Research Issues in Freight Transportation

Congestion and System Performance

October 22-23, 2007
Washington D.C.

Transportation Research Board
Freight Systems Group
Marine Group
Freight Transportation Data Committee

Kathleen Hancock, Editor
Virginia Polytechnic Institute and State University

December 2007

Transportation Research Board
500 Fifth Street, NW
Washington, DC 20001
www.TRB.org
The Transportation Research Board is a division of the National Research Council, which serves as an independent advisor to the federal government on scientific and technical questions of national importance. The National Research Council, jointly administered by the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine, brings the resources of the entire scientific and technical communities to bear on national problems through its volunteer advisory committees.

The Transportation Research Board is distributing this Circular to make the information contained herein available for use by individual practitioners in state and local transportation agencies, researchers in academic institutions, and other members of the transportation research community. The information in this Circular was taken directly from the submission of the authors. This document is not a report of the National Research Council or of the National Academy of Sciences.

Freight Systems Group
Chair

Marine Group
Chair

Freight Data Committee
Scott Drumm and, Chairs

Research Issues in Freight Transportation Conference Planning Committee
Michael D. Meyer, Chair, Georgia Institute of Technology
Teresa Adams, University of Wisconsin, Madison
Christina Casgar, U.S. Department of Transportation
Harold Cerveny, The Tioga Group
Ronald Duych, Research and Innovative Technology Administration
Genevieve Giuliano, University of Southern California
Kathleen Hancock, Virginia Polytechnic Institute and State University
Susie Lahsene, Port of Portland
Heather Nachtmann, University of Arkansas
Cecil Selness, Minnesota Department of Transportation
Thomas Marchessault, Research and Innovative Technology Administration
Robin Kline, Research and Innovative Technology Administration
Thomas Bolle, Research and Innovative Technology Administration

Elaine King, Senior Program Officer, TRB
Thomas Palmerlee, Senior Program Officer TRB
David Floyd, Senior Program Associate TRB

Transportation Research Board
500 Fifth Street, NW
Washington, DC 20001
www.TRB.org

, Production Editor; , Proofreader and Layout
Preface

The movement of freight is an important national issue. Not only does freight movement contribute directly to the nation’s and states’ economies, but eventually all the goods and commodities delivered and their way into the businesses and households of America, and thus freight affects the quality of life afforded Americans. The freight system is facing serious challenges. Congestion in ports, on access roads to intermodal facilities, and on the rail system has significant impacts on the productivity and competitiveness of the U.S. economy. Environmental issues where freight movement concentrates—such as in ports—are becoming of greater concern to the surrounding communities. Finding the funds to improve the nation’s freight infrastructure relies increasingly on innovative financing mechanisms that combine public and private investment sources.

The nation’s research universities have a great deal to offer in finding new solutions to the problems facing the freight system. The purpose of this conference is to provide a forum for researchers, government officials, and private-sector representatives to exchange ideas on how the freight transportation system can be improved.

An ad hoc committee, chaired by Michael D. Meyer of Georgia Institute of Technology and selected by the sponsoring committees, carried out the detailed planning for the conference. This circular consists of individually attributed summaries and proposed research needs statements. No language should be construed as consensus findings or recommendations on the part of workshop, the planning committee, or the sponsoring committees.

The planning committee represented academicians, researchers, analysts, and modelers. The 101 persons attending reflected organizational diversity as follows:

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic</td>
<td>46%</td>
</tr>
<tr>
<td>Federal</td>
<td>22%</td>
</tr>
<tr>
<td>State</td>
<td>6%</td>
</tr>
<tr>
<td>MPO and Local</td>
<td>6%</td>
</tr>
<tr>
<td>Consultant and private sector</td>
<td>8%</td>
</tr>
<tr>
<td>Rail and Marine/Port</td>
<td>6%</td>
</tr>
<tr>
<td>Other</td>
<td>5%</td>
</tr>
</tbody>
</table>

The Research and Innovative Technology Administration of the United States Department of Transportation provided funding to support travel and on-site expenses.

—Kathleen Hancock, Editor

Virginia Polytechnic Institute and State University
Contents

Introduction
   Michael D. Meyer

Introductory Address: Congestion and System Performance Initiatives at the U.S. Department of Transportation
   Kelly Leone

SESSION SUMMARIES

Measuring the Impact of Congestion on the Economy
   Susie Lahsene, Moderator
   David Ganovsky, Recorder
   Presenters: Matthew L. Garrett, Robert Sappio, Tim Lomax

What Are We Doing About It?
   Heather Nachtmann, Moderator
   Joseph Schofer, Recorder
   Presenters: Edward McCormack, Bruce Wang, Genevieve Giuliano

Implementation Strategies and Operational Modes
   Tina Casgar, Moderator
   Thomas Wakeman, Recorder
   Presenters: Maria Boile, Teresa Adams, Chip White

Conclusion and Summary
   Mike Meyer

POSTER SUMMARIES

Modeling Truck Traffic Volume Growth Congestion
   Michael Anderson

Strategies For Efficient Freight Movement In Metropolitan Transportation Networks With Applications To The Los Angeles/Long Beach Area
   Anastasios Chassiakos, Maged Dessouky, Petros Ioannou, and Hossein Jula

Advanced Technologies To Improve Cargo Movement In Metropolitan Areas With Applications To The Los Angeles/Long Beach Area
   Anastasios Chassiakos, Gen Giuliano, John Heidemann, Petros Ioannou

Evaluation Of Strategies For Efficient Cargo Movement And Public Policy Implications
   Gen Giuliano, Hahn Le-Griffin, Kristen Monaco, James Moore and Tom O’Brien
Research Needs Reported by Industry
Matthew R. Cuddy and Joseph L. Schofer

Glucose Intolerance and Commercial Truck Crashes
Jeff Foster

Improved Freight Modeling of Containerized Cargo Shipments between Ocean Port, Handling Facility, and Final Market for Regional Policy and Planning
Kaori Fujisawa, Anne Goodchild, and Eric Jessup

ARGOS: Dynamic Composition Of Web Services For Goods Movement Analysis And Planning
Jose-Luis Ambite, Genevieve Giuliano, Peter Gordon, and Qisheng Pan

Assessing Intermodal Transportation Planning At State Departments Of Transportation
Andrew R. Goetz, Joseph S. Szyliowicz, Timothy M. Vowles, and G. Stephen Taylor

Kathleen L. Hancock, Paul Bingham, and Joseph Schofer

A Freight Planning Framework
Gregory Harris

Essentials Of Analysis In The Control Of Overloaded Trucks
Eric Moreno-Quintero

Freight Modeling in Small and Medium-Sized MPOs: Update of the Fargo-Moorhead Metropolitan Area
Smadi Ayman and Motuba Diomo

Dynamic Freight Routing under ITS Information for Congestion Avoidance
Alper E. Murat

Safety Synthesis of Oversize/Overweight Commercial Vehicles
Leslie Anne Nicholson

Estimating Truck Equivalencies for Freeway Sections
Hesham Rakha, Kathleen Hancock, Anthony Ingle, and Ahmed Al-Kaisy

Evaluating Alternative Truck Management Strategies Along I-81
Hesham Rakha, Alejandra Medina Flinsch, Kyoungho Ahn, Ihab El-Shawarby, and Mazen Arafeh

The Effect of Auxiliary Power Units on Long Term Idling: A Case Study
Craig Schiller and L.R. Rilett
Meeting Freight Data Challenges: Report of a Transportation Research Board Workshop, July 10-11, 2007 Chicago, IL

Bridge Weigh-in-Motion Application in Alabama
   Virginia Sisiopiku

Mississippi Valley Freight Traveler Information Clearinghouse
   Bruce Wang and Peter Rafferty

Rail Relocation Projects in the U.S.: Case Studies and Lessons for Rail Planning
   Jeffery E. Warner, Leslie E. Olson, Craig E. Roco, Glenn C. Anderson, and Stephen S. Roop

APPENDIX
Workshop Attendees
Introduction

MICHAEL D. MEYER
Georgia Institute of Technology

The movement of freight is an important national issue. Not only does freight movement contribute directly to the nation’s and states’ economies, but eventually all the goods and commodities delivered find their way into the businesses and households of America, and thus freight affects the quality of life afforded Americans. The freight system is facing serious challenges. Congestion in ports, on access roads to intermodal facilities, and on the rail system has significant impacts on the productivity and competitiveness of the U.S. economy. Environmental issues where freight movement concentrates—such as in ports—are becoming of greater concern to the surrounding communities. Finding the funds to improve the nation’s freight infrastructure relies increasingly on innovative financing mechanisms that combine public and private investment sources.

The nation’s research universities have a great deal to offer in finding new solutions to the problems facing the freight system. The purpose of this conference is to provide a forum for researchers, government officials, and private-sector representatives to exchange ideas on how the freight transportation system can be improved.

This is the second University Transportation Center–oriented conference organized by TRB and supported by the U.S. Department of Transportation (DOT) Research and Innovative Technology Administration. The conference objectives are to:

• Improve collaboration among researchers;
• Encourage interaction and synergies among universities, government, private interests, and TRB committees;
• Define freight-related research opportunities of interest to academia, government, and the private sector; and
• Identify future freight-related critical issues for U.S. DOT personnel and other government staff, including state and metropolitan planning organization staff.

The conference will serve as a major point-of-departure for the transportation research community, with participants from all levels of government, the private sector, and the academic community identifying needed freight and logistics research topics.
Good morning. On behalf of the Research and Innovative Technology Administration (RITA) at the U. S. Department of Transportation, I am pleased to welcome you to this conference on Research Issues in Freight Transportation—Congestion and System Performance. We are pleased to have the participation of the U. S. DOT-sponsored universities, such as the University Transportation Centers (UTCs), the Federal Aviation Administration’s Centers of Excellence and universities funded under RITA’s Remote Sensing in Transportation Program. We are also pleased with the level of participation from other U. S. DOT modal administrations, other government agencies, the Transportation Research Board committees, as well as industry representatives from the freight industry.

This is the second of what we are informally calling “spotlight” conferences. They are so named because we hope to use them as one important way that we in the Department can shine a bright light on all the excellent work the universities are doing in critical areas. We have over 40 university researchers here this week and I am very pleased that there will be an opportunity for them to present the results of their research, to talk about what they were working on, and for them to meet U.S. DOT and state DOT officials working on freight issues.

Many of us close to the universities are well aware of the work that the UTCs have been doing for years on many of the important areas of transportation. These conferences are an opportunity to make this work more visible to the rest of the Department. These conferences are one of the steps that RITA is taking to ensure that the Department program staff and DOT officials know about the work of the UTCs and that the UTCs are aware of the Department’s research needs and priorities.

Freight transportation is one of these important DOT priorities. Secretary Peters has included the identification and implementation of strategies to improve freight transportation as one of the key components of the “National Strategy to Reduce Congestion.” Of particular relevance to freight transportation are the Corridors of the Future initiative, the Southern California Freight Congestion initiative, the Border Congestion initiatives, and the Operations and Technology Improvements initiative. For example, the “Corridors of the Future” initiative is aimed at developing innovative national and regional approaches to reduce congestion and improve the efficiency of freight delivery. The selected corridors carry 22.7 percent of the nation’s daily interstate travel.

As another example of how we are changing the way that research is conducted at the Department, we have just established working groups on eight areas for pursuit of intermodal research. We are actively seeking the interest of experts in our UTCs to become involved in the discussions of these working groups. These eight areas are:

- Safe Transportation in an Aging Society
- Human Factors Research
- Enhanced Safety Data and Knowledge
Over the next two days, you will be working to create an environment for increased communication and collaboration among researchers involved in freight research; you will have the opportunity to identify the synergies among US DOT-sponsored universities conducting freight research; you will help identify research opportunities that have potential to enhance the mobility of freight; and you will help to create an information base on the universities conducting freight research, development and technology for use by US DOT, other government agencies, TRB and industry.

The productivity of the freight system to provide timely and reliable service depends not only on the efficiency of individual modal systems and the effectiveness of the laws and regulations under which they operate, but also on the efficiency of intermodal facilities that govern the effectiveness of their connections to one another. U.S. intermodal freight transportation links the various modes to meet customers' market needs by providing integrated origin-to-destination service. It utilizes advanced technologies and operating systems designed to enhance productivity, reduce transportation costs, increase service speed and quality for shippers and lower prices for consumers.

We will do what we can to provide leadership in the coordination of Federal transportation research, including maintaining close dialogue with the private sector and State and local governments to ensure that DOT research funding reflects the priorities of freight transportation users and providers.

I have every reason to believe that these two days will be successful and that they will result in a better understanding of what is going on in freight research and that some new, strong partnerships will be forged during this conference. Again, thank you for your active participation in this meeting.
Opening Comments:

Freight Movement is the economy in motion! The globalization of trade has resulted in dramatic growth in freight movement in the United States. Coupled with passenger demand, freight has put unprecedented pressure on the nation’s transportation systems, both public and private. Our ability to keep up with this demand will directly affect our economic viability and attractiveness in a global environment. Congestion shrinks market areas and access to labor. More importantly it diminishes business competitiveness by affecting routes and reliability, while increasing land and logistics costs. We must do more to solve congestion issues – it is a matter of economic prosperity, opportunity, and survival.

A State DOT Perspective: Matthew L. Garrett, Director, Oregon DOT

Looking back, the 1956 Highway Act began a legacy of highway construction, with the need to build for future levels a part of this bill. Initially users became accustomed to excess capacity, but that changed when funding levels dropped. 1960 spending on highways equaled 2.5 percent of the state’s personal income declined to just .08 percent in the 1990’s. Costs of construction have soared, creating a need for new and innovative ways to deal with congestion. Congestion drives up costs of doing business in Oregon – whether personal travel or freight movements. Transportation plays a vital role in fostering economic activity and affects the state’s ability to compete. One in five jobs in Oregon (over 400,000 jobs) is directly transportation related or reliant on efficient transportation systems. Oregon freight is projected to grow by 80 percent by 2030, however, changes already occurring show evidence that industry is moving to less congested areas in Washington State. People are “voting with their feet”. In addition, studies in 2003 identified bridge cracking in some areas, raising concerns and resulting in some weight limits being lowered to 80,000 GVW on I-4 and I-84. As a result, trucks took longer routes,
many through small towns that were never designed for such traffic. Oregon DOT went to Oregon State University for assistance. OSU developed a model to explain the adverse impacts of bridge weight limits. As a result the Oregon Transportation Investment Act was passed, providing $2.5 billion, of which $1.6 billion has been spent on bridges over the last 3 years. Other work with OSU reveal the need for improved data, understanding of freight flows, and ITS. New partnerships in modeling are occurring, as is a new transportation research and education consortium. In 2006, Oregon DOT forged a 25-year State Transportation Plan, outlining facilities, services and needs and a Statewide Cost of Congestion Study in 2007. Current needs are: improved data; truck only options; best paybacks and a fully engaged State freight commission.

A Carrier’s Perspective: Robert Sappio, Senior Vice President of Trans-Pacific Trade, APL

“ Freight is a global problem and predictability is a must.” It is APL’s position that 2008 will be a freight challenge in a global economy. Why? The US is not coping with trade needs. World trade is growing at three times the GDP. Currently Vietnam, India, Hong Kong, and Singapore are all very congested. Many global investments are directed toward the far east forcing this growth. Today, many vessels have a capacity of 8,000 TEUs (twenty-foot equivalent containers). Economies of scale dictate that more 10,000 TEU vessels will be coming online, creating portside issues including labor, adequate sized cranes, and railroads inland infrastructure capacity.

Today most U.S. ports are already at or near capacity, and APL’s position is that the key focus should be improving productivity (TEU’s per acre). Currently Europe and Asia are doubling U.S. efficiency. APL expects a big shift of trade to the east coast, up 15 percent per year. The Panama Canal’s expansion will not be completed until 2015 or later. Meanwhile the Suez is improving to provide alternate routes to the east coast from the Far East. East-west train movement velocity has and is decreasing as rail capacity is strained, but meanwhile intermodal rates are up 20 percent. APL is feeling the impacts of higher fuel costs, up $600 million over last 3 years (at $86. barrel level in March 2007).

Other important factors with potential impacts on international trade include reopening of ILA in July 2008; U.S. presidential election in 2008; and the possible elimination of Steamship Line Conferences by the EU’s 2008 Conference.

A Researchers Perspective: Tim Lomax, Research Engineer, Texas Transportation Institute.

Mr. Lomax cautioned that “this is only one researcher’s perspective.” Congestion is getting worse! There are huge benefits in solving current and future congestion issues because quality of life, economic development, homes, schools, safety, and security are all impacted. In the U.S. in 2005 we wasted 2.9 billion gallons of fuel. Hours in congestion have increased from .8 billion in 1982 to 4.2 billion in 2005. He estimates $15 billion in costs in urban truck delay or 195 million truck hours. Our current choices are to grow or to hope for a recession (a bad option). Congestion also affects emergency evacuation plans. Major causes of congestion are bottlenecks and incidents that account for 65 percent of the problem, and work zones and weather represent 25 percent more.
As to the solution: No one fix has been found. Fixes vary by region and time of day. Fixes are all about access to jobs, workers and markets. He showed one example of $200 billion in costs yielding $550 benefits. He asks, “How would we operate if there were no trust fund?” His recommended next steps include discussion of benefits! What do I get for my gas tax increases? He feels the best story tellers will win recognition and funding sources. Meanwhile, the problem is bad and getting worse!

Wrap-up

The purpose of this effort was to reframe the question around the value of transportation investment to economic prosperity instead of simply convenience. Fifty years ago we knew the importance of transportation to our future, we also knew the importance of investing in that future. I would argue that we are at a similar point today – one that demands the same kind of vision – investment in the transportation system is both an economic benefit and an economic imperative if we value control over our destiny.
Developing Truck Mobility Benchmarks in Washington State
Edward McCormack

The objectives of this research are to measure the effects of roadway improvements on recurring congestion experienced by trucks and to identify additional opportunities for improvements. The approach uses readily available data sources describing truck volumes, speeds, and travel times in the Seattle metropolitan area and elsewhere in Washington State.

Data on truck performance in the traffic stream are scarce and tend to be project- or locally oriented, rather than network-wide. Yet there are important data sources that can be tapped – loop detectors, permanent count stations, and GPS navigators coupled with transponders on trucks. While on-board systems are intended for such purposes as fleet management, toll collection, weigh-in-motion and border crossing clearance, such data offer a potentially rich and inexpensive source of more general truck performance measures.

Transponders offer the advantage that truck operators have incentives to purchase these for vehicle tracking and rapid clearance. To make use of such data, there is a need for roadside transponder readers to query vehicles as they pass, record data, and provide a basis for comparing vehicle passages to gauge roadway performance. The primary disadvantage of this data source is limited network coverage, particularly outside urban areas and in some cases, on road sections of special interest.

However, the cost of transponder readers has been coming down rapidly, making both permanent and portable roadside readers a feasible option for gathering truck performance data. Together, transponders and readers provide near-real time data at reasonable cost.
In this research, roadside readers were networked to compare passage times of vehicles. The analysis algorithm “anonymized” data to protect privacy. Data were screened to identify the fastest truck passage over a section for a given time period, and this was assumed to be the valid performance measure; trucks making slower passages were assumed to do so for other, voluntary reasons, thus eliminating biases caused by trucks making stops between roadside readers.

In addition to road sections, reader data was used to assess processing time at selected border crossings.

Twenty-four logging GPS units were installed on volunteer trucks for 6 months to evaluate specific routes and locations of interest. Some additional GPS tracking data were purchased from vendors providing tracking to truck operators. This on-board logger data was useful for understanding route switching due to congestion and the extent to which different routes provided better performance outcomes.

This research demonstrated the feasibility of gathering truck performance data from available and relatively inexpensive sources. In the future, the work will develop quantitative truck performance measures, expand the statewide performance measurement program, and work more closely with the trucking industry to examine particular routes and problem locations. The intent is to expand the coverage of truck performance data with additional roadside readers and the purchase of commercial tracking data. The program is expected to identify sources of truck delays and suggest ways to reduce it.

Challenges include reducing the granularity of tracking data, gaining cooperation of truck operators, and creating performance measures useful for transportation agencies.

**Mississippi Valley Freight Traveler Information Clearinghouse**

Bruce Wang, Peter Rafferty and Teresa Adams

This research describes a plan for creating a one-stop Internet information center to support truck freight operations in the 10-state Mississippi Valley region. The information would support route planning and real-time routing decisions based on information about road closures, conditions, and congestion. Information is intended to provide 1-2 hours advance notice to support routing decisions at key decision points on the network at which path options exist, and, where appropriate, to suggest alternate routes.

Information in the clearinghouse source may include static factors such as size and weight restrictions, sensitive areas (school zones and neighborhoods), as well as variable factors such as road construction activities, special events, weather and pavement conditions, and traffic congestion (e.g., travel times). Fixed resources important for trucking operations, such as rest areas and parking facilities, would also be listed. All of this information would be gathered and integrated in a single, web-based information source.

This work is in progress, and future tasks include identifying data sources, assessing data collection and updating mechanisms, determining user needs, identifying critical routing decision points, and exploring sustainability issues. The products of the work are expected to include documentation of existing data sources and architectures, a plan for early deployment, estimated resource requirements, and scenarios to test data requirements and applications.

**Impacts of the Long Beach and Los Angeles Ports PierPASS Program**

Genevieve Giuliano and Thomas O’Brien
This study evaluated the impacts of a program to manage truck congestion at the ports of Long Beach and Los Angeles. Rapid growth of international trade, port capacity restrictions, and environmental consequences of congestion have together motivated actions to reduce congestion at the busiest container port in the U.S.

Congestion is exacerbated because drayage operations to move containers and chassis in and out of the ports have been restricted to day shift hours – Monday through Friday, 03:00 until 18:00. In response, a pricing scheme was established under a voluntary agreement among the marine terminal operators. The intent was to provide an incentive to shift some freight operations outside normal hours. The pricing scheme, PierPASS, charged $40 per twenty-foot equivalent unit (TEU) during the peak hours (subsequently increased to $50/TEU).

Hourly gate use by trucks during off peak hours was measured before and after PierPASS implementation. Trends showed a shift to off peak operations from about 35% to 45% of all operations. Hourly truck volumes on I-710 serving the Port of Long Beach showed a reduction in the mid-day period, and an associated increase off-peak. Weekend truck volumes went up after the introduction of PierPASS.

The effects on the local network vehicle miles and vehicle hours of travel (VMT and VHT) were estimated using a TransCAD simulation under various scenarios to consider the effect of growth in trade and the introduction of PierPass. The pricing program contributed to offsetting some growth effects, reduced traffic during the midday period and shifted it to night, increasing night time VMT and VHT. It reached stated diversion targets and produced important impacts on the highway system.

Truckers and warehouse operators had to adjust and absorb increased costs because of the need to work longer and less desirable hours. Some community residents objected to the shift of traffic into more sensitive hours. Terminal operators got some credit for being responsive to local congestion problems.
SESSION SUMMARY

Implementation Strategies and Operational Modes

TINA CASGAR
San Diego Council of Governments, Presider

THOMAS WAKEMAN
Stevens Institute of Technology, Recorder

MARIA BOILE
The State University of New Jersey

SOTIRIOS THEOFANIS
The State University of New Jersey

TERESA ADAMS
University of Wisconsin, Madison

CHELSEA (CHIP) WHITE
Georgia Institute of Technology

Summary of Presentations

This session examined new institutional models for university-government-industry collaborations for implementing strategies to improve freight mobility. Three examples were presented that described the institutional partnerships, their activities, and the benefits of their efforts on current or future operations. Christina S. Casgar, Good Movement Policy Manager, San Diego Council of Governments, presided and opened the session with a quote from Susie Lahsene that she had been given the day before: “Freight is the economy in motion.” Tina acknowledged the veracity of the statement and briefly discussed the need for partnerships in facing today’s freight transportation challenges. Thereafter, she introduced the entire morning panel and asked the first speaker to begin.

Partnership to Maximize Port Industry Performance: Can Advanced Research Methods Assist in Practice? The Case of Port of New York and New Jersey. Presented by Maria Boile, Director of Research and Education, Maritime Infrastructure Engineering and Management Program (MIEMP), Rutgers, State University of New Jersey, with co-authors Sotirios Theofanis, Assistant Director, Strategic Development, Center for Advanced Infrastructure and Transportation, Rutgers, and Robert James, Senior Transportation Planner, Port Authority of New York and New Jersey.

Dr. Maria Boile characterized the collaborative project as an effort to quantify traffic impacts and prioritize capital and operational improvement activities to enhance freight flow efficiencies at the Port of New York and New Jersey. She described the project’s supporters
starting with the Port Authority of New York and New Jersey and four primary partners (NJDOT, NYSA, Maher Terminals, and TRANSCOM) as well as mentioning outreach to several other region stakeholders. Roles of these partners were briefly discussed.

