Accounting for Commercial Vehicles in Urban Transportation Models

Summary Report

final

report

prepared for

Federal Highway Administration

prepared by

Cambridge Systematics, Inc.

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1.0 Overview

In October 2002, the Federal Highway Administration began a research project to evaluate the magnitude and distribution of commercial vehicles in urban transportation planning models. The research was designed to look at all travel that is not adequately represented by the current state-of-the-practice for urban transportation planning models, which are developed from household travel surveys. Household travel surveys are designed only to capture household-related personal travel. Trips made for commercial purposes or using commercial vehicles are not captured. Some household travel surveys may inadvertently capture commercial trips such as realtors or tradesman making door-to-door visits but this does not represent a comprehensive assessment of this type of commercial vehicle travel.

1.1 Purpose

Creating improved estimates of commercial vehicle travel will meet a variety of current needs of the transportation planning and design community. A partial list of studies for which accurate commercial vehicles estimates would be beneficial includes:

- Construction/expansion of major transportation projects;
- Air quality analysis (mobile emissions inventories, vehicle mix, acceleration/ deceleration and idling, speed estimation, CO analysis methods, and conformity determinations);
- Traffic operations and management;
- System reliability;
- Support for transportation planning documents (Transportation Plan, Transportation Improvement Program);
- Analysis of Transportation System Management (TSM) and Transportation Demand Management (TDM) strategies, and Congestion Mitigation and Air Quality (CMAQ) projects;
- Peak-spreading analysis;
- Induced travel considerations and trip chaining;
- Environmental justice issues;
- Intermodal planning; and
- Safety evaluations.

While traditional travel models are adequate for some of these analyses, improved methods for estimating commercial vehicle trips will provide capabilities that allow for more accurate analysis of many additional transportation planning functions and development of transportation policies. This is particularly true for transportation air quality analyses where vehicle type and operating conditions are important determinants of emissions.

1.2 Phases

This project is the first phase of a two-phase project to develop methods for forecasting commercial vehicles in urban transportation planning models. The goal of the first phase is to research, evaluate, and identify methods for forecasting commercial vehicles in urban transportation planning models and is designed to address the following specific questions:

- How much of the traffic in a metropolitan area is attributable to commercial vehicle movements?
- How are commercial vehicle trips distributed geographically, temporally, and by type of transportation facility?
- Can commercial vehicle trips be classified into meaningful categories, amenable to modeling and forecasting?
- What economic, demographic, and/or land use factors influence the magnitude and distribution of commercial vehicle trips in a metropolitan area?
- What data are needed to estimate and forecast commercial vehicle trips? How can this be acquired?

The first phase has been divided into the following three work tasks:

- The first is to assess recent and current literature for different types of commercial vehicles relevant to the treatment of commercial vehicles in urban transportation models. As part of this work, a set of commercial vehicle categories was established. This task was completed and the final report[1] has been submitted to FHWA in January 2003.
- The second is to compile available data and information and estimate the magnitude and spatial/temporal distribution of different types of commercial vehicles. As part of this work, the commercial vehicle categories were refined and prioritized. This task was completed and the final report[2] has been submitted to FHWA in November 2003.
- The third is to evaluate methods and data sources that can be used to forecast commercial vehicles in urban transportation planning models. This task also

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[1] Cambridge Systematics, Inc., *Accounting for Commercial Vehicles in Urban Transportation Models: Literature Review,* prepared for FHWA, January 2003. http://tmip.fhwa.dot.gov/clearinghouse/docs/accounting/.

[2] Cambridge Systematics, Inc., *Accounting for Commercial Vehicles in Urban Transportation Models: Magnitude and Distribution*, November 2003.

was completed and the draft report[3] has been submitted to FHWA in December 2003.

As mentioned above, all the above three tasks have been completed separately and independent reports have been prepared and submitted to FHWA. However, the focus of this report is to summarize the results of the entire project. For more detailed information, please refer to the individual reports.

