since 1972 and that light tight oil output could double by 2020. The Bakken, Permian, and Eagle Ford plays make up 75% to 80% of total U.S. tight oil production.

- Currie discussed U.S. light crude oil production and light refinery runs or throughput. An analysis by the consulting firm of Turner, Mason and Company indicates that light crude oil production will exceed refinery processing capacity by 2018 without substantial refining investments or allowing crude oil exports. She also described a mismatch between tight oil quality and U.S. refining configuration. She noted that a refiner looks for a yield of refined products, which differ significantly by oil type. Currie explained that the Eagle Ford play produces a very light crude oil, with a high yield of naphtha, gasoline, and middle distillates. It is not an optimal fit for the U.S. refinery configuration. She suggested that exporting U.S. light tight oil would enable a more optimal allocation of crude oils among refiners. Further, the United States has two-thirds of the world's coking capacity, which processes the heavy parts of a barrel of crude oil. She suggested that blending U.S. tight oil into a larger world pool would be a more efficient allocation.

- Currie noted that U.S. light crude oil imports have dwindled. She also noted there has been a decline in light sweet crude imports, and that reductions in light, sour, and medium crude imports are also likely. The United States will likely maintain

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heavy crude imports, however, that should match domestic refinery configuration. Currie noted that the potential exports from the United States could represent a relatively small segment of the market and that the United States would still be a net importer of crude oil, especially heavy crude oil from Mexico and Canada.

- Currie noted that U.S. gasoline prices are set globally by international crude oil prices. She also noted that gasoline prices track regionally within the United States, as well as with prices in Europe, Singapore, and other parts of the world.

- Currie reported that a 2014 National Economic Research Associates study prepared by the Brookings Institution estimated that lifting the ban on crude exports would increase U.S. production by 1.5 to 3.0 million barrels a day by 2020, which represents a 10% to 20% increase. The study also indicated that removing the domestic crude price discounts caused by the ban would increase investment in new production and jobs in the oil and gas industry and other manufacturing industries. Thus, she suggested that increased production from lifting the export ban would have significant economic benefits to the United States.

- In summary, Currie noted that the United States has a very large resource base of shale oil, which is allowing for a new abundance of light, low-sulfur tight oil production. This situation offers tremendous economic and security benefits to the country. She noted a current challenge in the industry is the mismatch between the quality of the new oil and U.S. refinery configurations. As a result of this mismatch, she noted that the current ban on U.S. exports of crude oil may limit tight oil development and its benefits to the United States.

PORT CORPUS CHRISTI AND SHALE OIL PRODUCTION IN TEXAS

John LaRue

John LaRue discussed the impacts of shale oil production in Texas on Port Corpus Christi. He suggested that other ports in Texas, including Houston, Beaumont, and Port Arthur, and Lake Charles in Louisiana, are probably experiencing similar impacts. He provided an overview of Port Corpus Christi, energy sector developments in Texas, and the impacts of these developments on the port. LaRue covered the following topics in his presentation:

- He explained that Port Corpus Christi, which is a public corporation and a Texas political subdivision, has 180 employees and covers approximately 22,000 acres of land and water. It is the fifth-largest U.S. port by tonnage, handling approximately 90 million tons of cargo a year. He noted that 100 million tons of cargo are projected for 2015, with approximately 90% of that growth related to shale oil. He also noted that the port generates almost 66,000 port-related jobs and accounts for \$319 million in

state and local tax revenue.

- LaRue reported the port's facilities and assets include 36 miles of ship channel. The port owns its own railroad, with 43 miles of track within the port, which is operated by a third-party short-line contractor that interfaces with the Class 1 railroads serving the port. The port also owns 48 docks and 528,800 square feet of warehouse space. The total assets of the port are approximately \$435 million.

- LaRue indicated that one of the current limiting factors for the port is the Harbor Bridge, which carries highway traffic over the ship channel. The bridge has only a 138-foot vertical clearance, which is not high enough to accommodate the new post-Panamax ships. A new bridge with a 204-foot vertical clearance is in the final stages of being approved by the Texas DOT and the U.S. DOT. Construction on the approximately \$1 billion bridge should begin in 2015.

- LaRue discussed the development of the Eagle Ford shale play in South Texas, which runs from northeast of San Antonio to the Mexican border west of Laredo. Corpus Christi is just to the east of the Eagle Ford shale play. He noted that the shale plays in Mexico and the recent policy change in Mexico allowing foreign investments in energy developments will have an impact on Texas and the United States. He suggested it will take time to develop the energy sector in Mexico, as the transportation infrastructure needed for production and distribution is lacking.

- LaRue discussed Figure 8, which highlights the inbound and outbound flows of crude oil from Port Corpus Christi. The outbound flow of crude oil from the port was relatively flat from the 1990s until 2011. Crude oil imports to the port, which serves the three major refineries, began to decline in 2011. He noted that in summer 2013 the outbound flow of crude oil from the port surpassed imports. The crude oil being shipped out of the port is from the Eagle Ford play. Oil from the Permian Basin will also be shipped out of the port in the near future.

- LaRue noted that the outbound crude oil is shipped to refineries at other U.S. ports. Due to the Jones Act, it is transported in U.S.-flagged vessels, with U.S. crews, and on ships that were built in the United States. He indicated that not many ships meet these requirements. The imported heavy crude oil used at the Corpus Christi refineries is transported in large foreign-flagged vessels from throughout the world. These vessels leave empty because they are not currently allowed to transport U.S. crude oil. The U.S.-flagged vessels arrive empty, pick up the Eagle Ford crude, and travel to ports in Louisiana, the East Coast, and Canada. He noted that Port Corpus Christi is currently handling approximately 560,000 barrels of oil a day from Eagle Ford. It is anticipated that approximately 300,000 barrels of crude oil a day from the Permian Basin will begin to flow through the port in 2016.

- In addition to dealing with the tremendous growth, LaRue described dealing with the tremendous logistic change from 90% inbound crude oil to 60% outbound and 40% inbound. Ship traffic has increased and barge traffic, which uses the Gulf Intercoastal Waterway, has increased by approximately 30%.

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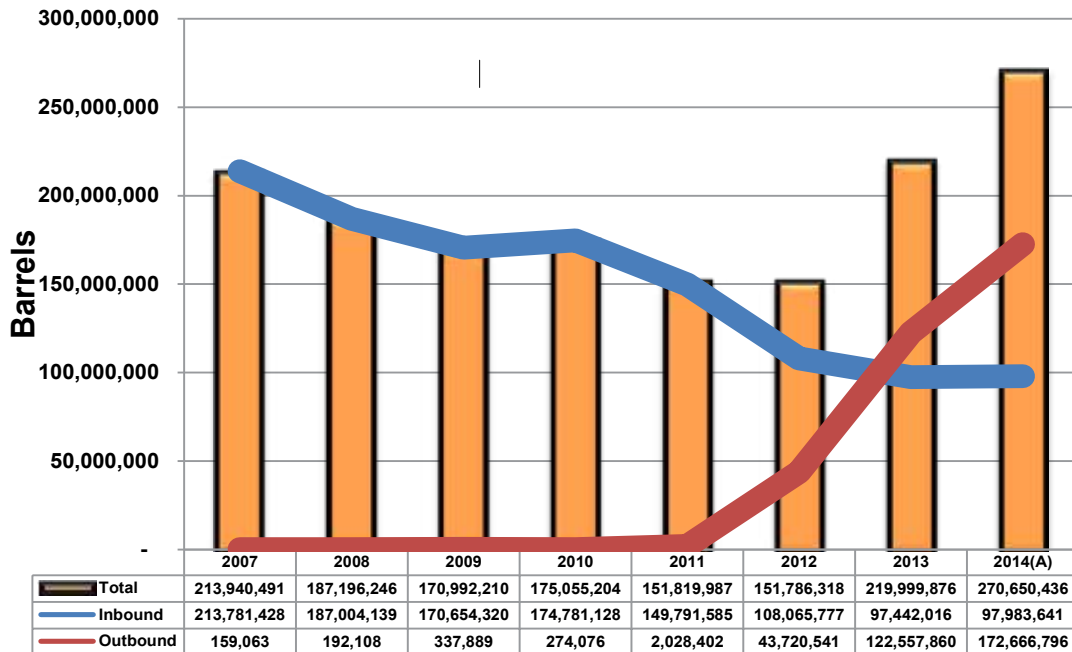


FIGURE 8 Port Corpus Christi inbound and outbound crude oil.
(Source: Port Corpus Christi.)

- LaRue noted that \$32 billion in major capital investments in new plants and facilities are under way in the Corpus Christi region. He noted that other Texas ports are experiencing similar growth. Port Corpus Christi is also investing in new docks and facilities.

- LaRue noted that many U.S. and international companies are building plants in Corpus Christi. Major investments are being made by companies from China, Italy, and Germany. A California company recently purchased the former Ingleside Naval Base, which had reverted to the port as the original landowner when the base closed. Cheniere Energy, Inc. has a \$13 billion liquefied natural gas (LNG) plant under construction. It follows the company’s first LNG plan in Sabine, Louisiana, focusing on the LNG export market. LaRue noted that the port plays a major role in the wind energy industry. Wind turbines are shipped to the port from Brazil. He commented that the turbine blades and tower components were initially transported to their destination by truck but are now moved by rail, with shipments as far as Oregon. He noted that the wind turbines are a good product for the port and the railroads.

- LaRue described the logistics and marketing coordination between Port Corpus Christi and the land ports in Laredo and San Antonio. Building on each other’s strengths, the three ports work together to promote South Texas.

- LaRue discussed the potential impacts of the Panama Canal expansion, noting that there continues to be uncertainty over what will happen with cargo flows. He

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explained that the current canal is only able to accommodate approximately 20% of the existing LNG fleet, but the expanded canal will be able to accommodate 85% of the LNG fleet. This change will benefit the LNG production facilities coming online along the Gulf Coast if the ban on exports is lifted. The expanded canal will also benefit grain exports through the use of larger ships. Although the coal export market is currently uncertain, the expanded canal will be able to accommodate larger coal ships. LaRue noted that the port has been working with ports and businesses in Columbia, which also has shale formations. There is a need there for fracking sand, drilling equipment, and other supplies, which are shipped from Corpus Christi.

A CONSUMER PERSPECTIVE ON SHALE OIL DEVELOPMENTS AND TRANSPORTATION

Michael Zehr

Michael Zehr provided a consumer perspective on shale oil development. He described the membership and activities of the Consumer Energy Alliance (CEA) and some of the recent concerns with energy sector developments, including those related to transportation. Zehr covered the following topics in his presentation:

- Zehr described the CEA, a nonprofit organization with approximately 240 members throughout the country. Approximately 65% of the CEA's members are energy-consuming businesses, including trucking, steel manufacturing industries, airlines, chemical companies, and small businesses. Energy producers (oil and gas, coal, wind, and solar) comprise the remaining 35% of members. He noted that CEA has a database of approximately 400,000 energy advocates.
- Zehr noted that the annual number of oil tanker cars moved by rail has increased over the past five years from approximately 10,000 cars a year to over 400,000 cars annually. He also reported that the amount of crude oil shipped by barge has increased by approximately 50%, and the amount transported by truck has increased by 40%. He suggested these shipments can affect the movement of other goods and commodities.
- Zehr reported that the American Chemistry Council recently announced \$125 billion in new projects, expanded developments, and restarted projects coming to the United States solely because of shale oil developments and lower energy costs. He also noted that some CEA members are reporting the conversion of vehicle fleets from diesel and gasoline to LNG and compressed natural gas. He suggested that from a consumer perspective, additional fuel options and choices are good. He noted that CEA focuses on promoting policies that encourage domestic energy growth and project options.

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- Zehr described some of the challenges CEA envisions related to freight and energy development. He noted that the alliance has been very active in local ballot initiatives and other activities focusing on restricting energy developments. The alliance works with local groups to educate the public on the benefits of energy developments. He suggested that the energy infrastructure is critical for the economic growth of the country. He further noted that many projects are generating opposition for a host of reasons, including concerns over increased truck traffic. CEA has worked with ATA, the National Tank Truck Carriers Association, and the American Petroleum Institute to form a National Trucking Safety Task Force. The task force focuses on common-sense approaches to working with local communities and neighborhood groups. Zehr commented that local ballot initiatives limiting or banning fracking will continue. He also suggested that rail, barge, ship, and truck traffic will all increase to meet increasing energy production demands, creating additional choke points in the system. CEA is interested in working with a wide range of groups to help address these concerns.

PLENARY SESSION

Global Freight Supply Chain Issues

Naomi Stein, *Economic Development Research Group*

Katherine Turnbull, *Texas A&M Transportation Institute*

David Austin, *U.S. Congressional Budget Office*

Reginald Souleyrette, *University of Kentucky, presiding*

This session featured speakers selected from the abstracts submitted for the conference across the three themes. Naomi Stein of the Economic Development Research Group described recent national research studies examining the economic productivity impacts of freight transportation investments. Katherine Turnbull of the Texas A&M Transportation Institute highlighted a research project developing and implementing a travel time measuring system for trucks at Texas–Mexico border crossings. David Austin of the U.S. Congressional Budget Office reviewed a recent study examining the choice of shipping freight by rail and by truck if the external costs of freight transportation were taxed.