Rutgers’ MIEMP leads the 3-year activities under a grant from the NSF. Maria described the overall project progress: first, the international supply chain movements in the NY/NJ metropolitan region were conceptually mapped, model networks were developed, and now micro-simulations are being used to examine port industry performance. The import supply was segmented into 3 tiers working with the Port Authority: Tier I from the berth to the port terminal fence line (under port operator control); Tier II from the fence line to the first point of rest, e.g., roads or rail to an international distribution center (under local/state government and CONRAIL control); and Tier III from the distribution center or warehouse to the shelf/business (under cargo owner’s control).

MIEMP’s current work is focusing on a mix of Tier I and Tier II road moves. Road networks for micro-, meso-, and macro-scales were developed using data from government agencies (particularly the North Jersey Transportation Planning Authority) and terminal operators. Micro- and meso-scale simulations were and continue to be conducted to examine individual truck local movements, routes to the first point of rest, congestion delays, etc. in an effort to identify actions that might improve port performance. Operational timing (24/7) options are being analyzed. Various strategies are being assessed with respect to the influence of terminal gate operations, virtual container yards, location and operations of freight villages, inland port facilities, truck restrictions, and roadway expansion options.

The partnership is demonstrating that academia can contribute to business and operational strategy development by applying research tools to predict outcomes of potential courses of action that government and industry could use to improve port performance. Maria concluded her comments by describing MIEMP’s activities in further developing their modeling tools, implementing results and, sustaining their institutional partnership.

Mississippi Valley Freight Coalition: Facilitating University-Industry-Government Partnerships. Presented by T. Adams, Director, National Center for Freight and Infrastructure Research and Education (CFIRE), Professor, University of Wisconsin, Madison

Similar to the first presentation, the second presentation was about a university-lead collaboration to improve freight mobility. In this case, however, the scale jumped from a single port complex to a multi-state region. The National Center for Freight and Infrastructure Research and Education (CFIRE) is a consortium of academic institutions including University of Wisconsin-Madison, University of Wisconsin-Milwaukee, University of Wisconsin-Superior, University of Toledo, and the University of Illinois-Chicago. CFIRE supports research to improve freight movement, increase freight capacity, and improve public sector decision-making related to freight. Dr. Teresa Adams began her talk by answering the question of why a broad-base multi-institutional partnership was essential to the Mississippi Valley region: “…to provide a regional voice” and “regional connectivity”.

Teresa described the importance of agricultural products and manufacturing enterprises to the economic health of the Midwest states. She discussed the linkages between freight transportation in the Midwest and the regional and the national economies. However the region’s goods are facing growing international competition in the marketplace while simultaneously facing growing congestion and bottlenecks on all modes. Since freight does not
know either jurisdictional or modal boundaries, it was prudent to organize the involved stakeholders including those across state-lines and extending to the local level to address these competitive issues.

The Mississippi Valley Freight Coalition (MVFC) began with high-level support and active participation among the state DOTs. The first workshop was held in April 2002. The MVFC organization is state directed but has significant Federal Highway Administration involvement. CFIRE acts as the facilitator. It quickly became apparent that “pooled funding” was necessary to meet the cross-jurisdictional challenges of freight mobility. That requirement led to the development and ratification of a Memorandum of Understanding among the partners in November 2006. Committees were established for the executive, technical, and customer partners. CFIRE not only took the role of facilitator but also leveraged available federal funding (utilizing their University Transportation Center, UTC, designation) and provided multi-disciplinary expertise to the organization. Teresa also mentioned CFIRE’s role as educator through their focus on future workforce development and providing UTC students access to the MVFC’s activities.

Dr. Adams described the current tasks under the MVFC agenda including work to increase public and political understanding of the freight mobility issues in the region such as presenting testimony to the National Commission on Surface Transportation and attending peer forums. There are activities relating to acting as a multi-state clearinghouse for freight traveler information, and undertaking research on parking issues, multi-modal bottlenecks, container vehicle load limits, etc., and of course continuing to build relationships among the partners. She emphasized the importance of sustaining communications among the participants to maintain a regional development agenda. Teresa concluded her presentation mentioning that activities are also underway to create regional standing of the Mississippi Valley as a unique freight corridor with its own importance and economic contributions.

Applying Operations Research to Improve Logistics Efficiency. Presented by Chelsea (Chip) C. White III, Milton and Carolyn Stewart Chair, Georgia Institute of Technology, and Hayriye Ayhan, Georgia Institute of Technology.

As with the first presentation, the final presentation addressed local freight mobility and congestions issues with respect to truck dray movements. Unlike the first presentation, this presentation described university-industry efforts to use real-time control of the supply chain. Dr. Chip White began his presentation by acknowledging that the concept of real-time control was conceived by the Intermodal Freight Technology Working Group and was initially for coordinating cross-town traffic to reduce empty moves between terminals. This talk discussed the potential partnership between university researchers and trucking fleets for a pilot study to be conducted in Kansas City for cross-town moves. Chip described the frequent requirement for multiple truck moves with international freight including land-bridge interruptions. He discussed the importance of truck moves in cross-town operations and their impact on congestion, pollution and safety. He suggested that increasing drayage fleet efficiency mitigates these impacts, and using real-time traffic data to improve real-time fleet routing and scheduling of truck movements was possible. Dr. White described the results of a simulated use of real-time traffic data for in-bound truck moves into an auto assembly plant in Southeast Michigan to illustrate the positive effects of the technique. He
mentioned the Georgia Institute of Technology project to examine the usefulness of the concept in the Kansas City area.

Dr. White introduces Hayriye Ayhan to discuss the methodology to be applied to routing decisions. Hayriye explained that a finite horizon Markov decision process would be used to solve the non-stationary stochastic shortest path problem. The solution would be generated with real-time traffic information obtained from sensors in trucks and loops that had been previously buried in the local roads. Cooperation with the data owner from the roadway sensors would be integrated with the truck sensor data as input data for the decision process. She proceeded to present the equations used in the Markov decision process and explaining that the calculation of the “optimal policy” for truck routing would occur while the truck is underway. Decision for the individual trucker to turn right, left or go straight would be determined by the “policy” calculated by the Markov process. A table was displayed that illustrated the potential vehicle usage reductions that could be achieved by application of real-time traffic data for several times during the day. These results suggested that savings of approximately 16 percent were possible during the period of heaviest flow. The conclusions offered were that vehicle routing integrated with real-time information technologies would benefit cross-town freight movement. Another conclusion was that university researchers, government agencies, and freight transportation operators working together could improve traffic flows for freight. Furthermore, this approach had many other applications including private vehicle routing, emergency situations, and other real-time information technology business uses.
Conclusion and Summary

MICHAEL D. MEYER
Georgia Institute of Technology

This conference focused on an important challenge facing the U.S. transportation system—congestion and system performance as they relate to the movement of freight and goods. In the two days of discussion, conference participants made numerous observations to help define the research opportunities that could contribute to improved system performance. The following summary is organized in four sections relating to the focus of conference activities.

Major Themes
Conference participants identified a long list of issues and factors that are important considerations when thinking about freight-related research that could truly have a positive impact on the freight sector.

Context Factors:

• Understanding the costs throughout the supply chain is an important point of departure for influencing logistics decisions and freight flows. This includes looking at the total costs in the supply chain, the individual cost components and the costs associated with environmental mitigation.

• Many of the participants noted that the cost of fuel has had a significant impact on logistics decisions and this will likely continue in the future. There is thus a need to focus on this important input in overall cost accounting and to examine both technologies and service strategies that improve fuel efficiency or reduce fuel consumption.

• One of the greatest challenges likely to face the freight sector relates to environmental sustainability and green approaches to distribution and production. This relates to the relationship between freight movement and the natural environment; less polluting and more efficient technologies, especially fuel; community impacts; and land use issues. This discussion led to a stated need for descriptions of best practices in each of these areas.

Decision-making Environment:

• The public decision-making process requires that the benefits of improvements to any transportation system be clearly understood and articulated. This is especially true for public investment in facilities or services that will benefit the freight sector, an area that has traditionally not received public attention.

• Several carriers and shippers noted the important of “external” factors in influencing freight transport decisions, ranging from congestion on port access roads to a varying monetary climate throughout the world (such as the value of the U.S. dollar in international markets). The point that being made was that even though many models focus on the internal transport production process, it is often these external factors that have more influence on final logistics decisions.
A representative from WalMart described the dynamic nature of the logistics decisions made by one of the largest shippers (and carriers) in the United States. The logistics strategy is frequently examined and modified based on the conditions being faced at any particular point in time, as well as an estimate of what the near future will bring with respect to production factors (such as the price of fuel).

With respect to both public and private organizations, how does one incorporate a performance management perspective into the decision making process? Performance management was distinguished from simply using performance measures.

Given the global and national scale of logistics and freight decisions, there is a need for a national perspective on where national investments should be made to enhance the competitiveness of the U.S. economy. However, this begs the question of how does one make such a decision and on what types of investments.

Analysis Methods and Tools:

Not surprisingly, conference participants noted the importance of quality data and data-driven analysis, as well as incorporating approaches for dealing with uncertainty in the analysis methods.

Freight network modeling needs to provide results that are of direct interest and use to those making service planning decisions. In addition, model results can examine overall network efficiencies and productivity. This is particularly important for service strategies that change over relatively short time periods. However, it is important to understand there are many different levels and types of models and analysis tools that relate to the types of decisions being made on freight movement (see Figure 1).

![Different Types of Analysis Tools Relating to Levels of Decision Making](image)

**Figure 1: Different Types of Analysis Tools Relating to Levels of Decision Making**
• A systems perspective is essential in examining the real interactions that occur in freight flows. This implies an analysis focus on important variables, variable relationships and linkages, network definitions and representation of service factors, etc. In particular, this requires building connectivity into the network model. Two examples that conference participants identified as an example of the systems nature of freight analysis were the impact of larger container vessels and new free trade agreements on the magnitude and distribution of freight flows in the world.

• Although many network models report on speed and flows, the more important measures are network path reliability and the flexibility/redundancy in network design.

*Institutional Issues:*

• Much of the institutional-related discussion related to the role of public investment in benefitting freight movements. Important questions included: what can the public sector do to improve freight efficiency? How can public investment be defined and presented as a “business case”? How can public and private benefits be allocated to the different actors involved in an investment? How have both public and private firms collaborated successfully with respect to freight investments? What are the different types of funding strategies that can be considered? What lessons can be drawn from historical experience with different approaches to influence freight flows—regulations, incentives, etc.?

*Issues That Did Not Receive Much Discussion*

Given the limited amount of time available to conference participants, it is not surprising that not all of the pressing issues facing the freight sector received sufficient attention in the conference discussions. Participants were thus asked to identify those issues that they felt were important today or even more so in the future (especially those that related to potential research). The following topics were noted as being especially important.

• Security and the need to provide secure entry into the United States, but in a way that does not seriously interfere with freight flows. Concerns were expressed on better understanding the balance between security needs and operational efficiency, especially at ports and border crossings. This topic also related to the importance of network resiliency and redundancy when an incident does occur. The security of food transport was identified as a topic that has received very little attention.

• Although data was noted as an important issue, not much discussion occurred on the need for real-time data collection and the linkage of this data to traffic management centers. What are the best strategies for data mining? There was a perception that there is a high potential payoff in the use of advanced technologies in providing data collection and data base management capability.

• Very little discussion occurred on the different types of strategies that could be used to improve accessibility and efficiency of freight movements, especially at ports. What is the impact of congestion pricing on truck and freight movement? This is especially important during peak flow periods. In addition, a very important question was asked on what happens if congestion is not reduced significantly? What are the implications to the economy? To logistics decisions? To regions?
• Although institutional issues were identified as an overarching issue, there was little discussion on how one implements a multi-jurisdictional strategy, and on the types of strategies that might be appropriate for rural and small communities. Who wins and loses when international trade increases? What form of compensation is necessary for those who bear the costs of this increased trade, but not the benefits? In addition, and linking to the data collection topic, conference participants felt there was a real need to incorporate freight data more effectively in the transportation planning process.

• Multiple levels of decision making were identified that could have some influence on freight movements (see Figure 2). What are the types of metrics that might be appropriate at different scales and levels of decision making?

<table>
<thead>
<tr>
<th>Decision Making Context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
</tr>
<tr>
<td>Multi-National (e.g., NAFTA)</td>
</tr>
<tr>
<td>National/Federal</td>
</tr>
<tr>
<td>MegaRegions, Multi-state, Market-oriented, Trade corridors</td>
</tr>
<tr>
<td>State</td>
</tr>
<tr>
<td>Metropolitan</td>
</tr>
<tr>
<td>Local/Site</td>
</tr>
</tbody>
</table>

Figure 2: Different Levels of Decision-making and Scales of Analysis

• Participants noted that the major focus of the conference was on research, but that the freight industry was also facing significant human resource needs and that universities can play an important role in this issue through short courses, certificate programs, curricula, etc.

Research Directions
The conference devoted time to discussions on research directions and how to improve collaborative research on topics of interest to the freight sector. The following sections summarize the conclusions made in several topical categories.

Topics not well researched -- Conference participants concluded that most, if not all, of the issues described above deserved more attention from the research community. In particular, participants noted that the topics not well researched included such issues as understanding the institutional and policy strategies used elsewhere in the world and how they could be applied in a U.S. context; delineating the characteristics of successful collaborations between public and private organizations that have benefited the freight sector; identifying the impacts of global
market changes on the national, regional, state and metropolitan economies; improving nodal operations (such as port operations) through non-conventional strategies; and using “almost-good-data” for network analysis.

*Research topics most appropriate for university research* – A major purpose of this conference was to identify research directions and projects that could become part of a structured university research program on freight and logistics issues. The types of research projects that were identified as being most appropriate for university research community included:

- New concepts, strategic thinking and innovative analysis approaches, especially as they relate to larger scale, multi-jurisdictional applications
- Evaluations of innovative implemented strategies and projects
- Case studies, syntheses and documentation of state-of-the-practice of freight-related strategies
- Interdisciplinary policy and institutional analyses of implemented strategies, with special focus on distributional impacts; also for politically controversial “lightening rod” issues
- Technology applications and material sciences

*Research topics most appropriate for government/industry/university collaboration* – Participants understood that the most effective research on freight and logistics issues would most likely include collaborative relationships with government and industry groups. However, several types of topics were considered most conducive to such collaboration, including public policy issues relating to intermodal transportation and those relating to community impacts; proof-of-concept projects; decision support frameworks that encompass the wide range of potential impacts; data resource design and development; program evaluation; social, community and sustainability issues; and projects that examine moving technology to application.

*Characteristics of successful collaboration* – Given the need for collaboration in many of the types of research projects that focus on freight issues, conference participants next described the characteristics of successful collaboration. Many of these characteristics are really applicable for all types of research, not just those relating to collaborative efforts on freight topics. The characteristics included:

- Providing research results that clearly benefit the participants and sponsors, building upon the strengths and capabilities of the research participants
- Establishing early on what the expected results should accomplish
- Building a consensus and bringing different agency agendas together on a common interpretation of research results
- Providing research results that are actionable, and that can be implemented in a reasonable time frame
- Creating long-term relationships that can lead to further research; participant should leave a particular research project with improved understandings or skills

Although these characteristics of collaboration seem obvious, conference participants also identified many barriers to such efforts, many of which are inherent to a university-based research program. The more common issues included such things as intellectual property rights,
use of graduate students (who will only be on a project for a short time), need for scholarly products, building of trust and credibility, and the need for funding for basic research (given that most research sponsors are more interested in applied research). With respect to collaborative freight research, the issues included managing the expectations of very different agencies and organizations, dealing with the challenge of research results not meeting the expectations of research sponsors, and an often disciplinary-focused research effort on what is inherently a multi-disciplinary issue.

**Priority Research Agenda**

Conference participants identified a freight research agenda that encompassed a broad range of topics deserving of attention. In no particular order of priority, the freight research agenda includes:

- **Broad relationships between economic factors and freight transportation demand.** A changing global market, and perhaps more importantly the often rapidly changing variables that influence logistics decisions, need to be better understood and incorporated into our world view of the supply chain.

- **Environmental sustainability and the strategies the freight sector can apply to become more environmentally neutral.** What metrics can be used to measure this? What are the effects of such strategies on the overall supply chain?

- **Freight planning and analysis frameworks.** Participants felt strongly that the freight planning process needed to be strengthened, including the use of improved data, new optimization tools, use of return on investment analysis, and better feedback into the planning process of the effectiveness of newly tried strategies.

- **Technology applications.** The role and application of new technologies to managing the supply chain as well as the public infrastructure that supports freight movements is an area that will continually change. There was a sense at the conference that technology applications could be a very important key to the future efficiency of freight movement in the United States.

- **Institutional structures and issues.** The respective roles of public and private organizations and the funding strategies used by each will continue to be an important topic for research in the foreseeable future.

- **Workforce issues.** An aging population and changing population demographics will mean that the future workforce in the freight sector will be very different than that of today. There was a sense among conference participants that important studies can be done in understanding the implications of these changes on the freight industry and, in particular, combine these studies with the technology focus from above.

Finally, although the focus of this conference was on research, many participants noted that universities can play many different roles and contribute in a variety of ways. The most noted role was as an educator and trainer of the next generation of transportation professionals. In addition, universities can act as a neutral forum or evaluator in considering controversial topics. The most important characteristic for all of these efforts was the collaborative nature of the identification of key issues facing the freight sector.
POSTER SESSION

Modeling Truck Traffic Volume Growth Congestion

MICHAEL ANDERSON
University of Alabama at Huntsville

Project Description. Modeling the statewide transportation infrastructure system is an important element in the identification of congestion locations and programming of funds to avert future congestion. As Alabama continues to grow its manufacturing economy, as has recently been occurring in the automotive and aerospace sectors, the number of heavy vehicles traveling on Alabama roadways will continue to rise, straining already limited infrastructure. This project is developing improved modeling tools consisting of a traditional travel demand modeling software coupled with a discrete event micro-simulation program to develop potential growth scenarios to analyze the resulting traffic congestion. The results from the successful completion of this project will include modeled scenarios identifying key congestion chokepoints and the establishment of a modeling tool that can effectively examine additional alternative scenarios in the future.

Background. The ability to make reasonable decisions regarding transportation investment is limited by the quality and quantity of information available on the transportation infrastructure. The ability to accurately model transportation systems, identify congestion choke points, and define needed capacity shortfalls is vital to the decision-making needs to support the transportation systems for both people and goods.

The movement of freight in a timely and efficient manner is quickly becoming one of the critical components of the U.S. economy. Heavy vehicles, 18 wheel trucks, are the backbone of the logistics and economic success of industry in the United States. National projections are that freight shipments will double in the next ten years. The increase in freight will have a significant impact on the level of congestion along the national transportation infrastructure and will require innovative congestion mitigation solutions. A detailed understanding of the impact of the projected increase in truck traffic on the existing highway system is needed to examine in the potential outcomes and develop a focused plan to accommodate the anticipated increase.

Process. The methodology studied in this research is the application and combination of urban planning model with a discrete event simulation. The urban planning model was used, with forecasted industry cluster data, to generate freight trips and distribute the trips based on survey results from representatives of the major industries in Alabama. Then, the trip exchange matrix is passed to a discrete event simulation model that determined the time-of-day congestion locations on the existing infrastructure. The discrete event simulation also provides a visual communication tool for educating the general population and governing officials not involved in the transportation industry.

This project will build upon existing transportation analysis and planning tools developed at the University of Alabama in Huntsville under a grant from the USDOT to develop a model to examine statewide freight transportation. The first of these tools is a statewide zone structure, using counties, and a highway network developed in TRANPLAN, a generally accepted travel
demand model, which has been modified and enhanced to support a statewide freight analysis. The travel demand model will be used to distribute freight trip productions and attractions developed from a disaggregation of the Freight Analysis Framework Version 2 (FAF2) between the various counties in Alabama.

The second tool is the Alabama Transportation Infrastructure Model (ATIM). The ATIM is an analytical tool that utilizes discrete-event simulation to model traffic flows over multiple 24-hour periods. By using discrete-event simulation, the ATIM is able to incorporate the stochastic random variation inherent in transportation systems with the raw traffic data collected by government, industry, and academic entities. This random variation is visible in the complex interactions of freight movement across the transportation infrastructure network and through intermodal transfer points. Freight traffic and passenger automobile traffic are independently calculated, and combined, to simulate overall traffic flows on the roadways. Railway and waterway transportation systems are also modeled to show the dynamics between the multiple shipping modes.

The research effort conducted in this project will develop a seamless interface between the two models to allow for easy sharing of volume, route and Origin/Destination data. The integration of these models will produce a tool capable of quickly analyzing scenarios and events on the transportation infrastructure that can be used to evaluate alternative solutions.

**Findings and Conclusions.** The results of the combined urban planning and discrete event simulation models is a tool with the ability to quickly evaluate options for infrastructure improvements and provide input to return on investment questions when deciding where to invest scarce infrastructure funds. The identification of congestion chokepoints within Alabama as well as a listing of high priority capacity improvements needed to ensure the continued mobility of the state highway infrastructure system are numerous and a validated tools with the capabilities presented in this summary is desperately needed. The interface that is under development will be capable of passing data between the programs allows for the efficient transfer of data, while preserving the nature of the individual programs.

**Recommendations for Further Action.** The combined system is developed and being tested with various scenarios. Future actions involve the refinement of the interface and the interrelationships between the two model types. Further enhancement of both models will also require continued refinement of the interface programs. The application of the combined tool and achieving acceptance of the tool results are all necessary further endeavors.

**Contact Information**
Heather Shar  
The University of Alabama in Huntsville  
Email: sharh@uah.edu  
Phone: 256-824-6248

Michael Anderson, Ph.D., P.E.  
The University of Alabama in Huntsville  
Email: mikea@uah.edu  
Phone: 256-824-5028
Acknowledgements. This research was sponsored by the University Transportation Center for Alabama, Project No. 07304.
Description. The current paper presents a summary of selected research projects at the Center for Metropolitan Transportation Research (METRANS, a joint Center between the University of Southern California and California State University, Long Beach) on issues related to efficient cargo movement in metropolitan transportation networks. In particular we present studies on empty container interchange, truck routing in metropolitan areas, and vehicle routing in the presence of uncertainty. The transportation network surrounding the twin ports of Los Angeles and Long Beach is used as our area of application.

Background. The research conducted here, is in response to the pressing needs for mitigating traffic congestion in the areas around container terminals, and for improving efficiencies within the terminals.

The elimination of international trade barriers, lower tariffs and shifting centers of global manufacturing and consumption has led to new dynamics in intermodal shipping. Worldwide container trade is growing at 9.5% annually, and by 2010, it is expected that 90% of all liner freight will be shipped in containers. Every major port is expected to double or triple its container traffic by 2020, which in turn will result in higher traffic congestion and increased air pollution. If we focus our attention on the three main container port complexes on the West Coast (Long Beach & Los Angeles, Seattle & Tacoma, and Oakland), we see that they handle almost 50% of the container traffic in the U.S. (a combined volume of 17,000,000 TEU for the West Coast out of 35,500,000 TEU total volume for the nation in 2003). The port complex of Long Beach & Los Angeles, the largest container port in the nation and the 3rd in the world, handles 33% of the total container traffic in the US. This huge volume moving from the local ports to the final destinations creates major congestion problems throughout the local transportation networks, and has very serious effects not only at the local and regional levels, but on a national scale as well.

The research has been sponsored by METRANS, a University Transportation Center funded by the U.S. Department of Transportation and the California Department of Transportation (CALTRANS).

Process. Many of the research projects at METRANS investigate potential strategies for traffic congestion mitigation. The strategies are formulated and studied analytically, and further investigated via simulations. The strategies presented in this paper include:

Empty Container Interchange. Empty container repositioning is one of the most significant contributors to the congestion at and around marine ports. For instance, in the year
2000 alone, 2.5 million out of 5.1 million containers moved in and out of the LA/LB ports were empty containers, which indicates that a significant number of truck trips in the LA/LB port area involves movement of empty containers. Such trips may be reduced if more sophisticated techniques are used to deal with empty containers. In our research we model and analyze the empty container repositioning practices.

**Truck Routing in Metropolitan Areas.** We investigate methods for improving the scheduling of trucks used to transfer ISO containers between marine terminals, intermodal facilities, and end customers. Each of these customers/facilities may have imposed time-window constraints on pick-up/drop-off containers. The objective is to reduce travel miles, and to improve customer service (i.e., satisfying the time-windows at customers/facilities locations). We formulate the problem and compare the solutions obtained by three different methodologies: (i) An exact method based on dynamic programming; (ii) A hybrid methodology consisting of dynamic programming in conjunction with genetic algorithms; (iii) A suboptimal heuristic insertion method.