1.3 Outline of the Report

This report contains eight sections. Section 2.0 presents a summary of the literature review. Section 3.0 details the definition of the term "commercial vehicles" and summarizes the commercial vehicles categories established for this study. Section 4.0 describes the data sources evaluated for this study. There are five general types of data reviewed for this study: commercial vehicle surveys, vehicle registration data, vehicle count data, category-specific data sources, and data from individual contacts.

Section 5.0 presents the results of the process to quantify the magnitude and distribution of commercial vehicles. The results of the analysis from the combined data sources are analyzed by category, urban area, time period, and facility type. Section 6.0 presents the methods for estimating and forecasting commercial vehicles travel and briefly summarized the three methods.

Section 7.0 presents the data available for calibration and validation of commercial vehicle models. These data are divided into three groups: registration records, VMT, and vehicle classification counts. Each is described in a separate subsection and its applicability for calibrating and validating commercial vehicles is discussed. Finally, Section 8.0 presents recommendations for future research.

[3] Cambridge Systematics, Inc., *Accounting for Commercial Vehicles in Urban Transportation Models: Methods, Parameters, and Data Sources*, January 2003.

2.0 Literature Review

The purpose of the literature review was to assess recent and current literature relevant to the treatment of commercial vehicles in urban transportation models. This literature review includes published literature, unpublished literature, information from the Internet, GIS and survey data sources and internal project documents on related topics.

To date, most of the literature on this topic revolves around urban freight distribution. The state-of-the-practice in the modeling of commercial vehicle travel in the urban transportation context has been geared toward developing a limited number of commercial vehicle trip generation factors, typically only disaggregated by truck type; for example, light, medium and heavy trucks. The traditional approach of relating these rates to land use activity has been found to be limited for application in travel demand modeling due to lack of data on differences in trip purpose, vehicle occupancy, and origin-destination (O-D) patterns. Other definitions of commercial vehicles rely on vehicle registration classifications.

To clarify the scope of the literature review, 13 categories of commercial vehicles were defined and included both individually and categorically in the literature review (these 13 categories were later modified and reduced to 12 categories, as described in Section 3.0). Initial reviews on commercial vehicles in general uncovered very few sources in the literature, so the majority of the literature review was focused on individual vehicle types.

In addition, the literature review was focused on trips within an urban area (intraregional trips) rather than on trips entering or leaving an urban area (interregional trips). This is a critical distinction for urban freight trips, where much of the current literature covers interregional freight distribution rather than intraregional freight distribution. This distinction is expected to carry forward in the development of methods for estimating commercial vehicle traffic, where the interregional traffic is estimated using different techniques related to external traffic than intraregional traffic, which is estimated using more specific methods related to trip purpose, demographics and other characteristics of the region.

The literature review provided an overview of the information found on state-of-the-practice techniques, on data sources, and on modeling approaches. The report also provided more detailed information on the individual literature reviews for each commercial vehicle type. The detailed summary of the literature review for individual references addressed the following questions:

- What is the objective or purpose of the study?
- What location or methods or models are described?
- What type of vehicle or service is covered?

- Are the magnitude of vehicles or trip rates described in the study?
- Are the distribution of vehicles or trip lengths or vehicle miles traveled described?
- What is the level of spatial detail?
- What data sources are used?
- Are forecasts included?
- Is the study facility-specific (e.g., airport or seaport)?
- What is the importance to our study?

3.0 Definition of Commercial Vehicles

This section presents the definition of the term "commercial vehicle" for the purposes of this study and summarizes the commercial vehicle categories.

3.1 Definitions

"Commercial vehicles" include a broad range of vehicle types that are used for commercial, rental, educational, and government services. Examples of the uses for such vehicles include: transportation of persons, package and mail delivery, urban freight distribution, utilities, trades and services, landscaping services, outside sales, product delivery, vehicle rental, transportation of school children, construction activity, and paratransit services.

