Session #4

FREIGHT MODELING TECHNIQUES FOR SMALL AND MEDIUM-SIZED AREAS

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ABSTRACT

This paper presents a practical and low cost modeling technique to include freight demand and truck movements in the development of long range transportation plans.

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the new Transportation Equity Act for the 21st Century (TEA 21) requires that States and Metropolitan Planning Organization (MPOs) consider urban freight in their long-range plans, transportation improvement programs, and annual work elements. However, in the last rounds of MPO long-range plan update certification reviews by the Federal Highway Administration (FHWA), one of the negative themes was the lack of freight and goods movement analysis within the current plans. This lack of analysis has occurred because most States and MPO's have little experience in freight planning, current and historical data on truck movements are limited, and most of the old freight models are extremely complicated.

In September 1996 the U.S. Department of Transportation released the final report on the *Quick Response Freight Manual* through the Travel Model Improvement Program. This manual provides the transportation modeler with simple techniques and transferable parameters which can be used to develop commercial truck movements within a conventional four-step planning model.

This paper combines the techniques presented in the *Quick Response Freight Manual* and a simple four-step TranPlan travel demand model to develop, assign and analyze commercial truck trips in a small to medium urban area. Using the simple techniques and transferable parameters, the model could be developed with a limited amount of actual truck data. In this model, truck trips are broken into three types: four-tire; single unit; and, combination. By keeping the truck trips and the auto driver trips in separate purposes, the modeler can preassign or assign the truck trips (all, four-tire, single unit, and combination) to a regular network or special truck network under a full equilibrium process.

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INTRODUCTION

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This paper combines the techniques presented in the *Quick Response Freight Manual* and a simple four-step TranPlan [2] travel demand model to develop, assign and analyze commercial truck trips in a small to medium sized urban area. The goal of this technique is to allow the planner to:

1. Estimate truck trip generation using default rates
2. Prepare a truck network from existing highway network
3. Split truck trips into light, medium and heavy trucks
4. Distribute the trips purposes with a Gravity Model
5. Assign and analyze truck trips to a truck network
6. Assign and analyze truck trips, along with passenger car trips, to the entire network

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Commercial vehicles under the quick response technique are broken down into three categories or purposes: Four-Tire Vehicles, Single Unit Trucks (6+ Tires) and Combination Trucks.

Existing Model Structure

This process assumes the urban area has a conventional four-step planning model with/or without a transit model or with/or without a separate truck purpose. For this discussion, let us assume that the area has a four-step planning model (using TranPlan), without transit, and with separate purposes for home-based work, home-based non-work, non home-based, truck, internal-external, and external-external.

One of the goals of determining the number of commercial vehicles is to be able to assign the medium and heavy trucks to a truck network. One simple approach is to develop a medium/heavy truck network from the existing highway network by removing most of the minor arterials and collectors from the network. Sufficient detail must be retained to allow access to each zone to be connected to the network for vehicles involved in local distribution. Another approach in establishing a truck network is to look at weight limits, truck restrictions and signed truck routes in the urban area. By creating the network with selected link identifiers, restrictions could be identified through a special lookup table.

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Zonal Data Files

A typical urban area normally organizes its demographic data into employment categories by the Standard Industrial Classification (SIC)[4] code for each traffic analysis zone. The existing employment categories will continue to be used to develop the initial productions and attractions for the internal purposes. An employment breakdown is shown below:

Industrial Employment (SIC 01-39)
Commercial Employment (SIC 50-59)
Service Employment (SIC 40-49, 60-99)
Total Employment (SIC 01-99)

In the quick-response trip generation for commercial vehicles, the recommended procedure breaks employment categories into four categories using the noted SIC codes for each traffic analysis zone. This set of employment data will be used to develop the internal-internal commercial trips.

Agriculture, Mining and Construction (SIC 1-19)
Manufacturing, Transportation/Communications/Utilities and
Wholesale Trade (SIC 20-51)
Retail Trade (SIC 52-59)
Office and Services (SIC 60-88)

Trip generation rates, shown in Table 1, will be applied to employment and dwelling unit by traffic analysis zone. These rates were taken from a survey in Phoenix, Arizona as detailed in the *Quick Response Freight Manual*. Although there are many freight trip generation studies that were reviewed as part of the effort to develop the QRF Manual, the Phoenix rates were selected as the default generation rates. The Phoenix rates were found to be close to the median value for all of the available generation studies. Additional values can be reviewed in the FHWA manual, "Characteristics of Urban Freight Systems."