**Robust Vehicle Routing in the Presence of Uncertainty.** This type of problem is faced daily by courier services, local trucking companies, and demand responsive transportation services. We develop a new methodology that aims at a robust routing solution, where by robust solution we mean the solution which has the best worst case uncertainty. Using real industry data, we construct representative uncertainty models for uncertain demands and uncertain travel times.

**Findings and Conclusions**

(a) *Empty Container Repositioning Strategy:* We use the current practices as the baseline, and we show that interchanging the empty containers outside of the ports can greatly reduce truck trips within the metropolitan area, thus mitigating congestion and reducing air pollution.

(b) *Truck Routing Problem:* The developed methodologies are applied to real data obtained from the dispatching center of a trucking company in the LA/LB metropolitan area. We show that the heuristic insertion method is computationally very fast and fairly efficient for medium to large size problems, and as such it can be used effectively to solve problems in real time.

(c) *Robust Vehicle Routing Strategy:* We determine routing solutions that consider travel time and demand uncertainties, and we introduce benchmarking metrics of interest to compare the performance of these solutions.

**Recommendations.** Future actions include a detailed mapping of the demands and supplies of empty containers in the Southern California region. The developed methodology will be applied to the detailed map, and the benefits of empty container reuse will be more accurately quantified. Regarding vehicle routing, future plans include introduction of uncertainty in the cost, the development of special solution procedure and implementation to a real life application.

**Contact Information**
Dr. Anastasios Chassiakos  
College of Engineering  
California State University  
Long Beach, CA. 90840  
Phone: 562-985-4278  
Email: achassk@csulb.edu
Advanced Technologies To Improve Cargo Movement In Metropolitan Areas With Applications To The Los Angeles/Long Beach Area

ANASTASIOS CHASSIAKOS, GEN GIULIANO, JOHN HEIDEMANN, PETROS IOANNOU

University of Southern California and California State University, Long Beach

Description. The current paper presents a summary of selected research projects at the Center for Metropolitan Transportation Research (METRANS, a joint Center between the University of Southern California and California State University, Long Beach) on issues related to advanced technologies for improving cargo movement in metropolitan areas. In particular, we present studies on the concept of automated container transport between inland port and terminals; on networks of inexpensive traffic sensors for vehicle classification; and on the development of a simulation test-bed for the evaluation of truck movement strategies. The transportation network surrounding the twin ports of Los Angeles and Long Beach is used as our area of application.

Background. The research conducted here, is in response to the pressing needs for mitigating traffic congestion in the areas around container terminals, and for improving efficiencies within the terminals.

The elimination of international trade barriers, lower tariffs and shifting centers of global manufacturing and consumption has led to new dynamics in intermodal shipping. Worldwide container trade is growing at 9.5% annually, and by 2010, it is expected that 90% of all liner freight will be shipped in containers. Every major port is expected to double or triple its container traffic by 2020, which in turn will result in higher traffic congestion and increased air pollution. If we focus our attention on the three main container port complexes on the West Coast (Long Beach & Los Angeles, Seattle & Tacoma, and Oakland), we see that they handle almost 50% of the container traffic in the U.S. (a combined volume of 17,000,000 TEU for the West Coast out of 35,500,000 TEU total volume for the nation in 2003). The port complex of Long Beach & Los Angeles, the largest container port in the nation and the 3rd in the world, handles 33% of the total container traffic in the US. This huge volume moving from the local ports to the final destinations creates major congestion problems throughout the local transportation networks, and has very serious effects not only at the local and regional levels, but on a national scale as well.

The research has been sponsored by METRANS, a University Transportation Center funded by the U.S. Department of Transportation and the California Department of Transportation (CALTRANS).

Process. Many of the research projects at METRANS investigate and develop advanced technologies to improve cargo movement, and reduce its negative effects on traffic. The technologies are studied analytically, experimentally and through simulations. The technologies presented in this paper include:
(a) The ACTIPOT Concept (Automated Container Transport System Between Inland Port and Terminals). The ACTIPOT concept involves the use of automated trucks to transfer containers between an inland port and container terminals. The inland port is located a few miles away from the terminals and is used for storing and processing import/export containers before distribution to customers or transfer to the terminals. In our research we design and analyze the ACTIPOT system with particular attention paid to the overall supervisory controller that synchronizes all the operations inside the ACTIPOT system. We employ the technique of truck platooning in order to simplify the control of the overall system and to minimize the possibility of deadlocks, congestion, and failures.

(b) Network of Inexpensive Traffic Sensors for Vehicle Classification. The purpose of this research is to demonstrate the feasibility of using sensor networks in traffic monitoring applications, specifically a rapidly deployable network of traffic sensors. A sensor network is an array of sensors attached to small computer nodes that have communications capabilities via wireless network. Our application problem is heavy duty truck data: vehicle classification and re-identification, particularly under slow or varying speed conditions. An experimental sensor, the IST Blade sensor, was used for our initial experiments.

(c) Evaluation of Truck Movement Strategies through a Simulation Test-bed. In this study we develop a microscopic simulation test bed that allows us to investigate the impact of various technologies and concepts on the terminal capacity and cost as well as on the traffic network outside the terminals in an integrated manner. The test bed is used to evaluate and analyze two truck movement concepts: (1) the use of an inland port with dedicated truck lanes (the ACTIPOT system) and (2) empty container reuse strategies. As a case study, a particular terminal from the Los Angeles/Long Beach port complex with associated traffic network outside the terminal is used to demonstrate the use of the test bed in evaluating and quantifying benefits associated with the proposed truck movement strategies.

Findings and Conclusions

(a) The ACTIPOT Concept: A feasible application of the ACTIPOT system was investigated as a case study, between Pier G Mega Terminal at the port of Long Beach and Union Pacific’s ICTF (intermodal container transfer facility) located a few miles north of the port. A microscopic simulation model was developed and used to demonstrate that the proposed system can operate in a safe manner and achieve desired performance in terms of container throughput.

(b) Network of Inexpensive Traffic Sensors for Vehicle Classification: We conducted a field experiment on the University of Southern California campus in order to collect data for development of classification algorithms. The results are encouraging: classification accuracy is comparable to that of other recent research efforts.

(c) Evaluation of Truck Movement Strategies through a Simulation Test-bed: The results of using the test bed to evaluate the empty container reuse strategies show that empty reuse can improve terminal capacity and traffic conditions on the roadway network. Simulation results from the evaluation of the inland port concept suggest that this concept should be considered very carefully, in conjunction with modifications to the existing roadway network, which will be necessary to accommodate the resulting traffic conditions.

Recommendations. For the ACTIPOT system, issues that require further investigation are cost analysis, acceptance by terminals and other stakeholders, and technical issues such as particular
choices of sensors, actuators, equipment based on cost, reliability, and performance considerations.

Regarding the network of traffic sensors, once we have developed acceptable classification algorithms, two directions are apparent for future research: use of multiple sensors with the goal of improving classification results, and the use of vehicle signatures to allow re-identification of vehicles across multiple sensors.

Contact Information
Dr. Anastasios Chassiakos
College of Engineering
California State University
Long Beach, CA. 90840
Phone: 562-985-4278
Email: achassk@csulb.edu
POSTER SESSION

Evaluation Of Strategies For Efficient Cargo Movement And Public Policy Implications

GEN GIULIANO, HAHN LE-GRIFFIN, KRISTEN MONACO, JAMES MOORE and TOM O’BRIEN

University of Southern California and California State University, Long Beach

Description. The current paper presents a summary of selected research projects at the Center for Metropolitan Transportation Research (METRANS, a joint Center between the University of Southern California and California State University, Long Beach) on issues related to evaluation of strategies for efficient cargo movement in metropolitan areas and public policy implications. In particular, we present studies on the terminal gate appointment system; on wages and working conditions of drivers at the port of Long Beach; and on short sea shipping

Background. The research conducted here, is in response to the pressing needs for mitigating traffic congestion in the areas around container terminals, and for improving efficiencies within the terminals.

The elimination of international trade barriers, lower tariffs and shifting centers of global manufacturing and consumption has led to new dynamics in intermodal shipping. Worldwide container trade is growing at 9.5% annually, and by 2010, it is expected that 90% of all liner freight will be shipped in containers. Every major port is expected to double or triple its container traffic by 2020, which in turn will result in higher traffic congestion and increased air pollution. If we focus our attention on the three main container port complexes on the West Coast (Long Beach & Los Angeles, Seattle & Tacoma, and Oakland), we see that they handle almost 50% of the container traffic in the U.S. (a combined volume of 17,000,000 TEU for the West Coast out of 35,500,000 TEU total volume for the nation in 2003). The port complex of Long Beach & Los Angeles, the largest container port in the nation and the 3rd in the world, handles 33% of the total container traffic in the US. This huge volume moving from the local ports to the final destinations creates major congestion problems throughout the local transportation networks, and has very serious effects not only at the local and regional levels, but on a national scale as well.

The research has been sponsored by METRANS, a University Transportation Center funded by the U.S. Department of Transportation and the California Department of Transportation (CALTRANS).

Process. Many of the research projects at METRANS obtain field data on various aspects of port related activities. Field data are used to compare and evaluate strategies that have already been implemented or are under study, regarding their effectiveness and their public policy implications. The studies presented in this paper include:

(a) Terminal Gate Appointment System. The California Assembly Bill AB-2650 imposes a fine on terminals if trucks waited longer than 30 minutes to enter the gates. Implementation of a gate appointment system for trucks was one means available to terminals to avoid possible fines. The objectives of the appointment system are to reduce truck waiting and idling time
outside marine terminal gates, and to distribute truck traffic more smoothly throughout the day to ameliorate the peaking phenomenon. In our research we conducted a comprehensive evaluation of AB-2650 to assess: (a) the impact of appointment system on air quality; (b) the response of trucking community; (c) the effectiveness of regulating trucks outside the gate as a means of changing terminal behavior inside the gate.

(b) **Wages and Working Conditions of Drivers at the Port of Long Beach.** Surveys of truck drivers at the Port of Long Beach were conducted in 2004. Using independent variables such as driver experience, tenure, race, place of birth (US born or not), firm size, owner operator, destination terminal, etc. and compiling the data from the survey responses, we constructed statistical models of earnings, waiting time during a trip to/from the port, and safety of chassis provided to the truck driver.

(c) **Short Sea Shipping.** In our research we assess what potential Short Sea Shipping holds for alleviating the congestion occurring on Southern California’s regional surface transportation system. Focusing on specific commodity and market segments, a number of shipments could be shifted to short sea shipping movements. Specific opportunities in Southern California are found with the re-directing of empty container flows to secondary ports, as well as with international movements to and from the manufacturing areas on the U.S.-Mexico border. Consideration was given to which type of maritime and port operation might be best suited for these market segments, and the use of RO-RO vessels was determined to be suitable for initial operations.

**Findings and Conclusions**

(a) **Terminal Gate Appointment System:** Among other conclusions, our evaluation showed that:
- A wide range of appointment policies are implemented across terminals;
- Appointments are primarily used for import pick-ups (42% of total transactions involve appointments);
- Appointments do not directly translate into reduced turn time; There is no evidence that transactions with appointments are shorter than those without appointments.

(b) **Wages and Working Conditions of Drivers at the Port of Long Beach:** Our research shows that the truck drivers, lower paid than truckers nationally, receive no returns to experience or tenure and spend, on average, 48 percent of their work day waiting to get into and out of the port. Paid by the trip, there is little incentive for firms to use drivers’ time efficiently and a great deal of pressure for drivers to complete trips quickly. We find that drivers who own their trucks have a higher probability of accepting unsafe chassis and taking them on the road. We conclude that the inefficient use of drivers’ time leads to negative externalities of pollution and unsafe driving.

(c) **Short Sea Shipping:** The study finds support for implementation on the West Coast, and argues in favor of the establishment of regional port systems to provide an appropriate institutional apparatus for the coordination of public and private investments in Short Sea Shipping.

**Recommendations.** The future use of appointments will depend upon both legislative pressures and the need to better accommodate increased container throughput during off-peak hours.

Regarding the Short Sea Shipping services, they could be introduced as part of a regional port system. Such a system would strengthen and add sustainability to the region’s container handling capacity, create alternative commercial corridors away from the most congested urban centers, and increase the reliability and security of the transportation system. Some likely next
steps should be taken to determine how regional port systems might be formed and administered, to quantify the economic development benefits that would accrue by this to both the private and public sectors, to determine the level of landside transportation and marine port investments necessary to establish a regional port system and implement SSS operations, and to identify the legislative measures required to authorize a regional port system. These steps would serve the interests of nearly all stakeholders involved in regional transportation and logistics, and provide the West Coast with a more reliable marine transportation system and one that is closely integrated with landside transportation systems.

Contact Information
Dr. Anastasios Chassiakos
College of Engineering
California State University
Long Beach, CA. 90840
Phone: 562-985-4278
Email: achassk@csulb.edu
Research Needs Reported by Industry

MATTHEW R. CUDDY and JOSEPH L. SCHOFER
Northwestern University

Project Description. This research was conducted to identify key challenges facing the transportation industry as seen by its senior executives. We surveyed top-level executives in companies involved in various aspects of transportation—shippers, carriers from all modes, finance, consultants, and other service providers. All of these executives are members of the 90-person Business Advisory Committee of Northwestern University’s Transportation Center; nearly all of them work exclusively with freight. The aim was to develop a better understanding of industry problems and research needs, and to use that information to inform an academic research program.

Background. The Transportation Center has maintained a long-standing relationship with the transportation industry through its Business Advisory Committee (BAC), which provides advice and guidance on academic and research programs, and serves as a window on the industry for faculty and students. As a part of a program to reinvent the Center, a proactive exploration of industry research needs and priorities was initiated to find common areas of interests and capabilities between leading industry representatives and Transportation Center faculty and students. A survey instrument was designed to test the hypotheses that executive surveys could elicit productive research priorities that would indicate opportunities for scholarly work.

Process. In October 2006, an open-ended survey was disseminated electronically to the members of the BAC. The survey contained two items of general interest:
1. What are the most significant transportation-related challenges that your company will face in the next five years?
2. What new methods, information and understanding could help you meet these challenges?

Response rates were boosted by repeated e-mails and personal contacts. Responses were collected until January 2007. Ninety-four surveys were sent out and thirty responses were received. This response rate, 32%, was deemed acceptable given that the typical committee member surveyed had titles such as President, CEO, Vice President for Logistics, etc. Responses were analyzed and organized, returned to the members of the BAC for confirmation and as a progress report, and distributed to faculty and staff.

Findings and Conclusions. Across transportation industry modes and roles, we found three consistent priority areas:
- Congestion, capacity and infrastructure,
- Workforce recruitment and retention, and
- Changing regulatory environments.

Generally, policy statements from the various industries approximate our survey results. The American Transportation Research Institute annually conducts a survey of truck fleet operators. In the 2006 survey results, driver shortages and retention ranked first and third
respectively. Highway congestion, infrastructure, and funding ranked fifth, seventh, and ninth. Hours-of-service regulation ranked fourth. The 2006 annual report of the Air Transport Association cites air traffic control modernization as its top priority, for reasons of capacity and safety. The Association of American Railroads website emphasizes infrastructure regulation & policy.

Nonetheless, this custom survey of transportation executives did produce concrete results that are guiding the Transportation Center's research agenda. Seed money was offered to faculty to encourage them to engage in research identified in this survey. Two summer projects were supported, one in traffic data management and one in congestion pricing by a trucking company.

Recommendations for Further Action. These responses have become the basis for an enhanced dialog with the transportation industry, and for shifting ways of talking about applied research in transportation and logistics. Transportation Center leadership plans to organize some of its interactions with the advisory committee around the findings of this survey. For example, small-group symposia are planned to bring industry respondents with shared concerns together with Northwestern academics, for brainstorming and problem formulation sessions. This survey will be repeated at least biennially to track trends in industry research needs and interests.

Contact Information
Matt Cuddy, Ph.D.
Research Coordinator at the Transportation Center at Northwestern University
m-cuddy@northwestern.edu
(847) 491-2787.

Appendix: Sample of Detailed Responses — “Transportation-Related Challenges”

- Infrastructure/congestion (18 total responses)
  - Coping with local and regional opposition to infrastructure projects (rail carrier)
  - Government investment in waterway infrastructure (waterway carrier)
  - Port capacity (shipper, consultant)
  - Rail infrastructure limitations (shipper, consultant, rail carriers)
  - Ever-increasing traffic density of US airspace (air carrier)
  - Infrastructure at border crossings inadequate to cope with major volumes (other)
- Recruiting and retention at all levels, in the face of accelerating retirements (8 responses)
- Regulation (6 total responses)
  - Responding to regulatory pressures on the spirit and letter of the Staggers Act (rail carriers)
  - Excessively restrictive returns on equity allowed by the FERC (pipeline)
  - Continued tightening of requirements for environmental and security reasons. (highway carrier)
- Consolidation & interfirm relationships
  - Consolidation of the industries which are our target customers – finding the right person at the right time and business changes. Understanding the critical events that lead to change in their supply chain. (highway carrier)
  - Interline relationships—mergers, acquisitions, strategic partnerships (rail carrier, shipper)
- Security in the supply chain (“security and logistics”) (shipper)
- Freight visibility throughout the entire supply chain (consultant)
Research Needs Synthesized from Survey Results

**Ensuring sufficient capacity – concerns for all modes, networks, and terminals**
- Methods for financing capital investments
  - Achieving sufficient return on investment to buy needed private infrastructure capacity, and guarding against unnecessary regulatory constraints on prices/earnings
  - Shaping public policy to ensure sufficient government investment in public infrastructure. Evaluating the case for public investment in terms of economic and social benefits
- Practical decision support tools for setting investment priorities, selecting projects and policies
  - Avoiding overbuilding in infrastructure renewal – investing with care
- Project implementation tools – strategies for building support, overcoming obstacles, and fostering effective public-private partnerships
- Operational strategies for getting the most throughput from fixed infrastructure

**Improving operational performance for efficiency, fuel economy, and safety**
- Tools for shipment consolidation, dispatch, and routing
- Information technologies

**Securing and deploying the workforce necessary to survive and thrive**
- Strategies for attracting and retaining skilled workers
- Response to large-scale retirements
- Approaches for negotiating realistic work rules and wage rates
- Avenues and incentives for attracting young people to career opportunities in transportation and logistics

**Dealing with regulations and the prospect of re-regulation**
- Measures of costs and benefits of environmental and security regulations
- Responses to regulatory restrictions on return on investment
- Responses to relaxation of regulations on truck size and weight
- Strategies for defusing re-regulation of railroads

**Managing supply chains**
- Methods to deal with inventory volatility
- Actions to ensure security in supply chains
- Performance measures applicable across the supply chain

**Anticipating and responding to change**
- Strategies for maintaining, managing and developing interfirm relationships in the context of continued consolidation
- Methods to predict future technology, markets, resources and prices, policies and regulations
- Studies to identify best practices across organizations and modes: surveys, case studies
Project Description. There is considerable controversy about the relation between diabetes and commercial truck crashes and no information about the crash risk of those with impaired glucose tolerance. We conducted a 1-year pilot (prospective cohort) study to determine the relationship between being a commercial-truck driver (CTD) with impaired glucose tolerance and the risk of being involved in a commercial-truck crash.

Background. The United States Commercial Trucking Industry accounts for ~$250 billion annually, 75% of goods shipped in the country based on value, and 66% of goods based on weight. In the United States, there are nearly 1.8 million commercial truck drivers and 7 million commercial trucks driving 200 trillion miles annually. There are over 400,000 police reported truck crashes annually in the United States, with approximately 5,000 fatalities and 86,000 injuries. Roughly 14% of large truck drivers were involved in crashes in the United States for 2003. Commercial trucks account for a large number of crashes in the United States. Specifically, trucks make up approximately 3.0% of all vehicles on the road, but are responsible for about 7.0% of all crashes and are involved in substantially more fatal crashes per 100 million vehicle miles traveled [2.2 vs. 1.8 per 100 million vehicle miles]. As with most crashes that occur in the United States, the majority of commercial truck crashes (80%) are non-fatal and involve property damage only. Large commercial truck crashes cost $20-25 billion annually in damages alone (total personal property, health status, etc.). A Federal Motor Carriers Association study performed in 2003 estimates that the average cost per large commercial truck crash in the United States was $62,613. Most studies have shown that age, drive time, trailer type, and driving during certain times of the day increase the risk for being involved in a crash.

Research was conducted in concert with private trucking companies and was made possible through a grant from the University of Alabama at Birmingham’s Injury Control Research Center.

Effects of Diabetes. One possible cause of commercial truck crashes is the manifestation of glucose intolerance and its treatment. This has been of such concern that insulin-dependent diabetics have been prohibited from interstate commercial truck driving [although this has recently been relaxed]. An estimated 7.0% of the US population is affected by diabetes; the prevalence of diabetes increases with age. Additionally, it is estimated that another 6.2 million US residents have undiagnosed diabetes. The prevalence of diabetes, both diagnosed and undiagnosed among truck drivers is unknown, but we estimate there may be as many as 126,000 CTDs with diabetes, many of them undiagnosed.

Impaired glucose tolerance and impaired fasting glucose form an intermediate stage in the natural history of diabetes mellitus. Anywhere from 10% to 15% of adults in the United States have one of the aforementioned conditions. Drivers with impaired glucose tolerance may
constitute a larger risk group for crashes. We estimate there may be as many as 270,000 CTDs in the U.S. with impaired glucose tolerance.

The manifestations of and treatment for Diabetes and impaired blood glucose levels may result in hyperglycemia (elevated blood sugar), or hypoglycemia (low blood sugar). Diabetes is known to increase risk of premature death, heart disease, stroke, renal failure, hypertension, visual impairment, nephropathy, and neuropathy. All of these could adversely affect driving performance. Acutely impaired blood glucose levels can adversely affect cognitive and physical performance by causing blurred vision, fatigue, nausea/vomiting, disorientation, dizziness, and shakiness. Any of these symptoms could adversely affect driving performance.

**Process.** We conducted a one-year pilot study involving 85 CTDs from Alabama and surrounding states. Participants were recruited through trucking companies, and completed a baseline questionnaire containing items to document “General Characteristics” such as age, race, sex, height, and weight, along with questions regarding current diabetes status, knowledge of diabetes, and medication history. Questions in the “Driving History” section gathered information on drivers’ truck type, trailer type, drive time, and distance driven, along with self report information on prior crash history. Along with the questionnaire participants were required to undergo a test to determine their baseline glucose tolerance utilizing HbA1c, a specific subtype of hemoglobin. HbA1c is highly sensitive and accurate measure of blood glucose allowing us the flexibility and convenience of obtaining a single measurement in a population that is highly mobile and therefore less likely to be compliant with a fasting blood glucose measure or an oral glucose tolerance test.

At the end of 6 months drivers were contacted [primarily through cell-phone] to obtain follow-up information regarding their current driving characteristics, known diabetes status and treatment, and truck crash history over the previous time period. Crash information was validated through services that utilize the Commercial Driver License Information System (CDLIS), a national clearing house for commercial driver license records. Upon completion of data collection the data set was cleaned and analyzed via multiple logistic regression; primary focus being given to the relationship between glucose tolerance status and crash-risk controlling for relevant confounders.

**Findings and Conclusions.** We are are in the final stages of the pilot study, and have focused on: 1) Developing and refining consent forms and recruitment literature through meetings with owners of commercial trucking companies and truck driver focus groups; 2) Testing and refining recruitment measures through owners and/or truck stops/rest-areas; 3) Obtaining commitments from owners of trucking companies enabling the research team to approach their drivers and request their participation (ex. Wal-Mart Inc.); 4) Testing and refining data collection methods, specifically the way the questionnaire is administered (self vs. interviewer), and development of a Spanish language version.

Our initial analysis shows that 15.29% of drivers tested in our above normal range (>6.5% HbA1c). This 15.29% corresponds to current projected national levels of glucose intolerance and is approximately what we expected. The overall crash history reported by drivers and confirmed via a CDL check is 53%.

**Recommendations for further action.** The purpose of this pilot study was to investigate the potential for a larger scale study. A large scale study investigating the true relationship between
diabetes and commercial truck crashes is important for many reasons, one being that current federal regulations prohibit interstate travel by diagnosed insulin dependent diabetics. In the interests of safety the US trucking industry, driver regulations should be based on sound science. This research is crucial because the federal regulation which prohibited insulin-using CTDs from engaging in commercial, interstate travel has recently been modified permitting those using insulin to apply for a federal waiver to continue driving between states. Moreover, federal regulations do not prohibit insulin-dependent CTDs from driving intrastate. None of these policy decisions are based on adequate data. Because the commercial truck industry is so important to the US economy, the frequency and cost of commercial truck crashes is high, and the prevalence of glucose intolerance in the US is increasing, a larger scale study, similar to the one we have discussed, is needed to ascertain whether glucose intolerance is a the contributory factor to these crashes.