Commercial vehicles demonstrate temporal and geographic distributions, which differ from those of personal vehicles. In traditional transportation planning studies, estimates of household vehicle trips are factored to correct for under-reporting and under predicting of commercial vehicle trips in traditional transportation planning data sources. While traditional travel models are adequate for some basic analyses, improved methods for estimating commercial vehicle trips would provide capabilities for more accurate analysis of additional transportation planning functions and for the analysis of a wider range of transportation policies.

Many vehicles registered as commercial vehicles can be defined as commercial vehicles, but other vehicles falling into these categories are registered as private vehicles. For example, a realtor may register his/her automobile as a private vehicle but often use it for business purposes. On the other hand, many vehicles are registered as commercial vehicles but also are used for personal non-commercial purposes. Any vehicle used for commercial purposes is considered in this study as a commercial vehicle, regardless of how it is registered. It should be noted that vehicle registration rules and practices with respect to commercial vehicles differ by state, further complicating the separate identification of commercial vehicle usage patterns.

3.2 Categories

Commercial vehicles are primarily organized into three groups, based on what is being carried and the economic, demographic, and land use factors influencing the magnitude and distribution of commercial vehicle trips in a metropolitan area. The three groups are:

1. Commercial passenger vehicles;
2. Freight vehicles; and
3. Service vehicles.

The **commercial passenger vehicles** category includes school buses, shuttle services, rental cars, taxis, and paratransit vehicles. In general, growth of this category of commercial vehicles tends to depend on the growth of population and employment in a metropolitan area.

The **freight vehicles** category includes mail delivery, trash collection, warehouse delivery, parcel pickup and delivery, and construction vehicles. In recent years, much attention has been paid to this category of commercial vehicle trips. In metropolitan areas, goods movement trips, similar to longer-haul freight movements, are becoming a larger share of the total on-road vehicle load.

Finally, the **services vehicles** category includes household/building services such as plumbers and cleaning services as well as public safety, utility maintenance, and retail support functions. Due to the shift in the United States from a manufacturing-oriented economy to a service-oriented economy, the number of service-related commercial vehicle trips is growing faster than the number of trips for other purposes.

These three groups are further subdivided into 12 specific categories of commercial vehicles, based again on what is being carried and what economic, demographic and land use factors influence the magnitude and distribution of these trips. These 12 categories of commercial vehicles are direct subsets of the three commercial vehicle groups, as shown in Table 3.1.

One additional category of commercial vehicles is public and private buses. These vehicles were not evaluated in this study because some metropolitan transportation agencies already are modeling public and private buses as part of the multimodal demand forecasting process. These would be modeled as part of the development of the transit network; bus vehicle miles traveled can be estimated from the bus services coded in the transit network. Private buses are not as frequently modeled in urban transportation planning models, primarily because they are primarily intercity trips and would be modeled using an intercity or statewide model.

Table 3.1 Commercial Vehicle Categories

Vehicle Groups	Vehicle Categories
Commercial Passenger Vehicles	1. School Bus
	2. Fixed Shuttle Services at Airports, Stations, etc.
	3. Private Transportation: Taxi, Limos, Shuttles
	4. Paratransit: Social Services, Church Buses
	5. Rental Cars
	6. Package, Product, and Mail Delivery (USPS, UPS, FedEx, etc.)
Freight Vehicles	7. Urban Freight Distribution, Warehouse Deliveries
	8. Construction Transport
	9. Safety Vehicles: Police, Fire, Building Inspections, Tow Trucks
Service Vehicles	10. Utility Vehicles: Trash, Meter Readers, Maintenance, Plumbers, Electricians
	11. Public Service: Federal, State, City, Local Government
	12. Business and Personal Services: Personal transportation, Realtors, Door-to-Door Sales

4.0 Data Sources

The effort to quantify the magnitude and distribution of commercial vehicle travel relied on a series of data sources that provided data on vehicles, trips, trip lengths, and/or vehicle miles traveled in each of 12 commercial vehicle categories. Based on these data, commercial vehicle travel was estimated for 13 urban areas in the United States, as shown in Table 4.1.