ASSESSING ECONOMIC PRODUCTIVITY IMPACTS OF FREIGHT TRANSPORTATION INVESTMENTS

Naomi Stein

Naomi Stein discussed incorporating economic productivity measures into freight transportation assessments. She highlighted the results of recent research projects documented in NCHRP Project 2-24, *Assessing Productivity Impacts of Transportation Investments* (NCHRP Report 786), and the Strategic Highway Research Program 2 (SHRP 2) report, *Development of Tools for Assessing Wider Economic Benefits of Transportation*. She also described areas for additional research to further improve the state of the practice in assessing freight productivity. Stein covered the following topics in her presentation:

- She reviewed the terminology used in the NCHRP and SHRP 2 projects. Economic productivity is defined as the ratio between the dollar value of output produced and the dollar value of inputs required for production. Cost competitiveness addresses the same concept, defined in the reverse as each dollar of input cost per output generated. Economic or development impacts are growth in the economy from greater competitiveness through one of three mechanisms: (1) a change in

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productivity with more income generated per existing base of labor and capital, (2) a change in export sales with more inflow of income and investment from an expanding business base due to greater competitiveness, and (3) a change in import substitution with less outflow of income due to purchased inputs, as local production becomes more feasible and competitive. Stein noted that these three mechanisms provide motivations for strategic investments in transportation facilities.

- Stein discussed the increasing recognition of the role freight plays in the economy and the importance of assessing productivity impacts. For example, MAP-21 includes a goal to “improve the national freight network, strengthen the ability of rural communities to access national and international trade markets, and support regional economic development.” She also presented a quotation from a senior Volvo official stressing the importance of transporting automobile parts from suppliers to factories and finished vehicles from factories to customers quickly and efficiently by various modes to maintain competitiveness.

- Stein noted that NCHRP Project 2-24, *Assessing Productivity Impacts of Transportation Investments*, looked beyond the factors traditionally captured in a benefit–cost analysis, including travel time savings, operating cost savings, safety, and environmental factors. Additional factors might include supporting cost-effectiveness for businesses and economic development, the importance of intermodal gateways, supply chain connections, and reliability. She noted it is difficult to quantify these and other nontraditional measures.

- Stein reviewed Figure 9, which highlights the effects of transportation on productivity. She noted these transportation effects influence all segments of the supply chain. Any change in transportation performance results in a variety of effects, such as cost savings or cost increases to customers moving goods, increased and decreased market access, and implementing just-in-time delivery and other more efficient processes.

- Stein said the two studies examine the impact categories of reliability, market access, and intermodal connectivity. Factors considered in the reliability category included reducing the buffer time required for on-time arrival; avoiding costs such as labor, inventory, and fleet requirements; and enabling new supply chain technologies. Market access factors included access to material input and customer markets and improving matching and economies of scale. Intermodal connectivity factors included increments in access from longer-distance modes, such as rail, marine, and air, and connections extending beyond the traditional metropolitan-scale analysis region.

- Stein described the process used to incorporate reliability into a benefit–cost analysis. The first step was to estimate changes in vehicle hours of buffer time due to a transportation improvement. These transportation improvements can be captured using changes in the volume-to-capacity ratio for capacity expansion and tolling projects or the reduction in the frequency and duration of incidents for

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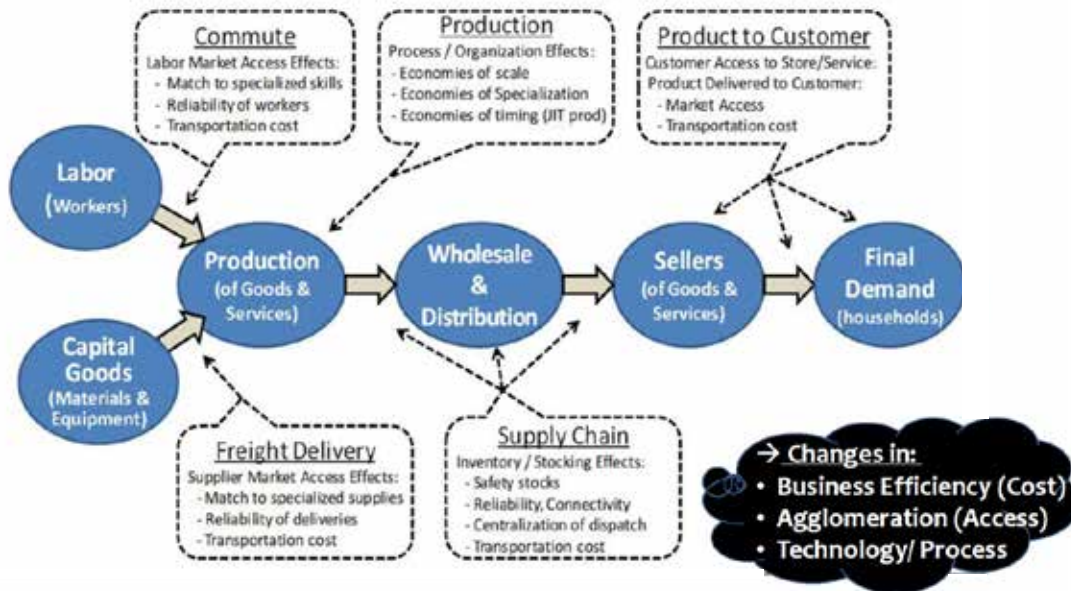


FIGURE 9 Transportation effects on productivity.

(Source: Economic Development Research Group.)

incident management systems. The second step was to apply per hour cost factors by multiplying the reliability ratio by the value of time. Stein described more advanced approaches for possible future use, including estimating commodity-specific reliability and logistics costs. She noted the goods being transported affect the costs associated with reliability and delay. Examples of commodity-specific information include capital lock-up costs (the opportunity cost associated with having the value of goods tied up), perishability costs, and supply chain costs.

- Stein noted that the same improvement in reliability or performance can have very different effects depending on the composition of the freight being transported. She offered an example of the difference in capital lock-up costs for corridors carrying higher- and lower-value goods, such as motor vehicle parts at \$8,732 a ton versus ready-mix concrete at \$69 a ton. Perishability costs can be determined by identifying corridors carrying commodities with high perishability, such as fresh fruits, vegetables, fish, and dairy products. Supply chain costs can be determined by identifying corridors carrying commodities whose disruption would impose costs on just-in-time supply chains, such as electronics and motor vehicles.

- Next, Stein noted that market access focuses on improved freight access to material inputs and customers, enables traditional time and cost savings, and offers productivity improvements from economies of scale and improved matching between buyers and suppliers. She suggested that multiple measures of access are available for use, including employment as a generic measure of economic activity; the size of a one-day delivery market or employment within a three-hour drive; and “effective

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FIGURE 10 Cities within two-hour drive or flight to destinations with at least hourly air service. (Source: Economic Research Development Group.)

density,” or the sum of all employment in surrounding zones weighted by an inverse function of impedance (e.g., travel time/cost).

- Stein indicated that intermodal (rail, air, marine) connectivity is related to market access, but it is broader in scale. She noted that transportation modeling typically focuses on metropolitan areas and has difficulty capturing freight modes. She described intermodal terminals, which provide access to broader customer markets. She noted that proven measures, such as the travel time to major intermodal terminals, can be used in benefit–cost analysis. The change in productivity due to a new project can be estimated using elasticities from empirical research. She described the example presented in Figure 10, which illustrates cities within two hours’ total travel time from downtown Boston if the traveler is driving a car or flying to destinations that have hourly or more frequent air service during business hours.

- Stein discussed Figure 11, which illustrates another example of the elasticity response to improved access. Elasticity is defined as the percentage change in productivity due to a percentage change in access. The figure illustrates the impact of improved access on I-43 in Wisconsin on local manufacturing industries. The percentage change in effective density from transportation improvements was calculated and multiplied by appropriate elasticity, which in this example was manufacturing access for buyer–supplier connections. For Brown County, a 16.55% change in access multiplied by a 0.04 elasticity resulted in a 0.66 change

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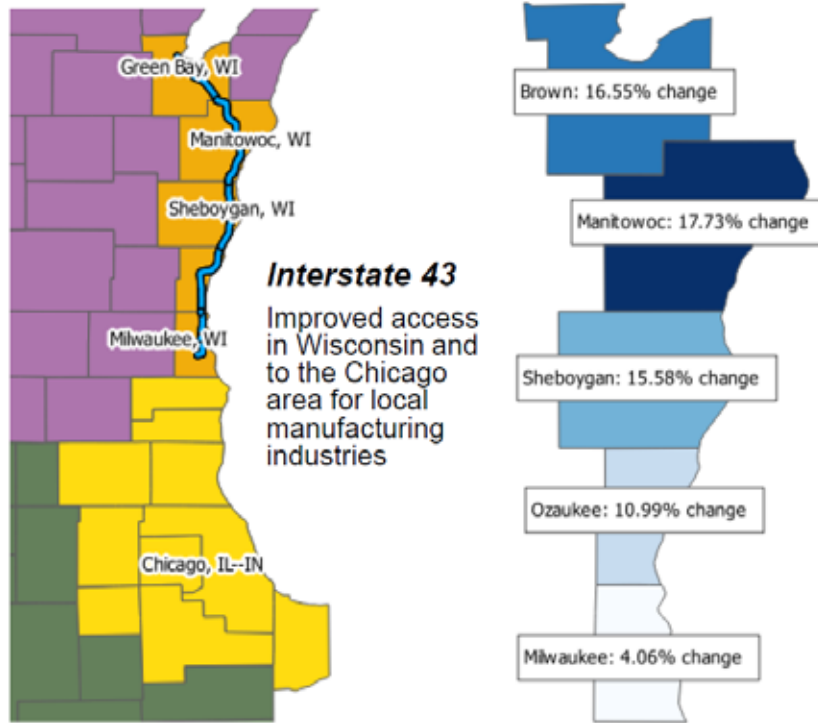


FIGURE 11 Effects of improved I-43 access on local manufacturing industries.
(Source: Economic Research Development Group.)

in productivity. She also noted that access is the joint result of transportation performance and the geographic distribution of economic activities.

- Stein also discussed Figure 12, which highlights areas with change in accessibility by type following the completion of the Appalachian Development

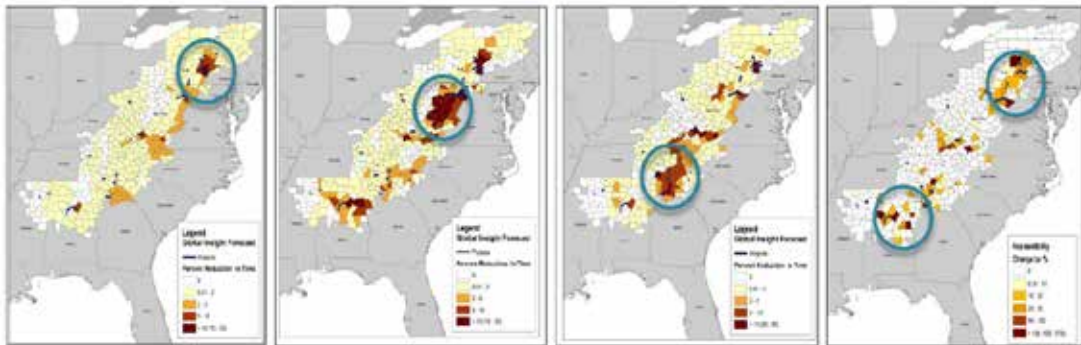


FIGURE 12 Changes in access following completion of the Appalachian Development Highway System.
(Source: Economic Impact Study of Completing the Appalachian Development Highway System. Appalachian Regional Commission, 2008.)

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Highway System. The different maps demonstrate how the same change in transportation performance can result in different geographic distributions of market access improvements, depending on the type of access considered. She also noted that industry sensitivity to access varies by type of industry. For example, resource industries are sensitive to rail access, manufactured goods require one-day truck delivery markets, and technical and service industries tend to rely more on labor market and airport access.

- In conclusion, Stein discussed opportunities for future refinements, such as further differentiation based on an understanding of supply chain relationships and studying productivity response to improved access to the material inputs required by a particular industry. She summarized the presentation takeaway as how reliability, market access, and intermodal connectivity influence freight performance and how the combination of those factors translates into industry productivity. She noted there is an opportunity to move from a generic, high-level perspective to one that differentiates by different commodities and different industry responses.

INNOVATIVE FREIGHT DATA COLLECTION METHODS AND PERFORMANCE MEASURES AT THE UNITED STATES–MEXICO BORDER

Katherine Turnbull

Katherine Turnbull discussed the operations of the land border crossings between the United States and Mexico, the development of a land-border crossing travel time measuring system for commercial vehicles along the Texas–Mexico border, performance measures using the data from this system, and ongoing research and development activities. Turnbull covered the following topics in her presentation:

- She suggested discussing this project at a UTC spotlight conference was appropriate because it illustrates the benefits from the cooperative efforts of universities, the U.S. DOT, other federal agencies, and a state DOT. She noted that it also highlights many of the elements of successful research project partnerships. First, this project takes time to identify issues; evaluate possible approaches; and develop, implement, and operate the selected alternative. Second, it also takes time to develop strong working relationships among agencies at various levels, and in the case of this project, with agencies in Mexico. Third, the institutional issues in the project were often more challenging to address than the technical issues. Finally, the project illustrates the importance of continuing to make improvements and to take advantage of evolving technologies.

- Turnbull noted that surface trade between the United States and Mexico grew from approximately \$97 billion in 1995 to \$400 billion in 2012. This cross-border

traffic accounts for approximately \$30 billion in trade on a monthly basis. Turnbull indicated that land-border truck crossings from Mexico to the United States grew from approximately 3 million in 2000 to slightly over 3.5 million in 2013. She remarked that both the volume and value of cross-border trade has been increasing.

