Tour-based and Supply Chain Modeling for Freight in Chicago

Broad Agency Announcement Number Solicitation DTFH61-10-R-00013 for Transformational Changes and Revolutionary Advances for Transportation Planning

15 February 2010

Submitted to:

Mr. Joseph Fusari (FHWA)

Submitted by:

Maren Outwater, *Principal Investigator*
Resource Systems Group Inc.
917 E. Spooner Rd.
Fox Point, WI 53217
425-269-9684

with

Chicago Metropolitan Agency for Planning

University of Illinois at Chicago

and

John Bowman

Primary Focus Area:
Freight Planning: How new planning tools and programs such as freight analytical techniques, freight modeling improvements, methods of innovative freight data collection and data sharing can be used.

Secondary Focus Areas:
Congestion Management: What advanced analysis tools are available for use in the measurement and evaluation of operational improvements and strategies in transportation planning and advance the Congestion Management Process
Global Climate Change and Air Quality: How entities can develop and assess analytical methods to adequately identify and reduce transportation emissions that contribute to global climate change,

STATEMENT OF OBJECTIVES

The product of this research would be a proof of concept that tour-based and logistics supply chain models can be used in combination to address the weaknesses of current freight forecasting techniques for the Chicago region. Existing data would be used to apply the models in this study. A secondary product of this research would be recommendations for the data required to support the estimation of new models with this structure. The proof of concept would include the application of truck demand models but would not include validation of traffic assignments for trucks.

Both tour-based and logistics supply chain models have been researched for use in freight forecasting over many years and would greatly enhance the behavioral realism for Metropolitan Planning Organizations (MPOs). The state of the practice for freight forecasting models in metropolitan areas is typically commodity-based freight models, 3-step or 4-step truck models or a combination of these methods. The primary weaknesses of these approaches is the lack of detail at the traffic analysis zone level, the lack of information about the local pickup and delivery trips and service trips, and the ability to capture trip-chaining that occurs. The two proposed analytical methods will address these weaknesses by applying models at a traffic analysis zone level that include local pickup and delivery and service trips and directly modeling trip chaining that occurs in truck travel. The two techniques are recommended because certain industries generate truck trips that are linear in nature (i.e. they begin where the goods are produced and travel to the place where the goods are consumed and they may stop along the way at intermodal terminals or distribution centers) and certain industries are more circular in nature (i.e. they begin and end at the same place, with numerous delivery stops along the way). Typically, the industries that follow a logistics supply chain model represent inter-regional goods movements and industries that follow a tour-based model represent intra-regional goods movements.

We will also research the framework for using freight data at the national and international level as inputs for regional models. For the last three years, the UIC team has been developing an activity-based micro-simulation model of freight movements for the entire U.S. Such model will be able to capture the effects of broad shifts in the international freight flow and major infrastructure projects (e.g. widening of Panama canal) on the freight flow to/from/through the major transportation hub like Chicago. In contrast to the Transearch data, the UIC model will produce freight movement at the shipment level, and may prove to be a better fit with the tour-based and logistics supply chain models.

We believe that this proof of concept could be used by many MPOs to address the known weaknesses in their current freight forecasting methods and demonstrate that these new models are both possible and practical. The development of recommendations for collecting data required to support model estimation will also be of use to many MPOs. The Chicago Metropolitan Agency for Planning (CMAP) plans to use these recommendations to collect data and develop freight forecasting models using this framework for regional planning purposes.

WORK PLAN

Task 1: Develop the Freight Forecasting Framework

We begin by reviewing the literature on tour-based and logistics supply chain models to identify potential models that could be transferred for use in Chicago (and elsewhere). This review will include identifying geographic detail, industries and commodities, time periods, special generators that will be included in the models. We will study the connectivity between national freight models and the regional freight model in terms of consistency and data flow. The framework will focus on the trip generation, distribution and possibly vehicle types, aspects of freight modeling, but not mode choice or assignment. The product of this task will be a technical memorandum describing the freight forecasting framework for developing a proof of concept model for the Chicago region.

Task 2: Review input datasets

We will review and prepare relevant freight data required for input to apply the freight forecasting framework in the Chicago region. These data will include (but not be limited to) Transearch data (commodity flow) data, which CMAP has purchased, Commodity Flow Survey (CFS) data[1], UIC freight survey data, intermodal terminal data, county level inbound and outbound shipments, warehouse handbook (hard copy), land use and economic data, input/output data from Implan, County business patterns, and travel model networks and skims. The product of this task will be a technical memorandum describing the input data sources for the freight forecasting model and the associated databases.