We propose to determine the role of impaired glucose tolerance in commercial truck crashes by following 2000 currently licensed CTD’s (intrastate and interstate) whose glucose tolerance status will be assessed by both physician diagnosis and treatment, or an impaired HbA1c. In the proposed study, we will recruit and follow (average follow-up-2 years) for any crash, 2000 CTD’s, in Alabama and the 4 surrounding states, on whom we have obtained at baseline, glucose tolerance status by physician report or use of medications or an impaired HgA1c. We will also obtain at baseline, information on all the likely glucose intolerance symptoms, potential confounders and pathways of possible mechanisms. The results of this study will have important impact, not only on public health, but potentially on important public policy affecting the lives of many.

Contact Information
Jeff Foster
University of Alabama Birmingham
Injury Control Research Center
933 19th Street South Suite 401
Birmingham, AL 35294
Phone:205-996-6086
Fax:205-975-8143
POSTER SESSION

Improved Freight Modeling of Containerized Cargo Shipments between Ocean Port, Handling Facility, and Final Market for Regional Policy and Planning

KAORI FUJISAWA and ANNE GOODCHILD
University of Washington

ERIC JESSUP
Washington State University

Project Description. The purpose of this research is to understand the dynamics of regional freight movements through the development of a regional freight model. The model mimics the economic choices shippers make between modes and whether to ship direct or transload. The model is a tool for transportation planners to consider the impact of changes to the transportation system. With the model we can answer questions such as:

- How would a truck-only lane on SR 167 affect the ratio of shippers that choose to transload containers originating at the Port of Seattle?
- If the truck-only lane is built, what is the impact on travel times?
- What will the cost of real estate mean to transloading behavior in Puget Sound? How will counties choices to limit warehousing activity affect the traffic burden?

Background. There are many freight models that capture national goods movements with reasonable precision. Also, individual company behavior is fairly predictable given knowledge of the company’s import volume, type of good, and operating characteristic. However, there are few models that consider the movement of goods at a less than state scale, and we are aware of only one other model that considers shippers economic choices in modeling goods movement. We found the literature lacking in its ability to illustrate how freight movements by many shippers affect regional goods movement. Most freight models have been developed from passenger travel models and poorly replicate goods movement dynamics.

Process

1. Literature Review. A thorough review of existing freight transportation models was conducted. Of the models available for consideration of goods movement at a regional scale, none captured the trade-off between transportation cost and inventory cost considered by supply chain managers in making logistics choices. Rob Leachman of UC Berkeley has developed a national model of goods movement that is based on this economic choice.

2. Data Collection and Review. A thorough review of existing data sources that could support the development of a Puget Sound freight model was conducted. There are many sources of data including state and federal agencies and private companies. These are either surveys, required data submissions for regulatory purposes, or data collected on an ongoing basis by sensors. We have relied on operational data from the Ports of Seattle and Tacoma, pricing
data from the railroads and private trucking companies, publicly available real-estate and infrastructure data, and traffic volume data from City, County, and state agencies.

3. Model Development. The model consists of two origin nodes (the Ports of Seattle and Tacoma), four transportation choices, 1) direct shipping by a truck, 2) direct shipping by rail, 3) rail stopping initially at a warehouse, and 4) truck stopping initially at a warehouse.

Final destinations are considered to be 21 locations distributed throughout the United States. Allocation of commodity flows is made based on population and average income in each region. Larger population and higher income area have more purchasing power; therefore, a larger volume of commodity movement is assigned to that location. The model considers transportation and inventory cost and calculates the least cost transportation choice for each importer and exporter. The model then overlays these choices on the transportation network to consider the total traffic burden. Transportation cost is based on truck and rail rates provided by the industry. Inventory cost is based on the volume and value of goods moved. The model considers both pipeline and safety stock when calculating inventory cost.

4. Model Validation and Application. The model has been validated through comparison with known importer behavior. The transportation choices of a low, medium, and high value shipper as well as a low, medium, and high volume shipper are known and the model is able to predict these 9 choices. We have used the model to consider the following scenarios, which are discussed in the findings and conclusions below.

1. An increase in land values in the Puget Sound Region.
2. The introduction of a truck only toll lane on SR 167.
3. Consolidation of shipping companies.

Findings and conclusions. The model shows that it is usually cost effective to deliver by direct truck when the distance from port of entry to the final destination is less than approximately 500 miles. However, transloading by truck becomes the least cost alternative when the volume of goods is more than 70 TEU per week per destination (a large importer). Large importers benefit most from transloading because of benefits of economy of scale. Importers of high value goods are most likely to ship direct due to the high cost of inventory when using a transloading strategy.

Regarding three scenarios above, the model run indicates the following results.

1. An increase in land values in the Puget Sound Region: Logically, an increase in land values in the Puget Sound Region would affect shippers to move warehouse somewhere affordable assuming a similar transportation cost. When replicating current conditions in the model, land values in the Kent area are set at approximately $0.03/ft² higher than in the Sumner area. This cost difference is not large enough to cause a strong preference for location, therefore the decision to utilize a warehouse in Kent or Sumner depends primarily on operational factors such as transportation cost and congestion.

2. The introduction of a truck only toll lane on SR 167: State Route 167 connects the Ports of Seattle and Tacoma with the Kent warehousing district. The transportation cost to trucking companies would increase due to tolls paid for use of the roadway but inventory costs may decrease due to reduced travel times and reduced travel time uncertainties. The anticipated improvements in travel times and in travel time reliability are small, and within the current slack in the drayage trucking industry would not provide a transformative improvement, so the operational improvement is negligible. Given that drayage trucks are currently primarily owner operated, the operational benefit in time reduction goes to the truck driver. We plan to consider
the use of alternative routes in light of a SR167 toll lane, and the use of other warehousing regions.

3. Consolidation of shipping companies: Consolidation of shipping companies would reduce the number of small shippers while increasing the number of medium and large shippers, and increase the use of warehouses. In the model a large shipper of more than 200 TEU per week per region can benefit from trasloading because of large volume of containers. The model also shows a large shipper is able to diversify logistics strategies using direct truck, trasloading-truck/rail, or direct rail options for uncertainty.

**Recommendation.** The advantage of using this model is to be able to examine interesting what-if scenarios and uncertainties with change in variables or adding more variables simultaneously. We have presented a few examples here, but there are many more that could be considered. For example, what the impact will be of increasing fuel costs, bans on warehousing facilities, and other roadway capacity improvements.

We hope to use the conference both to communicate our research to others but also, given this is work in progress, to develop ideas for further scenario analysis, and gather input on whether significant parameters should be added or removed from the model. We would like to see the methodology deployed for other regions of the country and this conference will be a good opportunity to identify possible applications.

**Contact Information**
Kaori Fujisawa, Ph. D. Student, University of Washington  
Phone: (206) 685-6817  
E-mail: fujisk@u.washington.edu

Prof. Anne Goodchild, Assistant Professor, University of Washington  
Phone: (206) 543-3747  
E-mail: annegood@u.washington.edu

Prof. Eric Jessup, Washington State University  
Phone: (509) 335-5558  
E-mail: eric_jessup@wsu.edu
ARGOS: Dynamic Composition Of Web Services For Goods Movement Analysis And Planning

JOSE-LUIS AMBITE, GENEVIEVE GIULIANO, and PETER GORDON
University of Southern California

QISHENG PAN
University of Southern Texas

**Project Description.** The Argos project seeks to develop new modeling tools for metropolitan goods movement analysis and planning using state of the art computer science tools and a new approach for estimating freight flows on a highway network. Adequate models for metropolitan freight transportation planning are not yet well developed. In this research we explore the potential of web services workflows for developing intra-metropolitan freight flow models that are easily updated and based on widely available data sources. This poster summarizes our work on two topics: 1) workflow composition of the Argos planner, which automatically generates a freight origin-destination matrix that is used to generate a freight network assignment, 2) use of freight accessibility measures, an intermediate product of the Argos planner, to test impacts of economic activity on residential land values.

**Background.** Economic restructuring and globalization have vastly increased the volume of commodity flows by all transport modes. Increased freight flows have had significant impacts on metropolitan areas. Traffic at major freight generators (ports, airports, rail yards, warehouse/distribution nodes) has greatly increased, adding to congestion and impacting surrounding neighborhoods. Increased train traffic interrupts road traffic and often conflicts with demands for passenger commuter service. Increased truck traffic is associated with added highway congestion, more delay due to accidents, and accelerated highway deterioration. As freight flows and their impacts increase, transportation planners, managers and operators have a greater interest in developing better methods for tracking and monitoring commodity flows, and for analyzing these flows as they impact transportation nodes and networks.

There is also a growing interest in metropolitan freight flows among urban researchers. The increased importance of international trade leads to questions of costs and impacts of commodity flows on regions and local areas; relationships between supply chains, flows and firm location behavior; costs and benefits of international trade, and impacts of goods movement on urban form and land values.

Current freight flow estimation and analysis methods have several problems, some related to data and some related to the estimation methods themselves. The Argos project, funded by the National Science Foundation, combines computer science and social science to develop better, more efficient methods for freight flow estimation. Our work includes data integration and automation techniques to make possible continuously updated and detailed freight flow estimates (Ambite and Kapoor, 2007). We use a local-area input/output model and combine its information with available import/export commodity flow data from secondary sources to estimate detailed commodity flow matrices (Giuliano, Gordon, Pan, Park and Wang,
Finally, we use accessibility measures produced by the Argos planner to test hypotheses regarding residential land values and economic activity.

**Process**

**ARGOS Planner.** We have developed a general approach to construct data processing workflows, where the data sources and data processing operations are represented as web services. These services consume and produce relational tables, and thus are able to represent general computations. We describe each service as relational formulas in an expressive logic using terms from an ontology of the application domain. These logical descriptions enable the Argos planner to automatically construct a computational workflow in response to a user data request, as illustrated in Figure 1.

![FIGURE 1 Automatically generated workflow](image)

We used the Argos automated workflow to generate inputs to our intra-metropolitan freight flow model using 2001 data for the Los Angeles region. The O-D matrix was input to a conventional network assignment model, and freight volumes were estimated. Results were good: simple correlation of estimated and actual counts across 18 screenlines is 0.80.

**Economic Accessibility And Land Values.** One of the goals of the Argos project was to demonstrate the use of the Argos planner in other applications. Development of the computational workflow generated various measure of economic activity that could be used to develop measures of industry sector accessibility. Urban economic theory posits relationships...
between land values and accessibility. We estimated the impact of various industry sector measures on residential land values using a multi-level modeling approach. The models were applied to residential sales in the Los Angeles region.

We find that most of the variation in residential land values is accounted for by distance to the coast, a proxy for amenities. Accessibility impacts are significant and differ by sector. For example, heavy manufacturing and resource extraction have a negative impact on housing price, while retail services, finance, health care and entertainment have a positive effect.

<table>
<thead>
<tr>
<th>TABLE 1 Impact of accessibility measures on residential land prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job factor 1 Heavy manufacturing</td>
</tr>
<tr>
<td>Job factor 2 Manufacturing</td>
</tr>
<tr>
<td>Job factor 3 Retail/Services</td>
</tr>
<tr>
<td>Job factor 4 Resource Extraction</td>
</tr>
<tr>
<td>Job factor 5 Communication</td>
</tr>
<tr>
<td>Job factor 6 Construction</td>
</tr>
<tr>
<td>Job factor 7 Utilities</td>
</tr>
<tr>
<td>Job factor 8 Prof and other services</td>
</tr>
<tr>
<td>Freight factor 1 Heavy manufacturing</td>
</tr>
<tr>
<td>Freight factor 2 Light manufacturing</td>
</tr>
</tbody>
</table>

Findings And Conclusions. We have developed a new method for automated composition of workflows, and we have applied the method to the problem of freight flow estimation, using the Los Angeles region as a case study. We have developed a new method for estimating intra-metropolitan freight flows that relies primarily on easy to access, regularly updated secondary data sources. We have also shown that the intermediate products of the workflow can be applied to other problems, in this case the relationship between economic activities and residential land values.

Further Actions. Our further research includes various tests of the robustness of our modeling system, e.g. scalability and transferability. We are now developing scenarios to test the use of the model for sketch level planning at the metropolitan level. Extensions of the research include integrating the model with emissions and air quality estimations.

Contact Information
Contact author: Genevieve Giuliano, giuliano@usc.edu
Project website: http://www.isi.edu/~argos/

References

POSTER SESSION

Assessing Intermodal Transportation Planning At State Departments Of Transportation

ANDREW R. GOETZ, JOSEPH S. SZYLIOWICZ, TIMOTHY M. VOWLES, and G. STEPHEN TAYLOR
University of Denver

Project Description. The practice of freight and passenger intermodal planning at seven state departments of transportation (state DOTs)—Alabama, Arizona, Colorado, Florida, Louisiana, Mississippi, and Texas—is assessed through analysis of previous studies, long-range and short-range plans, organizational structures, surveys, and interviews. Respondents from state DOTs, metropolitan planning organizations, rural planning commissions, transit agencies, public interest groups, businesses, and consultants were queried on a range of topics including leadership support for intermodalism, effectiveness of planning processes and implementation capabilities, adequacy of funding for intermodalism, coordination and communication between and among relevant organizations, and provision of a range of transportation mode choices. Additional information about best intermodal projects in each state was also obtained.

Background. This project is a focused effort to evaluate the progress that state DOTs have made in implementing the intermodal planning initiatives called for in the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 and the Transportation Equity Act for the 21st Century (TEA-21) of 1998. The ISTEA legislation in particular signaled the beginning of a new era in transportation policy and planning through its explicit use of the word “intermodal” in the title. This usage was intended to “bring the need for intermodalism to the forefront of the nation’s transportation and economic debate.” More specifically, ISTEA introduced several innovations into transportation planning practices including: increasing flexibility for state and local governments to redirect highway funds to accommodate other modes and modal connections; directly linking transportation planning with air quality planning; enhancing the role of metropolitan planning organizations in regional transportation planning; broadening the goals for transportation planning; and increasing the number and variety of stakeholders that should be involved in the transportation planning process. ISTEA also specifically called for state DOTs to adopt an intermodal approach to transportation planning, as reflected by their long-range and short-range plans, their resource allocations, and the characteristics of their planning processes.

Process. To collect data on the effectiveness of state DOT intermodal planning processes, three measurement strategies were followed: (1) analysis of institutional structures and recent plans produced by the state DOTs (2) questionnaires to collect effectiveness ratings across a wide range of participants and observers, and (3) face-to-face and phone interviews to collect more in-depth responses from a more selective group of experts most knowledgeable about state DOT planning processes. A total of 325 respondents chose to take part in this study: Arizona (27 respondents), Colorado (40 respondents), Texas (41 respondents), Alabama (24 respondents), Florida (133 respondents), Louisiana (23 respondents), and Mississippi (30 respondents). All
respondents were involved in or affected by the state DOT transportation planning process. A stratified random-sampling approach was used to create comparable samples across the states for the in-depth structured interviews, based on the following categories of participants:
1. State DOT executive directors and planning directors
2. MPO executive directors and transportation planning directors
3. Transit agency executive directors and planning directors
4. Port authority executive directors and planning directors
5. Rural transportation planning officials
6. Statewide transportation commission members
7. State legislators—transportation committee chairs

Findings and Conclusions. Research has shown that state DOTs have made significant progress in becoming more intermodal agencies, and many have been cited for developing best practices in various categories of planning activities. But while organizational structures have changed to reflect this expanding role, there are questions as to whether institutional cultures have kept pace with these changes. On the one hand, an increasing number of intermodal projects have been built in virtually every state. State DOTs are adjusting to the increased role that MPOs, rural planning commissions, transit agencies, the freight industry, business interests, environmental organizations, public interest groups, and the public at-large are now playing in transportation planning as the role of transportation, broadly defined, to the economy, environment, and national security becomes more fully recognized.

Yet on the other hand, research also has shown that the shift to this broader intermodal approach has not been universally embraced. Many state DOTs are still largely highway-focused since a major responsibility continues to be highway maintenance and operations. Similarly, many of these DOTs remain staffed with a large cadre of highway engineers, and most funding is still directed to the highway mode. As a result, not all state DOTs have embraced an intermodal philosophy to the same degree or adopted policies that promote intermodalism; indeed, some state DOTs have lagged behind others and much remains to be done before all embrace the commitment to intermodalism that some states have already made.

Our study was designed to contribute to the stream of research on statewide intermodal planning by examining in detail the situation in several important states in two different regions of the country. From an analysis of statewide comprehensive plans, it is clear that each of these states is becoming more attuned to intermodal issues. Later plans especially tend to devote greater consideration to a variety of modes, rather than just focusing on highways. There are an increasing number of intermodal projects identified in comprehensive plans, and an increasing number of specific plans being produced on intermodal aspects of transportation. Each state DOT also has changed its organizational structures to reflect a more intermodal approach.

However, despite these efforts, the results of the survey show that respondents rated these state DOTs from a score of 2 (“to a little degree”) to slightly above 3 (“to some degree”) in meeting intermodal planning objectives. Even though intermodal objectives are reflected in organizational structures and long-range plans, most respondents generally felt that more could and should be done to improve intermodal planning. Perhaps predictably, a major concern focused on the lack of funding for intermodal projects, especially the degree to which ISTEA and TEA-21 ensure adequate state funding. Respondents rated investments for roads and safety fairly high (between “to some degree” and “to a great degree”) but rated investment for transit, bicycle/pedestrian, and intermodal connectors much lower. Except for Florida and Louisiana,
leadership support for intermodalism and staff training were generally not rated very high. Qualitative responses suggested that highway interests remain dominant and that an intermodal mindset has not permeated the entire transportation policy community—state transportation commission, state legislature, state DOT leadership, state DOT staff—charged with transportation decision-making and planning. Intermodal planning processes generally received only average scores, except for public involvement which was rated more highly. Responses to questions about cooperation and coordination among agencies varied across the states. Respondents also identified the best intermodal projects in each state and were generally quite complimentary toward these—though it must be noted that in some cases there were few to choose from and many involved highway construction in some way or other. Nevertheless, the respondents felt that these projects increased mobility, provided more connectivity, increased energy efficiency, and increased environmental benefits to a fairly great degree.

Given these results, it is important to consider more broadly why respondents from most of these states rated their DOTs as just average when it comes to intermodal planning. It should be said at the outset that geography and settlement history play a large role in explaining the differences in the extent to which states have embraced intermodalism. Most of the states that have been cited by previous research as examples of best practices in intermodal planning tend to have larger populations with relatively high population densities and a large number of metropolitan areas. Many of them also have seaports or major freight activity. Geographically large, mostly rural states with low population densities do not generally rate as high when it comes to intermodalism. These are natural conditions that tend to predispose some states over others when it comes to a broad transportation perspective.

**Recommendations for Further Action.** This study focused only on a specific subset of state DOTs. A nationwide study that built on this research and looked in detail at intermodal planning processes and the degree to which intermodal projects were actually implemented is highly desirable. Particular attention should be paid to the reasons why projects were not implemented or failed to contribute the anticipated results. Pressures for intermodalism are not limited to the United States. There is an urgent need for comparative analyses of the intermodal situation in many other countries.

This research was originally published as a report funded by the National Center for Intermodal Transportation (NCIT) at the University of Denver and Mississippi State University (http://www.ie.msstate.edu/ncit/RESEARCH.html). A journal article based on this study was published in *World Review of Intermodal Transportation Research* Vol, 1, No. 2, 2007, pp. 119-145.

**Contact Information**
Andrew R Goetz, Professor
Department of Geography and Intermodal Transportation Institute
University of Denver
agoetz@du.edu
303-871-2674.
Introduction. North American freight transportation data are important for understanding cross-border issues between Canada, Mexico, and the United States. Two Transportation Research Board (TRB) standing committees, the Committee on Freight Data and the Committee on International Trade and Transportation, initiated a conference to allow data users and providers to discuss freight transportation data from a North American perspective, highlighting recent changes in government-supplied data sources, and assessing users needs for today and the future. The workshop showcased recent and innovative applications of cross-border and freight flow data to address important transportation, policy, and development issues and offered an interactive format for a diverse set of participants to engage in productive dialogue.

Background. Several groups are concerned with North American trade activity and the statistics that quantify it, including:

- Trade Community - Importers, Exporters, Intermediaries
- Transportation Industry - Carriers, Facility Operators, Railroads, Truckers
- Government - National, State, Local: Regulators and Planners
- Others - Consultants, Media, Lawyers, Researchers, Bankers, and Equity Investors

Their interests overlap but mirror their roles as users, providers, regulators, and facilitators. Their common need is for information on cross-border trade activity that is comprehensive and consistent over time. Federal freight transportation data programs have been developed to provide this needed information and address questions such as:

- What are existing and potential markets?
- What infrastructure is needed?
- What are implications from and for policy decisions?
- What are the emerging trends? What’s changing?
- What resources are needed? Where to deploy them?
- Are we collecting all revenues due?
- What is the competition doing?

These programs also satisfy congressional mandates and reduce patchwork data collection by states and MPOs.
The desired outcome from the workshop is to assure that North American freight data continues to help decision makers address growing problems such as:

- Worsening congestion
- Deteriorating travel times / delivery time reliability
- Increasing freight transportation / logistics costs
- Increased complexity of supply and services chains, and
- Increased impacts of gateway activity on communities and related trade corridors.

**Uses Of Freight Data.** Showcased applications that use North American freight data to support decisions in several dimensions and levels addressed the following:

- Problem identification and priority setting for problem solving.
- Operations management.
- Design of improved crossing facilities and access networks.
- Design and evaluation of investments in border facilities and networks.
- Assessment of economic development and environmental impacts of current and proposed facilities and policies.
- Security and safety analyses.
- Broader, before-after evaluations to support future decisions, e.g., assessment of the consequences of privatization of Mexican railroads, and evaluations of changes in the design or operations of border crossing facilities.

**Freight Data Issues And Opportunities.** Agencies across and among countries face similar concerns about cross border freight flows and the operation of border crossings. This commonality suggests the value of **stronger communications** to:

- exchange ideas
- share methods
- pursue more integrated joint efforts to develop better tools
- advocate for the required freight data.

**Sharing practices in analysis and modeling** of freight data is likely to lead to both economies and more rapid advances in the field. Data across agencies is commonly integrated in decision support actions, emphasizing the synergistic value of a collaborative approach to maintaining national data programs.

**Easy access** to freight data is now available through the WEB and provides a reminder of the importance of having *data in your pocket* – users, both analysts and decision makers, often demand quick answers, and quick and easy data access supports these applications and encourages data use.

Current use of **commercial GPS truck tracking data** in Ontario illustrates several important opportunities and issues.

- both private and public sectors are interested in freight data for operation management, problem identification, and priority setting.
- rich data sources remain to be tapped for a broad spectrum of applications.
- shared use of data can produce high value at relatively low cost.
- public use of private sector tracking data requires clear agreements on allowable applications and protection of proprietary data.
• when each side understands the value to the other, negotiation of sharing agreements that bring mutual benefits are possible.

**Data Uses, Users, And Program Sustainability.** Data programs are sustained by their users and the applications of the data. Both private and public sector users rely on North American freight data. Private uses parallel public applications: operations management, and strategic decisions about equipment, locations, and markets. Carriers and shippers use these data to help influence government decision making. That these private users also benefit from the data needs to be communicated broadly to ensure future support for such data programs.

Applications are mostly based on data that are integrated from multiple sources. This integration is essential, particularly in terms of geographic and commodity detail. National data programs, including the Commodity Flow Survey and the Bureau of Transportation Statistics Transborder Freight Data program, are almost always at the core of these decisions. However, this foundational connection is not always revealed. This unrevealed or *stealth* use of essential national data sets is troublesome, because it fails to provide critical market signals in support of national data programs. In the competition for resources for all data programs, policy makers need to understand the sources of the data they are using, and work to ensure that national data programs are maintained.

An emerging concern is the risk to continued availability of freight border crossing data based on security issues. While ensuring the safety and security of our borders is essential, and good data will contribute to that objective, it is important to avoid blanket restrictions on the distribution of such data for public and private analysis and decision making. In the long term, the most serious threats to national security may be economic competition for resources and markets. An efficient, integrated, secure logistics system, well-managed with accurate, comprehensive and timely data, may be the best protection for national interests. Any data access restrictions should be carefully considered with this broader view in mind.

**Lessons Learned.** Progress has been made in the collection, organization, dissemination and application of North American transborder freight data. This progress should and does motivate the need for more progress to collect and apply better data in more advanced and responsive ways.