- Turnbull reviewed the current process for commercial vehicles entering the United States from Mexico and discussed some of the challenges associated with this process. She described the three potential inspection points (the Mexican Export Lot, the U.S. Federal Compound, and the State Safety Inspection Facility) at each border crossing. The stakeholders include federal, state, and local agencies in both countries as well as businesses and private-sector groups. Turnbull noted that these stakeholders often have different goals, objectives, and responsibilities, making coordination among all these entities challenging.

- Turnbull reviewed the current United States–Mexico border crossing operations and the operating scenario under the North American Free Trade Agreement plan, which is illustrated in Figure 13. Mexican trucks are not currently allowed to travel beyond a commercial zone in the United States, requiring the use of drayage trucks, which adds freight movement that further complicates the process. Trucks traveling south into Mexico need to use a Mexican customs broker. She noted that the unreliability of travel times at land border crossings has negative impacts on supply chain performance, inventory costs, vehicle emissions, and regional economies. As a result, studies examining methods to reduce delays and decrease the time it takes trucks to cross the border were initiated in 2004 and 2005.

- Turnbull described a study conducted by the Texas A&M Transportation Institute for the Texas DOT and the Federal Highway Administration to develop a system to measure northbound commercial vehicle travel times and establish land-border performance measures. At the time, only anecdotal information from truck operators was available on travel times and travel speeds. Six technologies were initially evaluated, with radio frequency identification selected. The system, which is illustrated in Figure 14, is now deployed at 96% of the Texas–Mexico border crossings. In addition, she noted that the system is in operation at border crossings in Arizona, and work is under way to add measuring systems in California.

- Turnbull noted that the system measures wait times and total crossing times. An additional radio frequency identification reader will be installed in 2015 at the toll both in Mexico to measure the Customs and Border Protection wait time. Two performance measures were developed and are being used in the project. These measures are delay, as measured by the annual hours of delay per crossing, and the planning time index, which measures reliability. The planning time index is the ratio of the 95th percentile travel time to the uncongested travel time. The border crossing system (available at <http://bcis.tamu.edu>) provides users with both real-time and

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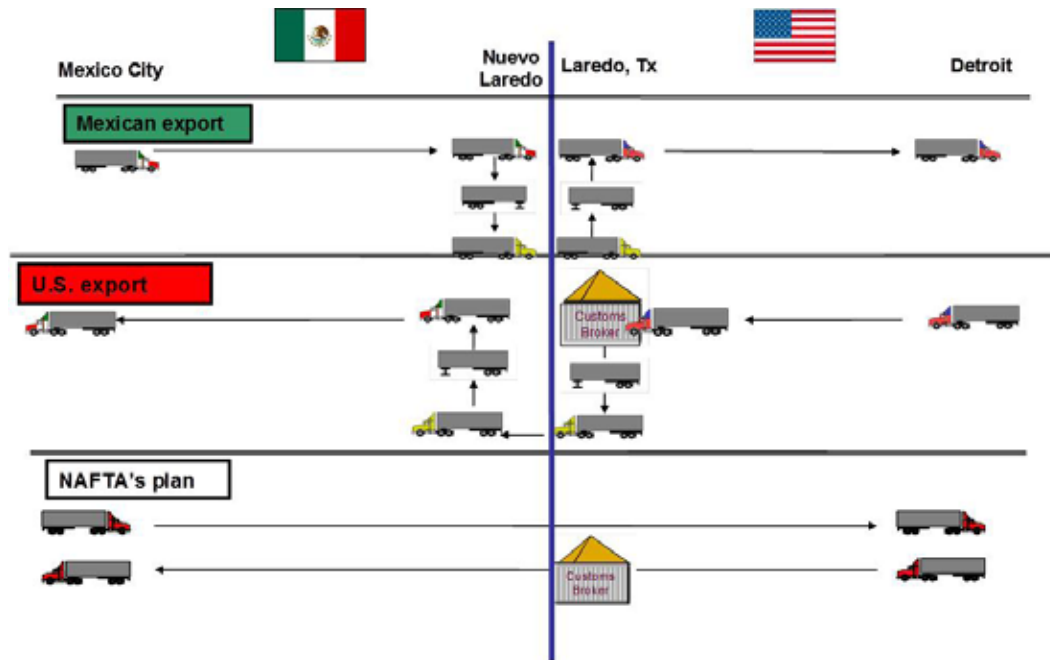


FIGURE 13 United States–Mexico commercial vehicle crossing process.
 (Source: Texas A&M Transportation Institute.)

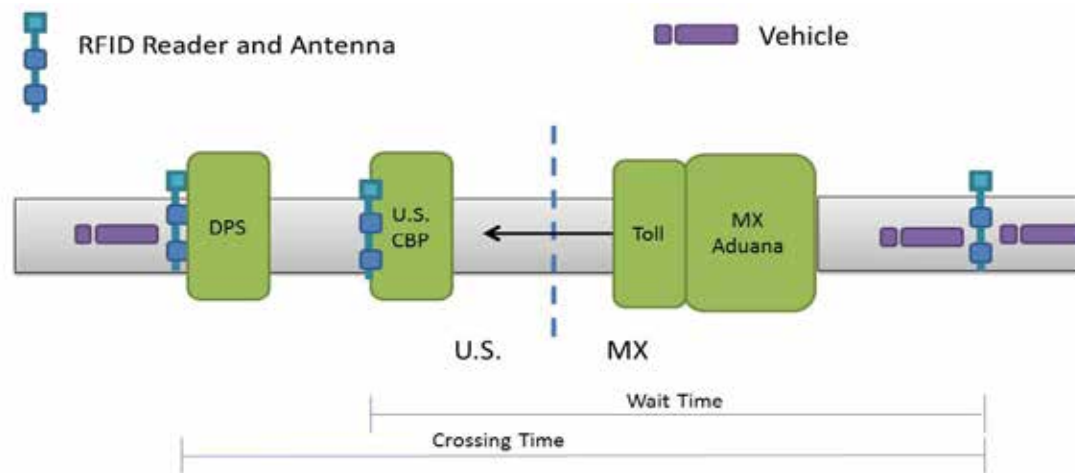


FIGURE 14 Border crossing radio frequency identification system.
 (Source: Texas A&M Transportation Institute.)

archived travel time data. She noted that at least one year of data are available for all border crossings, with a few having two years of data.

- Turnbull highlighted examples of the different methods used to analyze and present the data. Figure 15 illustrates the northbound average monthly wait times in minutes at five border crossings from January 2012 through July 2013. Figure 16 illustrates truck wait times in percentage of days over a six-month period. The wait times are defined as low (30 minutes or less), medium (31 to 60 minutes), and high (over 30 minutes). She noted some of the trends that have been identified through analysis of the data. For example, the last Friday of the month tends to be very busy, resulting in longer truck wait times. In addition, because the Maquiladora facilities in Mexico do not operate on Sundays, Monday tends to be a lighter day for truck crossings. She commented that this type of information can be of benefit to shippers and carriers in trip planning and agency personnel in assigning staff. She also cautioned that the system is not focused on reducing congestion, but rather on providing information for better decision making.

- Turnbull described some of the challenges encountered in developing and operating the system. First, binational cooperation is important because the system includes sensors on both sides of the border to identify trucks. Currently, only northbound traffic is monitored, but monitoring southbound traffic could be added if more resources were available. She noted that funding is also needed to support the ongoing operation of the system. Another challenge Turnbull identified was capturing additional information to supplement the current measures, including truck volumes by empty, loaded, freight action strategy, non-freight action strategy, and commodity

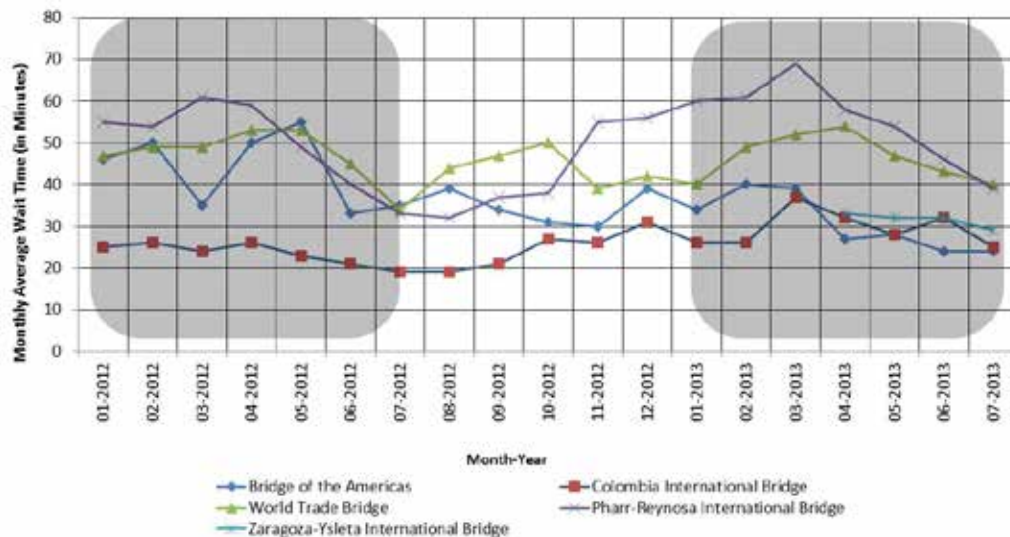


FIGURE 15 Average monthly wait time trends in minutes for U.S.-bound trucks.
(Source: Texas A&M Transportation Institute.)

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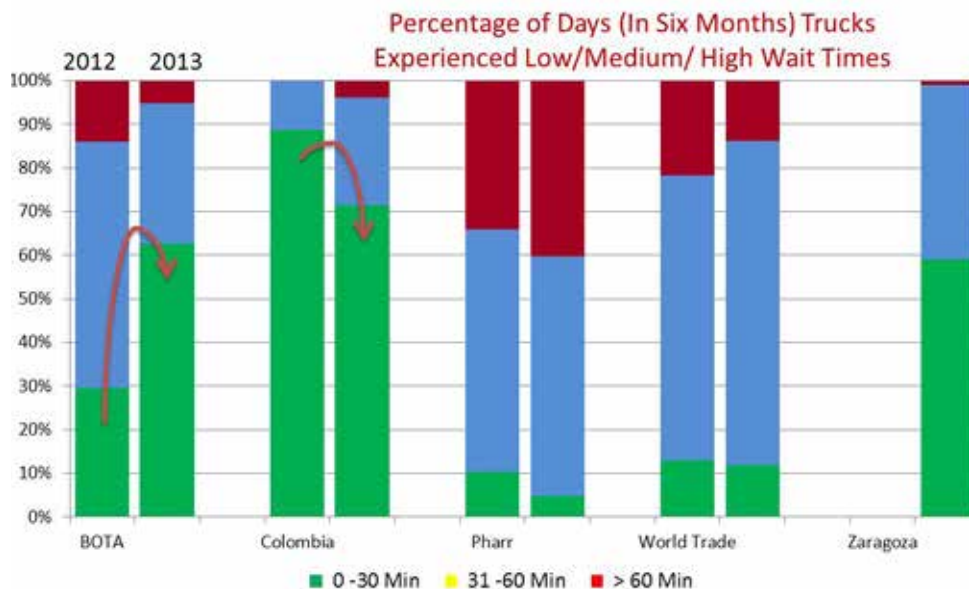


FIGURE 16 Percentage of days in a six-month period U.S.-bound trucks experienced low, medium, and high wait times.
(Source: Texas A&M Transportation Institute.)

categories. She noted that developing an annual congestion cost, including the value of truck-operating costs plus the cost of wasted fuel, would be possible with additional data. Developing other complementary measures for the entire supply chain represented a final challenge.

- In closing, Turnbull described opportunities for expanding the use of the existing system and combining the results with data from other sources. She noted that the use of additional technologies (such as Global Positioning System, Bluetooth, and Wi-Fi) to expand and enhance the current system are being explored. Developing additional applications with input from private- and public-sector stakeholders, including the annual congestion cost, represents another opportunity. Providing targeted information on border crossing operations to carriers, shippers, federal and state agencies, and other groups represents the final opportunity suggested by Turnbull.

SOCIAL COST PRICING IN FREIGHT TRANSPORTATION

David Austin

David Austin discussed his recent study for the U.S. Congressional Budget Office examining how the choice of shipping freight by truck and by rail would be affected if the external costs of freight transportation were taxed. He noted that the point of departure for his work was a Government Accountability Office study from several years ago that estimated the unpriced external costs of freight transportation. He noted the analysis results are preliminary and that feedback on the approach and results are welcomed. Austin covered the following topics in his presentation:

- He described the typical external costs for truck and rail, which include accident risk, pavement damage, traffic congestion, particulates and oxides of nitrogen (NO_x), and carbon dioxide. He noted that not all the costs used in the simulation model were from the Government Accountability Office report; the two emissions costs, particulates and NO_x and carbon dioxide, were based on other studies. Austin indicated that when the costs for these factors are added together, the ratio of truck external costs is approximately eight times higher than the rail external costs per ton-mile. He noted that the analysis estimated the extent to which imposing a higher tax on truck shipments than on rail would induce a shift toward rail.

- Austin outlined the approach used in the simulation model. He noted that mode choice is modeled as responsive to changes in shipping costs by truck and rail. The model depends on mode- and commodity-specific price elasticities. The initial conditions are market shares of ton-miles for truck and rail from the 2007 Freight Analysis Framework (FAF). Prices are changed in the simulation model by adding external costs to estimates of the rates charged by truck and rail carriers. The final conditions predicted by the simulation model are observed in changes in ton-miles carried by truck and rail, the dollar value of reductions in external costs, and revenue from taxing external costs. Austin used demand elasticity estimates to represent the demand curves for truck and rail, which were used to estimate those policy responses.