Task 3: Apply logistics supply chain models by industry

There may be up to five components for the logistics supply chain models for each industry: goods movement, facility models (number and type), distribution and/or consolidation location models, shipment size and time models. The specifics of these model components and the relevant industries will be defined by the forecasting framework developed in Task 1. The product of this task will be a technical memorandum describing the application of each model component and programs to implement these models.

Task 4: Apply tour-based models by industry

Current research for tour-based models includes model components for tour generation[2], vehicle-type models, trip purpose models, time of day models, stop location models, and stop duration models. The specifics of these model components and the relevant industries will be defined by the forecasting framework developed in Task 1. The product of this task will be a technical memorandum describing the application of each model component and programs to implement these models.

Task 5: Develop recommendations for data collection

The application of the models will allow us to determine data collection requirements to support model estimation of these models for the Chicago region. These data collection activities may include shipper/carrier surveys for freight flows, establishment surveys for in/out commodity flows, and roadside surveys for truck travel. The product of this task will be a technical memorandum on recommendations for data collection.

---

[1] Ruan, M., J. Lin (forthcoming) A Synthesis Framework for Generating County Level Freight Data Using Public Sources for Spatial Autocorrelation Analysis, Transportation Research Record: the Journal of Transportation Research Board , accepted and forthcoming

[2] Ruan, M., J. Lin, K. Kawamura (2009) Modeling Urban Commercial Vehicle Daily Tour Choice Using the Texas Commercial Vehicle Survey Data, presented at the 89th Transportation Research Board Annual Meeting, National Research Council, Washington, D.C., January 10-14, 2010

HOW RESEARCH WILL ADVANCE THE PRACTICE

While tour-based and logistics supply chain methods have been researched in the U.S. and applied in other countries (Canada, Japan and Europe), there are currently no known examples of an application of these types of freight models in the U.S. for a metropolitan region. Ohio and Oregon have developed and applied disaggregate logistics supply chain type models for statewide freight forecasting in combination with activity-based passenger travel demand models. Calgary and Edmonton in Canada have developed and applied tour-based models for urban freight forecasting. The Netherlands, Sweden and the UK have developed logistics supply chain models for urban freight forecasting and Japanese City Logistics attempted to optimize these logistics and transportation activities in urban areas. We propose to rely on these existing models to develop a prototype for applying these modeling techniques in the Chicago region. The modeling techniques will be applied to specific industries according to the behavior most prevalent in that industry. This proposed framework was developed initially for the Los Angeles County Metropolitan Transportation Authority (LAMTA) by the principal investigator, Maren Outwater and Michael Fischer from Cambridge Systematics[1].

An integrated tour-based and logistics supply chain model may prove to be a superior tool for forecasting the complex system of freight movements. To our knowledge, this research would lead to a significant advancement in the application of freight forecasting models by bringing current research methods into practice and specifically addressing many of the current limitations of existing freight forecasting models. While this project is proposed as a proof of concept, CMAP feels it would be an important step towards a full implementation in the Chicago area.

In recent years, freight forecasting has been identified as a way to understand the patterns of interstate and international trade, economic growth, and the impacts created by use of the nation's transportation system for the movement of freight. These impacts can include congestion and delay, potential exposure to hazardous materials and other safety concerns, as well as energy use and environmental consequences. The fact that more and more freight today is moved by heavy trucks on the nation's interstate system has become an area of particular concern to planners.

Despite recent advances in freight forecasting, the current methods are not adequate to address the increasingly complex issues related to freight demand. Current models are mostly based on methods that were developed for personal passenger travel, and this is true for Chicago where truck travel is loosely based on non-home-based passenger travel. Freight is obviously different than personal vehicle travel and requires a different technical approach. Given the transition that is currently underway to implement disaggregate modeling techniques, it is only logical to begin investigating disaggregate techniques for modeling the movement of freight as well.

