Developing Validated Freight Transportation Models Utilizing Highly Aggregated Data

Topic Area: Models for transportation, port, air, intermodal operation; impact analysis

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ABSTRACT

It is commonly accepted in the transportation planning community that local data is the only legitimate data that can be used to forecast travel. Therefore, large, highly aggregated data sets are often discredited and deemed an inappropriate data source without extensive consideration. Additionally, since freight flow databases are generally large and highly aggregated, freight transportation traditionally has not been explicitly included in the process; rather, freight is implicitly included through the application of a factor related to passenger travel.

This paper presents the results obtained modeling freight transportation in an urban area using a highly aggregated, publicly available, freight flow database, known to have limitations. The paper discusses approaches to maximize the use of the aggregated freight flow data at various scales, disaggregation factors included in the process, and methods to overcome known limitations as part of the methodology to format the data for entry into a traditional travel model. The paper applies statistical validation techniques proving the freight volumes obtained from the aggregated data within a traditional transportation model do, in fact, provide reasonable matches to the existing counts, demonstrating that rejection of the data is not warranted. The paper concludes that a highly aggregated freight data set can be used in transportation planning activities, achieving acceptable levels of accuracy. Use of the highly aggregated data set, considering the result of a validated and acceptable model, is a preferable outcome to the options of ignoring freight in the modeling process or accepting freight is simply a portion of passenger travel.

INTRODUCTION

Transportation modeling initiatives focus on the development of travel demand models to support infrastructure investment decisions in urban areas. These models typically focus on passenger transportation to determine the existing and future roadway congestion and to test alternatives. The commonly used process is to develop the amount of travel or number of trips (trip generation), origin/destination pairs for the trips (trip distribution), mode for the trip, if alternate modes are available which is not the case in smaller urban areas, (mode choice), and finally the route for the trip (traffic assignment) [1]. Considerable research has been undertaken into this process, and although there is more work to be done, this modeling is relatively well understood.

NCHRP 570 Guidebook for Freight Policy, Planning, and Programming in Small- and Medium-Sized Metropolitan Areas and ongoing research being performed by the National Cooperative Freight Research Program (NCFRP) describes the need for the integration of freight traffic into the transportation modeling [2, 3]. Even with this greater recognition of the importance of freight transportation in the modeling environment, it is still difficult for transportation professionals to obtain accurate data for use in the models and data required for the verification and validation of theses models. The problem exists because freight data is proprietary and companies are reluctant to release this information. Many freight activities occur outside the study area and transportation professionals have no direct mechanism to collect freight trip information as with passenger trip information [2].

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BACKGROUND

The application of freight within a travel demand model is not a new concept. There have been several attempts to collect and incorporate freight flow information into a community's travel model. NCHRP 570 contains a brief examination of 15 case studies performed in small and medium sized communities [2]. However, these model options often act as a stop-gap, or place-holder, for freight within the travel demand model and these applications are difficult to validate to actual travel patterns. This paper focuses on the development, verification and validation of a transportation model of Mobile, Alabama, a medium sized urban area.

The Database

The highly aggregated database used in this application was the Federal Highway Administration's Freight Analysis Framework, Version 2.2 (FAF2). The FAF2 is a commodity flow database that contains 114 internal zones and 17 ports of entry for the United States, shown in figure 1 [4]. Flow data is provided for 43 specific commodities, for 7 transport modes, in either kilotons transported annually or value of shipment transported annually [4].

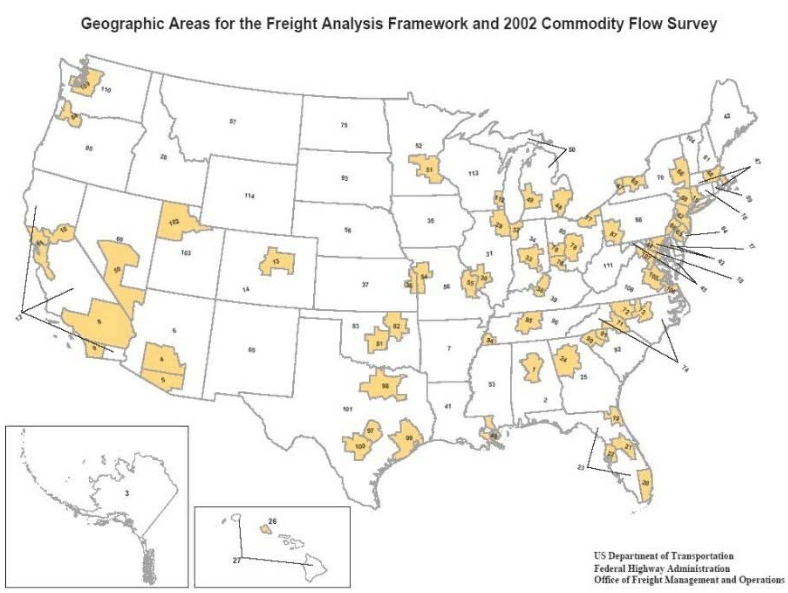

FIGURE 1 FAF2 Zones

Use of the freight flow information in FAF2 is questionable due to some limitations in the data due to the scale for the zones and the lack of empty vehicles being included in the database. Some of the limitations are:

- Estimating freight origin and destination movements at the sub-state or freight analysis zone (FAZ) level is often complicated by both availability of the data, and comparability issues.
- Data on the movement of intermediate goods originating from manufacturing, agriculture and mining are not readily available.
- Data are often repressed because they might reveal facts about individual firms.
- Economic data is classified by the North American Industrial Classification System (NAICS) and FAF2 data is classified by Standard Classification of Transported Goods (SCTG). Of the 43 SCTG codes only 14 have identical counterparts under the NAICS classification system.
- Translating data into truckloads, train cars or barges is questionable.
- Empty vehicles are typically not accounted for in the data conversions.