- Austin described the four policy options analyzed using the simulation model. The first option used average social cost (ASC) pricing, which combines a weight–distance tax on surface costs plus a fuel tax on emissions. The second option used a VMT tax based on distance only, not weight, plus a fuel tax. The third option included only a VMT tax, and the fourth option included only a fuel tax. He noted that the base prices for truck and rail differ: because rail prices per ton-mile are somewhat lower, a tax of a given amount will have a greater effect on rail. Even so, he commented that the simulated taxes caused a shift toward rail because the truck taxes are sufficiently higher than the rail taxes.

- Austin reviewed the findings from the preliminary analysis. He noted that because shippers pay more for truck transport than for rail, and because the simulated

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tax rates reflect external costs net of existing taxes on diesel fuel, the effect of the ASC tax on truck and rail rates is different from the 8:1 ratio of the external costs of truck versus rail. The average predicted increase in shipping costs from the ASC tax was 19% for trucks and 12% for rail. He pointed out that the model results are driven by these percentage changes.

- Austin reported that the predicted effects vary by commodity and route, with little effect on short-haul trips made mostly by truck or on bulk transport commodities carried mostly by rail. Overall, averaging all the markets and commodities, the model predicted a 3.6% shift in ton-miles from truck to rail, along with a decline of 0.8% in total tons shipped. Translating ton-miles into truck trips resulted in 3 million fewer truck trips over a year and an increase of 0.8 million railcar trips. This shift would save almost 700 million gallons of diesel fuel. Further, external costs would have been reduced by about \$2 billion in 2007 (expressed in 2014 dollars).

- Austin reviewed the simulation model data and parameters. He noted that the unit of observation for freight shipping used in the model was total ton-miles and tons shipped in 2007, separately for every state pair, for 39 commodities and the two modes. The data set included almost 76,000 observations. The data are from the FAF, based primarily on the 2007 Commodity Flow Survey. He suggested that because 2007 was before the recession, the results may also reflect the current economic situation after several years of recovery. Austin indicated the model's parameters are specified as ranges of possible values. Examples of these parameters include shipping rates, drayage costs, transportation's share of production and distribution costs, demand elasticities, rail route circuitry, empty returns, tax pass-throughs, and payload capacities. He noted that mode choice elasticities, or the propensity to switch modes when prices change, are much lower for bulk commodities than for finished goods. He also suggested that elasticities are typically difficult to estimate. For each iteration in the simulation model, a specific value was drawn at random from each parameter's specified elasticity range. The results are averages over 1,000 iterations.

- Austin noted that among the policy options analyzed, the ASC tax (weight–distance tax plus fuel tax) most accurately reflected external costs. It would also be the most costly to administer because the weight and distance of every shipment would have to be known. The VMT tax, however, only requires knowing distance. He noted that the fuel tax is the least costly to administer as the collection mechanism is already in place. The VMT and fuel taxes have lower administrative costs, but they reflect external costs less accurately or less comprehensively.

- Austin described the preliminary analysis of implementing the four policy options in 2007. He noted that the effects of the VMT tax plus the fuel tax are generally a little larger than those of the ASC tax alone. He suggested that the ASC tax is a more accurate reflection of external costs and that by ignoring weight, the VMT tax is greater than the ASC tax for lighter shipments and lower than the ASC

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tax on heavier shipments. Those inaccuracies are drawbacks, but the trade-off is lower administrative costs. He also suggested that by itself, the VMT tax has effects nearly as large as the combination of a VMT tax plus a fuel tax, while imposing a smaller tax burden on shippers. Austin discussed the likely range and the sensitivity analysis. The variation in model predictions over the 1,000 iterations is summarized as the likely range of values the modeled outcomes might take, which is defined as containing two-thirds of the model's predictions, centered on the median prediction. He noted that individual parameters can be modified based on changing conditions, and the model can be rerun.

CLOSING SESSION

Breakout Session Reports

Caroline Mays, *Texas Department of Transportation*
Melissa Tooley, *Texas A&M Transportation Institute*
Herby Lissade, *California Department of Transportation*
Denver Tolliver, *North Dakota State University, presiding*

The conference included three parallel breakout sessions on the topics of energy sector developments, freight supply chains, and transportation system resiliency. Participants chose which session to attend based on their interests. Discussions in each of the breakout groups focused on major takeaways from the presentations, issues and opportunities, research needs, and potential follow-up activities. Members of the conference planning committee acted as breakout session facilitators and recorders. During the closing session the facilitators summarized the major topics discussed in their session. Participants were able to provide additional comments and suggestions for further research and follow-up activities.

ENERGY SECTOR DEVELOPMENTS

Caroline Mays

Caroline Mays summarized the discussion in the energy sector developments breakout group. She described the key conference takeaways, data concerns, and research needs identified by participants. She noted the discussion also covered supply chains, resiliency, and economic competitiveness. Mays covered the following topics in her presentation:

- In discussing the key takeaways from the conference, some breakout group participants noted that states face different issues from different types of energy developments. It was suggested that understanding the situations and needs in different states and areas, and matching appropriate responses, was important. Participants identified focusing on the complete supply chain, not just individual sections or modes, as a second takeaway message. It was suggested that this supply chain focus represents a change in thinking. A third takeaway message was the importance of the global marketplace and associated issues and opportunities.
- Mays noted that participants discussed data needs associated with energy sector developments and energy supply chains. Concerns were voiced over the lack of data and outdated data on the transportation elements of energy sector exploration,

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development, and production. Different public- and private-sector data sources were discussed, with participants noting that data from the public and private sectors do not always match. The difficulty in obtaining data from energy companies, railroads, trucking companies, and other businesses was discussed. Participants identified opportunities to collaborate with industries and businesses to share data. A few participants noted that many state DOTs and metropolitan planning organizations have established freight advisory committees that could be used to facilitate the exchange of data and the more active involvement of the freight community in the transportation planning and project development processes. It was also suggested that the private sector does not always have a good understanding of federal transportation planning requirements and the roles and responsibilities of metropolitan planning organizations and state DOTs.

- Participants noted the private-sector concerns with data privacy, especially in highly competitive markets. A research project examining methods to anonymize data and reduce concerns over proprietary data was suggested. It was also suggested that research identifying data gaps and inconsistencies in data for different supply chains would be beneficial, along with developing approaches to fill these gaps with public- and private-sector data. Providing examples of successful methods for obtaining private-sector data, including approaching businesses in a coordinated manner and providing them with information they can use in return, were also mentioned for inclusion in the research.

- Participants observed that research on techniques to analyze multistate multimodal freight corridors would be beneficial. It was suggested that research focusing on both the institutional issues and techniques to bring diverse groups together and the technical issues associated with analyzing highway, rail, water, and air modes was needed. Some participants mentioned that the local links in the system, such as trucks operating on arterial streets, should be included in the analysis. Other participants pointed out that focusing on corridors (such as the I-95 Corridor or the Crescent Corridor) would provide opportunities to engage diverse private-sector groups.

- The need for more sophisticated models and analysis tools to inform decision making at all levels was discussed by participants. Participants identified the need for a research project reviewing the capabilities of current models, identifying enhancements and improvements to expand these capabilities, and identifying the need for new models to address new situations. The model enhancements and development of new models could be undertaken in follow-up research projects. Some participants noted that models are needed that can address supply chains and freight flows on international, national, regional, state, metropolitan, and local levels. Participants also suggested that the models need to be sensitive to the rapid rate of change today and the impact of change on different modes and supply chains.

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- Developing and applying indicators to track energy sector development and potential impacts on the transportation system represents another research topic identified by participants. Tracking oil and gas drilling permit applications at the state level represents one indicator that has been used to identify potential impacts in advance of developments. Transportation agencies can then take more proactive approaches to harden infrastructure and make other improvements.
- Exploring public–private partnerships (P3s) for project delivery and operations related to energy sector transportation and supply chain infrastructure and operations was suggested by a number of participants as another research topic. Possible P3 applications that could be explored included port and inland waterway infrastructure, truck parking, railroad grade crossings, and highway bottlenecks. Exploring lessons learned and best practices from existing P3 projects, international P3 freight applications, and issues to consider and address with expanded applications were suggested by participants as part of the P3-related research.
- Participants noted that several NCHRP and NCFRP projects have developed toolkits and scenario-planning techniques for different types of applications. It was suggested that examining these toolkits and scenario-planning techniques to assess energy sector developments, supply chains, and transportation impacts would be beneficial. The research would focus on any changes needed in the toolkits for application with energy sector developments and the availability of data needed as input to the tools. Participants further suggested that the research include testing the toolkits and using the scenario-planning applications in case study examples involving energy sector developments and supply chains.
- Some participants suggested that many agencies and public-sector groups have a limited understanding of the private-sector business model, key factors influencing decisions on supply chains and shipping modes, and the impacts of public-sector decisions on businesses. Conducting research to better understand these factors was noted as beneficial by participants. It was also suggested that involving shippers, carriers, and businesses in scenario-planning exercises, workshops, roundtable discussions, and other information-sharing opportunities would be beneficial. Participants commented that continuing to invite private-sector representatives to speak at TRB conferences and workshops would be valuable.
- Options for funding needed research were also discussed in the breakout group. Some participants mentioned that taking more proactive approaches to seeking funding from a wide range of sponsors may be appropriate to consider. Another suggestion was working with private-sector groups to cofund research projects. Participants observed that this approach would not only provide needed funding, but would also more actively engage the private sector in identifying topics, managing projects, and helping implement results.
- Follow-up comments from conference participants on the breakout group summary addressed the need for consistent data on freight transportation and supply

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chains, the potential impacts of emerging energy sources, and the need to educate the public on the importance of freight transportation. Other comments from conference participants included the need for multimodal freight and supply chain performance measures, developing a better understanding of the forces behind the current energy boom, and examining safety and environmental impacts of energy sector developments.

FREIGHT SUPPLY CHAINS

Melissa Tooley

Melissa Tooley summarized the discussion in the freight supply chains breakout group. She highlighted the three overarching themes of better understanding global and domestic supply chains, policy and legislative challenges, and current and future workforce needs. She reviewed the research needs identified by participants, noting that many of the same issues highlighted by Caroline Mays were also discussed in the freight supply chains breakout group. Focusing on topics not covered by Mays, Tooley addressed the following points in her presentation:

- According to Tooley, the first overarching theme emerging from the breakout group discussion was the importance of global and domestic multimodal supply chains for economic competitiveness. Participants discussed the need for a better understanding of complete supply chains, not just portions within one state or country or provided by one mode. It was noted that infrastructure and operational improvements can be targeted to ensure all links, including border crossings, provide reliable and efficient service. Participants observed that this holistic view highlights the importance of all modes, including the inland waterways, air freight services, and the intermodal links at ports, airports, and rail terminals.
- Policy and legislative challenges represented the second overarching theme from the breakout group summarized by Tooley. Participants voiced the need for stable, long-term funding for transportation infrastructure, operations, and research. The potential for action on a federal transportation bill was discussed. Some participants noted that the UTCs play a valuable role in conducting research, education, workforce development, and outreach on key transportation issues including freight supply chains, global logistics, resiliency, and energy sector developments.
- Tooley noted that workforce development to ensure an adequate pool of well-trained employees for all modes and fields of transportation was the third overarching theme emerging from the breakout group discussion. Participants discussed the shortage of truck drivers and the need for personnel in the rail, maritime, and aviation industries. It was noted that individuals with an understanding of freight planning and operations, supply chains, and logistics are needed at public agencies. Participants suggested that UTCs were well-situated to address many of these needs. Developing

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courses and degree programs in logistics, freight, and other disciplines was suggested to help meet these needs. It was also suggested that UTCs could reach out to technical and junior colleges to address shortages in truck drivers and technical workers. Developing programs at the junior high and high school levels was also suggested to engage younger people and introduce them to possible careers in transportation. Participants suggested that research identifying the workforce needs in different modes and disciplines would be a logical first step. Courses, degree programs, certificates, and training programs could then be developed and offered to meet the identified needs.

- Participants identified various challenges facing freight transportation and supply chains, including the increasing number and intensity of extreme weather events, the lack of funding for infrastructure improvements, security concerns, and the impact of climate change on agricultural production areas. Some participants also noted the need to use, coordinate, and streamline all modes to ensure efficient and effective supply chains. Potential opportunities discussed by participants included the expansion of the Panama Canal and the use of new technologies to reduce delays at border crossings. Participants also discussed the potential impact of 3-D printing on supply chains, measuring the performance of supply chains, and increasing the use of the inland waterway system.

- One research topic suggested by participants focused on improving methods and techniques to integrate multimodal corridor planning and operations. Participants commented that the United States could learn from the European Union, which appears to do a better job at coordinating integrated multimodal corridor planning. Participants suggested that research examining the European Union approach and experience would be beneficial.

- Another research topic discussed by participants focused on how the development of autonomous vehicles and connected vehicles (AV/CV) might affect freight transportation and supply chains. A few participants suggested that freight transportation might be one of the early AV/CV applications. Conducting research on potential freight AV/CV projects, including an examination of the technical, institutional, and policy issues, was identified as beneficial by participants. Developing, deploying, and evaluating freight AV/CV pilot tests and demonstration projects were also suggested by participants. Other participants discussed the need for research examining the potential use of drones, dirigibles, and other nontraditional transportation modes for freight.

- Participants identified mode-specific research needs. Suggested research topics related to trucking included examining crash and VMT data by truck configuration type, exploring the impacts of hours of service requirements, and assessing methods to attract and retain drivers. Recognizing the complexities of the maritime system and the unique elements of difficult ports and waterway systems, participants also noted as desirable research examining the infrastructure needs of the inland waterway

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system and ocean ports. Considering land use impacts, innovative financing, and potential markets and barriers were suggested as potential elements of this research. Another related topic was examining the impact of larger ships on railroad, trucking, and landside access needs.