Tour-based and economic methods have become the state-of-the-art in household travel modeling. This new approach offers a myriad of benefits that include the ability to model various aspects of choice behavior explicitly. These factors are relevant in personal travel, but are also important in freight modeling as well. We believe the proposed research to implement existing research on tour-based and logistics supply chain models for urban commercial movements will provide a glimpse into the future for practitioners. The proposed research will demonstrate the potential of these new methods and how well they serve to address the limitations of current freight demand forecasting models.

---

[1] Fischer, Michael; Outwater, Maren; Cheng, Lihung Luke; Ahanotu, Dike; Calix, Robert; An Innovative Framework for Modeling Freight Transportation in Los Angeles County, California; Transportation Research Record 1906, 2005.

HOW RESEARCH WILL RESPOND TO CURRENT AND FUTURE TRENDS

Planners have and will continue to face a difficult question: Specifically, how to accommodate the growing demands of freight movement on a transportation infrastructure that is shared by the traveling public who are likewise placing more demands on the system? A modeling framework that produces accurate forecasts and can be used to test different policies and strategies related to the movement of goods is badly needed. The next generation of freight models must be able to differentiate between different alternatives and be sensitive to policies such as truck restrictions, truck only routes, impact fees and pricing, and varied land use planning/zoning strategies.

In the past decade, freight has become a critical issue in the transportation community. The nation's highways, railroads, and ports are struggling to accommodate the substantial increases in the volume of goods being moved into and throughout the country. The safe, efficient, and reliable movement of goods has become a critical component of the nation's economic prosperity. This is also true in Chicago now and into the future, "In 2040, the Chicago region's freight system will contribute to the growth, productivity, and changing needs of business and industry by providing cost-effective and reliable access to resources, markets, and labor and will serve as an International hub for goods movement."[1]

Forecasting truck travel often proves to be much more difficult than forecasting personal travel. The challenge of freight forecasting is that changes in freight traffic are often related to economic, political, geographic, and business operation factors. In addition, data sources are often proprietary and difficult to obtain.

Containerization is a technological improvement that has impacted all aspects of goods movement. Containerization is the system of intermodal freight transport using standard-size containers that can be loaded and sealed intact onto ships, railroad cars, planes, and trucks. The introduction of containers vastly improved port-handling efficiency, thus lowering costs and helping lower freight charges and, in turn, boosting trade flows. Almost every manufactured product that humans consume spends some time in a container.

Changes in the manufacturing supply chain have also significantly changed the movement of goods. The nation's transportation infrastructure enabled the development of the just-in-time economy in which industries reduced their warehousing space because they no longer stockpile the materials used in production. These materials are delivered by suppliers at the very moment they are needed and move directly from loading dock to the production line.

In addition to technological and productivity changes, the past decade has also seen major political changes that affect the movement of goods. The global nature of the U.S. economy, aided by policies such as the North American Free Trade Agreement (NAFTA), has had a profound impact on all forms of freight movement. NAFTA in particular resulted in sharp increases in truck traffic across the borders with Mexico and Canada.

The factors above have led to dramatic increases in the number of trucks on the nation's highway system. Truck volumes are reaching staggering levels on the interstate system. The American Association of State Highway and Transportation Officials (AASHTO) estimates that in 2005, 30 miles of interstate highways carried more than 50,000 trucks per day. By 2035, that number is estimated to grow to 2,500 miles carrying more than 50 million trucks per day.

---

[1] Chicago Metropolitan Agency for Planning, *Freight Systems Planning Recommendations Project*, presentation by Tom Murtha to the CMAP Transportation Committee, November 20, 2009.

RESEARCH TEAM QUALIFICATIONS

Resource Systems Group, Inc. (RSG), founded in 1986 by a trio of Dartmouth College professors, specializes in the planning, analysis, and management of business, infrastructure and natural resources. RSG's approach to transportation planning and policy encompasses a balance of sophisticated planning tools and person-to-person communication and interaction, giving them an enviable record of success and innovation. Their core capabilities include integrated transportation-land use modeling and forecasting, multimodal transportation planning and analysis, best practices reviews and applications and strategic planning and organizational development. RSG's solutions are creative and grounded by over 20 years of experience with clients as large as federal agencies and Fortune 500 companies and as small as local interest groups and municipalities. **Maren Outwater, PE,** the proposed Principal Investigator has 25 years experience in developing forecasting models for land use, transportation, environmental and economic analysis. She has developed freight forecasting models in Seattle, Los Angeles, San Joaquin Valley, Phoenix, Tucson, Anchorage, Maine and Vermont and has conducted research on the distribution of commercial vehicles for Federal Highway Administration and statewide freight forecasting for the National Cooperative Highway Research Program.

