MPC-363

January 1, 2012 – December 31, 2012

Project Title:
A two-stage approach for estimating a statewide truck trip table

University:
Utah State University

Principal Investigators:

Anthony Chen, Ph.D. (PI)
Professor (Utah State University)
anthony.chen@usu.edu
(435) 797-7109

Kevin Heaslip, Ph.D., P.E. (Co-PI)
Assistant Professor (Utah State University)
kevin.heaslip@usu.edu
(435) 797-8289

Research Needs:
Statewide models including passenger and freight movements are frequently used for supporting numerous statewide planning activities. Many states use them for air quality conformity analysis, freight planning, traffic impact studies, economic development studies, project prioritization, and many other planning needs (Horowitz, 2006). Recently, the importance of truck demand in the statewide planning process has increased due to its significant influence on the economy of each individual state and the nation as a whole. The current practice in estimating statewide truck origin-destination (O-D) trip table is through using truck trip rate estimation method in the Quick Response Freight Manual (QRFM), or from private freight database (i.e., TRANSEARCH by Global Insight). However, because of the nature of the shared database or borrowed parameters derived from different sources, the state Department of Transportation (DOT) has to spend tremendous efforts to improve the accuracy of the estimation to match the local observations (e.g., truck counts). Calibration (or estimation) is usually a lengthy process and requires specialized technical staffs to operate. There is an urgent need to develop innovative methodologies that make use of the publicly available data from both federal and state levels to estimate reliable and accurate statewide truck O-D trip table.

Research Objectives:
The goal of this research is to develop a two-stage approach for estimating truck O-D trip table using both commodity flows from the national commodity O-D database and truck counts from the state-level database. The specific objectives of this research project include the followings:

1. Collect data from different sources:
    a. Freight Analysis Framework version 3 (FAF^3), a newly released national commodity O-D database from the Federal Highway Administration (FHWA)
    b. Up-to-date statewide truck counts from the state DOT
2. Develop a commodity-based truck trip table using the national commodity flow data from the FAF^3 database
3. Develop a path flow estimator procedure to refine the commodity-based truck trip table using the up-to-date truck counts from the statewide truck count program.

Research Methods:
This research proposes a two-stage approach to estimate a statewide truck O-D trip table. Stage one estimates a commodity-based truck O-D trip table using the newly released national commodity flow database from the Federal Highway Administration (FHWA), while stage two adopts the concept of path flow estimator (PFE) to refine (or adjust) the commodity-based truck O-D trip table developed in stage one using the up-to-date daily truck counts from state DOT to reflect the actual truck traffic conditions observed in the real world.

• *Stage 1: Develop a commodity-based truck O-D trip table*
In stage one, we will develop a procedure to estimate a commodity-based truck trip table using the national commodity flow data from the newly released FAF^3 developed by the FHWA. The FAF^3 database provides estimates of commodity flows in the United States in terms of tonnage and value, by commodity type, mode, origin, and destination for 2007, and forecasts through 2040. It is publicly accessible from the Freight Management and Operations Database from the FHWA website[1]. This stage estimates the intrastate, interstate, and through commodity-based truck flows of a particular state. To accomplish this, it involves four tasks: i) extract a state-specific commodity flows by from FAF^3, ii) conduct subarea analysis to estimate the through commodity flows (i.e., passing through a particular state) iii) disaggregate the state-specific to county-specific commodity flows, and iv) converted the commodity flows into truck trips.

• *Stage 2: Develop a path flow estimator (PFE) procedure to refine the commodity-based truck trip table*
In stage two, we will develop a path flow estimator (PFE) procedure to refine the truck trip table obtained from stage one using the up-to-date truck counts from the statewide truck count program. PFE, originally developed by Bell and Shields (1995) and further enhanced by Chen et al. (2005, 2009, 2010), is a network observer capable of estimating path flows and path travel times using only traffic counts from a subset of network links. The basic idea is to find a set of path flows, hence an O-D trip table by aggregating the path flows for each O-D pair, which can reproduce the observed counts. This task involves modifying the PFE procedure to accept the daily truck counts collected by the statewide truck count program (i.e., from the permanent counting stations within the state, the weigh-in-motion (WIM) stations, and at the state borders) and an initial trip table from stage one to refine the statewide truck trip table. This PFE procedure will adjust the spatial distribution of the commodity-based truck O-D demand pattern to better reflect the actual truck traffic conditions in the statewide highway network. Validation of the results will be assessed by the accuracy of the assignment estimates measured by the root mean square error (RMSE) between the estimated and observed truck counts. The reasonableness of the estimated statewide truck O-D trip table will also be assessed with the available statewide land use information (e.g., population and employment density maps), observed truck screen-line counts, and statewide vehicle miles traveled (VMT) for trucks.