- Participants identified research needs relating to the impacts of policies and regulations on freight movement and supply chains. It was suggested that some policies, such as those related to driver hours of service, may have both intended and unintended consequences. Some participants indicated that research examining these impacts would be beneficial.

- Research focusing on developing better methods to analyze overall supply chains and supply chain components was suggested by participants. It was noted that the results of this research would be beneficial for identifying key supply chain corridors and developing key performance measures for use by the public and private sectors.

- Conducting research examining the impacts of changing demographics, labor markets, purchasing patterns, driving trends, and other factors on freight movements and supply chains was suggested as needed by participants. Research on how these changes might influence the demand for agricultural products, finished goods, and supply chains was suggested as beneficial.

TRANSPORTATION SYSTEM RESILIENCY

Herby Lissade

Herby Lissade summarized the discussion in the transportation system resiliency breakout group. He described the research needs identified by participants, noting that the discussion focused on the four phases of emergency management: preparation, response, recovery, and mitigation. Lissade covered the following topics in his presentation:

- He commented that the key takeaways discussed by participants in the breakout group addressed the need to educate policy makers and the public on the importance of freight transportation and supply chains, the key role the highway system and other modes play in resiliency, and the importance of establishing clear roles and responsibilities in emergency management. He also noted that participants indicated the seven principles of supply chain resilience developed through the U.S. DOT and the Asia–Pacific Economic Cooperation collaborative effort provided a good focus for moving forward with needed research, training, and coordination.

- Participants identified exploring opportunities to expand the use of new technologies to aid in all phases of emergency management as a needed research area. It was suggested that technologies can enhance preparation, response, recovery, and

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mitigation activities, but that resources are needed to procure, operate, and maintain those systems. Some participants noted that providing public agencies with a better indication of the costs and benefits associated with different technology would be of help.

- Participants discussed education, training, and workforce development needs related to resiliency and responding to disasters and extreme weather events. It was noted that working in interdisciplinary groups is a key element of emergency management. As a result, education and training in participating in multiagency teams was noted as a need. Developing programs for cross-training among agencies and job skills was also identified as important.

- Participants suggested that more research is needed examining the short- and long-term economic impacts of disruptions on all types and sizes of businesses. Developing approaches to measure the public and private costs associated with disruptions, as well as the recovery costs, was also noted as a potential research topic. Some participants noted that strategies can then be developed to address the most significant impacts to facilitate successful business recovery.

- Lissade noted that participants discussed the need for research examining supply chain security needs during disruptions. Issues that could be addressed in the research included special security needs at border crossings, security needs at locations accepting diverted shipments, and the security impacts of different types, sizes, and weights of shipments. The interaction among transportation and security agencies could also be examined, along with technologies to enhance security and improve coordination.

- Participants identified other possible research topics, including using P3s to support transportation system resiliency, examining environmental concerns, and exploring the interdependence between modes. Participants noted air freight had not been discussed at the conference, but represented an important element of supply chains for high-value goods. It was suggested that research on the role of air freight, landside needs associated with air freight, and opportunities to enhance air freight in the United States would all be beneficial. Other possible research topics suggested by participants focused on the impacts of larger trucks and ships on the transportation infrastructure, the need to update design standards and emergency response plans, the use of big data to enhance supply chains, and possible social impacts from supply chains and transportation resiliency.

OPEN DISCUSSION

Conference participants were invited to expand on the breakout group summaries and highlight additional issues and research needs. The following topics were noted by different participants during the open discussion:

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- It was suggested that research examining the impacts of traffic congestion on supply chain reliability would be beneficial. Possible impacts identified were shifting trucks to operate during off-peak hours, relocating businesses facilities, and shipping by rail rather than truck.

- In addition to the omission of air freight, it was noted that pipelines were not addressed at the conference. Some participants observed that pipelines are a key part of the oil and gas supply chain infrastructure, and research on resiliency for oil and gas pipelines was suggested.

- An example was provided of the difficulty of determining the ownership of a private bridge damaged during an earthquake. It was suggested that identifying methods to incorporate private roads and bridges into supply chain resiliency would be beneficial.

- Research to develop methods to record and display key data on supply chains and on transportation system resiliency geospatially was suggested.

- Another research topic identified during the open discussion was examining institutional issues associated with multistate and multicounty supply chain resiliency planning and recovery. It was noted that Hurricanes Katrina and Ike and Superstorm Sandy showed the need for multistate coordination and cooperation.

- It was suggested that relatively small events may have major impacts and disruptions on supply chains. Further, the net results of multiple small events may be significant. Research identifying possible triggers and measures to help agencies better manage smaller events to prevent major disruptions was suggested as beneficial.

- Conference participants discussed several topics related to the interdependency of freight and passenger transportation during disasters and extreme weather events. The links to land use planning, housing and school locations, and public health were also discussed. Participants suggested the need for research on methods to better coordinate these activities among the wide range of public agencies and private-sector groups involved.

- One conference participant pointed out the link between human trafficking and freight movements. Research examining this link and identifying methods to prevent smuggling humans in freight shipments, especially cross-border shipments, was suggested.

- Examining potential health issues associated with truck drivers, rail operators, and other personnel working different shifts was identified as another potential research topic. It was suggested these issues may be barriers to recruiting needed workers to these professions and that these issues may become even more important during major events and recovery periods.

APPENDIX A

Abstracts of Poster Presentations

VULNERABILITIES TO TEXAS TRANSPORTATION NETWORKS RESULTING FROM THE MEXICAN ENERGY REFORM

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Mexico's recent energy reform, which is opening the traditionally state-run energy market for international investments, will have a strong influence on Texas transportation networks. This preliminary research, conducted by the Texas A&M Transportation Institute's Mexico City office, analyzed Mexico's recent energy reform and its objectives to determine how an increase in oil exploration may affect Texas transportation networks. By using a case study analysis of the energy market's influence on Texas transportation, it was possible to identify and predict vulnerabilities in the Texas transportation infrastructure. This research identified vulnerabilities in Texas' rail network: safety concerns, increased border crossings, and increased traffic on both sides of the border.

Mexico's energy reform, signed in December 2013, is intended to end the monopoly of the state oil company (Petróleos Mexicanos) and encourage foreign investment in Mexico's energy sector. The energy reform's key details (secondary laws) have recently been negotiated in the Mexican congress. These negotiations centered around the Mexican regulations pertaining to the transition, the tax burden on Petróleos Mexicanos, and Mexico's petroleum fund. The potential extraction of oil, condensate, and natural gas from the Burgos Basin is expected to have a significant impact on the Texas transportation system because of a lack of infrastructure in Mexico.

Mexico is currently working on a plan that focuses on roadways, railways, and marine ports for investing in infrastructure to support business development. The goal of the National Infrastructure Program is to enhance the country's export competitiveness and stimulate economic growth. With this in mind, research has pointed toward a likely increase of foreign investment in Mexico's energy industry.

Energy reforms and the development of the Burgos Basin will likely have a significant impact on Texas' ports, rail system, highways, and border crossings. The

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impacts include U.S. firms expanding their operations, sending drilling equipment into Mexico, and shipping oil from Mexico to Texas and Louisiana for processing. These movements could generate substantial freight volumes, consisting of heavy oil field equipment and other materials (such as pipelines) from Texas into Mexico, as well as crude from the Burgos Basin to Texas. It is also possible that during the earliest stages of shale gas and oil production in the Burgos Basin, and before companies invest in infrastructure in Mexico, that pipe, frac sand, and chemicals will be transported by truck or rail, or both, across the Texas–Mexico border. These movements would place new pressures on the state’s transportation system along the border region and on the operations of the state’s border crossings.

**BEYOND PUBLIC VERSUS PRIVATE:
IS THERE A THIRD OPTION TO IMPROVE
THE ECONOMIC COMPETITIVENESS OF U.S. PORTS?**

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The competitiveness of U.S. gateway ports is critical to U.S. foreign trade. Two important dimensions of port competitiveness are efficiency and effectiveness, both of which can be affected by the port’s form of ownership. Although the impact of privatization on port efficiency has been examined in previous studies, comprehensive investigation of a full range of port ownership forms has not been undertaken, and their impact on port competitiveness and effectiveness remains incompletely understood.

In this study, we propose a new method to quantify different forms of private-sector involvement at major U.S. gateway ports. Driven by interport competition, the determinants of port competitiveness can be ascertained through studies of port ownership structure, connectivity to rail service, accessibility to immediate hinterland markets, and related and supporting industries. We develop multiple econometric models to quantify the impacts of these factors on the competitiveness of major U.S. gateway ports. Our focus is on how different ownership forms—ranging from pure public to mixtures of public–private partnership—and the association with an inland port affect port competitiveness. The results from our empirical investigation reveal the advantage of adopting public–private partnerships to enhance port competitiveness and the importance of having the right balance between public and private participation. In addition, the presence of a proximate inland port is also important for port competitiveness.

USING INFORMATION TECHNOLOGY TO IMPROVE THE COMPETITIVENESS OF INLAND WATERWAYS FREIGHT MOVEMENT

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Inland waterway transportation has historically played an integral role in the domestic movement of goods. Although the cost advantages that waterways offer to shippers are well understood, the broad social benefits they generate in the form of reduced emissions, energy efficiency, and congestion relief are less appreciated. These overall benefits make a compelling social case for promoting the use of the inland waterways system. Unfortunately, the current infrastructure for waterway navigation is outdated and in poor condition. The deteriorating infrastructure is further constrained by antiquated communication systems, adding to the operational inefficiencies of the system. To address these capacity issues, it is imperative that the nation make a structured investment plan to build and maintain the inland waterways system.

This study highlights an opportunity to address waterways operational issues and increase the economic competitiveness of this mode through the implementation of a wireless area network for navigable rivers in 15 states covering 6,840 square miles. The case study focuses on identifying factors that represent bottlenecks to the efficient transportation of goods through the waterways and measuring the improvements in supply chain workflow resulting from the implementation of a wireless broadband network for waterways data transport. The operational improvements to the inland waterways are analyzed from a systemic (network) perspective, as opposed to a lock-by-lock basis. The key analytic components featured in the study include the development of a framework to identify and quantify benefits from the movement of goods through the inland waterways.

ECONOMIC IMPORTANCE OF THE CHICKAMAUGA LOCK

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The Chickamauga Lock and Dam were constructed by the Tennessee Valley Authority (TVA) in the late 1930s as part of President Franklin D. Roosevelt's New Deal program. The navigation lock was opened for service in 1940. This lock, in

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combination with Watts Bar and Fort Loudoun Locks and Dams, allows navigation to extend up the Tennessee River from Chattanooga (RM 417) to Knoxville (RM 652), a distance of 181 miles. However, the Chickamauga Lock was found to be physically moving early in its operational life. The problem was ultimately linked to “aggregate alkali reaction,” which occurs as a reaction between alkaline cement paste and noncrystalline silicon dioxide. Slots have been cut in the lock walls to allow for expansion, only to close as the walls expand. Posttensioning has been used to fasten the lock chamber to bed rock to minimize movement. Considerable deterioration is evident where large chunks of concrete have fallen off the lock into the river. Finite element analysis performed at TVA beginning in the middle to late 1990s isolated the source of the pressure caused by the expansion. The problem was found to be so severe in key areas of the lock that TVA began to warn users in the mid-1990s that a permanent closure of the lock was imminent. Closure is now a very real possibility absent construction of a new lock chamber.

About 1 million tons of commodities, primarily crude materials, petroleum products, and farm products, are shipped through the lock annually. The lock is used by TVA to ship overweight and overdimensioned power plant components from plants located above the lock to the maintenance shop located below the lock for repairs. Recreational boat manufacturers are located in the area, and the lock is also used by recreational boaters in a variety of activities, including fishing, sporting events, and foliage cruises. Governmental users include the U.S. Coast Guard, which sets the mainstream buoys and day markers on the main channel, and TVA, which sets buoys on the secondary channel and performs dock inspections to ensure conformance with the TVA Act. With a permanent closure, bulk goods freight rates would be expected to increase, and one major manufacturer could cease operations. Furthermore, a boat manufacturer with a partially constructed plant would likely never open for business. Two other manufacturers have plans to shift to rail transportation. Many power plant components would be forced to use truck transportation to make repairs, but for some, maintenance would have to be performed on site. Thus, utility transportation costs would increase. Recreational boating and marina activities would be diminished, especially for large yachts that would have problems navigating without navigation aids.

ASSESSING THE IMPACT OF BORDER WAIT TIMES AT THE EL PASO–JUAREZ BORDER CROSSING ON MANUFACTURERS’ JUST-IN-TIME CARGO SUPPLY CHAINS

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Long wait times at the U.S.–Mexican border can make the difference between profit and loss for businesses whose supply chains rely on just-in-time inventory systems to meet consumer demand. Businesses need a predictive model to assist in optimizing their shipping schedules to minimize time lost at the border. Congestion at border crossings has increased in recent years. One reason for this increased congestion is the recent phenomenon of near-sourcing. Rising production costs abroad have made local production more attractive. Businesses that once outsourced manufacturing overseas to countries like China are now moving production back to North America, especially Mexico. Add to that change the expansion of the Panama Canal and Mexico’s recent investment in seaport and railroad improvements, and more cargo will likely be flowing between the United States and Mexico.

These changes are good news for border communities like El Paso, Texas, and Juarez, Mexico. Additional cross-border shipping means increased economic vitality on both sides of the border, but increased freight traffic resulting from nearby production also means increased congestion at the border. Longer wait times will put a dent in any just-in-time shipping plan as production lines slow down or even stop manufacturing completely until existing inventory is shipped. Delays can also mean increased production costs.