Collaborations offer good ways to focus efforts, learn from others, and accelerate the rate of progress in freight planning. The challenge is shared by business and governments, and each has something to offer the other. These issues and their solutions readily cross borders, making a North American effort logical and worthwhile.

The foundational role of national databases emphasizes the importance of securing and improving data sources for the future of freight planning and management.

*Proceedings from this workshop are published as Transportation Research Circular E-C119 through the Transportation Research Board and can be accessed at* [http://onlinepubs.trb.org/onlinepubs/circulars/ec119.pdf](http://onlinepubs.trb.org/onlinepubs/circulars/ec119.pdf).

**Workshop Planning Committee**

Paul Bingham, *Chair, Global Insight, Inc.*

Thomas Bolle, *Research and Innovative Technology Administration*

Sarah Clements, *Federal Highway Administration*
Gordon Rogers, *Whatcom Council of Governments*
Michael Sprung, *Bureau of Transportation Statistics*
Juan Carlos Villa, *Texas Transportation Institute*
Kathleen Hancock, *Virginia Polytechnic Institute and State University*
Thomas Palmerlee, *TRB Staff Representative*
POSTER SESSION

A Freight Planning Framework

GREGORY HARRIS

University of Alabama at Huntsville

Project Description. Effective freight transportation is vital to the economic growth of a region. Accurately modeling the impact of freight demand on the existing transportation infrastructure is paramount to identifying deficiencies in the system and can improve resource allocation to ensure congestion does not limit economic growth. This project focuses on improving transportation and freight modeling and decision making by the development of a Freight Planning Framework (FPF) that employs existing federal freight data, and a variety of tools to develop statewide origin/destination freight flow patterns, freight specific traffic models, a discrete-event simulation of freight activities, and system performance measures.

Background. Traditional transportation planning activities often ignore freight in the modeling process or add freight as an afterthought. Freight planning applications, if included in the process, often rely on historically based projections that cannot account for major changes in the workforce or economy of the area. By design, trend-line forecasting assumes that what has happened in the past will happen in the future, a method rendered wholly inadequate in today’s U.S. economy by the growth in global supply chains and international trade. Therefore, an approach to freight modeling that accounts for economic activity, and can be incorporated into the transportation planning process, or used independently, is needed to better allocate resources to transportation infrastructure.

Transportation planning activities performed in almost every metropolitan planning organization (MPO) nationwide, and many states that maintain statewide planning efforts, follow the traditional sequential four-step methodology. The four steps are; trip generation, trip distribution, modal split, and traffic assignment. In recent years, researchers attempted to optimize the process and improve forecasting results. Major areas of study include adding feedback loops to incorporate congestion effects, and the detailed examination of individual steps in an attempt to reduce the error in each step. Even as these improvements are shown to be successful, the underlying notion of the sequential, four-step model has remained.

Process. Rather than basing transportation infrastructure decisions upon backward looking trend line forecasting, the FPF is designed to incorporate the interaction between economic activity, infrastructure, population, and congestion of a given region using a forward-looking industry cluster based analysis. The concept of using industry clusters for freight planning is relatively straightforward. By understanding how an industry cluster creates the need to access the transportation infrastructure for freight, it is possible to develop relationships that can be used to determine freight needs anywhere that industry cluster is present. Aggregating the known freight behaviors for all major industry clusters in an area provides a better approximation of the freight needs in that area. The FPF builds upon the traditional four-step transportation planning process by creating a forward looking approach to trip generation. Figure 1 provides a graphic depiction of the FPF.
The industry cluster based planning factors used in the FPF approach are Value of Shipments, Personal Income, Population, and Employment. These four factors are used because one single factor cannot adequately define the demand for freight system requirements. The factors employed must be capable of describing the freight generation characteristics and the freight attraction characteristics of a region. For example, the use of employment as a proxy for the generation of freight does not take into account the effects of increased productivity associated with productivity or technology improvement activities of a company.

**Freight Planning Framework**

FIGURE 1 The Freight Planning Framework

Data is critical to any reasonable analysis of freight activity. Currently, the best available freight data is the FHWA’s Freight Analysis Framework (FAF) database. The second generation of the FAF, known as FAF2, is a continuation of the original FAF. The FAF2 provides commodity flow origin-destination (O-D) and freight movement data on all highways within the FAF2 highway network, while avoiding the proprietary limitations of the original FAF. The O-D data covers the base year (2002) and projections between 2010 and 2035 in 5-year intervals. In addition to FAF2, industry surveys are conducted to supplement the data. The surveys provide a clearer understanding of the activity of industries in a region, and the factors that affect freight generation and attraction. Appropriate conversion factors for determining the number of vehicles the data represents must be developed to use the FAF2 and survey data successfully.

Because the FAF2 database is highly aggregated, the usefulness of this data is limited for sub-state freight planning. It is important to derive the potential freight volume destined for, originating from, passing through, and internal to a state, and then disaggregate the data to a...
smaller geographic level. The disaggregation of the FAF2 is accomplished through the development of Freight Analysis Zones (FAZ) to capture the level of freight activity in an area. The FAZs are also the basis for the forecast, by industry clusters, used to predict the freight volume for periods in the future. To do this, an industry cluster forecast for the state is needed that can be segmented at the NACIS level and applied at the local level.

The local freight projections are distributed using a gravity model for both the base and future year alternatives. The freight origin/destination matrix is assigned to the transportation infrastructure network to determine the travel paths. Passenger car volumes are added to the freight traffic for separate roadway segments using a separate travel model.

With the freight volume distributed and assigned to specific roadways, the next step is to understand how the freight traffic affects, and is affected by, the transportation network and the built-in constraints of the system. This understanding is achieved by employing simulation resources. The tool used in the FPF is the Alabama Transportation Infrastructure Model (ATIM), developed by researchers at the University of Alabama in Huntsville. The ATIM is a discrete event simulation of the statewide multi-modal freight transportation system, with the ability to rapidly evaluate the impact of system decisions.

Finally, the FPF provides the ability to measure the performance of the transportation system. The FPF is a tool for continuously improving the transportation system’s ability to efficiently, effectively and safely move people and freight. Improvement does not take place without a measurement system in place to quantify the performance.

**Findings and Conclusions.** This project is a work in progress. There are several ongoing projects defining many of the parameters and methods involved in this framework. Current research is being performed to develop a methodology for disaggregation of FAF2 data to the local level, to develop the appropriate local geographic level of disaggregation, developing methods for forecasting and projecting final sector demand and pass through freight, and the development of system performance measures.

**Recommendations for Further Action.** The design and methodology of the Freight Planning Framework and systems view of transportation, which relates economic activity, population, infrastructure and congestion, are the key contributions of this project. Passenger car forecasting techniques have been studied and improved for over half a century, but freight modeling has often been neglected by the planning community or at best considered only at minimal levels. As discussed, this level of effort will continue to cause potential for misallocation of scarce transportation infrastructure investment resources.

The FPF methodology proposed here takes freight flow data at the national level and structures it in a format usable for freight planning purposes at a variety of levels. This methodology is expected to be a valuable piece of the overall transportation planning toolbox in the future. As with all new ideas, significant research is needed within each component of the FPF to ensure the final product provides value added information and data to transportation planners in Alabama and throughout the nation.

**Contact Information**
Gregory A. Harris, Ph.D., P.E.
The University of Alabama in Huntsville
Email: harrisg@uah.edu
Acknowledgement. This research was sponsored by the U.S. Department of Transportation, Federal Transit Administration, Project No. AL-26-7262-00.
Project description. This project aims to develop a framework to analyse the issue of overloaded trucks in Mexico. As in many countries, even if a fine and penalties system exists to deter overloading, the limited surveillance capacity and the need to cover long road network extensions has proved to be a poor control in practice. The main objective of this project is to base a re-design of the current penalisation system as to improve its efficacy and so to alleviate the maintenance tasks faced by the Mexican Transportation Secretariat (SCT) on the non-tolled paved network, usually supported by public funding.

Background. The Mexican Paved Network composition, having around 48,000 km, most of which (about 41,000 km) are non-tolled, poses a hard maintenance load on the Mexican Secretariat of Transport. Even more, a recent controversy on the legal weight limit for the full-truck configuration (T3-S2-R4) fostered by truckers in order to increase this limit on the basis of productivity reasons has strained this situation since the end of 2006.

In view of this the Mexican Transportation Institute (IMT), a R&D institute linked to the SCT, decided on looking at the general problem of overloading control, considering its current research lines.

Process. From a literature review on the overloading problem around the world, a research work on modelling interactions between road users and road authority was developed at IMT, having as a central piece a bi-level optimisation scheme with the road authority as the leader and the road user as the follower. For the leader, the decision variables chosen were the level of fines and the number of inspection points on the paved road network; for the follower the decision variable was the truck load factor. Objective functions for both leader and follower corresponded to their respective costs: road repair costs for the leader and operation costs for the follower. This research helped to identify both the actors intervening in the overloading problem, and the potential actions to improve the control on the overloading issue. The optimisation model used to represent interactions among road users and road authority has suggested a mechanism to control overloading by an adequate mix of number of inspection points and fining levels subject to restrictions related to the perceived cost of travel by truckers.

Findings and Conclusions. As basic result, the research has emphasised the unavoidable conflict between the economic rationality guiding truckers to overload and the technical rationality of the weight regulations. Additionally, the analysis of the main elements to consider in the design of the penalties system has shed some light on basic principles of the penalties system as the sanction severity, the quick response of the authority in applying the fines and the persistency of the penalty scheme on the truckers’ perception.
**Recommendations for Further Action.** More research in the same line as the first one is needed, in order to assess potential strategies to improve the control and penalties system, through educational campaigns, ameliorated inspection schemes based on random surveillance and suitable combinations of fixed and mobile stations, and enhanced authority image on the road network system.

As a line of future research, this project can be framed in a more general study of the conflictive relationships between economic profitable violations to traffic regulations and the technical basis of these regulations, summarized in three common illegal practices observed around the world: a) speeding, b) overloading and c) exceeding the legal driving time.

Undoubtedly, any improvement of the corresponding controls on these illegal practices will render ameliorated indexes of accidents, fatalities, and infrastructure damage, as compared to the actual values observed.

**Contact Information**
Eric Moreno-Quintero, Dr;
Instituto Mexicano del Transporte, Apdo.
Postal 1098, Querétaro, Qro., MÉXICO;
e-Mail: emoreno@imt.mx;
Phone:+52(442) 216-9777 ext 3002
Fax:+52(442) 216-9671
Executive Summary. An efficient transportation system is indispensable for economic growth and sustainability for any region as it supports personal and freight mobility. Focusing on the freight sector, transportation plays a key role in moving commodities, supporting industries, and delivering goods to consumers. Following the economic gains of the last decades, freight traffic has experienced significant gains, greatly outpacing passenger traffic across much of the U.S. transportation system.

The increasing freight volumes pose significant challenges to the transportation system and need to be modeled in order to balance the needs of businesses, those of other users and the environment. There is an increasing need for models capable of forecasting freight in order to provide decision makers with the best available tools for optimal decision making pertaining to the transportation system. Freight models have witnessed significant but insufficient advances in recent years; but still lag significantly behind passenger equivalents in terms of data, methodologies and applications in travel demand models. Data deficiencies, complexity of freight movements, and limited capital (both financial and human) are reasons given for the deficiency in freight modeling. The problem is exacerbated in small and medium-sized MPOs which are further constrained by these barriers to freight modeling. This research is an update on current efforts to develop a truck-based freight forecasting model for the Fargo-Moorhead Metropolitan area. Particularly, this update focuses on data collection efforts, proposed methodology and current experiences with the whole process.

Background. The absence of a freight component in travel demand models could significantly reduce the ability of these models to correctly forecast travel as freight and passenger trip making behaviors are considerably different from each other. Methods such as those assuming a small portion of all traffic is truck traffic could severely overestimate highway capacities resulting in higher than anticipated future costs to both the private and public sectors. The Freight Analysis Framework (FAF) estimated urban truck vehicle miles traveled (vmt) increased at a higher rate (36%) than passenger vmt (25%) between 1993 and 2002 (FHWA). This trend is expected to continue with urban truck movements expected to increase at 3% annually compared to a 2.6% annual increase in passenger VMT. The passage of the Transportation Equity Act for the 21st century (TEA-21) in 1998 and more recently the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) in 2005 all emphasized inclusion of freight in transportation planning models for transportation planning agencies.

The overall goal of this research is to develop modeling procedures using state-of-the-art in freight methodologies with locally collected data to develop a standalone truck freight model for large trucks (vehicle class 8 and higher) that will be incorporated into a travel demand model. The Fargo-Moorhead (FM) area which is traversed by two interstates and several local highways is being used as the case-study area. The FM area is the largest metropolitan area in North
Dakota with great potential and projections for future growth both in terms of population and businesses. Freight, and specifically truck traffic, is already an important component in the FM area transportation system. Truck traffic already accounts for more than 25% of the total average daily traffic on some area highway links. The Fargo-Moorhead Council of Government (FMCOG), the MPO for the Fargo-Moorhead in coordination with the Advanced Traffic Analysis Center (ATAC) of North Dakota State University are cooperating to achieve the overall goal of the study. The FMCOG has the primary role of using its network with area agencies and businesses for supporting the data collection in this study and. The role of ATAC is developing and implementing the freight model into the FM Regional Travel Model.

**Research Process.** The project was divided into four phases, including: conducting a comprehensive literature review of current freight modeling practices, developing a conceptual framework to model truck movement for the FM region, collecting data to support the model, and applying the model to the case study and collecting the results. The first two stages are complete, while work is currently underway in the data collection phase.

Data requirements may be divided into two categories: network data and socioeconomic data. Network data such as traffic counts, link-node network system, and network attributes (intersection control, geometry, and speed limits) have already been collected. Socioeconomic data are being collected primarily through surveys. Two surveys are being administered, one to all freight generation businesses and the other one to truck drivers at truck stop. The survey to businesses is designed to obtain Origin Destination (OD) data, trip generation data and land use intensity data for trips with at least one end in the study area. The survey to truck drivers is to obtain OD data for through trips and with intercept surveys being illegal in the state, it is the opinion of the researchers that truck stops will provide valuable insight on through truck trip ODs.

**Findings and Conclusions.** This paper is an update on the current efforts to model trucks in the FM area and the findings so far are related to the current stage of the process. The literature review revealed a severe lack of applications of freight travel demand models, especially in small and medium-sized urban areas. Using state-of-the-art in travel demand models, a modeling framework has been developed and will be used to model truck movements when all data is available. Data collection efforts have so far been very successful with the response rate for the survey to businesses currently at 56% even before reminders have been sent out. This is a significant rate compared to other studies which have typically cited the proprietary nature of data needed for freight studies as one of the key reasons for low response rates. Another factor in the high response rate is that every effort was made to keep the questionnaire short, in fact to one page in length. There has also been some interest from the freight industry after the FMCOG published information about the study in their quarterly newsletter. The researchers have been invited to talk to the Transportation Club of Fargo and Moorhead with membership including several freight generating businesses in the FM area with the club offering their assistance in encouraging members to fill in surveys.

**Recommendations for Further Action.** The study is still in the data collection phase and several recommendations will be made when the study is complete. However based on current experiences, the following observations can be made.
Freight data collection should be included when data are being collected for passenger travel demand models. For example, truck counts, and socioeconomic data to support freight should be included.

The freight model should be further enhanced by including trips that originate and terminate in the study area, mostly trips involving smaller trucks.

Studies to include all commercial trucks such as those for services, not just freight moving trucks should be conducted and included in travel demand models.

Inclusion of private businesses in future data collection through the formation of a freight committee will enhance and simplify the data collection process and also provide input from the industry to the MPO as to what is important to them in terms of transportation projects.

Contact Information
Smadi Ayman, Ph.D, Program Director,
Advanced Traffic Analysis Center, North Dakota State University
ayman.smadi@ndsu.edu

Motuba Diomo, Graduate Research Assistant
Advanced Traffic Analysis Center, North Dakota State University
diomo.motuba@ndsu.edu
POSTER SESSION

Dynamic Freight Routing under ITS Information for Congestion Avoidance

ALPER E. MURAT
Wayne State University

Project Description. Our research aims to address a major issue contributing to transportation network congestion that directly affects supply chain efficiency. This issue is the effect of “recurrent congestion” as well as “non-recurrent congestion” (attributable to incidents such as accidents) in the transportation network (e.g., road network, railway network) and inter-modal facilities (e.g., airports, railroad terminals, ports). We develop methods/tools to improve the logistics efficiency of supply chains using real-time information available through current and future ITS systems to avoid congestion in the transportation network infrastructure and inter-modal facilities. Traditional methods such as capacity expansion with infrastructure investments (network and inter-modal terminals) or buffering methods (e.g., inventory, headways, surplus fleet capacity) prove to be expensive coping mechanisms. Alternative to these, Intelligent Transportation Systems (ITS) can provide real-time information (on the congestion status of network and inter-modal facilities) and navigation to users who can then avoid congestion and thereby reduce the impact of transportation delays. Our research group is developing and testing various state-of-the-art algorithms and heuristics for optimal routing and navigation of vehicles in dynamic transportation networks under ITS systems.

Our collaborators in this project are UPS, UPS Supply Chain Solutions, Ford’s Material, Planning & Logistics (MP&L), C.H. Robinson, MDOT - Intelligent Transportation Systems (ITS), MDOT- Michigan Intelligent Transportation Systems (MITS) Center, and the Transportation Research Group (TRG) of Wayne State University. In this project, we are also measuring the inter-modal delivery reliability and quantify the impact of delays in inter-modal freight transportation systems on the operations of selected carriers (UPS and C.H. Robinson) and JIT supply chains (Ford inbound and outbound logistics).

Background. Over the last two decades, transformation in supply chains to a pull-based demand sensing and response in global networks have necessitated efficient supply chain (SC) operations such as just-in-time (JIT) deliveries and reduction of inventories, both in-transit and in facilities. For example, our collaborator, Ford MP&L, reports that nearly 80% of all parts and assemblies supplied to vehicle assembly plants in the Detroit metropolitan area are JIT based and involve 5 to 6 deliveries per day per part (with no more than 3 hours of inventory in most cases). Hence, the reliability and efficiency throughout the SC operations including transportation and distribution has become more important than ever. The reliability of logistics operations is most affected by inefficiencies in the transportation network. Examples of transportation inefficiencies are late/early pickup/delivery and longer transportation times, causing increased fuel costs and driver costs. These inefficiencies have “direct” effects on the economics of logistics operations, but more importantly, they more significantly affect SC operations through missed deliveries, idled capacity/labor, and increased schedule nervousness. For example, Ford’s MP&L reports the
cost of “idling” a final vehicle assembly plant due to part shortages and missed deliveries to be $50-$60 thousand/hour.

The JIT and globalization trends have also changed national freight realities. According to U.S. DOT’s 2002 Commodity Flow Survey, between 1993 and 2002, shipments by air (including inter-modal truck-air shipments) grew the most whether measured by value, tons, or ton-miles. The value of air freight shipments almost doubled (97 percent) during this time, followed by increases in inter-modal combinations of 67 percent and trucking of 42 percent. By tonnage, air freight shipments increased 46 percent, followed by trucking with 26 percent and rail with 20 percent. Although trucking dominates the freight transportation system, these trends indicate that inter-modal transportation is increasingly becoming more important. With the rising freight value per ton, shippers prefer more frequent and smaller just-in-time (JIT) shipments, which put a premium on transportation system reliability and flexibility of inter-modal combinations. Federal Highway Administration’s (FHWA) research on freight also concludes that despite the infrastructure investment efforts, the efficiency and reliability of the inter-modal freight network, congestion remains a problem.

Congestion (recurring and non-recurring) is an important source of logistics system inefficiencies at all levels (local, national and global). Traditional methods of coping with congestion prove to be expensive and futile coping mechanisms. Alternatively, using the transportation network and facilities efficiently presents itself as an effective and cost efficient approach. Current and potential future technology to measure/disseminate transportation system congestion information allows efficient user-based allocation of the load on the transportation network. Hence, using real-time congestion state information (network and inter-modal facilities) for dynamic freight routing on transportation networks is preferable over traditional methods. While there exist several dynamic routing algorithms that can utilize real-time information, there are several significant short-comings with these algorithms such as focusing only on road networks, not accounting for non-recurring congestion, and being unscalable for practical applications.

Process. For single-mode freight transportation on road networks, there exist several dynamic routing algorithms that can utilize real-time information. However, they fail to account for congestion resulting from non-recurring events, such as accidents. Non-recurrent congestion due to incidents (i.e., accidents, breakdowns) on the road network plays an important role on the delivery reliability within JIT supply chain operations. AASHTO reports that over half of all traffic congestion in urban areas occurs because of incidents (not because of traffic volumes). Furthermore, the impact of non-recurrent congestion has significant correlation with the recurrent congestion state. For instance, impact of a minor incident in low density traffic would be insignificant compared to high density case. Therefore an approach that accounts for both types of congestion is more realistic. We developed and implemented stochastic backward dynamic programming algorithms and heuristic methods (e.g., AO*) for dynamic routing by incorporating real-time information regarding non-recurrent events. We did this through an incident shock-wave model that estimates the impact of non-recurrent events using dynamic ITS information on the link travel time, modeled as a time-varying stochastic incident delay.

2 FHWA, Freight Operations and Technology. (http://ops.fhwa.dot.gov/freight/inter-modal/index.htm)
3 The American Association of State Highway and Transportation Officials. (http://www.aashto.org)
Currently, we are in the process of developing computationally efficient shock-wave models as well as heuristics for effective dynamic vehicle routing.

For dynamic routing on inter-modal transportation networks, we have selected two problems. First one is the dynamic routing and airport-flight selection for a time-sensitive air cargo forwarder. We developed stochastic dynamic programming models and algorithms for forwarder’s problem of dynamically choosing airport-flight pairs to ship the cargo. In this problem, both the historical and real-time airport and flight delay information is used to decide on the optimal road network routing and air-shipment policy. Second problem is dynamic container routing in global inter-modal transportation network. We first developed a large-scale integer programming model to determine a static shipment policy for a containerized cargo from Asia to Michigan. We are currently in the process of developing a dynamic routing model that will allow container unloading/loading at different ports and mode selection (e.g. between rail and road) and load-splitting based on the real-time congestion information on the inter-modal network.

Findings and Conclusions. In our implementation of dynamic routing models and algorithms on single-mode and inter-modal networks, we found that accounting for non-recurring congestion (from incidents such as accidents) along with recurring congestion has far more potential for system efficiency than modeling recurring congestion alone. However, these models become intractable for practical applications demanding sufficiently optimal but quick results. Therefore, there is a great demand for effective heuristic development and model preprocessing. Lastly, we found that the impact of congestion on inter-modal networks exhibits system interaction effects between different modes and connecting points (inter-modal facilities).

Contact Information
Alper E Murat, Ph.D. Assistant Professor, amurat@wayne.edu
Ratna Babu Chinnam, Ph.D., Associate Professor, r_chinnam@wayne.edu
Dept. of Industrial and Manufacturing Engineering
Wayne State University, Detroit, MI 48202, USA
Introduction and Objective. State DOTs are increasingly concerned about growing trucks weights and infrastructure damage in permitting oversized/overweight (OS/OW) vehicles. As a result, in the summer of 2006 FHWA and AASHTO conducted a European scanning study of commercial motor vehicle size and weight (VSW) enforcement. The objective of this project is to address one of the seven high priority topics, identified by the tour team: A Safety Synthesis on Oversize/Overweight Commercial Vehicles. It is hoped that the synthesis will allow the inclusion of safety in the permit issuance process.

During the tour, the team learned that in European countries, safety plays a stronger role in both issuing permits to OS/OW vehicles and in enforcement than in the United States. Research in Belgium identified a safety relationship involving excessive weight of OS/OW vehicles, and the Belgian government adopted aggressive legislation against commercial motor vehicles (CMVs).

Overview of This Project. This project is being conducted under the guidance of a strong advisory panel composed of representatives from the scan team, FHWA and AASHTO. The research is evaluating previous domestic and international research studies, using the following work steps:

- **Evaluate Background Information:** Background information was acquired and is being evaluated as the first stage of the research. This includes examination of the VSW Scan Tour Final Report; other documents acquired during the tour, and pertinent reports from prior scan tours; interviews with VSW Scan Tour representatives; contacts with and interviews of appropriate officials in Belgium; and similar exercises.

- **Conduct Literature Review/Interviews:** This consists of a traditional web-based literature review, supplemented by telephone interviews with officials involved with large trucks. The phone calls are yielding leads to ongoing research, additional completed research and literature to incorporate into the study.

- **Prepare Synthesis Report:** The report will document existing research into relationships between commercial motor vehicle weight and safety in the U.S and internationally. It will indicate what is known, what additional knowledge is desired, and potential ways to acquire the additional knowledge.