Approaches to Utilize the FAF2

Studies have been performed to disaggregate the FAF2 data to smaller geographic regions [5, 6, 7] and empty vehicles can be accounted through the inclusion of a percentage of empty vehicles in converting of kilotons to vehicles [8]. To overcome the NAICS/SCTG commodity classification issues a cross-walk table was developed at the three digit NAICS code level.

Employment data has typically been used to generate a freight traffic forecast in a study area. Employment, however, has been shown to be a poor predictor of freight traffic increases, primarily because it does not take into consideration productivity improvements in goods producing industries [7]. The Value of Sales or Value of Shipments (based upon the database being utilized) has been shown to be a better predictor of freight generation activity. Using value of sales instead of employment factors in future productivity improvements and consequently should provide a better forecast of future freight traffic [9].

Personal income was chosen to proxy the value of retail and wholesale sales to households and businesses in a study region. The growth of personal income is highly correlated with the growth of household consumption expenditures and consequently should give a more accurate forecast than either population or employment growth [9].

Local Surveys

The forecast of freight transportation can be improved dramatically by accurately collecting local freight data. Freight data generation studies are usually developed and disseminated at the national level and not specific to the urban area, [10] and [11]. Unfortunately, there are limited guides and literature available to aid in the development of a local freight collection system to tailor the freight model to the local level. This is not surprising due to the fact that freight is explicitly modeled in the process and freight data is proprietary.

The question then is can industry input provide insight when developing a long-term freight plan? The answer is yes because, after all, it is the conduct of business that creates freight through the attempt of suppliers to meet the demands of customers. Each company has a view of their industry sector’s freight transportation system. Gaining insight from these companies alerts planners to pattern shifts, network realignments, or simply current industry trends. Maybe the greatest benefit from obtaining input from local industry is the building of relationships with business leaders.

A system was designed and implemented for collecting, storing and analyzing local freight data within an MPO area and the application of that freight data to transportation planning. In addition, several other data sources were used to shore up the FAF2.

THE MODEL AND VALIDATION

The study location selected was Mobile, AL. The study community has an area population of approximately 350,000, an international port for bulk and container freight, and is positioned at the intersection of Interstate 10 and Interstate 65 – two important freight corridors within the U.S. (see figure 2).

The existing travel demand model for the study area was developed in TRANPLAN and implicitly models trucks. The trucks passing through the area are accounted for through the use of traffic counts at the study boundaries. The external-external trips are preloaded in the model and the trips constrained to selected roadways in the networks. The internal truck trips are assumed to be a portion of the non-home-based trips in the study area. These trips are distributed through a gravity model and assigned to the network using an equilibrium assignment.

Truck Trip Purposes

Initial examination of the study area, the aggregation levels and geography of the FAF2 database identified nine possible freight movements in the area.

The freight movements identified are:

1. External-External Trips (through trips)
2. Port to the US (non Alabama)
3. Alabama to the US (non Mobile)
4. Port to Alabama (non Mobile)
5. Mobile, AL and the rest of Alabama (non Birmingham, Alabama area)
6. Mobile, AL to Birmingham, Alabama area
7. Port to Mobile, AL
8. Mobile, AL to the US (non Alabama)
9. Internal to Mobile

Birmingham, Alabama area freight trips are considered separately because it is a different FAF2 zone, see figure 1.

Input to the Model

The aggregation of the nine trip purposes described form a single truck origin/destination matrix for Mobile. To incorporate this new matrix into the model, a few changes to the modeling structure were required. The external station traffic count volumes were reduced to remove trucks and the non-home-based trips were reduced to reflect the removal of trucks, both were done to avoid double counting. Second, the model structure was altered such that the truck matrix was assigned through a preload to the network as a separate mode which was constrained to selected roadways in the network. The selected roadways in the networks for truck traffic were carefully identified examining locations that contained limited turning radii and existing traffic calming devices.