Texas A&M Transportation Institute’s Center for International Intelligent Transportation Research is working on a reliable forecasting model that will help border communities—and the businesses that pass their goods through them—to make better-informed decisions. Caught between the need for profit and the demands of fierce competition, businesses can sometimes be reluctant to change. Our model will demonstrate the value of making needed changes. The center is working with the Coalición Empresarial Pro Libre Comercio and researching the way border congestion affects just-in-time inventory systems of companies on both sides of the border. The effort will also assess existing systems for inefficiencies associated with crossing the border. Working with the private sector, border-crossing data will be gathered and reviewed to help develop a border-forecasting model. With improved information about border wait times at hand, businesses can improve their shipping efficiencies. These improvements are good for business as well as the local

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community's economic development because lower production costs mean lower prices for consumers.

THE COST OF RAILWAY CONGESTION AND DELAY

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Growth in freight traffic and demand for passenger rail service will increase future rail network congestion and delay. The cost of congestion and delay to the rail industry, shippers, and society includes increased operating costs, service variability, and emissions; decreased fuel efficiency; loss of traffic to other modes; and infrastructure investment. The combination of these costs may jeopardize the role of the railway mode in providing safe, efficient, and low-cost transportation of freight over long distances, thus decreasing the economic competitiveness of industries that rely on this transportation service. The National University Rail Center is conducting research to gain a more detailed understanding of the full cost of railway congestion. Increased knowledge of the magnitude and allocation of these costs will help determine the impact of freight rail congestion on economic competitiveness and aid planning and justification of future infrastructure projects to increase rail network capacity.

TRANSPORTATION ENGINEERING EDUCATION AND WORKFORCE DEVELOPMENT EFFORTS IN THE RIO GRANDE VALLEY

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For over 60 years, the adequacy of the U.S. science and engineering workforce has been a continuous concern for Congress because of the significant role of these fields on U.S. economic strength, national defense, and other societal needs. Scientists and engineers are essential to U.S. technological leadership, innovation, manufacturing, and services; however, not enough degree-holders have been produced by the nation's colleges and universities. At the current rate, employers in 2025 will need about 23 million more science, technology, engineering, and mathematics (STEM) college graduates than what will be produced. Consequently, the percentage of working-age

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Americans with high-quality degrees and credentials needs to be increased markedly.

To this end, one of the main missions of the University Transportation Center for Railway Safety (UTCRS) at University of Texas–Pan American has focused on developing a multitiered educational and workforce development approach to increase awareness of the field of transportation engineering, with an emphasis on railway safety. The plan of action has targeted several demographic groups, from elementary school students to industry professionals. Exposing students to transportation engineering at an early age (as early as third grade) enables them to develop an interest in transportation engineering and encourages them to pursue a professional career in this field. UTCRS developed specialized summer camps for elementary, middle school, and high school students in which carefully designed scalable modules were delivered in the course of one week. To maximize effectiveness, these teaching modules were aligned with K–12 Texas Essential Knowledge and Skills standards so they can be easily adopted by teachers in their classrooms. The summer activities also included research experience for teachers (RETs) and research experience for undergraduates (REUs) program components. The teachers participating in the RET program acquired professional on-the-job training by delivering the curriculum to the students who attended the camps. As part of their professional training, RET participants held two workshops for 60 STEM teachers from all local school districts to introduce them to the teaching modules and train them on how to scale these modules to the appropriate student age groups. In addition, railway safety modules are being designed for training purposes of railroad industry professionals. In the summer of 2014, as part of the national effort to cultivate future professionals, the UTCRS educational and workforce development programs benefited 700 kindergarten through grade 12 students (300 elementary, 300 middle school, and 100 high school students), five RETs, eight REUs, and 60 STEM teachers.

IMPACT OF BAKKEN SHALE OIL DEVELOPMENT ON RURAL ROADS

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This study outlines the development of a rural travel demand model to assess the impacts of increased truck volumes due to exploration and production of crude oil in the Bakken and Three Forks oil formations in North Dakota. Traditional trend-line traffic forecasts provide reasonable truck and equivalent single-axle load estimates for

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traditional rural traffic sources such as agriculture and light manufacturing. However, with the widespread growth of oil drilling and production in western North Dakota and eastern Montana, the trend-line forecasts over- or underpredict depending on the timing and duration of the traffic counts used.

Oil from the Bakken and Three Forks formations is extracted using a combination of horizontal drilling and hydraulic fracturing. These processes require a significant number of truck trips due to the large inputs of sand, chemicals, and water required. It is estimated that a single Bakken well requires approximately 2,300 truck trips to complete the drilling and fracturing processes. Once this stage is complete, outbound movements of crude oil and saltwater are transported via truck or gathering pipeline; the volumes are dependent on the production rate of the well. Estimation of the number of annual trips generated by oil exploration and development was completed using county-level forecasts from North Dakota regulators combined with hot spot analysis of existing well locations and spacing units. Based on estimated maximum well numbers per spacing unit, annual wells drilled per county, and existing clustering measured by the Getis-Ord G_i^* statistic, 2,000 new wells were added. As new wells were added to spacing units with the highest levels of clustering, the G_i^* z-score was recalculated for each subsequent year and the process was repeated. The resulting data set provided the geographic location and timing of the forecasted well development within North Dakota.

A well location may serve as an origin or a destination. When a well site is being drilled, it is the destination for sand, water, fuel, equipment, pipe, and other inputs. Once the well goes into production, it is an origin for outbound crude oil and saltwater. Bakken well production declines significantly within the first three years of production. A production function was applied to each well to generate outbound movements of crude oil and saltwater for use in a gravity model to select origin–destination pairs. All potential origins and destinations within the region, regardless of distance, were considered in the model.

Eighteen movement-specific origin–destination models were estimated and combined prior to network assignment. Trips were assigned to the state, county, and township road network using travel time as the cost function. Preliminary results were calibrated against traffic counts. The resulting traffic forecasts provide segment-specific truck volumes and equivalent single-axle loads for use in local road planning efforts.

SUPPLY CHAIN SKILLS SHORTAGE: A THREAT TO ECONOMIC COMPETITIVENESS?

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The research presented is based on an extensive review of literature and studies that focus on the supply chain talent that will be required for future business competitiveness in the United States. The expectations are that there will be shortages in supply chain personnel to fill positions in business. Four main reasons for the shortage are anticipated retirement of the baby boomer generation, increasing awareness by business of the importance of supply chain management, global competition for supply chain talent, and too few supply chain faculty being trained and recruited into teaching positions. Due to demographics, many related disciplines, such as transportation engineering, will also be facing talent shortages. The combined talent shortages in transportation engineering and supply chain management will affect U.S. economic competitiveness because not only will there be a shortage of the builders and operators of U.S. transportation systems, but there will be a shortage in the skills needed to move people and freight on the many types of transportation systems.

This research also highlights the top skills and education required by businesses in the supply chain profession today and in the future. The most desired skills and traits appear to be in the areas of team leadership and collaboration built on a foundation of technical skills. The options for obtaining these skills and education span traditional colleges and universities, professional and trade organizations, and company training programs. Education delivery options also range from traditional resident college classes to e-learning (Internet based) and m-learning (use of mobile devices in addition to or instead of computers). Given that these many options exist, how can they be used to address the predicted shortages? Recommendations for solving the supply chain talent shortage are offered from the perspectives of institutions of higher education, industrial, professional organizations, and government.

A 2014 study suggests five strategies for helping to address the talent shortage: (1) provide employees with a career roadmap and opportunities to acquire the skills and knowledge they need to broaden their career potential, (2) map talent needs by identifying competencies required by an organization, (3) focus on retention of the most talented employees, (4) invest in talent and leadership development, and (5) recruit and land top talent for the next decade.

ECONOMIC IMPACT OF INVESTMENT ON HIGHWAY CONSTRUCTION AND HIGHWAY MAINTENANCE

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Transportation investment is usually seen as an effective way to boost the economy. Through enhancing the level of service provided by the highway system, both passenger and freight transportation can benefit from improved mobility, accessibility, and safety, which would further lead to economic growth. Unlike most of the existing research that analyzes the impact of transportation investment from an economic perspective, this paper addresses the transportation perspective. Structural equation models were developed and three main issues were addressed: (1) physical measurement of highway infrastructure was used instead of financial measurement to avoid bias caused by price variance, (2) both infrastructure supply and demand were included in the model to represent the relationship between transportation service and economic growth, and (3) the endogeneity of travel demand and transportation investment were considered simultaneously during the analysis. Empirical study at the metropolitan level in the United States was conducted, and the results confirm that transportation investment has a positive effect on economic growth. A 10% increase of highway capacity can create an increase of \$548.9 billion in U.S. gross domestic product in the long run. In addition, the effects of investment on highway construction and highway maintenance in promoting economic growth were compared. According to the results estimated from regional-level models in Maryland, in the short run, improving highway mileage by 1% would create less economic growth than improving the overall quality of the existing highway system by 1%, and the effect of highway construction would be larger than that of highway maintenance in the long run.

FREIGHT MANAGEMENT TOOL FOR THE NEW JERSEY DEPARTMENT OF TRANSPORTATION

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The scarce resources for investment in transportation systems are driving state and local transportation agencies to strategically plan their infrastructure projects. Many state DOTs are forced to balance continuous maintenance and repairs of aging

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transportation infrastructure with investments in new infrastructure and technology improvements and information technology systems. DOTs across the country have developed evaluation and prioritization processes to address the need to select the projects that will produce the highest benefit to the traveling public while considering funding and other constraints. In addition, MAP-21 requires implementation of performance-based planning and programming that can assist stakeholders and decision makers by providing a better understanding of the performance implications of transportation investment decisions. MAP-21 also provides new incentives for states to invest in freight projects.

Because the investment projects that improve freight transportation infrastructure compete with other infrastructure projects for the same funds, there is a need to evaluate the potential benefits of the transportation improvement projects from the freight perspective. Thus the New Jersey DOT initiated a project to develop a freight management tool, the purpose of which is to determine the level of importance of statewide transportation improvement program (STIP) projects from the freight perspective. To comply with MAP-21 guidelines, the tool includes freight performance measures in its evaluation process. The evaluation process is based on a scorecard method designed to prioritize STIP projects by using criteria based on selected freight performance measures and indicators. Twelve preliminary freight performance measures and indicators, such as safety, maintenance, or preservation of the system and freight connectivity and mobility, were selected to address the general freight performance categories. Each freight performance measure and indicator is assigned a weight depending on the importance of the measure and indicator in meeting the goals of safety, system preservation, and mobility. The visual aspect of the tool (developed using a geographic information system application) geographically displays scorecards for STIP project(s) and other relevant freight data. The visual capabilities of the tool are designed with the intent of efficiently conveying the information to public and private stakeholders as well as the general public.

MODELING CRUDE OIL RAIL SHIPMENTS AND POTENTIAL POPULATION AT RISK BY USING WAYBILL DATA AND GEOGRAPHIC INFORMATION SYSTEMS

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Crude oil volumes by rail have grown exponentially over the past several years as oil producers in regions such as the Bakken Formation of North Dakota have sought to take advantage of the destination flexibility provided by rail connections. Several phenomena characterize this growth: the significant increase in railcar waybills for the

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movement of crude oil between 2010 and 2012, the increased number of origin and destination locations during the same period, and the potential for adverse impacts on human populations associated with derailments and fires, such as the accident in Lac-Mégantic, Quebec.

To identify the critical corridors for crude oil and the potential human populations affected by such moves, Oak Ridge National Laboratory (ORNL) generated routes by using the origin and destination information contained in annual waybill surveys from 2010, 2011, and 2012. The routes were generated by ORNL's WebTRAGIS (Transportation Routing Analysis Geographic Information System) routing platform. The WebTRAGIS system is connected to ORNL's LandScan USA population model, which provides estimates of population counts at a spatial resolution of ~90 m. The results identify several components of the national rail network that have emerged as critical corridors for crude oil shipment and the human populations that might be at risk along these routes.

ECONOMIC AND OPERATIONAL IMPACTS OF COMMERCIAL TRUCKS ON FLORIDA FREEWAYS AND MULTILANE HIGHWAYS

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Traffic congestion is one of the key factors that affect the movement of people and goods. Even though the general public normally focuses on the effects of congestion on movement of people due to the in-vehicle travel time increase congestion causes, traffic congestion is equally, if not more, costly for the movement of goods. Bottlenecks on strategic freight routes are found to be one of the most costly occurrences not only because of their negative impact on travel time reliability, but on vehicle emissions and fuel consumption rates, as well. In addition, the impact of commercial trucks on traffic flow is much larger than that of passenger cars due to the trucks' extreme physical characteristics, such as vehicle weight and length. Currently, long-haul truck traffic in the United States is concentrated on major routes connecting population centers, ports, border crossings, and other major hubs of activity and is mainly on Interstate highways.

The Freight Analysis Framework estimates that by 2040 long-haul freight truck traffic will increase dramatically on Interstate highways and other arterials throughout the United States. Therefore, there is a need for accurate modeling of commercial truck performance and movements in simulation tools so the impacts of commercial

trucks on traffic operations can be quantified. This study describes the development of a complete vehicle dynamics modeling approach that includes the transmission gear-changing capabilities of commercial trucks and its implementation into a custom traffic microsimulation tool. This new tool can have a significant impact in calculating the passenger car equivalent values of commercial trucks, assessing traffic stream conditions (e.g., free-flow conditions, freight bottlenecks), and capacity on grade. As an initial step this tool was successfully applied to a study to estimate updated passenger car equivalent values. Larger passenger car equivalent values in the current Highway Capacity Manual correlate to the estimation of decreased capacity on strategic freight routes (highways and multilane highways), which can lead to the estimation of worse-than-observed freight bottleneck phenomena.