The Problem Will Grow (Freight Volume and Larger Loads). Significant growth in domestic and international commerce, coupled with ever-increasing traffic congestion and consequent delays on surface transportation networks, challenges the ability of industry to move freight economically without the use of larger and heavier loads. Over the past 20 years (1982-2002), there has been a 42% increase in registered large trucks and the mileage they have driven has almost doubled \( I \). The thought among transportation planners is that over the next 20 years, the mileage will again double. Many interstates are near capacity. Roadways are not
being built or maintained at the same rate as the traffic is growing. If that 20-year prediction holds true, the nation’s roadways are in dire straights (2).

**Overview of Large Truck Crashes.** In 2005, a total of 5,212 people were killed in crashes involving large trucks. This corresponds to approximately 12-13% of all traffic fatalities that occurred that year. Amazingly, this value has been relatively consistent for the past 20 years (1, 4, and 5). But this value is high considering that large trucks account for only 3% of all registered vehicles (5).

As documented by the U.S. Department of Transportation, there are several “reasons why it has been difficult to isolate effects of vehicle weights and dimensions on highway crash rates” [as follows:]

- “weights and dimensions of vehicles involved in crashes often are not known or recorded on accident reports;
- even where data on the number of crashes for certain types of vehicles are known, the [vehicle miles traveled (VMT)] for those vehicles often is not known, so it is difficult to develop crash rates for vehicles larger than the typical vehicles in use; and
- Crash rates for larger vehicles used in certain regions of the country or on turnpikes may not be transferable to operations in other parts of the country where traffic volumes are higher and the operating environment is less safe.” (3).

Vehicle handling is an important factor in understanding OS/OW commercial motor vehicles (CMVs). Vehicle characteristics (i.e. turning radii, sight distance…) are the standard by which roadway geometric designs are established. Most often, these designs are based on the critical vehicle using the roadway in question (5). Unfortunately, CMVs have been increasing in size and weight. Because of this, off-tracking is a major concern especially in areas where multi-trailer combinations are prevalent (3). Also, because of their irregular size, OS vehicles can disrupt a perfectly working roadway. For example, these larger vehicles “can block the view of highway signs” that would normally be accessible by all motorists (6).

Other factors influencing CMV handling include braking and stability. “A 100,000 pound truck takes 25% longer to stop than a 80,000 pound truck and a 120,000 pound truck can travel as much as 50% further before stopping than an 80,000 pound truck” (1). “Antilock brakes are now required by Federal regulation for all newly manufactured heavy vehicles. Braking capabilities of trucks have improved to the point that the braking distances of passenger cars and trucks on wet pavements, where braking distance is most critical to safety, are now equal” (5). Unfortunately, only the new trucks require antilock brakes. There is no similar legislation applicable to trailers (7). Rollover is another big issue. Of all fatal accidents, approximately 60% of truck trailer deaths are caused by rollovers. OS/OW vehicles are more prone to rollover than all other large trucks because of their height and center of gravity (3).

One article in particular focused on the various factors contributing to crashes. The “Report to Congress on the Large Truck Crash Causation Study (LTCCS),” was written to describe a “nationally representative sample” of statistics involving large trucks. A total of 967 crashes involving at least one large truck and at least one injury or fatality, were studied. The LTCCS found that the truck driver was the “critical reason” for the investigated accident 87.2% of the time. Environmental factors and vehicle quality were both addressed in this article (8).

This report produced some compelling data, but the collection techniques utilized are under scrutiny by several organizations such the University of Michigan Transportation Research Institute (UMTRI) and the Truck Safety Coalition.
**Enforcement Factors.** Overloading and enforcement visibility have an inverse relationship. When a vehicle is OS/OW and a weigh station is open on the road on which it is traveling, some drivers will purposely lag to the rear of a convoy. The driver knows that the station will become saturated and will have to temporarily stop accepting vehicles. This technique, “plugging”, allows the OS/OW driver to bypass the weigh stations (2). To combat the “plugging” practice, weigh-in-motion (WIM) devices could be used to pre-sort CMVs (9).

Another enforcement avoidance practice is avoiding the weigh stations all together. According to the article “Heavyweight Safety,” if a weigh station was open, up to 14% of truck drivers “would travel up to 160 miles to avoid a weigh station” (2). Another method to combat this traffic shift to secondary the roadways would be to utilize portable WIMs (2).

Interviews with enforcement officers have identified small firms (typically one to five trucks) as more likely to carry overweight or over-length loads. The term “ma and pa one-truck operation” occurred in interviews frequently, because such operations are operated at a low margin, are overloaded to help make their businesses profitable, and are hard pressed to upgrade their trucks. Officials in both the US and Europe expressed the same feelings. These same firms are usually loaded away from scales (logs, gravel, agricultural, etc.) and may deliberately operate off the state system of roads or at night to avoid enforcement officers.

**Preliminary Conclusions and Recommendations.** Although the study is ongoing, several preliminary conclusions have been drawn and recommendations are beginning to emerge:

1. There are few existing studies on the role of freight loads in crashes. Possible reasons include:
   a. In a severe OS/OW crash, the load is normally scattered from the vehicle, making weight and loading patterns difficult to determine.
   b. Gathering the complex data from a severe heavy vehicle crash requires special knowledge and is very time consuming.
   c. It is usually necessary to reconstruct such a crash to determine the specific circumstances associated with the crash, which requires extensive work from highly trained officers.

2. In general, we know much less about heavy commercial vehicle crashes than car crashes.

3. Interviews with enforcement officials in both the US and Europe indicate that the smaller firms (one to five vehicles) are most likely to exceed size or weight limits, and that their vehicles are typically older and less maintained that those of larger firms. US officials indicated that vehicles that operate entirely within a state are more likely to exceed limitations and dodge enforcement officers by operating on “off system” roadways or at night.

4. The Federal Motor Carrier Safety Administration (FMCSA) has traditionally focused on the safety of vehicles (tires, brakes, etc.) and drivers (fatigue, falsifying records, risk taking, etc.) FHWA has traditionally focused on the road and its role in crashes. The research agendas of the two agencies have begun to point toward common ground, and there is a need for them to work closely to develop an understanding of types, rates, and causes of heavy commercial vehicle crashes. Such knowledge is needed to develop optimum, cost-effective countermeasures.

5. Intuitively, there has to be an increased safety risk when OS/OW vehicles exceed the posted speed limit or their permitted weight (tendency to rollover, exceeding braking system capacity, high kinetic energy expended during the crash, etc.), but there is little information
in existing safety studies to conclusively support this concept. That does not mean that the relationship does not exist, just that it has not been proven through crash research.

6. There is no reliable data for longer vehicles, bigger combination vehicles and especially triples allowed by nine western states and five eastern states (turnpikes only for eastern states).

7. It seems clear that an intensive effort is warranted to gather significant, high-quality data to analyze OS/OW commercial vehicle crashes. Such an effort will be expensive, will require high levels of training, and should be a highly-organized federal agency effort.

References


Contact Information
Leslie Anne Nicholson, EI
Department of Civil and Environmental Engineering, The University of Alabama
Phone: 205-348-5414
Email: nicho057@bama.ua.edu
Introduction. Highway capacity is expressed in vehicles per hour per lane. This is a measure of
the maximum throughput of vehicles that can be expected to pass a point on a section of highway
under prevailing roadway, traffic, and control conditions. The presence of large and/or low
performance vehicles in the traffic stream results in a reduction of the allowable throughput. The
Highway Capacity Manual (HCM) reasons that the reduction in allowable throughput is due to
the fact that heavy vehicles take up more space and, more importantly, have lower performance,
especially on grades.\(^{(1)}\) Traffic volumes containing a mix of vehicle types must be converted
into an equivalent flow of passenger cars using passenger car equivalents (PCEs). The procedure
in the HCM adjusts freeway traffic volumes containing a mix of vehicle types through the use of
a heavy vehicle factor, \(f_{HV}\), into an equivalent flow rate of passenger cars. The HCM 2000 heavy
vehicle adjustment factor is based on the passenger car equivalence of trucks, buses, and
recreation vehicles (RVs) and is computed as

\[
f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)} \quad \text{(1)}
\]

where \(P_T\) and \(P_R\) are the proportion of trucks/buses and RVs in the traffic stream, respectively,
and \(E_T\) and \(E_R\) are the PCEs for trucks/buses and RVs, respectively.

The objective of this research is to extend the current HCM 2000 PCE procedures for
basic freeway segments by considering more variables and covering a wider range of truck
weight-to-power ratios, pavement type and condition, truck aerodynamic treatment features, the
number of freeway lanes, different truck speed limits, and the level of congestion on the freeway
section under consideration. The truck equivalency factors are then computed as

\[
E_T = E_{Tb} \cdot \prod_i F_i \quad \text{(2)}
\]

where \(E_T\) is the final truck equivalency factor, \(E_{Tb}\) is the base truck equivalency, and \(F_i\) are
correction factors for different variables (e.g., vehicle weight-to-power ratio, congestion, etc.).

The significance of this research is that the developed PCEs can be used to enhance the
HCM 2000. Improvements to the accuracy of highway capacity analysis should increase
justification for capacity improvements. PCEs developed as part of this research are tabulated in
a form compatible with the current HCM 2000, with the hope that they can be incorporated into a
future edition of the HCM.
Background. The use of the speed-flow-density relationship to calculate PCEs has been practiced since the late 1970s. In 1982, Huber (2) derived a truck PCE as

\[ E_T = \frac{1}{P_T} \left( \frac{q_B}{q_M} - 1 \right) + 1 \]  

[3]

where \( P_T \) is the proportion of trucks in the mixed traffic flow, \( q_B \) is the base flow rate (veh/h) (passenger cars only), and \( q_M \) is the mixed flow rate (veh/h). This formula computes the PCE by relating the flow of a passenger car only traffic stream to that of a mixed vehicle traffic stream. The effect of trucks is quantified by relating the traffic flows for an equal Level of Service (LOS).

In 1984, Sumner et al. (3) expanded the relationship described by Huber to calculate the PCE of a single truck in a mixed traffic stream by accounting for multiple truck types and is formulated as

\[ E_T = \frac{1}{\Delta P} \left( \frac{q_B}{q_i} - \frac{q_B}{q_M} \right) + 1 \]  

[4]

where \( \Delta P \) is the proportion of subject vehicles that is added to the mixed flow and subtracted from the passenger car proportion, \( q_B \) is the base flow rate (passenger cars only), \( q_M \) is the mixed flow rate, and \( q_S \) is the flow rate including the added subject vehicles.

Webster and Elefteriadou (4) used this method to compute truck PCEs. As is the case in this study, they used traffic simulation to derive the flow-density relationship for base and mixed flows. The analysis concluded that PCEs increase with increasing traffic flow on freeway segments and decrease with the increasing proportion of trucks and number of lanes. The most important conclusion was that truck type, as defined by length and weight-to-power ratio, was critical for determination of PCEs. The study, however, did not derive PCEs for these various factors nor did it expand the domain of PCE equivalencies beyond a truck proportion of 25%.

In 2003, Demarchi and Setti (5) highlighted the limitations of deriving PCEs for traffic streams with multiple truck types. In an algebraic derivation, they proved that PCEs developed for a single truck type in a mixed traffic flow containing multiple truck types using equation [4] do not fully account for the interaction between trucks. They reasoned that considered separately, “the PCE value for the subject vehicle is normally underestimated, because the marginal impact decreases as the proportion of subject vehicles in the stream increases.” Conversely, the impact of trucks already in the mixed traffic stream is over-estimated because their actual proportion should be smaller than it is prior to the addition of subject vehicles. They recommended calculating an aggregate PCE formulated as

\[ E_T = \frac{1}{n} \sum_{i=1}^{n} \left[ P_i \left( \frac{q_B}{q_M} - 1 \right) \right] + 1 \]  

[5]

where \( P_i \) is the proportion of trucks of type \( i \) out of all trucks \( n \) in the mixed traffic flow and all other variables as defined earlier. This equation is put forth by Huber and modified for multiple truck types in the mixed traffic stream. This approach, using an aggregate PCE, seems to have been adopted in the 1994, 1997, and 2000 editions of the HCM. PCEs in the HCM 2000 are reported by percent grade, length of grade, and percent trucks.

Methodology. An equivalent flow-density relationship was used in deriving the PCE. The flow of a passenger-car-only traffic stream may be related to a mixed traffic stream flow of \( n \) different truck types using an aggregate PCE as
\[ q_B = \left(1 - \sum_{i=1}^{n} P_i \right) q_M + E_T q_M \sum_{i=1}^{n} P_i. \]  
Equation [6]

Dividing through by \( q_M \) and subtracting 1 from each side yields

\[ \frac{q_B}{q_M} - 1 = \sum_{i=1}^{n} P_i \left( E_T - 1 \right) \]  
Equation [7]

Finally, dividing through by \( \sum_{i=1}^{n} P_i \) and adding one to each side yields Equation [5] that was derived earlier.

The flow-density relationship may be obtained for a traffic stream by measuring the density and flow rate measured over multiple simulations of the traffic stream. This research investigates whether the ratio of \( q_B \) to \( q_M \) remains the same for different traffic stream density levels as is implicitly assumed in the current HCM 2000 procedures.

The general method for calculating the PCE according to Equation [5] is as follows. First, generate a flow versus density relationship for the base vehicle stream by simulating passenger cars only. Simulations of the traffic stream were obtained using the microscopic traffic simulator INTEGRATION.\(^{(6-9)}\) The simulation was conducted at five different flow rates corresponding to the maximum service flow rate for each LOS category from the HCM 2000. Second, generate a flow versus density relationship for the mixed vehicle stream, replacing passenger cars with an equal number of trucks from the subject truck population. The proportion of trucks in this research was varied from 2 to 100%. Third, interpolate between observed values to obtain the base flow rate and mixed vehicle flow rate at an equal density value. Initially, an equal density value of 12.4 pc/km/ln (20 pc/mi/ln), corresponding to a density at LOS C, was used. Fourth, calculate the PCE using Equation [5].

Data Analysis

**PCE Validation.** The INTEGRATION software models vehicle motion by considering the various tractive (engine and maximum tractive axle force) and resistance forces (aerodynamic, rolling, and grade) that act on a vehicle \((8,9)\). This vehicle dynamics model was validated against field measurements. Furthermore, Al-Kaisy, Jung, and Rakha \((10)\) validated PCE value estimates obtained from the INTEGRATION software against field observed PCEs during congestion. A further validation effort was conducted by comparing the PCE estimates to those provided in the HCM 2000. The 83.7 kg/kW (137.5 lb/hp) truck population was found to match the HCM PCEs accurately across the various grade length and intensity levels. Consequently, the PCE computation procedure used was deemed consistent with the HCM 2000 procedures.

**Impact of Mixed Flow on Traffic Stream Behavior.** The first task was to characterize the impact of heavy vehicles on the steady-state speed-flow-density relationship in the uncongested regime. The speed-flow-density relationship for the base vehicle flow was shown to not be affected by the roadway grade level. Furthermore, the roadway capacity remains the same across the various grade levels given that vehicles are able to maintain their desired speeds. Alternatively, the speed-flow-density relationships for mixed traffic, passenger cars with a single truck population, was shown to vary as a function of the grade level and truck proportion.

**Single versus Multiple Trucks.** A realistic truck population may contain any number of trucks with different operating characteristics. Multiple truck populations were investigated to examine the validity of the single truck population simplification. Considering the fact that a truck weight-to-power ratio of 83.7 kg/kW (137.5 lb/hp) most closely matched the HCM 2000 PCEs, six multiple truck populations were created to have the same average weight-to-power
ratio. PCEs calculated for a multiple truck population were not significantly different from the
PCEs calculated for a single truck population; percentage differences rarely exceeded 10%. The
M multiple truck population most closely matched the HCM 2000 PCEs for the range of values
presented in the figure. Overall, the calculated PCEs for the multiple truck populations were
rarely more than 0.5 in absolute difference from the HCM 2000 PCEs. Consequently, further
analyses are conducted using a single truck population.

**Base Truck Equivalency Factors.** The HCM 2000 only considers a proportion of trucks
up to 25%. However, the current demand on many U.S. freeways exceeds 25%. Consequently,
the study considers truck proportions up to 60% in increments of 10%. The simulation results
demonstrated that the proportion of trucks in the traffic stream has a significant impact on the
heavy-vehicle PCE only at low proportions. Heavy vehicle PCE factors are developed for a truck
population of weight-to-power ratio of 83.7 kg/kW and LOS C as summarized in Table 1. These
PCEs serve as the base PCE factor ($E_T^b$ in Equation [2]). This base PCE equivalency factor is
adjusted to account for other factors including the truck weight-to-power ratio, the pavement
type and condition, etc., as will be presented in the following sections.

**Effect of Truck Weight-to-Power Ratio ($F_{wp}$).** In studying the effect of the vehicle
weight-to-power ratio on the heavy vehicle PCE, nine simulation runs were considered for a
single truck population, with a weight-to-power ratio that ranged from 38.1 to 159.9 kg/kW (62.5
to 262.5 lb/hp) in increments of 5.2 kg/kW (25 lb/hp). The heavy vehicle PCEs were computed
for each truck population at an equal density value of 12.4 pc/km/lane (20 pc/mi/lane),
corresponding to LOS C. The results demonstrated significantly less variability in the predicted
PCE for short and mild grades than for long and steep grades. Consequently, it appears that
heavy-vehicle impacts are more pronounced as the grade length and intensity increase.
Multiplicative PCE scale factors ($F_{wp}$) that account for vehicle weight-to-power ratio differences
from the base case are summarized in Table 2. These multiplicative factors are applied to the
base PCE factors presented in Table 1.

**Effect of Pavement Type and Condition ($F_{pav}$).** Pavement type and condition for the
entire network was altered with the modification of the rolling coefficient and the coefficient of
friction in the vehicle dynamics input. Values for these parameters were obtained from the
literature (8). The simulation was run with seven pavement types and conditions: rigid pavement
in excellent condition, rigid pavement in good condition, rigid pavement in poor condition,
asphalt pavement in good condition, asphalt pavement in fair condition, asphalt pavement in
poor condition, and a snow-covered pavement. The default was fair asphalt pavement. This
factor was found to have a significant effect, with percentage differences exceeding 10% and
thus PCE adjustment factors ($F_{pav}$) were developed as summarized in Table 3.

**Effect of Truck Aerodynamic Treatment.** The aerodynamic treatment of trucks affects
the vehicle drag coefficient. The default drag coefficient is 0.58 (full aerodynamic treatment).
Rakha et al. (8) found that 55% of trucks had full aerodynamic treatment, 15% had partial
aerodynamic treatment, and 29% had no aerodynamic treatment. The vehicle drag coefficient
was changed to reflect the three different aerodynamic treatments and was found only to have a
significant effect on the calculated PCE for a 10% truck proportion, with a difference of 14%.
Consequently, this factor was not considered further.
TABLE 1 Heavy vehicle PCE equivalency (ET) (LOS C)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Length (km)</th>
<th>Length (mi)</th>
<th>2</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.40</td>
<td>0.25</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>0.80</td>
<td>0.50</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>1.20</td>
<td>0.75</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>1.60</td>
<td>1.00</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>2.00</td>
<td>1.25</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>2.40</td>
<td>1.50</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>3.20</td>
<td>2.00</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
</tbody>
</table>

TABLE 2 Truck PCE weight-to-power ratio adjustment factor (Fwp)

<table>
<thead>
<tr>
<th>Grade (%)</th>
<th>Weight-to-power Ratio 68.5 kg/kW</th>
<th>Weight-to-power Ratio 106.6 kg/kW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percentage Trucks</td>
<td>Percentage Trucks</td>
</tr>
<tr>
<td>5%</td>
<td>10%</td>
<td>25%</td>
</tr>
<tr>
<td>≤2</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>2-4</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>4-6</td>
<td>0.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>

70
Effect of Number of Lanes. The number of lanes was increased from two to three while maintaining the same volume-to-capacity ratio. The study also examined the effect of lane restrictions on heavy vehicle PCEs. The calculated PCEs for three lane freeway segments was found to be significantly different from two lane freeway segments at a 5% truck proportion only. At higher truck proportions, the PCE for three lane segments showed no difference from that of two lane segments. Truck lane restrictions also showed no difference in the PCE. Consequently, no adjustments are required.

Effect of Differential Truck Speed Limit. In many states, the truck speed limit is regulated to as much as 24.1 km/h (15 mph) below the speed limit for other vehicles. This lowers the speed of trucks approaching a grade and thus could increase the effect of the grade on trucks. The study concluded that the institution of a truck speed limit significantly affected the calculated PCE. The base condition was an equal speed limit of 112.6 km/h (70 mph) and PCE adjustment factors \((F_{ds})\) were developed for different speed limit differentials, as summarized in Table 4.

Effect of Level of Congestion. The effect of the level of congestion was considered for different traffic stream density levels ranging from 9 to 25 pc/km/lane (15 to 40 pc/mi/lane) at increments of 3.1 pc/km/lane (5 pc/mi/lane) and was found to significantly affect the calculated PCE with percentage differences exceeding 10%. Consequently, multiplicative factors were developed and summarized in Table 5.

<table>
<thead>
<tr>
<th>Grade (%)</th>
<th>Percentage Trucks</th>
<th>Asphalt Poor</th>
<th>Asphalt Good</th>
<th>Concrete Poor</th>
<th>Concrete Good</th>
<th>Concrete Excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤2</td>
<td>1.1 1.1 1.0</td>
<td>1.0 1.0 1.0</td>
<td>1.1 1.1 1.0</td>
<td>0.9 1.0 1.0</td>
<td>0.9 0.9 1.0</td>
<td></td>
</tr>
<tr>
<td>2-4</td>
<td>1.1 1.1 1.0</td>
<td>1.0 1.0 1.0</td>
<td>1.1 1.1 1.0</td>
<td>0.9 1.0 1.0</td>
<td>0.9 0.9 1.0</td>
<td></td>
</tr>
<tr>
<td>4-6</td>
<td>1.1 1.1 1.0</td>
<td>1.0 1.0 1.0</td>
<td>1.1 1.1 1.0</td>
<td>0.9 1.0 1.0</td>
<td>0.9 0.9 1.0</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LOS</th>
<th>Density</th>
<th>(F_{LOS})</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>9.4</td>
<td>15.0 0.8</td>
</tr>
<tr>
<td>C</td>
<td>12.5</td>
<td>20.0 1.0</td>
</tr>
<tr>
<td>C</td>
<td>15.6</td>
<td>25.0 1.1</td>
</tr>
<tr>
<td>D</td>
<td>18.8</td>
<td>30.0 1.2</td>
</tr>
<tr>
<td>D</td>
<td>21.9</td>
<td>35.0 1.2</td>
</tr>
<tr>
<td>E</td>
<td>25.0</td>
<td>40.0 1.1</td>
</tr>
</tbody>
</table>

Conclusions. This research developed a base PCE table (Table 1) that extends the HCM 2000 procedures by considering higher than a 25% truck proportion and considering longer grade sections. The PCEs were computed for a single truck population with an average weight-to-power ratio of 83.7 kg/kW (137.5 lb/hp), with full aerodynamic aids, fair asphalt pavement, and a roadway LOS C. Multiplicative scale factors were developed to account for pavement type and condition, roadway LOS, a speed limit differential between trucks and cars, and the truck population average weight-to-power ratio.
References

Acknowledgements. The authors acknowledge the financial support of the Mid-Atlantic University Transportation Center (MAUTC) and the editorial help of Vikki Fitchett.

Contact Information:
Hesham Rakha, Virginia Tech Transportation Institute
3500 Transportation Research Plaza (0536), Blacksburg, VA 24061
Phone: (540) 231-1505, Fax: (540) 231-1555
E-mail: hrakha@vt.edu
POSTER SESSION

Evaluating Alternative Truck Management Strategies Along I-81

HESHAM RAKHA, ALEJANDRA MEDINA FLINTSCH, KYOUNGHO AHN, Ihab EL-SHAWARBY, and MAZEN ARAFEH
Virginia Tech Transportation Institute

Introduction. I-81 is one of the top eight truck routes in the U.S. The highway was designed for 15 percent truck traffic, however trucks now account for somewhere between 20 to 40 percent of the total traffic volume. Consequently, the study evaluates a number of lane management strategies along one of the most highly traveled roadway sections of I-81 in the State of Virginia using the INTEGRATION traffic simulation software in an attempt to identify strategies to mitigate congestion along this corridor. The lane management strategies that are considered include the separation of heavy-duty trucks from light-duty traffic, the restriction of trucks to specific lanes, and the construction of climbing lanes at strategic locations. The paper describes a study that attempts to quantify the efficiency, energy, environmental, and safety benefits of different alternatives to the existing conditions using simulation tools. Network-level impacts are determined from an analysis of microscopic simulation results using the INTEGRATION traffic simulation software. Overall, the results demonstrate that a physical separation of heavy-duty trucks from the regular traffic offers the maximum benefits in terms of efficiency, energy, and environmental impacts. The study also demonstrates that restricting trucks from the use of the leftmost lane offers the second highest benefits in terms of efficiency, energy, and environmental impacts. Considering a cost-benefit analysis the second alternative is the preferred approach.