In order to compute truck productions and attractions simple spreadsheets can be utilized. It is recommended that production and attraction be created for all three truck categories. This step is critical because as will be shown later in the paper the trip length frequency for the three truck categories are significantly different and must be distributed separately.

During the trip generation balancing process the trip destinations or attractions will be set equal to origin or productions. Shown in Table 1 are the recommended truck trip generation rates. If more current rates are available from local or state studies those rates should be used.

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TABLE 1 TRIP GENERATION RATES[3]				
Generator	Commercial Vehicle Trips Per Day			
Employment	Four-Tire Vehicle	Single Unit (6+ Tires)	Combinations	Total
Agriculture, Mining, Construction	1.110	0.289	0.174	1.573
Manuf, Comm,Util, Wholesale	0.938	0.242	0.104	1.284
Retail	0.888	0.253	0.065	1.206
Office & Service	0.437	0.068	0.009	0.514
Households	0.251	0.099	0.038	0.388

External-Internal

The external-internal productions can be determined by using the existing external-internal purposes and applying the default values in Table 2 - Percent Distribution of Traffic by Vehicle Class, Surveys: HPMS Defaults, *Quick Response Freight Manual*, the vehicle types can be assessed at each station. If external station surveys or classification studies near the external stations are conducted, they should be used rather than Table 2.

TABLE 2 Percent Distribution of Traffic by Vehicle Class					
Functional Class	Non-Commercial Vehicles	Commercial Vehicle			
		Four-Tire Vehicle	Single Unit (6+ Tires)	Combinations	Total
Rural					
Interstate	87.20%	3.3%	2.9%	12.2%	100.0%
Other Principal Arterials	88.50%	4.7%	3.2%	4.9%	100.0%
Minor Arterial, Collector, Local	86.60%	5.3%	3.6%	2.6%	100.0%
Average - Rural	86.60%	4.7%	3.4%	5.3%	100.0%
Urban					
Interstate	88.20%	5.5%	1.8%	4.5%	100.0%
Other Freeways/Expressways	90.50%	5.5%	1.7%	2.3%	100.0%
Other Principal Arterials	89.50%	6.6%	1.7%	2.2%	100.0%
Minor Arterials	90.40%	6.4%	1.7%	1.5%	100.0%
Collectors	90.30%	6.4%	1.8%	1.5%	100.0%
Locals	91.00%	6.4%	1.8%	0.8%	100.0%
Average - Urban	89.80%	6.2%	1.7%	2.3%	100.0%

Source: Vehicle Classification Data of FHWA and Census' Truck Inventory User Survey[2]

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External to internal productions are normally established from existing counts and percent splits between external-external and external-internal for each station. The resulting external-internal number at the external station becomes the total vehicle production for the station. The external-internal productions are then split by non-commercial and commercial vehicles as noted in Table 2. The total internal-internal attractions computed during the internal-internal generation step can be utilized to scale the internal-external attractions to the internal-internal productions by each purpose.

External-External

The existing trip table can be factored using Table 2 Percent Distribution of Traffic by Vehicle Class as noted above to develop a new set of external-external trip tables for four-tired, single unit, and combinations.

MODEL PREPARATION

The existing trip purposes have been expanded to accommodate the commercial truck breakdown. From the existing six purposes, trucks is the only purpose not used in creating the eleven new purposes as noted below:

Existing Purposes	
Purpose 1 - HB Work	No Change
Purpose 2 - HB Non Work	No Change
Purpose 3 - Non HB	No Change
Purpose 4 - Truck	Not Used - New purposes
Purpose 5 - External-Internal	Non Commercial - New purpose
Purpose 6 - External-External	Non Commercial - New purpose
New Purposes (Trucks Internal-Internal)	
Purpose 7 - Int-Int Four-Tired Trucks	New
Purpose 8 - Int-Int Six-Tired Trucks	New
Purpose 9 - Int-Int Combination Trucks	New
New Purposes (Trucks External-Internal)	
Purpose 10 - Ext-Int Four-Tired Trucks	New
Purpose 11 - Ext-Int Six-Tired Trucks	New
Purpose 12 - Ext-Int Combination Trucks	New
New Purposes (Trucks External-External)	
Purpose 13 - Ext-Ext Four-Tired Trucks	New
Purpose 14 - Ext-Ext Six-Tired Trucks	New
Purpose 15 - Ext-Ext Combination Trucks	New

Simple spread sheets can be utilized to compute the internal-internal and external-internal truck purposes. By using the Matrix utility program in TranPlan the external-external trip table was split into the commercial and non commercial vehicle trips.