The assessment of commercial truck impacts on the traffic stream supplied through this study provides a more accurate estimate of how the current truck fleet on Florida freeways and multilane highways affects traffic flow and therefore affects economic competitiveness. By using this custom simulation tool, more accurate commercial truck congestion (e.g., freight bottleneck) studies can be performed because the engines and physical characteristics of commercial trucks are more accurately simulated than in other commercially available simulation tools.

VISUALIZING THE ROLE OF INTERMODAL TERMINALS ON THE PRIMARY FREIGHT NETWORK: UNCOVERING DATA GAPS FOR SYSTEMS ANALYSIS

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In 2014, the Mid-America Freight Coalition profiled and mapped 58 intermodal terminals in its ten states: Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Ohio, and Wisconsin. This inventory, geared to state DOTs provides information about truck access to and from Interstates, intermodal movements (lifts), intermodal lane information, and intermodal connectors. Each profile includes an access map that is shown against aerial photography to display the extent of the intermodal terminal, the intermodal terminal gates, intermodal connectors, MAP-21 National Highway System routes, and Highway Performance Monitoring System or state DOT truck counts. Another map shows warehouses and distribution centers surrounding the intermodal terminal. These maps represent the first step in determining the impact of lifts on intermodal connectors or other truck routes that form part of the primary freight network. An ultimate goal is to rationalize

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priorities on the primary freight network. This exercise revealed inconsistencies in truck data collection surrounding intermodal terminals, as well as gaps in lift data that could be converted to truck counts. Visual inspection of the intermodal connectors also showed that some routes are in poor condition. Beyond providing a visual understanding of the data gaps, these maps serve as a starting point for the classification of intermodal terminals in the Mid-America Freight Coalition region. Terminal locations range from suburban to urban and have corresponding implications for expansion, as well as impacts on surrounding communities.

MODELING MULTIMODAL FREIGHT TRANSPORTATION NETWORK PERFORMANCE UNDER DISRUPTIONS: IOWA CASE STUDY

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Freight transportation is one of the major sources of traffic on our roads and one that greatly affects the entire economy. Disruptions—both short and long term—to the transportation network can directly affect freight movements, causing increases in congestion and the transportation cost of goods. Less research and data exist on freight traffic than on passenger traffic, in part because of the proprietary nature of the industry. This research presents a multimodal model to measure the performance and characteristics of regional freight flows when parts of the network face disruptions.

A case study using cereal grains shipped from Iowa was used to create the model. The model assumes that total origin–destination flows are constant before and after the disruption. The Federal Highway Administration’s Freight Analysis Framework version 3 data set for 2007 was used to determine the volume of cereal grains shipped from Iowa. Similar destinations from this model were grouped together to simplify the model. Geographic information systems software was used to create multiple routes to each destination on the available modes: highway, rail, and inland waterway. These routes were aggregated to determine travel time, congestion, delay, speed, and other metrics for each destination and for each mode. A nested logit model was used to determine whether these factors had any bearing on the proportion of shipments on each mode. We found the main factors that caused a difference in modal share were the distance between the destinations (i.e., longer destinations use rail predominantly) and the availability of suitable inland waterways (i.e., only four destinations had workable waterways).

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Three disruption scenarios were tested in the case study area. The first was a reduced service level at locks along the Mississippi River. The second disruption was a bridge outage on I-80 at the Missouri River. The third was severe weather in central Iowa closing the Union Pacific tracks in the area. The framework takes into account the increased travel distance and time to calculate aggregate cost increases for the commodity. In addition, we used a queuing model to calculate the increase in delay at rail yards and river locks due to the added traffic. The impacts of these disruptions on the transportation of cereal grains from Iowa were quantified and analyzed using the proposed freight network model.

UNDERSTANDING GOVERNMENT AND RAILROAD STRATEGIES FOR CRUDE OIL TRANSPORTATION IN NORTH AMERICA

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On July 6, 2013, an oil-laden unit train derailed and exploded in Lac-Mégantic, Quebec, killing 47 people and leading to significantly increased public scrutiny of crude oil transported by rail. Simultaneously, there has been intense scrutiny of proposed pipelines, most notably the TransCanada Keystone XL, from the oil and tar sands in Alberta. Not only is there concern about the potential environmental impacts of the pipelines themselves, such as a potential spill of diluted bitumen, but there is also concern about the consequences of greenhouse gas emissions caused by the energy-intensiveness of bitumen production and refining. Proponents argue that a denial of pipeline permits by governments in Canada and the United States would lead to more crude by rail, an outcome pipeline supporters believe would not only be less cost-effective, less safe, and less environmentally friendly, but would also ultimately lead to the same amount of greenhouse gases being emitted from the production and refining of oil sands bitumen.

Railroads, with much of the required infrastructure already in place to transport crude, usually do not need to undergo the same environmental assessments as pipelines for modest capacity expansions. As a result, when pipelines are evaluated through political and regulatory processes in Canada and the United States, much of the focus is on what railroads might do if a pipeline permit is not approved, rather than what they should do. The CLIOS (complex large-scale integrated open systems) process, an approach for studying complex sociotechnical systems, is used to study the relationships between the oil sands production and transportation systems, the institutional actors that govern them, and the critical contemporary issues of economic development, energy security, climate change, and safety. Specifically,

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strategic alternatives for adding transportation capacity from the oil sands (in this case, pipelines and railroads) are identified and their performance along dimensions of societal concern are compared and contrasted. Because railroad safety is of particular concern, CAST, an accident investigation tool built on the systems theoretic accident model and processes (STAMP) accident causation model, was used to study the safety control structure of the Canadian railway industry that existed prior to the Lac-Mégantic accident. This research describes how environmental acceptability is implicit in advancing energy security and economic development. The research also raises questions about the acceptability of safety risks associated with rail transportation of crude oil, and it recommends that this issue be further debated at railway management, regulatory, and political levels.

IMPLEMENTATION OF THE OFF-HOUR DELIVERY PROGRAM IN NEW YORK CITY

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Integrative freight demand management in the New York City metropolitan area project, also known as the off-hour delivery project, is an innovative example of receiver-centered freight traffic demand management. The project uses financial and other incentives to induce receivers to accept deliveries in the off hours (7 p.m. to 6 a.m.). Because the incentives remove receivers' opposition and the carriers are generally in favor, entire supply chains can switch to the off hours, which provides numerous benefits. After a successful pilot phase in 2010, the Office of the Assistant Secretary for Research and Technology of the U.S. DOT sponsored the current phase in 2011. The project was led by Rensselaer Polytechnic Institute with the support of the New York City DOT.

The program is a win-win solution that benefits carriers, receivers, and urban communities at all hours by enhancing quality of life, economic development, and environmental sustainability. It is estimated that over 400 businesses, predominantly located in Midtown and Lower Manhattan, shifted some of their deliveries to the off hours. It is further estimated that 40 to 50 daily delivery tours in Manhattan have switched because of this project, for a total carrier savings of over \$2.25 million per year. The estimates produced using the regional planning model show that if 20.9% of Manhattan deliveries were shifted to the off hours, each receiver would be responsible for an annual reduction of about 551 vehicle miles traveled, 195 vehicle hours traveled, 12 kg carbon monoxide (CO), 1.9 kg hydrocarbons (HC), 0.7 kg oxides of nitrogen (NO_x), and 0.004 kg of <10-mm particulate matter (PM₁₀). These reductions translate to a total reduction of 202.7 tons of CO, 40 tons of HC, 11.8 tons of NO_x, and 70 kg of PM₁₀ per year. The differences between regular and off hours

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are generally greater than 20% for highway and toll road segments and greater than 50% for urban arterial road segments. The potential economic impacts are enormous; savings in New York City are estimated at \$100 to \$200 million per year. In addition to being financially sustainable, the program is socially and politically sustainable; if properly implemented, its impacts are positive for all involved through enhancing urban quality of life, economic development, and environmental sustainability.

INNOVATIVE FREIGHT DATA COLLECTION METHODS AND PERFORMANCE MEASURES AT THE UNITED STATES–MEXICO BORDER

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More than \$500 billion of goods were traded between the United States and Mexico in 2013. Trade between these two countries is expected to rise due to recent trends in nearshoring that are modifying trade patterns. Land border crossings handle the majority of this trade and are an important element of cross-border supply chains. Crossing time and delay for commercial motor vehicles entering and leaving the United States at ports of entry with Mexico are key indicators of transportation and international supply-chain performance and should be quantified in a systematic and consistent way to provide accurate information for decision making by planners, freight carriers and shippers, and agencies operating at international border crossings.

This research documents the development and implementation of an innovative truck border-crossing time data collection and dissemination system. The system is in operation and provides real-time and archived information of northbound crossing and wait times at the U.S. and Mexican border. Current research efforts to use the border crossing time information to develop additional performance measures such as a border-crossing time fluidity index and a border planning time index are also described. The research presents recommendations on future data collection technologies that could be applied to enhance the system already developed and identifies other uses of the information to measure economic competitiveness.

IMPACT OF MEXICO'S NORTHERN TRADE CORRIDOR ON TEXAS' HIGHWAY INFRASTRUCTURE

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Mexico's 2014 to 2018 National Infrastructure Plan includes \$587 billion of investment in the nation's infrastructure, including new roads, railways, telecommunications infrastructure, and ports. These investments could affect the flow of trade across the U.S.–Mexican border. Specifically, it is widely projected that Mexico's Northern Trade Corridor, also known as the Mazatlán–Durango–Matamoros Highway, will divert a substantial share of the international shipments of fruit and vegetables destined for the United States away from Arizona border crossings to crossings in Texas. This study shows the origins and destinations of these shipments, plausible routes, and potential impact on the border crossings in Texas. Further, it shows the need for highway infrastructure investments to facilitate the movement of these shipments on the U.S. side through Texas and to their final destinations in the North and Northeast.

A MULTIFACETED APPROACH TO ASSESSING ECONOMIC PRODUCTIVITY IMPACTS OF FREIGHT TRANSPORTATION INVESTMENTS

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Recently, an international team of researchers completed NCHRP Project 2-24, Assessing Productivity Impacts of Transportation Investments, the goal of which was to develop a guide for incorporating productivity effects into the analysis and prioritization of transportation investments. This presentation focuses on the results of that study, in particular, the freight transportation factors that lead to improved economic productivity. The analytic framework developed extends beyond traditionally measured transportation cost effects, such as travel time delay cost or vehicle operating costs, to include approaches for incorporating three impact categories (reliability effects, market access effects, and intermodal connectivity effects) not generally included in standard traveler benefit calculations. Reliability effects include reducing the variation of travel times around the mean, which

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reduces the need for companies to pad delivery schedules with extra buffer time to ensure on-time arrival. Improved reliability can have a variety of productivity-related impacts, including reduced costs for extra labor time, reductions in inventory and fleet requirements, and new supply chain technologies such as just-in-time manufacturing and lean supply chain processes. Market access, a form of agglomeration economies, refers to benefits businesses experience from improved access to a variety of necessary inputs. Specific to the freight transportation realm are the effects of expanding the effective breadth of the market area from which same-day deliveries can be made. Also relevant to freight are the effects of broadened customer delivery markets. Improved access can result in both economies of scale and other agglomeration-type benefits, such as improved matching between buyers and suppliers. Intermodal connectivity is a specific case of market access that extends beyond a single region to consider the increment in access provided by longer-distance modes to destinations outside the region. Because current modeling practice does not usually integrate road travel time with impedance information for intermodal rail corridors, marine, or air freight, alternate approaches are needed to assess the value of these additional connections. These three elements either reduce business operating costs or increase business output in a given region. Areas in need of future research and methodological development are discussed. Although NCHRP Project 2-24 provides a framework for understanding the economic productivity effects of freight transportation investment, along with a set of presently available tools, work remains to be done in developing more refined factor valuations and economic response elasticities.

POTENTIAL CRUDE PETROLEUM NATIONAL TRANSPORTATION NETWORK “BOOM” LEADING INDICATOR METHODOLOGY

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New transportation demands have been and are being created by the current “tight oil boom” in the United States. The Association of American Railroads reports that from 2009 through the beginning of 2013, Class 1–terminated rail carload shipments of crude petroleum increased from less than 5,000 carloads per quarter to almost 100,000 carloads per quarter. Academia, the public, and the government seem to have been blindsided by this development, although oil industry insiders appear to have been making plans for this eventuality. In 2011, the International Energy Agency

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predicted that North America could have a moderate crude oil production increase of 1 million barrels per day, and in 2013, the agency projected that North America could increase crude oil production by approximately 3.9 million barrels a day.

Were there early or leading indicators in the changes of crude petroleum transportation modes, routes, and volumes that could have helped highlight the coming of the “oil boom”? This research examines the millions of records of the 2007 Freight Analysis Framework (FAF), the 2011 and 2012 provisional FAFs, and supporting data for indicators and indicator confirmation of the crude oil production explosion that began in 2011 in the United States. Transportation pattern changes are examined by FAF zone in the national crude petroleum transportation system by using spectral analysis algorithms. Results of methods of zonal, modal, and volume differential pattern evaluations are presented. Abstract indices and a sample of visual, graphical representations of crude petroleum transportation modes, routes, and volumes are also provided demonstrating the feasibility of predictions, the value of spectral visualization techniques, and the limitations of the methods developed.