Background

Study Area. The section of I-81 that was considered for the study is a 40-km (25-mile) section that extends from the Blacksburg/Christiansburg area to Roanoke. This section serves the Roanoke/Salem area, a metropolitan area of 200,000 people, which connects to an Interstate spur connector to downtown Roanoke, I-581. This corridor covers a total of 25 mi from milepost 118 to milepost 143. It contains 8 interchanges at mileposts 118, 119, 128, 132, 137, 140, 141 and 143 and a rest area in the northbound direction. This section of I-81 is a two-lane freeway in most segments, with some locations with three lanes. The Study Area includes several service roads near urban areas.

Truck-Only Lanes and Managed-Lane Facilities. Truck-only lanes are defined as lanes that are separated from the remaining roadway lanes by a physical barrier and equipped with their own access and exit ramps. These truck lanes are custom designed for longer and heavier trucks because trucks have very different accelerating, turning, and braking characteristics in comparison to cars. According to (2) today’s mixture of large trucks and small cars, traveling at high speeds poses serious collision risks. Regardless of which party may be at fault in initiating a car/truck crash, the results are very costly. For example, the National Safety Council has noted, “in truck/automobile collisions, the car driver is 49 times as likely to be killed as the truck driver because of the difference in mass.”

For the proponents of these “freeways-within freeways” the benefits of this type of system include: increasing safety because they will put the heaviest and potentially most...
dangerous rigs behind sturdy concrete barriers and take them travel away from regular traffic lanes and potentially increase productivity because they will allow trucking companies to deploy highly efficient rigs, ultimately saving shippers billions of dollars a year. The full implementation of this type of system requires changes in truck, freeway, taxes and toll regulations. Alternatively, a managed-lane facility “is a lane that increases freeway efficiency by packaging various operational and design actions” (3). Lane management operations may be adjusted at any time to better match regional goals. The restrictions that can be applied to this type of lane include: vehicle-type restrictions, allowing access to a specific type of vehicle; and time-of-day-restrictions, allowing access at certain periods or value pricing. The benefits of this type of lane are: maximizing existing capacity, improving safety, managing demand, reducing environmental impacts, and generating revenue (1).

**Truck Climbing Lanes.** A climbing lane is defined by AASHTO (4) as an extra lane for a vehicle moving slowly uphill so that other vehicles using the normal lanes are not restricted and are able to pass the slower moving vehicle. AASHTO recommends that a 16-km/h (10 mi/h) reduction criterion be used as the general guide for determining critical lengths of grades and locating truck-climbing lanes. The TruckSIM software (5), developed by Virginia Tech, provides a flexible tool for locating truck-climbing lanes that mimics the AASHTO procedures. Specifically, the software identifies the start and end points of climbing lanes considering the AASHTO criteria previously specified. The application of the model to the Study Area is discussed in a later section.

![Study area truck-climbing lanes needs’ using TruckSIM.](image)

**INTEGRATION Model Overview.** This section provides a brief overview of the INTEGRATION software given that it was the tool that was utilized to conduct the study. The INTEGRATION software is a microscopic traffic assignment and simulation model which was developed over the past two decades. It was conceived as an integrated simulation and traffic assignment model and performs traffic simulations by tracking the movement of individual vehicles every 1/10th of a second. This allows detailed analyses of lane-changing movements.
and shock wave propagations. This also permits the steady-state fuel consumption rate for each vehicle to be computed each second on the basis of its current instantaneous speed and acceleration level \((6, 7)\). In addition to estimating stops and delays \((8)\), the model can also estimate the fuel consumed by individual vehicles, as well as the emissions. The model also uses a vehicle dynamics model that is used to estimate the maximum vehicle acceleration. Specifically, the model utilizes a variable power vehicle dynamics model to estimate the vehicle’s tractive force that implicitly accounts for gear-shifting on vehicle acceleration. The model also considers the aerodynamic, rolling, and grade resistance forces on the vehicle.

**Evaluation of Alternative Management Strategies: Simulation Results**

**Traffic Data collection and Demand Calibration.** With the objective to generate a seed O-D for the Study Area, a field survey was conducted by tracking all trucks entering and exiting I-81 during four four-hour periods along the 25 mi study section. The data collection efforts were conducted on Sundays and Wednesdays. Mondays and Fridays were not considered as studies have shown that these days are not necessarily reflective of typical weekday conditions \((9)\). Nine sites were monitored for the southbound direction and 10 sites for the northbound direction. The sites included the north and south ends of the study area, where video cameras were installed and traffic conditions were recorded for the four periods. The other sites included all possible entrances and exits for each interchange in the Study Area. At each location, one or two people manually recorded the time and truck characteristics: color, manufacturer, and presence of trailers. The information and the video data were used to identify the truck movements in order to compute an O-D matrix. The results of Figure 2 clearly demonstrate a good match between link flows and O-D demands.

![FIGURE 2 Demand calibration illustration](image)

**Simulation Model Construction.** The simulation network construction involved building a network from AutoCAD designs. This design was used to define the horizontal profile with a high degree of accuracy. Alternatively, the roadway grades for each section were generated by driving a vehicle equipped with a Global Positioning System (GPS) along the study section. Lane characteristics in terms of capacity, free-flow speed, speed-at-capacity, and jam density were derived based on typical freeway sections.

Trucks were modelled as a 200 lb/hp truck as recommended by the Highway Capacity Manual (HCM) for highway design purposes. Based on a limited survey of 150 trucks at the
Troutville weigh station, this represents the 95th percentile truck weight-to-power ratio. The cars were modelled as light-duty vehicle 3 (LDV3), which is a vehicle of model year 1995 or later, an engine size less than 3.2 L, and an average mileage of less than 83,653 km. The use of different vehicle types would affect the fuel consumption and emission estimates of the various scenarios.

The results obtained when the TruckSIM simulation model were utilized to identify locations of climbing lanes within the study section, as illustrated in Figure 6. When the truck speed is lower than the minimum design speed, a climbing lane is recommended. There is a clear need for a truck-climbing lane in the southbound direction from miles 127.9 to 125.6, from 123.4 to 122.4, and from 121 to 118.8.

**Summary Results.** Eight scenarios for improving traffic flow on the I-81 corridor were modelled, as follows:

- **Scenario 1 (S1). Do-nothing:** Represents the base case do-nothing scenario.
- **Scenario 2 (S2). Separated Truck Lane:** Two truck lanes are included in each direction. These additional lanes are physically separated from the existing lanes and are dedicated to truck traffic only. Truck access is attained through the starting and ending points along the study section and through a flyover at milepost 132 from the truck express lanes to the general purpose lanes.
- **Scenario 3 (S3). Managed–Lane Facility, Left lane:** This scenario is identical to scenario 1 with one additional lane to the left dedicated to cars only and a truck climbing lane in the southbound direction from milepost 128 to milepost 122.
- **Scenario 4 (S4). Managed–Lane Facility, Right lane:** This scenario is identical to scenario 3 except that the managed lane is the rightmost lane instead of the leftmost lane as is the case in Scenario 3.
- **Scenario 5 (S5).-Extra Lane-No Managed Lane Facility:** This scenario is identical to scenario 3 except that there are no lane restrictions.
- **Scenario 6 (S6). Managed-Lane Facility, Left Lane, LOS C:** This scenario is identical to scenario 3 with additional lanes to guarantee a level of service C for the entire section.
- **Scenario 7 (S7). Managed-Lane Facility, Right Lane, LOS C:** This scenario is identical to scenario 6 except that the managed lane is the rightmost lane instead of the leftmost lane as is the case in scenario 6.
- **Scenario 8 (S8). Extra Lanes to guarantee LOS C. No Managed Lane Facility:** This scenario is identical to scenario 6 without any lane restrictions.
- **Scenario 9 (S9). S3 without Truck Climbing Lanes:** This scenario is identical to scenario 3 without truck climbing lanes.

In the alternative selection process it is important to analyze the impact of the different scenarios on the entire network and on individual vehicle classes. For this reason the results were also categorized by four vehicle classes, namely: local cars (LC), local trucks (LT), through cars (TC), and through trucks (TT). Through cars and trucks were defined as the vehicles that complete the entire section from north to south and vice versa. Vehicles that originate or end their trip along the study section are categorized as local trucks or cars.

Table 1 shows the average speed, travel time, delay and vehicle emissions for the nine alternatives. All scenarios produce significant benefits when compared to the base case scenario. However, the strategy of separate truck lanes (S2) produces the highest benefits. There is a substantial increase in speed (71 percent) and decrease in travel time (42 percent) and delay (73 percent) when this scenario is applied. The second highest benefits are obtained from scenario 6 which increases speed (57 percent), reduces travel time (36 percent), and delay (60 percent). The
application of truck lane restrictions to the right lane (S7) results in slight negative impacts with respect to scenarios S6 and S8. Alternative S3 with truck restrictions to the left lane produce the most benefits among the manage-lane facilities that do not comply with an LOS for the entire corridor. This alternative also produces higher benefits than S9 that does not include the truck climbing lane. The restriction of the right lane for trucks (S5) has negative impacts compare to the left lane control (S3) and no control operation at all. The benefits obtained through scenarios 3 and 6 confirm previous studies that conclude that restricting trucks from the left lane with steep grades may decrease density (10). Table 1 also shows positive environmental impacts for all the strategies compared to the base case.

### TABLE 1 Average MOE’s for the various scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed (mph)</td>
<td>33.38</td>
<td>57.10</td>
<td>47.53</td>
<td>41.08</td>
<td>46.85</td>
<td>52.29</td>
<td>50.36</td>
<td>51.44</td>
<td>46.37</td>
</tr>
<tr>
<td>Travel Time (min.)</td>
<td>31.74</td>
<td>18.54</td>
<td>22.30</td>
<td>25.80</td>
<td>22.62</td>
<td>20.29</td>
<td>21.07</td>
<td>20.63</td>
<td>22.85</td>
</tr>
<tr>
<td>Delay (min.)</td>
<td>13.79</td>
<td>3.77</td>
<td>7.53</td>
<td>11.03</td>
<td>7.85</td>
<td>5.51</td>
<td>6.29</td>
<td>5.84</td>
<td>8.09</td>
</tr>
<tr>
<td>Fuel (l)</td>
<td>3.28</td>
<td>3.03</td>
<td>3.18</td>
<td>3.31</td>
<td>3.19</td>
<td>3.14</td>
<td>3.17</td>
<td>3.14</td>
<td>3.18</td>
</tr>
<tr>
<td>HC (g)</td>
<td>3.31</td>
<td>2.77</td>
<td>3.20</td>
<td>3.28</td>
<td>3.20</td>
<td>3.13</td>
<td>3.06</td>
<td>3.13</td>
<td>0.35</td>
</tr>
<tr>
<td>CO (g)</td>
<td>35.17</td>
<td>42.42</td>
<td>66.53</td>
<td>62.19</td>
<td>63.76</td>
<td>68.33</td>
<td>57.50</td>
<td>67.83</td>
<td>62.21</td>
</tr>
<tr>
<td>NOx (g)</td>
<td>43.44</td>
<td>41.34</td>
<td>43.12</td>
<td>43.79</td>
<td>43.28</td>
<td>42.81</td>
<td>42.11</td>
<td>42.67</td>
<td>42.98</td>
</tr>
</tbody>
</table>

Overall, the results demonstrate that a physical separation of heavy-duty trucks from the regular traffic offers the maximum benefits in terms of efficiency, energy, and environmental impacts. The study also demonstrates that restricting trucks from the use of the leftmost lane offers the second highest benefits. To further evaluate the relative impacts of these two alternatives, additional runs were conducted using 10 different random number seeds. The results of the simulation indicate that separating heavy-duty trucks from the general traffic results in an increase in system efficiency. Statistical t-tests indicate that the two alternatives produce statistically different speed, travel time, delay and fuel consumption MOE’s with a degree of confidence of 95 percent. Furthermore, the results indicate that alternative S2 offers higher benefits compared to alternative S6 when the entire traffic stream is considered. A more detailed statistical analysis for each of the traffic subclasses (LC, LT, TC, and TT) also indicates statistically significant differences in favor of alternative S2.

**Conclusions.** The study evaluated a number of lane management strategies along one of the most highly traveled roadway sections along I-81 in the State of Virginia using the INTEGRATION simulation software. The lane management strategies that were considered include the separation of heavy-duty trucks from light-duty traffic, the restriction of trucks to specific lanes, and the construction of climbing lanes at strategic locations. Overall, the results demonstrate that a physical separation of heavy-duty trucks from the regular traffic offers the maximum benefits in terms of efficiency, energy, and environmental benefits. The study also
demonstrates that restricting trucks from the use of the leftmost lane offers the second highest benefits in terms of efficiency, energy, and environmental impacts. Considering the much higher cost of making a physical separation between trucks and cars, the best alternative appears to be to build truck climbing lanes at strategic locations, add lanes to maintain a LOS C, and restrict trucks from the leftmost median lanes.

References
5. TruckSIM

Contact Information
Hesham Rakha, Virginia Tech Transportation Institute
3500 Transportation Research Plaza (0536), Blacksburg, VA 24061
Phone: (540) 231-1505, Fax: (540) 231-1555
E-mail: hrakha@vt.edu
The Effect of Auxiliary Power Units on Long Term Idling: A Case Study

CRAIG SCHILLER and L.R. RILETT
University of Nebraska-Lincoln

Project description. The Nebraska Transportation Center (NTC) conducted research on the idling activity of long haul truckers. The research was sponsored by the U.S. Environmental Protection Agency. The goal was to see if the installation of Auxiliary Power Units (APUs) reduced the long-term idling of truck drivers.

Background. The nature of the trucking industry requires long haul truck drivers to spend much of their time away from their homes. In addition, current rules of operation dictate that drivers have a 10 hour break for every 14 hours of operation. Taken together this means that drivers spend much of their 10 hour break in their cabs. Comforts such as television and climate control require power, and, particularly for extreme weather conditions (both hot and cold), the drivers will often run their trucks to maintain a reasonable level of comfort. There are two problems associated with this. The first is that engine idling is highly inefficient in terms of energy use. The second is that many jurisdictions limit the amount of idling time by trucks (e.g., less than 10 minutes) in order to limit emissions. These problems adversely affect the drivers’ ability to maintain even basic comforts.

Process. In partnership with a local small (e.g. less than 50 trucks) trucking company, NTC has tracked the idling times of 26 long haul trucks – 11 of which have been equipped with APUs and 15 of which have not – with the disaggregate idling times, the geospatial coordinates, distance traveled, fuel used, active time, and date of observation were also logged. Using the geospatial data, it was possible to overlay the observations on such factors as average monthly temperature, pressure and humidity. It is important to note that the location at which the idling occurred is not known. Therefore, the values recovered for a single day were aggregated via an arithmetic mean. An example of an overlay on the NCDC Climate Atlas of the United States v2.0 is shown in Figure 1.

Calling those vehicles that were eventually equipped with APUs the Test Group and those that were not the Control Group, the means and quartiles of each of the observed variables weighted by vehicle were plotted over their respective groups and over month, season, temperature, etc. Reductions in the sample used for direct comparisons were made as differences were observed between such categories as owner-operated and fleet vehicles. The idling times of the Test Group and Control Group were subjected to two-sample t-Tests for Control before to Control after, Test before and Test after, Control before and Test before, and Control after and Test after.
For many of the vehicles in the Test Group, the vehicle entered the study equipped with its APU as opposed to being upgraded. Bear this in mind as the aggregate analysis assumes these vehicles to have behaved in the same manner as those that appeared prior to being equipped. Individual Test vehicles with sufficient number of observations prior to being equipped with the APU were examined alongside a comparable Control for a before-after statistical analysis.

**Findings and conclusions.** Long-term idling times were not found to be correlated with average daily temperature for each month when taken in aggregate across drivers and grouped by test group and control group. While expected to take a convex parabolic shape, it did not as shown in Figure 2. This is likely due to the bias previously noted in the description of the overlay process along with such other factors as relevant ordinances.
Without a strong temperature relationship, the means of the long-term idling times for the aggregate groups were plotted over the months of the year in Figure 3. The related statistical tests show that the mean of the Test Group was already less than that of the Control Group, so the study is not in control. Thus, the reduction, or lack thereof, cannot be stated without including additional assumptions.

FIGURE 3 Average long-term idling of trucks each month

Comparisons of pairs of individual vehicles both present during the same time of the dataset yield promising but inconclusive results. An example of such a pair is shown in Figure 4, but the following map of the locations observed for the pair’s idling behavior shows that their assignments vary greatly.

FIGURE 4 Average long-term idle time for a pair of trucks 122 (control) and 123 (test)
FIGURE 5 Average time spent long-term idling at locations in the US for a pair of trucks

It does not take a study to say an APU should eliminate the need for long-term idling. If anything is shown by this study thus far, it is that there are many other factors affecting long term idling. For example, non-zero means exist on the after side of the Test Group in Figure 3. Why those APU equipped vehicles responsible would need to idle cannot be known without a more in-depth study. But anecdotal evidence has included such explanations as “can’t sleep without the engine running.”

Recommendations for Further Action. It is recommended that a larger, controlled and more detailed study on the effect of APUs on idling be conducted. Ideally, this would be a controlled experiment whether the drivers, vehicles and routes are randomly assigned to test and control groups. The study should include a survey of drivers’ preferences, the actual location of idling, the climate factors inside and outside the cab, the APU usage time, a survey of relevant legislation, etc. In particular, the effect on driver attentiveness as a function of cab comfort level needs to be ascertained. The APUs may pay for themselves not only through fuel savings but also through improved driver performance and value to the drivers themselves; thus the key issue of financing also needs to be studied. In terms of this project the researchers will continue to gather additional data and continue with the analyses.

Contact information
L. R. Rilett, Ph.D., P.E.
Keith W. Klaasmeyer Chair in Engineering and Technology, and
Director, Nebraska Transportation Center
University of Nebraska-Lincoln
121B Nebraska Hall, P.O. Box 880531
Lincoln, NE 68588-0531
Phone: (402) 472-1992
Fax: (402) 472-0859
E-mail: lrlilett2@unl.edu
PROJECT DESCRIPTION. Efficient, safe goods movement is critical to the U.S. economy; both globalization and competitive pressures are demanding more from the freight system, even as infrastructure growth is stagnant. A key asset of the freight system is timely, comprehensive and accurate data to support operations, planning and investment decisions in both public and private sectors. Yet current freight data is insufficient to the decision support tasks.

This report summarizes the findings of the Transportation Research Board Workshop on Freight Data Challenges held in Chicago, Illinois, on July 10-11, 2007, bringing together both providers and users of freight data to meet the following objectives:
1. Understand the use of freight data in decision making, and identify priority public domain freight data requirements to address key decisions.
2. Explore dimensions of a freight data architecture that would enable assembling relevant data for decision making.
3. Consider business models, including public-private partnerships, that could provide adequate resources for freight data programs, reflecting the variety of data users and asset owners involved.
4. Define research initiatives to address the priority freight data needs.
5. Identify initial activities to move those research initiatives forward.

BACKGROUND. Prior work on freight data issues has been based on the general importance of freight in the U.S. economy and the need to manage the logistic system to ensure capacity, efficiency, safety and security. Numerous prior studies and conference reports have laid a foundation for findings of this workshop in four areas:

**Freight data architecture**: there have been repeated prior calls for the creation of a general architecture for freight data to establish consistent definitions and guide data collection, organization, and integration. This architecture should reflect the needs of data users in terms of quality, timeliness, and documentation of data.

**Data needs**: The emphasis of past work has been on coverage of key commodity and vehicle flows and increased detail to support decision making. These relate to sample size – and thus resources for data programs – as well as data collection techniques.

**Data collection and dissemination**: Prior recommendations have called for increased use of current and emerging technologies to make collection of freight data more effective and efficient. Sharing freight data, analyses, and reports via the Internet has been proposed. The integration of multiple data sets to support user needs has also been a consistent theme of past efforts.

**Data partnerships**: collaborations between public agencies, and between governments and the private sector, have been recommended to increase the efficiency of data use – collect it once and use it many times - and more importantly as the key to gaining access to essential private freight data.
Process. These themes were addressed in this 1½ day workshop, after presentation and discussion of several specific applications of freight data to policy issues. A series of breakout groups then addressed these topics:
1. Current and future freight data sources to meet user needs.
2. Requirements for the freight data architecture.
3. Growing the freight data enterprise – partnerships, motivations and resources.
Each breakout group then produced a set of research recommendations, which were integrated in the final plenary session into a more focused set of topics. Based on the guidance offered by conference participants, a subset of members of the conference planning committee then developed a priority set of research needs statements as a basis for seeking support for the research.

Research Recommendations. Five research needs statements were originated in the workshop. The first has been selected for funding by AASHTO under the NCHRP Quick Response Planning Research Program. The last four have been submitted to the National Cooperative Freight Research Program.

Scoping Study for a Freight Data Exchange Network. This study would assess the feasibility of sharing freight data efficiently via the Internet. This requires identifying willing and interested data providers and users, promising data contents, and the benefits and costs, risk and barriers to sharing. Results would define tools for data sharing, metadata standards, incentives, and stewardship. The work would require interviewing both providers and users to assess interest, willingness, obstacles and ways to overcome them. Products would include a feasibility assessment, cost estimates, and implementation steps.

Integrated Assessment of Freight Data Needs for Management and Policy Decisions. This research would define the core data needs for public and private freight transportation decision-making at all levels. The product would be a compendium of the data needed to address high priority freight issues, including system inventory and usage, performance measures and outcomes, problems and obstacles, and environmental/community impacts.

Specifications for Freight Transportation Data Architecture. This research would establish the basic content of a freight data architecture to: (1) integrate data from multiple sources to produce a national picture of freight activity; (2) guide state and regional freight planners on acquisition of local detail consistent with the national picture; and (3) help government and business planners understand the local consequences of freight movement and the contributions of local shipping decisions to interregional freight activity. A well-defined and robust freight data architecture will facilitate the collection, use, and maintenance of interoperable freight data, guiding investments in freight data that will increase the knowledge of freight activity.

Successful Partnerships for Data Development. This research, based on the fact that much needed freight data originates in private firms, would identify opportunities, motivations, incentives, and mechanisms to encourage and enhance public-private partnerships to collect and use freight data. Expected outcomes include: (1) Identification of data sets appropriate for sharing; (2) Analysis of benefits, risks and motivations for data collection through public/private partnerships; (3) Analysis of state and federal laws and regulations that may hinder or preclude public-private data sharing partnerships; (4) Documentation of business models to provide private sector data to support public sector decisions; and (5) Compendium of model language,
tools and agreements that can be used by government and academia to create data sharing partnerships.

**Technology Road Map for Freight Data Acquisition.** This research would improve the efficiency and accuracy of freight data by developing a detailed plan to guide the freight data community in selecting technologies for the efficient capture of more accurate freight data. This technology road map would support a business plan that integrates new technologies into the freight data collection process and identifies the enabling technologies critical to future success. It would evaluate technologies in current use by the freight transport industry as well as those that are on the horizon, thus influencing future research and development decisions.

**Recommendations for Further Actions.** As stated, one project proposal has been funded, and the others submitted as candidate projects to the National Cooperative Freight Research Program.

**Workshop Planning Committee**
Michael Bronzini, George Mason University, Chair
John Allen, Battelle Memorial Institute
Paul Bingham, Global Insight, Inc.
Thomas Bolle, Research & Innovative Technology Administration
Scott Drumm, Port of Portland
Ronald Duych, Research & Innovative Technology Administration
Michael Fischer, Cambridge Systematics, Inc.
Anthony Furst, Federal Highway Administration
Kathleen Hancock, Virginia Polytechnic Institute and State University
Doug MacIvor, California Department of Transportation
Arnim Meyburg, Cornell University
Daniel C. Murray, American Transportation Research Institute (ATRI)
Vidya Mysore, Florida Department of Transportation
Benjamin Ritchey, Battelle Memorial Institute
Joseph Schofer, Northwestern University
Joy Sharp, Bureau of Transportation Statistics/RITA
Robert Tardif, Ontario Ministry of Transportation
Johanna Zmud, Nustats LLP
Thomas M. Palmerlee, TRB

Summary prepared by: Thomas Bolle, Michael Bronzini, Kathleen Hancock, Daniel Murray, Thomas Palmerlee, Joseph Schofer, and Johanna Zmud.