Kermit Wies, PhD., is the Deputy Executive Director for Research and Analysis for the Chicago Metropolitan Agency for Planning (CMAP). CMAP is supportive of this research because the analytical framework aligns with their own thinking about freight forecasting and because the recommendations for data collection will provide useful direction for their data collection activities in support of this framework. CMAP recognizes the current limitations of existing freight forecasting models and has developed a broader vision of freight forecasting at the macro-, meso-, and micro-scales which incorporates the current research at the meso-scale level. Dr. Wies was the principal author for the 2030 Regional Transportation Plan for metropolitan Chicago and is central to the maintenance and enhancement of the travel demand models used for regional planning in the Chicago area.

University of Illinois at Chicago (UIC) has been a consortium member of the National Center for Freight and Infrastructure Research and Education (CFIRE) based at the University of Wisconsin, Madison since 2007. **Kazuya Kawamura, PhD,** is Associate Professor and Head of Department of Urban Planning and Policy at the University of Illinois at Chicago. Dr. Kawamura's expertise includes freight transportation planning, economic impacts evaluation of transportation projects, transportation-land use interactions, and empirical evaluation of accessibility measures. He serves in CMAP Freight Committee. **Kouros Mohammadian, PhD,** is an Associate Professor of Transportation Systems in the Department of Civil and Materials Engineering at UIC. His research has covered various areas of transportation planning including travel behavior analysis, modeling of activity and travel patterns, travel survey, freight planning and logistics, and development of state-of-the-art travel demand models. **Jane Lin, PhD,** is PI and co-PI on several ongoing freight research projects: Partnership in Freight Planning and Modeling, funded by CFIRE, Development of Freight Planning Support System for Northern Illinois, funded by IDOT, Mississippi Valley Commodity Flow Project, and Environmental and Energy Benefits of Freight Delivery Consolidation in Urban Areas, funded by CFIRE.

John Bowman is best known for his development and ongoing improvement of the activity schedule approach for the forecasting of regional passenger travel demand, and for enabling planning agencies to develop knowledge, skills, models and software needed to implement and use the approach. He is an expert in developing methods to model real world phenomena that are manifestations of choices made by individuals and firms. Recently he has been assisting CMAP to develop a long term strategy for advanced model development, with emphases on freight models and the needed data. Dr. Bowman earned graduate degrees from MIT (MST 1995, PhD Transportation Systems and Decision Sciences 1998).

PROJECT SCHEDULE AND BUDGET

RSG will serve as the prime on this project and will lead model development (tasks 3 and 4) and data development (task 2) as well as co-leading the development of the framework (task 1). CMAP will support the project with CMAP data and strategies to integrate this research with the Chicago area travel demand models. UIC will co-lead the development of the framework (task 1) and support the data and model development (tasks 2-4). John Bowman will support the data development (task 1) and tour-based model development (task 4) and lead the development of recommendations for data collection (task 5). Table 1 summarizes these roles by task and team member.

Table 1. Proposed Roles and Responsibilities of Team Members

Project Task	RSG	CMAP	UIC	Bowman
Task 1: Framework	Co-Lead	Advise	Co-Lead	Advise
Task 2: Data	Lead	Assist	Assist	Advise
Task 3: Supply Chain Models	Lead	Advise	Assist	Advise
Task 4: Tour-based Models	Lead	Advise	Assist	Assist
Task 5: Data Recommendations	Assist	Advise	Assist	Lead

Table 2 proposes an allocation of resources among the team members consistent with the proposed roles outlines above. CMAP will contribute in-kind services for the project in data development as well as advising on all aspects of the project.

Table 2. Proposed Allocation of Resources

Project Stage	RSG	UIC	Bowman	Total
Task 1: Framework	$12,500	$12,500	$2,500	$27,500
Task 2: Data	$30,000	$5,000	$5,000	$40,000
Task 3: Supply Chain Models	$75,000	$10,000	$2,500	$87,500
Task 4: Tour-based Models	$70,000	$10,000	$2,500	$82,500
Task 5: Data Recommendations	$2,500	$2,500	$7,500	$12,500
Total	$190,000	$40,000	$20,000	$250,000