Expected Outcomes:
The estimated statewide truck O-D trip table will be useful to the state DOT and metropolitan planning organizations (MPO) in addressing the impacts of truck traffic to congestion, infrastructure deterioration, safety, and environment. Specifically, the statewide O-D truck trip

[1] http://ops.fhwa.dot.gov/freight/freight_analysis/faf/index.htm

table can contribute to better understanding of the impacts of truck traffic in the transportation network and allow planners for better planning, design, and management of transportation infrastructures including highways, bridges and pavements. Common usage of truck flows information includes: pavement and bridge design and management, prediction of freight movements, capacity expansions of highway segments and freight corridors, accident analysis, and environmental analysis.

Reliable and accurate statewide truck O-D trip table is critical to freight transportation planning, design, operations, and infrastructure decision making for the state. Because the O-D trip table is not directly obtainable in practice, the development of a two-stage procedure to estimate a statewide truck O-D trip table using the publicly available data from both federal and state levels provides a cost-effective way. We believe that the statewide truck O-D trip table estimation procedure developed in this research project will be a valuable tool for state DOT and MPO as these agencies look for ways to manage the truck traffic within their regions.

Relevance to Strategic Goals:
As mentioned above, the estimated statewide truck O-D trip table will assist state DOT and MPO to better plan, design, and manage the impacts (e.g., congestion, infrastructure development, pavement deterioration, accident and safety issues) caused by truck traffic. These results aim to improve mobility of truck traffic along state and interstate highway systems, and hence have the potential to support regional and national economic developments. The results of this research project contribute to the following goals: (1) state of good repair, (2) safety, and (3) economic competitiveness.

Educational Benefits:
Freight transportation planning is an important component of the overall travel demand forecasting process. This research project will provide useful information and real-world data to develop a freight transportation planning module for two courses taught by the PI at USU: CEE 5240/6240 Urban and Regional Transportation Planning and CEE 6290 Transportation Network Analysis. Our students will have the opportunity to learn about the actual freight transportation planning process conducted by the state DOT and to obtain hands-on experience with using the CUBE software used by both state and MPO planners in Utah.

Work Plan:
To meet the objectives set out above, we propose to undertake the following tasks in 18 months. Specifically, these tasks are to:

1. Conduct a literature review on estimating statewide truck O-D trip table (2 months)
2. Investigate and update the FAF^3 commodity flow database (2 months)
3. Collect both national and state-level data to build the statewide network (3 months)
4. Develop a stage-one procedure to estimate a commodity-based truck trip table using the national commodity flow database (3 months)
5. Develop a stage-two procedure to refine the commodity-based truck trip table using the up-to-date statewide truck counts (3 months)
6. Conduct a case study using the Utah statewide network (3 months)
7. Document findings and prepare final report (2 months).

Project Cost:
Total Project Costs: $100,000
MPC Funds Requested: $100,000
Matching Funds: $ $101,856
Source of Matching Funds: Faculty Salary, Tuition & Fees award for Ph.D. student, Fellowship for a visiting Ph.D. Student from China (See Budget for breakdown)

TRB Keywords:
Truck O-D Trip Table, Path Flow Estimator, Statewide Planning Model, Commodity Flows, Truck Counts.

References:

1. Horowitz, A. NCHRP Report 358: Statewide travel Forecasting Models. Transportation Research Board of National Academies, Washington D.C., 2006.
2. Office of Operations, Federal Highway Administration. Freight Analysis Framework (updated November, 2011). Available at: http://ops.fhwa.dot.gov/freight/freight_analysis/faf/index.htm [Accessed December 2011].
3. Bell, M.G.H. and Shield, C.M. A log-linear model for path flow estimation. In Proceedings of the 4th International Conference on the Applications of Advanced Technologies in Transportation Engineering, Carpi, Italy, 1995, pp. 695-699.
4. Chen, A., Chootinan, P., and Recker, W. Examining the quality of synthetic origin-destination trip table estimated by path flow estimator. Journal of Transportation Engineering, Vol. 131, Issue 7, 2005, pp. 506-513.
5. Chen, A., Chootinan, P., and Recker, W. Norm approximation method for handling traffic count inconsistencies in path flow estimator. Transportation Research Part B, Vol. 43, Issue 8, 2009, pp. 852-872.
6. Chen, A., Ryu, S., and Chootinan, P. L_∞-norm path flow estimator for handling traffic count inconsistencies: Formulation and solution algorithm. Journal of Transportation Engineering, Vol. 136, Issue 6, 2010, pp. 565-575.