**Contact Information**
Thomas Palmerlee
Transportation Research Board
500 Fifth Street, NW
Washington D.C. 20001
202-334-2907
TPalmerlee@nas.edu
Project Description. The continued advancement and acceptance in Europe of the Bridge Weigh-in Motion (B-WIM) technology as a tool for highway maintenance, safety and enforcement has established an interest for field demonstrations of the technology and potential applications in the United States. In this project, researchers at three University of Alabama campuses are collaborating to apply bridge weigh-in-motion (B-WIM) technology developed in Europe to Alabama bridges.

A portable B-WIM system has several advantages over traditional systems including:
1. Can be employed to monitor truck weight and size without interfering with traffic flow.
2. Portable installations are not visible to truck traffic as it crosses the instrumented bridge.
3. Can be installed without damaging the pavement or interfering with the traffic, and
4. Can be moved from one location to another without influencing accuracy of the results.

At this stage of development many of the potential benefits of B-WIM in terms of traffic safety and maintenance are largely anecdotal. This project aims at filling in the knowledge gaps by answering the following questions:
- Is the European B-WIM system a practical and effective tool for vehicle weight enforcement in Alabama (and hence other US states)?
- How difficult is it to install and calibrate the system?
- Can the system identify overweight vehicles traveling at highway speeds?
- Can the B-WIM system be used effectively on typical Alabama bridges such as concrete girder and steel stringer bridges?

More specifically, the project has three primary objectives: 1) Identify the potential benefits of using B-WIM technology in Alabama 2) Perform a pilot B-WIM system field test program in Alabama to evaluate the potential for deployment and 3) Use the results of the technical research and field testing as both an educational tool and a foundation for further discussion on a national level.

To assist in this effort, the Alabama Department of Transportation has recently purchased a B-WIM system developed by the Slovenian National Building and Civil Engineering Institute (Zavod Za gradbenisto Slovenije, ZAG) and a Slovenian private firm, Cestel, and made it available to the University of Alabama research team. The system developed by ZAG and Cestel is trademarked SiWIM. Representatives from Cestel visited the University of Alabama at Birmingham (UAB) October 18 through 25, 2007 to help install the B-WIM system on an Alabama bridge for experimentation.

Background. The expansion in freight shipments on the nation’s highways has led to a substantial increase in road traffic congestion. Of particular concern is the increase in the number, size and weight of heavy commercial vehicles. Because of the limited resources available to enforcement agencies, an effective program of highway maintenance and safety could benefit substantially from an affordable traffic sampling and enforcement program that is...
not man power intensive. A reliable, accurate and portable dynamic sampling system capable of delivering measurements of moving vehicle type, size, and weight would be very attractive. B-WIM is such a system.

In the late 1970s B-WIM research was performed in the United States by Fred Moses and his team, however, European researchers have advanced the technology considerably over the last fifteen years. In the summer of 2006 a ten-member team of experts composed of AASHTO, FHWA, law enforcement and academia representatives participated in a Commercial Motor Vehicle Size and Weight Enforcement (VSW) Scan Tour in Europe. Team members observed that a B-WIM system was being used successfully in Slovenia and other countries for pre-selection for mobile weight enforcement and to monitor alternate routes used by truckers to bypass scales. The AASHTO Technology Implementation Group (TIG) has identified WIM as a focus technology for vehicle size and weight enforcement.

In response to this recommendation, a collaborative research partnership was developed between researchers from the University of Alabama at Birmingham (UAB) that serves as the lead institution on this project, the University of Alabama at Tuscaloosa (UA), and the University of Alabama in Huntsville (UAH). The 18-month research project is supported by the University Transportation Center for Alabama (UTCA) and began in May 2007.

**Process**

**Task 1: Appraisal of Applicability of Bridge Weigh-in-Motion Technology.** Detailed literature and state-of-practice review is being performed and recommendations will be developed to the potential beneficial use of weigh-in-motion (B-WIM) system technology in Alabama.

**Task 2: Alabama Suitability for Potential B-WIM Systems Deployment.** This task evaluates the database of bridges in Alabama and sorts the inventory of bridges to identify good candidates for equipment installation.

**Task 3: Purchase and Delivery of a Portable B-WIM System.** Based on the collaboration with key stakeholders, ALDOT purchased a B-WIM system and made it available for testing.

**Task 4: Field Testing and Data Analysis.** Initial laboratory testing and analysis will verify the recommended installation procedure and calibration methodology and will confirm the suitability of the site recommended for initial field testing. The field testing program will provide the data for the full range of capabilities of the purchased B-WIM system. The field demonstrations will be documented carefully (written and video) so that the knowledge gained will be available for technology exchange and educational applications. This task will include the following steps:

- Controlled laboratory-scale demonstrations of the B-WIM system components and software before the field installation. A crucial requirement of this task is the establishment of a reliable system calibration methodology.
- A detailed physical equipment installation methodology will be confirmed and the data collection and transmission equipment setup tested and finalized.
- A detailed field testing plan for the selected field test demonstration will be developed and coordinated with ALDOT and other stakeholders.
- Field system demonstration testing and calibration will be accomplished using the selected preliminary field test bridges. A minimum of two trucks will be utilized in the testing. The trucks will first be weighed on a static scale and then driven multiple times over the test.
bridge instrumented with the B-WIM system. The software calibration algorithms built into the B-WIM system by the equipment vendor will be evaluated.

- Advanced WIM calibration technologies, such as calibration by axle rank will also be investigated.
- The B-WIM system will be demonstrated to ALDOT engineers by measuring the axle weights of several “unknown” trucks which will then be weighed on static truck scales.
- Analysis of results for the bridge structural configuration tested and recommendations for future application to different types of bridges.

**Task 5: National B-WIM Symposium.** A national symposium is being organized for April 2008 in Birmingham Alabama on the topic of B-WIM. The purpose of the symposium is to bring together potential users and researchers to share information and ideas concerning B-WIM systems, and to discuss research needs for effective deployment of B-WIM in the United States.

**Findings and Conclusions.** Results from the testing and evaluation of the SiWIM system in Alabama are not available since the initial installation is scheduled for this month (October, 2007). Review of relevant research and practice indicates B-WIM has great potential as a tool to help agencies control the loads on their bridges and highways. If successfully mated with license plate recognition technology, for example, highway agencies could identify owners of frequently overweight vehicles.

B-WIM issues under active investigation in Europe include: development of influence surfaces to identify multiple vehicles on the bridge simultaneously, calculating the truck static weight based on the measured dynamic response of the bridge to a moving truck, and determining axle spacings and truck speeds using under-bridge sensors only.

**Contact Information**

Wilbur A. Hitchcock, Ph.D.,
Professor, Department of Civil and Environmental Engineering
The University of Alabama at Birmingham
Hoehn 140, 1530 3rd Avenue South
Birmingham, AL 35294-4440
Phone: 205-934-8472; E-mail: wah@uab.edu
Description. Reliable and timely information is essential to efficient and safe commercial vehicle operations, which play a significant role in the Mississippi Valley Region. Many transportation-related information systems have been developed by agencies and governments to serve various local needs. However, as freight-travelers make their way through multiple localities in the region, the current decentralized structure of the region’s travel-related information infrastructure results in suboptimal driving decisions being made by motor carriers. Proliferation of the current information systems is a problem, as is the consistency and completeness of the information in these systems. A centralized, one-stop shop for information would enable freight-travelers to make accurate and up-to-the-minute adjustments in their routes, which would improve efficiency and lower costs for freight travel throughout the region.

The main objective is to design the basic architecture of a reliable traveler information clearinghouse for the 10-state Mississippi Valley Region that provides necessary information to commercial vehicle operators and associated industries to improve region-wide mobility and safety.

The clearinghouse will serve as the center of information from which motor carriers get critical travel information regarding travel time (e.g., congestion), work zones, special events, unplanned incidents, critical routing decision points, lane closure and restriction information, rest areas, and applicable regulations (e.g., weight). As part of a regional approach to dealing with transportation problems, the clearinghouse will propose a platform on which multiple states in the Mississippi Valley region manage and share critical travel related information for commercial vehicle operators. Note that this study focuses on clarifying the needs from the motor carriers, transportation planners, and traffic operations perspectives. It does not address data structural issues such as storage requirement, searching/indexing, or computational and networking requirements of the hosting servers. Important sources of information that are well worth careful examination include 511 systems, other local traveler information resources, and the Transportation Management Data Dictionary (TMDD).

Background. This clearinghouse project emerged from four projects previously considered of high importance by the Mississippi Valley Freight Coalition (MVFC) in February, 2007. Those four projects are:

- Identification of advanced traveler decision points.
- Combine state static closure information.
- Real time traveler information needs of the trucking industry.
- Identification of alternative routes.

Consolidation of these projects into this project will result in more helpful and comprehensive information for the end-users in the form of the proposed freight traveler information clearinghouse. This project was approved by the MVFC Board of Directors in July, 2007.
By background, the Mississippi Valley Freight Coalition is a ten-state organization with participation from the DOTs (Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Ohio, and Wisconsin). The MVFC is housed in the National Center for Freight and Infrastructure Research and Education (CFIRE) at the University of Wisconsin – Madison. A pooled fund was established to support research to address challenging freight issues facing the region. Approved along with this Information Clearinghouse project by the Board of Directors were Assessment of Multimodal Freight Bottlenecks and Alleviation Strategies for the Midwest Region, Expanded Truck Parking in the Mississippi Valley Region, and Mississippi Valley Freight Coalition Workshop on Responding to National Transportation Initiatives.

On the research team of this Clearinghouse project are David Noyce, Teresa M. Adams, Peter Rafferty, Steven Parker and Bruce X. Wang.

**Process.** The duration of this Clearinghouse project is 15 months, starting in October, 2007. Currently, this project is in the process of finalizing its work plan. Tasks identified are as follows.

- Review literature on freight traveler information system.
- Record the list of agencies/organizations in charge of relevant traveler information systems for motor carriers.
- Develop a list of currently available data/information sources available to freight travelers.
- Conduct a survey and interviews of motor carrier representatives to identify challenges with current information systems and needs for information.
- Conduct survey/interviews with planners/regulators to estimate potential volumes of inquiries from travelers to the clearinghouse and identify effective means of conveying traveler information en route or off the road.
- Estimate the system requirements for the clearinghouse (volume of data transmission, storage, indexing, searching, and maintenance).
- Determine data and functional requirements of the clearinghouse.
- Exploratory study to identify traveler decision points (advanced information point).
- Exploratory study of data collection and update mechanism and other critical issues identified.
- Identification of potential issues in maintaining the clearinghouse and approaches to these problems.

**Findings.** We expect to deliver the following products

- Documented interview and survey results.
- Documented list of currently available information.
- Documents throughout and final report on clearinghouse architecture.
- Conceptual GIS interface mock-up of use case scenarios.
- Final report encapsulating all tasks and deliverables noted above.

**Recommendations for Further Action.** The findings of this research will be recommended to the Mississippi Valley Freight Coalition Board of Directors for consideration of establishing a traveler information clearinghouse to help improve movement of freight travelers across the region. Detailed recommendation will include issues related to the complete set of information attributes based on use scenarios analysis, information standards, platform of the information system (distributed vs. centralized), information deployment, etc.
Contact Information
Bruce Wang, Ph.D.
National Center for Freight and Infrastructure Research and Education
College of Engineering,
University of Wisconsin-Madison
Tel: 608-262-6639
Fax: 608-263-2512
Email: wangx@engr.wisc.edu

Peter Rafferty, PE, PTOE, AICP
Wisconsin Traffic Operations and Safety Lab
Department of Civil and Environmental Engineering
College of Engineering
University of Wisconsin-Madison
Tel: 608-890-1218
Fax: 608-262-5199
Email: prafferty@wisc.edu
POSTER SESSION

Rail Relocation Projects in the U.S.: Case Studies and Lessons for Rail Planning

JEFFERY E. WARNER, LESLIE E. OLSON, CRAIG E. ROCO, GLENN C. ANDERSON, and STEPHEN S. ROOP
Texas Transportation Institute

Project Description. This project, performed for the Texas Department of Transportation (TxDOT), examines rail relocation projects in the United States to determine best practices, document project costs and expected benefits, and develop recommended policies for rail planner use in assessing potential urban rail relocation projects. Case studies deliver information on a broad variety of issues to be considered in railroad relocation projects including example project costs, impacts upon urban and outlying communities, potential funding mechanisms, and how potential rail relocation projects may be integrated with planning for other transportation improvements.

Background. The increase in the volume of truck and rail freight in recent years has been dramatic. This trend is expected to continue as international trade levels grow both in North America and via seaborne trade with the rest of the world. In no place are the effects of this increase felt more than in metropolitan areas, where freight movement is often choked by local traffic. Traffic conflicts in urban areas are especially acute in areas surrounding urban rail facilities and at the many at-grade highway-rail grade crossings. Rail operations are also hindered in the urban environment where urban rail yards have become constrained by neighboring land uses and city ordinances that seek to restrict certain railroad operations. One approach to addressing urban vehicular-train conflict and urban rail operational issues is to consider the relocation of train operations to new rail corridors and facilities located outside urban boundaries or to depressed, grade separated corridors.

Process. Texas Transportation Institute (TTI) researchers analyzed a range of critical issues related to rail relocations, identified known major rail relocation projects around the country (both past and planned projects), and thoroughly analyzed five of those projects as case studies. The critical information gathered from the literature review and case studies assisted the research team in creating a list of best practices related to implementing this type of project and identified significant factors for TxDOT and other rail planners to consider.

Findings and Conclusions. The research team developed a table listing information on 30 rail relocation projects around the United States that had been planned, studied, or implemented since 1973 when the Federal Aid to Highways Act implemented a demonstration program for funding rail relocation projects. Several of those projects were later cancelled in the mid-1980s due to the lack of progress, yet other rail relocation projects were advanced using alternative funding sources. Many of the original projects have only recently been completed—more than 30 years after their inception.
By examining the national relocation projects and the potential Texas rail relocation projects listed in the Texas Rail System Plan, TTI determined that the projects can be classified into three broad classifications:
1) Small urban area bypass – Relocation would move the rail line out of a small or mid-sized urban area to minimize traffic and/or safety conflicts.
2) Large urban area consolidation/relocation – Consolidation or relocation of routes within a large urbanized area.
3) Extra-urban consolidation/bypass – Consolidation or relocation of rail lines to an area outside urbanized boundaries meant to bypass completely the urban area.

Five of the rail relocation projects, selected jointly by TTI and TxDOT project advisors, were advanced as detailed case studies. The case study projects were chosen based upon similarity to projects being considered in Texas and are located in: Marysville, Kansas; Lafayette, Indiana; Reno, Nevada; Salt Lake City, Utah; and the State of Colorado (Front Range Project). The in-depth examination of these projects provided critical information related to project motivation, costs and benefits, and lessons learned.

The lessons compiled from the case studies identified several issues important for the state of Texas as it begins to consider rail relocation projects as part of its long-term strategy to address urban highway-rail conflicts. Issue areas include:
- Project prioritization/selection characteristics,
- Potential funding sources and methods,
- Partnering principles for railroad companies and other private sector partners,
- Public information/involvement recommendations, and
- Corridor relocation and subsequent development recommendations.

**Recommendations for Further Action.** Based on the in-depth evaluation of rail relocation projects in the United States there are several areas recommended for further investigation:
- Examination of relocating rail operations as compared to other possible solutions, such as grade separating, rail infrastructure improvements, or operational changes.
- Incorporation of rail relocation projects into the planning process and how to compare rail relocation projects against other important transportation projects.
- In depth evaluation of public and private sector direct and indirect costs and benefits associated with relocating freight rail operations or other projects involving public investment in private infrastructure.
- Examination into the roles passenger rail, transit, and economic development play in the development of rail relocation projects.
- Evaluation of the ability of the public sector to develop restrictions on development along newly relocated rail corridors that call for compatible land uses and restrict residential encroachment along the corridor.
- Investigation of existing federal, state, and local funding and financing options available for rail relocation projects, along with the investigation of potential creative funding and financing solutions.

**Contact Information**
Curtis A. Morgan
Program Manager
Multimodal Freight Transportation Programs
Texas Transportation Institute
3135 TAMU
College Station, TX 77843
Phone: (979) 458-1683
Fax: (979) 862-2708
E-mail: c-morgan@ttimail.tamu.edu

Jeffery E. Warner, Presenting at Poster Session
Associate Transportation Researcher
Multimodal Freight Transportation Programs
Texas Transportation Institute
3135 TAMU
College Station, TX 77843
Phone: (979) 862-2915
Fax: (979) 862-2708
E-mail: j-warner@tamu.edu
APPENDIX

Attendees
(number indicates breakout group)

Teresa Adams - 1
WI Transportation Center
adams@engr.wisc.edu

Keith Bucklew - 2
Indiana DOT
kbucklew@indot.in.gov

Felix Ammah-Tagoe - 8
E-Ternational Research Consulting
felixat@eternational.com

Randolph Butler - 7
US DOT - FHWA
Randy.Butler@dot.gov

Michael Anderson - 1
UAH
mikea@cee.uah.edu

Joedy Cambridge - None
TRB
jcambridge@nas.edu

Erik Autor - 6
National Retail Federation
autore@nrf.com

Christina Casgar - 2
San Diego Association of Governments
cca@sandag.org

Hayriye Ayhan - 3
Georgia Tech
hayhan@isye.gatech.edu

Harold Cerveny - 3
The Tioga Group
hcerveny@tiogagroup.com

Anne Aylward - 1
US DOT/Volpe Center
ayward@volpe.dot.gov

Anastasios Chassiakos - 8
California State University
achassk@csulb.edu

Farshid Azadian - 6
Wayne State University
f_azadian@wayne.edu

Rantu Chinnam - 1
Wayne State University
r_chinnam@wayne.edu

Richard Begley - 2
Rahall Transportation Institute
begley@marshall.edu

Matt Cuddy - 5
Northwestern University Trans. Ctr
m-cuddy@northwestern.edu

Maria Boile - 3
Rutgers University
boile@rci.rutgers.edu

Ronald Duych - 6
US DOT- RITA/BTS
ronald.duych@dot.gov

Thomas Bolle - 2
US DOT - RITA
thomas.bolle@dot.gov

Andrew Farkas - 7
Morgan State University
zfarkas@eng.morgan.edu

Travis Brouwer - 1
Oregon DOT
brouwer@odot.state.or.us

Darryl Fields - 2
Mid-America Regional Council
dfields@marc.org

Reinhardt Brown - 4
SC State University
rbrown@scsu.edu

Miguel Figliozzi - 8
Portland State University
figliozzi@pdx.edu

Paul Brubaker - None
US DOT - RITA
paul.brubaker@dot.gov

MJ Fiocco - 3
RITA RD&T
mj.fiocco@dot.gov
David Floyd - None
TRB
dfloyd@nas.edu

Jeff Foster - 1
UAB University Transportation Center
jeffrey.foster@ccc.uab.edu

Kaori Fujisawa - 2
U of Washington
fujisk@u.washington.edu

Anthony Furst - 4
US DOT - FHWA
tony.furst@dot.gov

David Ganovski - 3
Maryland DOT
dganovski@mdot.state.md.us

Matthew Garrett - 4
Oregon DOT
mathew.l.garrett@odot.state.or.us

Genevieve Giuliano - 4
University of Southern CA
giuliano@usc.edu

Andy Goetz - 3
University of Denver
agoetz@du.edu

James Gosnell - 2
Southern California Assoc. of Governments
gosnell@scag.ca.gov

John Gray - 5
Union Pacific Railroad Company
jtgray@up.com

Kathleen Hancock - 4
Virginia Tech - CGIT
hancockk@vt.edu

Gregory Harris - 3
University of Alabama
harrisg@uah.edu

Keith Hofseth - 5
USACE, Institute for Water Resources
keith.d.hofseth@usace.army.mil

Gloria Jeff - 3
Los Angeles DOT
gloria.jeff@lacity.org

Eric Jessup - 1
Washington State University
eric_jessup@WSU.edu

Crystal Jones - 6
US DOT - FHWA
crystal.jones@dot.gov

Kazuya Kawamura - 5
University of IL, Chicago
kazuya@uic.edu

Elaine King - None
TRB
eking@nas.edu

Norm King - 7
Leonard Trans. Ctr, Cal State
nking@csusb.edu

Robin Kline - 7
US DOT - RITA
robin.kline@dot.gov

Susie Lahsene - 5
Port of Portland
susie.lahsene@portofportland.com

Catherine Lawson - 4
University at Albany
lawsonc@albany.edu

Kelly Leone - 8
US DOT
kelly.leone@dot.gov

Martin Lipinski - 8
University of Memphis
mlipinsk@memphis.edu

Timothy Lomax - 1
Texas TI
t-lomax@tamu.edu

Thomas Marchessault - 8
US DOT- RITA
thomas.marchessault@dot.gov

Thomas Maze - 2
Iowa State University
tmaze@iastate.edu

Edward McCormack - 3
University of Washington
dedm@u.washington.edu
Michael McGurrin - 1
Noblis, Inc.
mcgurrin@noblis.org

Lydia Mercado - 1
US DOT - RITA
lydia.mercado@dot.gov

Michael Meyer - None
Georgia Tech
mmeyer@ce.gatech.edu

Eric Moreno-Quintero - 5
Instituto Mexicano del Transporte
emoreno@imt.mx

Diomo Motuba - 6
ATAC
diomo.motuba@ndsu.edu

Alper Murat - 4
Wayne State University
amurat@wayne.edu

Heather Nachtmann - 7
Mack Blackwell Rural Trans. Center
hln@uark.edu

Diane Newton - 2
SAIC
newtondia@saic.com

Leslie Anne Nicholson - 8
University of Alabama
nicho057@bama.ua.edu

Nancy Nihan - 1
Transportation Northwest
nihan@u.washington.edu

Val Noronha - 3
Digital Geographic
noronha@digitalgeographic.com

Thomas O'Brien - 2
CSU Long Beach
tobrien@csulb.edu

Amr Oloufa - 3
University of Central FL
aoloufa@mail.ucf.edu

John Orr - 4
Atlanta Regional Commission
jorr@atlantareregional.com

Thomas Palmerlee - None
TRB
tpalmerlee@nas.edu

Rhona Pavis - 4
Jack Faucett Associates
pavis@jfauccett.com

Leo Penne - 7
AASHTO
lpenne@aashto.org

Robert Plymale - 4
Rahall Transportation Institute
bob.plymale@njrati.org

Kate Quinn - 5
US DOT - FHWA
kate.quinn@dot.gov

Craig Rockey - 6
Assn. of American Railroads
crockey@aar.org

Caroline Rodier - 5
University of CA
cjrodier@path.berkeley.edu

William Rogers - 5
TRB

Matthew Roorda - 6
University of Toronto
roordam@ecf.utoronto.ca

Tracy Rosser - None
Wal-Mart Stores, Inc.
tracy.rosser@wal-mart.com

Bernie Sanders - 7
CSX Technology
bernie_sanders@csx.com

Rolf Schmitt - 3
US DOT - FHWA
rolf.schmitt@dot.gov

Joseph Schofer - 7
Northwestern University
j-schofer@northwestern.edu

Cecil Selness - 7
Minnesota DOT
cecil.selness@dot.state.mn.us
John Selter - 8
University of Central FL
hbalram@mail.ucf.edu

Caesar Singh - 4
US DOT - RITA
caeasar.singh@dot.gov

Amy Stearns - 5
US DOT - RITA
amy.stearns@dot.gov

Edward Strocko - 6
US DOT - FHWA
ed.strocko@dot.gov

Tianjia Tang - 6
US DOT - FHWA
tianjia.tang@dot.gov

Mary Lynn Tisher - 5
Virginia DOT
mary.tischer@vdot.virginia.gov

Curtis Tompkins - 7
Research and Innovative Tech. Admin.
curtis.tompkins@dot.gov

Daniel Turner - 7
University of Alabama
dturner@eng.ua.edu

Ava Vollbrecht - 8
Norfolk Southern
acvollbr@nscorp.com

Thomas Wakeman - 4
Stevens Institute of Technology
twakeman@panynj.gov

Bruce Wang - 6
University of WI - Madison
wangx@engr.wisc.edu

Jeff Warner - 7
Texas TI./Multimodal Freight Programs
l-navejar@ttimail.tamu.edu

Joyce Wenger - 8
Booz Allen Hamilton, Inc.
wenger_joyce@bah.com

Karen White - 8
FHWA
kwhite@dot.gov

Chelsea White III - 8
Georgia Institute of Technology
chelsea.white@isye.gatech.edu

Tom Whitney - 5
South Carolina State University
twhitney@scsu.edu

Kermit Wies - 5
Chicago Metro. Agency for Planning
kwies@cmap.illinois.gov

Ron Wing - 5
Rahall Transportation Institute
ronwwing@earthlink.net