THE LAST 50 MILES: MAKING PLACE MATTER IN EVALUATING FREIGHT SYSTEMS’ ECONOMIC PERFORMANCE

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The U.S. DOT calculates that Americans generate 40 tons of freight per capita each year. This makes freight an important issue—and a potential asset—that is too often ignored by urban planners and policy makers. The federal and state focus on freight is often on the long-distance character of movement and the role of capital improvements that increase connectivity to transcontinental and global markets. Although longer-distance trips carry the potential for higher energy efficiencies, as shown by the switch from truck-only to truck–rail intermodal, cargo often travels inefficiently during its first and last 50 miles of transportation. Because local officials are often unaware of the options and potential economic opportunities of cargo-oriented development, they default to letting freight operations move to the periphery of cities rather than address the issues at hand. When freight activity is pushed to the outer edges of urban areas, job seekers find their commuting distance and time increase, thus limiting the labor pool. The Manufacturing Institute reports 600,000 new manufacturing jobs were created in less than four years, yet over 80% of manufacturers still cannot find the workers they need to fill jobs. Moreover, wages have not, in many cases, kept pace with inflation. Ignoring the effects of inefficient freight transportation can result in a loss of economic opportunity for American cities, particularly legacy

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cities still recovering from recession or major industrial shifts. For these cities and many others, a focus on cargo-oriented development, including the development of logistics and manufacturing related to freight centers in urban cores and good transportation access, could provide a major boost.

The authors previously created a framework to study how economic impact from transportation investment is measured by various state agencies. They found that the measures used emphasize system throughput and speed and system condition. By contrast, local governments and regional planners stress measures such as cost of living, cost of business, fiscal net impact, long-term job creation, and various measures of livability. This paper focuses on rail and rail intermodal freight and presents a framework for comprehensive measures of freight performance that incorporate local value creation and value capture. The report applies key measures to freight terminals in Memphis, Tennessee, and Charlotte, North Carolina, and describes a range of current freight-related development issues in other regions. The report captures the importance of new technologies both for terminal operations and reduced local impacts from operations. It highlights innovations by companies that have led to both operational efficiencies and increases in land use intensity, offering the potential for increased adjacent manufacturing and distribution developments and local value capture. Class 1 railroads have doubled their capital investment since the recession, and a better understanding of the value proposition associated with terminal modernization can help encourage both private investment in and public understanding of and commitment to these type of investments. In short, efficiency upgrades to the nation's freight system are important for businesses and consumers, but efficiency upgrades to the beginning and end of each delivery are critical to the economies of American cities and to their citizens' quality of life.

SPATIAL ANALYSIS OF THE ECONOMIC AND COMMUNITY IMPACTS OF FREIGHT RAIL IN MINNESOTA

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Minnesota has the eighth-largest rail system in the United States. The system carries more than 3.6 million carloads of freight each year, helping to move products quickly and efficiently, whether trains are loaded with iron ore exports to Canada via the Great Lakes, or grain traveling to China, or heavy equipment going south. Minnesota's overall economic growth rate from 2007 to 2013 was 27% better than the U.S. gross domestic product. This study examines the relationship of industry clusters and freight rail as it relates to this growth.

This spatially focused research used quantitative and qualitative analyses to

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evaluate the effect of freight rail on the economy of different regions in Minnesota. The project conducted a series of inquiries into gross state product changes, shift-share analysis, and mode share specialization to determine industry cluster locations and contributions to Minnesota's economy. Using these data, combined with qualitative information, the study identified several industry clusters that are heavy rail users, then employed a location quotient-based approach to understand these industries' significance to Minnesota and its national competitiveness. By linking these rail-dependent industries to spatial analysis—mapping them for the state of Minnesota as well as other states' rail-dependent industries—this study found associations between the ability to ship by rail efficiently and the performance of certain industries that are critical to the economies of Minnesota and other Midwestern states. The spatial analysis can be seen at <http://freighteconomy.org>.

The study contains a policy analysis component that arrives at six major findings. First, freight rail provides a key, privately funded transportation link to many of Minnesota's most significant industry clusters located in differing regions of the state, including agriculture, iron ore, heavy machinery, and processed food. Second, the partnership between Class 1 and short-line railroads is essential for economic growth throughout Minnesota. Third, because rail infrastructure is generally the business of the private sector, the public-private partnership is unique compared to other infrastructure elements (e.g., highways) and requires a new approach to governance. Fourth, even with freight rail's strong private-sector orientation, successful public-private partnerships have been pursued when needed, such as in the Chicago Region Environmental and Transportation Efficiency program, a practice that needs to be considered in Minnesota. Fifth, as the economy continues to improve, all modes of transportation will be challenged to move goods efficiently, thereby placing new demands on intermodal facilities. Finally, the freight transportation community needs to maintain an ongoing dialogue with the public on freight rail. In comparison to highway or transit programs, freight rail is less fully understood by the public and so outreach is essential to achieving consensus on freight infrastructure plans.

MULTIMODAL OPPORTUNITIES TO REDUCE THE EFFECTS OF CHANGING FUEL PRICES: CASE STUDIES OF THE UPPER MIDWEST FOREST PRODUCTS INDUSTRY

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Forest products are a competitive and low-margin industry in which even small savings are important to secure a healthy industry outcome. Transportation represents a significant portion of the overall supply chain costs, and shipments have high levels of cross-price elasticity, making them prone to modal shift-based variations in total

price. Although the role of rail transportation has diminished significantly over recent decades, increasing trucking and fuel prices are causing the industry to take another look at the potential cost savings offered by multimodal transportation by truck and rail. The outcomes of three analyses on potential savings, all conducted with three fuel price levels, are presented.

The first study used a spatially based model to investigate the movements of over 100,000 actual truckload shipments of logs with a transportation alternative that combined truck and rail transportation. The results suggested that over 20% of ton-miles shipped by trucks could have moved more cost-effectively through multimodal transportation and would have led to roughly a 3.75% reduction in transportation costs. The sensitivity analysis of changing fuel prices suggested that every \$1.00 increase in fuel price would warrant an additional 7% shift of ton-miles to multimodal transportation. The second study expanded the use of the model to analyze the economic supply radius of logs to a proposed production facility by developing a series of cost gradient maps for different fuel prices. The maps highlighted the expanded economic distance at the areas with nearby rail access, and the fuel price sensitivity analysis demonstrated the increasing discrepancy between areas with and without rail access as fuel prices increased. The final case study compared the transportation cost of lumber products in two scenarios, one with a truck–rail transload facility in the region and one without. The results revealed that the presence of a transload facility could potentially reduce overall shipping costs, even for shipments to adjacent states. The escalation of fuel prices would increase the potential savings of such shipments.

UNDERSTANDING THE ROLE OF INLAND NAVIGATION IN COAL MOVEMENTS

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The goal in this research, which describes a geographic information system–based intermodal network model for the shipment of coal in the United States, was to better understand a portion of the energy transportation system and how the three ground-based modes of rail, water, and highways integrate to deliver energy goods. The background transportation network used a variety of data sources, and the coal movements were modeled across the network by using the Energy Information Administration’s 2010 data providing detailed origin, destination, primary mode, and volume information for all energy movements in the United States. The model

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identified the optimum routes for coal shipments based on a rate structure that accounts for the relative costs of shipping by each of the modes.

The ultimate model revealed the strong spatial domination of the United States by Powder River Basin coal, the market area of which reaches well across the West and into the Midwest. Both Texas and Illinois, the two largest coal consumers, derive virtually all their coal from the West or from within state, and little or none from the more closely located Appalachian Basin. Conversely, Appalachian Basin coal serves domestic and export markets primarily in the eastern and southeastern United States. Only the Ohio River provides significant movement of Central Appalachian Basin coal to the West and South. This modeling effort demonstrates the potential for such integrated models to accommodate energy-related or similar data and serves as a tool for freight planners in identifying energy transportation corridors of significance. Results from this model can help inform MAP-21–related efforts to develop a National Freight Network and National Freight Strategic Plan.

FREIGHT GENERATION, FREIGHT TRIP GENERATION, AND LAND USE

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The effective incorporation of freight transportation considerations into the transportation planning process is important because the freight system is a crucial contributor to a vibrant economy, quality of life, and efforts to combat global warming and climate change. The freight transportation system is important because of both its positive and negative contributions to modern life. An efficient freight transportation system is a necessary condition for economic competitiveness and for realizing the full potential of economic globalization. However, the freight transportation system is poorly understood, resulting in the lack of appropriate freight modeling methodologies. The lack of research and data concerning freight affects all facets of transportation demand analysis: generation of cargo, distribution, mode choice, and traffic assignment. The need for research to enhance the state of the quantitative aspects of freight generation is the underlying rationale for this research. A better understanding of the variables driving the generation of freight demand and their connection to land use would help provide more accurate demand forecasts and better quantification of the traffic impacts from freight activity.

This presentation described the research findings of NCFRP Project 25, Freight Trip Generation and Land Use, and discussed the freight system and how freight trip generation and land use are related. The analyses reveal various practices of great relevance for freight transportation modeling purposes, including (1) using land

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use classification systems that lead to internally homogeneous classes in terms of the determinants and patterns of freight generation (FG) and freight trip generation (FTG) activity, (2) using variables that correctly measure the intensity of FG and FTG activity as predictors of FG and FTG, and (3) using the aggregation procedure that corresponds to the underlying disaggregate FG and FTG models. These premises and conjectures were tested using cases studies. The case studies confirmed the superiority of economic classification systems over standard land use classification systems and how proportionality between FTG and business size only happens in a minority of industry segments. In addition, results from the case studies suggested that the models estimated at the establishment level are transferable and that the NCFRP 25 models outperform Institute of Transportation Engineers' models and some industry segments of the Quick Freight Response Manual. Finally, the case studies showed that multiple classification analysis performed better than ordinary least squares models.

IMPACTS OF POLICY-INDUCED FREIGHT MODAL SHIFTS

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This presentation described the preliminary research findings of NCFRP Project 44, Impacts of Policy-Induced Freight Modal Shifts. The presentation discussed the research conducted to identify the variables influencing freight mode choice that allow the development of more accurate demand forecasts, a better quantification of the impacts of freight activity, and the development of more effective policies. The investigation conducted by the authors is aimed at gaining actionable insights into how best to induce desired mode shifts through freight mode choice policy. However, for the public sector to have a clear idea about how to accomplish a policy goal, policy makers need to (1) understand behavior, (2) identify appropriate policy measures, (3) identify the roles of the stakeholders in the execution of policy to gain their cooperation, (4) assess the effectiveness of alternative policies, and (5) test and implement the policies. To this effect, the team conducted a comprehensive review of examples of freight mode shift, and they are using Commodity Flow Survey microdata to estimate aggregate and disaggregate freight mode choice models.

IMPACT OF FREIGHT TRANSPORTATION ON THE COMPETITIVENESS OF TEXAS EXPORTS

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Texas ranked first in merchandise exports in the United States, with exports totaling \$279.7 billion in 2013. The Texas transportation system plays a vital role in facilitating export trade through its roads, railroads, ports, border crossings, airports, and pipelines. However, an increase in the generalized cost of transportation can have a substantial impact on the competitiveness of major export industries in Texas. Inadequate infrastructure or operational policies at the border crossings, a lack of redundancy in the transportation system, unreliability, damage and pilfering en route, and regulations on truck size and weight limits can have direct and indirect impacts on the generalized cost of transportation. This study describes the logistic chains for several major export industries in Texas and identifies the role of transportation in the logistics chain. Researchers examine the transportation concerns of exporters, transportation policies and regulations affecting the costs of exports, and the potential options for reducing the cost of transportation and improving the quality of service.

APPENDIX B

Conference Attendees

Teresa Adams, Center for Freight & Infrastructure Research & Education, University of Wisconsin–Madison

Bala Akundi, Baltimore Metropolitan Council

Felipe Aros-Vera, Rensselaer Polytechnic Institute

David Austin, U.S. Congressional Budget Office

Scott Babcock, Transportation Research Board

Yun Bai, Center for Advanced Infrastructure and Transportation

Janet Benini, Office of Intelligence, Security, and Emergency Response, U.S. Department of Transportation

Scott Bernstein, Center for Neighborhood Technology

Dejan Besenski, New Jersey Institute of Technology

Benjamin Blandford, Kentucky Transportation Center, University of Kentucky

Thomas Bolle, Office of the Assistant Secretary for Research and Technology, U.S. Department of Transportation

Deborah Bowden, Maryland Department of Transportation

Larry Bray, Center for Transportation Research, University of Tennessee

Scott Brotemarkle, Transportation Research Board

Alexander Bühler-Rose, Texas A&M Transportation Institute

Sarah Campbell, Center for Neighborhood Technology

Anne Canby, OneRail Coalition

Joel Carlson, CPCS Transcom Ltd.

Angela Chapman, University of Texas–Pan American

Bob Costello, American Trucking Associations

Silvana Croope, Delaware Department of Transportation

Helen Currie, ConocoPhillips

Michael Dinning, Volpe National Transportation Systems Center, U.S. Department of Transportation

Jing Dong, Iowa State University

Mortimer Downey, Mort Downey Consulting, LLC

Denise Dunn, Office of the Assistant Secretary for Research and Technology, U.S. Department of Transportation

Alan Dybing, Upper Great Plains Transportation Institute, North Dakota State University

Mark Eastburn, Delaware Department of Transportation

Bryan Gibson, Kentucky Transportation Center, University of Kentucky

CONFERENCE ATTENDEES

Brittney Gick, Transportation Research Board
John Gray, Association of American Railroads
José Holguín-Veras, Rensselaer Polytechnic Institute
Thomas Horan, Claremont Graduate University
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