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Since the new purposes created by this procedure are all auto driver trips and assumed to have one person per vehicle, this procedure will work for both transit and highway only models. The trip purposes may be referenced by a different number. However, the process is the same.

MODEL APPLICATION

The model application includes the following additional steps in the process:

Truck Network

Building the truck network
Building minimum time paths
Skimming the truck minimum paths

Distribution

The distribution process uses the Gravity Model to distribute the productions and attractions. This process is divided into three passes as noted below:
Pass 1 - Non-Commercial: Computes standard distribution for HB Work (1), HB Non-Work (2) and Non Home-Based (3).

Pass 2 - Light Truck: Computes distribution for external-internal and internal-internal trip purposes using the normal updated free-flow skim paths. This pass will compute trip tables for int-int four-tired trucks (7), ext-int non-commercial vehicles (5) and ext-int four-tired trucks (10).

Pass 3 - Medium and Heavy Trucks: Computes distribution for external-internal and internal-internal trip purposes using the special updated free-flow truck skim paths. This pass will compute trip tables for int-int six-tired trucks (8), int-int combination trucks (9), ext-int six-tired trucks (11) and ext-int combination trucks (12). Friction factors may need to be adjusted to account for the heavy trucks.

When applying the gravity model, separate friction factors will have to be used for the three truck classifications (four-tire commercial, single unit-six tired, and combination) due to their different trip length characteristics. If local friction factors are not available default values from the QRF manual are available. Table 3 lists the default values.

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Table 3
Friction Factor Default Values

Four-tire Commercial Vehicles	-	Fij = e-0.08*tij
Single Unit Trucks	-	Fij= e-0.1*tij
Combination Trucks	-	Fij= e-0.03*tij

The important characteristic of Table 3's friction factors is that combination vehicles will have a longer average trip length than four-tire and combination trucks.

Mode

Each of the trip tables are converted to auto driver trips (purposes 1-3), split into origin and destinations and saved as individual trip tables. This allows the trip tables to be combined in different ways during the assignment process. A simple matrix utility is utilized to combine the individual trip tables. A vehicle occupancy conversion is not necessary for truck trips since they are considered to single occupant vehicles.

Assignment

Three assignment processes are setup for this analysis. The first process assigns medium/heavy trucks to a special truck network. The second process preloads medium/heavy truck trips and assigns the remaining light trucks, non-commercial vehicle trips to the full network using the equilibrium assignment techniques. The third process preloads medium/heavy truck trips and assigns remaining light trucks to the full network using an all-or-nothing assignment technique.

The preload technique is part of TranPlan Modeling Package. This technique can be utilized with the equilibrium assignment technique.

CONCLUSIONS

This quick response process of developing truck trips using the default generation rates and external truck classification can be successfully implemented in TranPlan or any other planning model as a first step in the evaluation of truck trips. Later, as existing truck counts are obtained and internal and external surveys are completed, the default values could be replaced with local updated parameters. This procedure is valid for small to medium sized urban areas.

Application of this procedure has also been done in larger urbanized areas such as Detroit. In the Detroit application overall truck vehicle miles travel (vmt) simulated from the truck model was

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consistent with vmt truck estimates from field surveys. There was a tendency for truck forecasts to be high or low by 20% when stratifying the results by highway functional classification.

REFERENCES:

1) U.S. Department of Transportation, Travel Model Improvement Program, Quick Response Freight Manual, Final Report, September 1996, Washington, D.C. 20590

2) The Urban Analysis Group, URBAN/SYS User Manual for TranPlan, Version 9.0, Hayward, CA 94541

3) Earl Ruiter, Cambridge Systematics, Inc, Development of an Urban Truck Travel Model for the Phoenix Metropolitan Area, February 1992, Report Number FHWA-AZ92-314, prepared for the Arizona Department of Transportation and the Federal Highway Administration.

4) U.S. Department of Transportation, Travel Model Improvement Program, Quick Response Freight Manual, Appendix C, Standard Industrial Classification (SIC) Codes, Final Report, September 1996, Washington, D.C. 20590

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