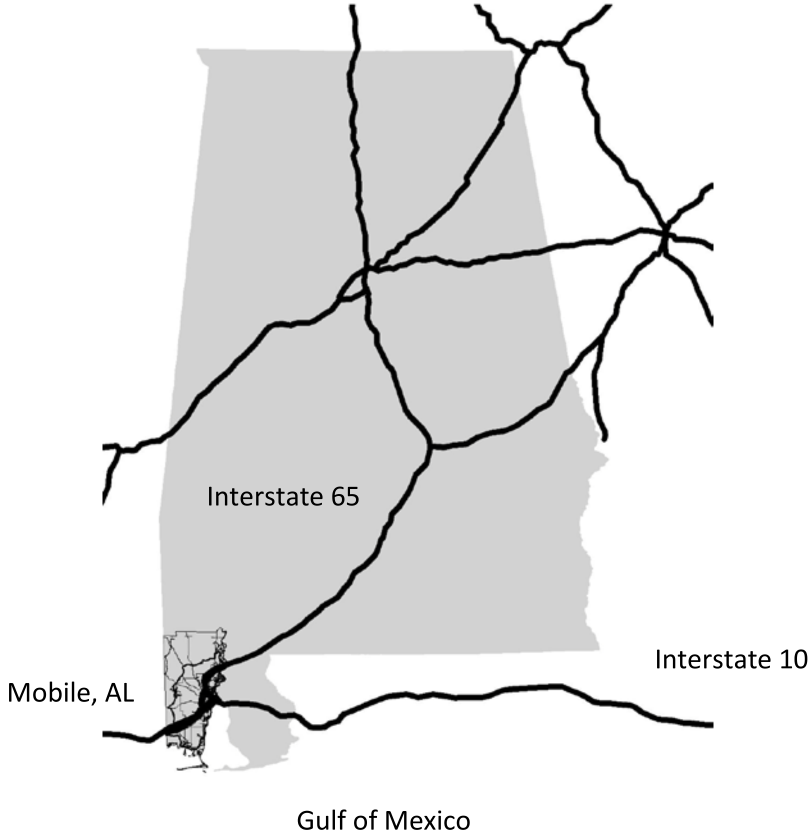

FIGURE 2 Mobile, AL location in relation to the Interstate System

Model Verification and Validation

The nine separate trip purposes were aggregated to create a total truck origin/destination matrix for the study area. This truck matrix was assigned to the study area network and validated to truck counts previously collected in the study area by the Alabama Department of Transportation.

The calibration of the model led to two important changes from the methodology mentioned previously. For the trips from the Port of Mobile to Alabama and the US, it was determined that there were shippers responsible for taking the trucks solely onto and off the port property. Investigation by the research team and MPO personnel determined that these shippers were not located on the main road and were not taking the obvious path the trucks would take if the trucks were to travel directly from the Port to their destination. Therefore, a change was made in the trip table to reflect a stop-over point for these trips.

The second change related to the Mobile – US trip, which were distributed using an industry survey to identify directionality. Based on the limited data collected in the industry survey at the time of the study, the directionality was adjusted to reflect the actual traffic conditions. This decision was made because the research team was unsure of the route used to leave town for long-haul trips into and out of the study area. For example, a trip listed as heading north, might instead head west out of Mobile to continue on a north-south interstate in Mississippi.

Validation of the truck model was performed using a comparison of the assigned trucks and the trucks counts collected in the study area. The validation plot of the data is shown in Figure 3 and the R-square coefficient for the data is 0.767.

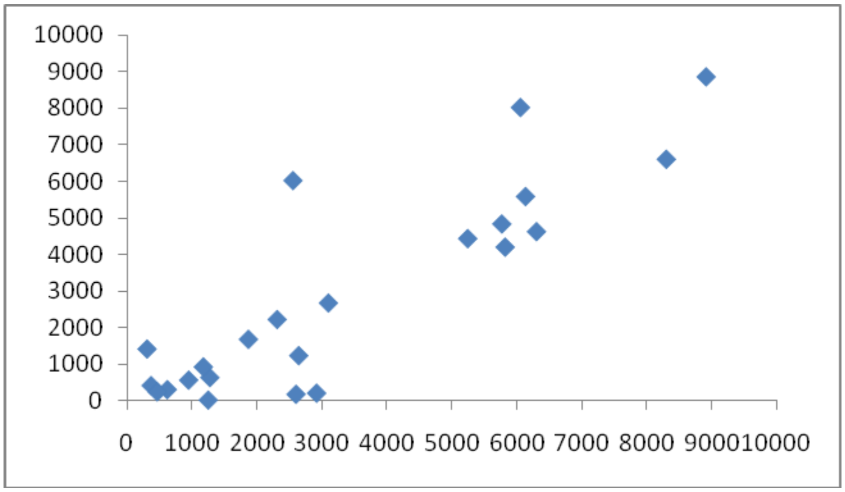

FIGURE 3 Validation of the Trucks in the Model

CONCLUSIONS

This study examined the use of a publically available, highly aggregated commodity flow database to incorporate freight into an urban model. The process required a multi-tiered modeling approach with many trip purposes to complete the endeavor. The validation of the model demonstrates that, with proper calibration, the aggregated freight data can be used as a satisfactory transportation planning tool. While some will point to the results and conclude that the output does not provide perfectly accurate model results, the results demonstrated in this paper present a method that is preferable over the alternative, ignoring freight in the modeling process. Finally, as a transportation planning tool, the model results justify the application of the FAF2 2035 forecast as a tool for developing future truck forecasts. These future forecast can be used model future scenarios and examine freight impacts.

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