Table 4.1 Urban Areas Used in the Evaluation of Commercial Vehicle Travel

	Region	Population
Los Angeles	West	12,384,000
San Francisco	West	4,022,000
Detroit	Midwest	3,836,000
Atlanta	South	2,977,000
San Diego	West	2,653,000
Houston	South	2,487,000
Denver	Midwest	1,993,000
Portland	West	1,552,000
Sacramento	West	1,394,000
Orlando	South	1,160,000
Winston-Salem	South	233,000
Greensboro	South	223,000
High Point	South	125,000

Most of the data sources provided data for multiple categories of commercial vehicles (such as the registration data and the commercial vehicle surveys) but some data sources were category-specific (such as the school bus fleet data, the taxi fact book, the National Transit Database for Paratransit Vehicles (formerly FTA section 15 data). The primary data sources and the urban areas available in each are provided below in the following sections.

4.1 Commercial Vehicle Surveys

Vehicle Inventory and Use Survey

The 1997 Vehicle Inventory and Use Survey (VIUS) is a probability sample of private and commercial trucks registered (or licensed) in the United States as of July 1, 1997. This survey excludes vehicles owned by Federal, state, or local governments;

ambulances; buses; motor homes; farm tractors; unpowered trailer units; and trucks reported to have been sold, junked, or wrecked by the respondents prior to July 1, 1996. A sample of about 131,000 trucks was surveyed to measure the characteristics of nearly 75 million trucks registered in the United States.

Many states allow pickups, small vans, and sport utility vehicles to be registered as either cars or commercial vehicles. Therefore, during the development of the VIUS sampling frame, passenger car registration files were searched and appropriate vehicles were included. Some vehicles, such as "off-highway" trucks used exclusively on private property, do not have to be registered. These vehicles were not included in the sampling frame.

Commercial Vehicle Surveys by City

Commercial vehicle survey data for Detroit, Atlanta, Denver, and the Piedmont-Triad area (Winston-Salem, Greensboro, and High Point) were obtained from the relevant authority and analyzed for this study. A brief description of the data is given below:

- **Atlanta Area Commercial Vehicle Survey –** NuStats International conducted the Atlanta Area Commercial Vehicle Survey for the Atlanta Regional Commission (ARC) in the spring of 1996.[4] The primary objective of the survey was to provide insight into truck movements in the Atlanta region. Specifically, the goals of the study were to determine the number of trips per truck and the average truck trip length, and to develop a truck trip table that would provide critical information for the regional travel demand model.
- **Denver Commercial Vehicle Survey –** The Denver Regional Council of Governments (DRCOG), in partnership with the Regional Transportation District, the Colorado Department of Transportation, and the Regional Air Quality Council, initiated the Regional Travel Behavior Inventory (TBI) in 1996.[5] The TBI was undertaken to provide a snapshot of travel patterns and characteristics of travelers in the Denver region and to collect the data needed to develop and "freshen" traditional travel models, while providing for the possible development of new modeling techniques.
- **Detroit Commercial Vehicle Survey –** The Southeast Michigan Council of Governments (SEMCOG) Commercial Vehicle Survey (CVS) collected detailed information on truck travel within the seven-county area of Southeast Michigan, for use in SEMCOG's Regional Travel Forecast Model.[6]

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[4] NuStats International, *Atlanta Area Commercial Vehicle Survey*. Draft Final Report. 1996.

[5] Parsons Transportation Group, *Commercial Vehicle Survey Report*, Prepared for Denver Regional County of Governments, 2001.

[6] Wilbur Smith Associates, *Commercial Vehicle Survey*, prepared for Southeast Michigan County of Governments, 1999.

The information also will assist with other intermodal and freight planning activities. The universe for the commercial vehicles is from a data file from the Michigan Secretary of State containing the universe of commercial vehicles registered within the region. A supplemental business survey was conducted to determine the proportion of businesses located within the region that have commercial vehicles, registered at locations outside the region, but which operate within the region for business purposes on a regular basis.

- **Piedmont-Triad Commercial Vehicle Survey –** The Piedmont-Triad Commercial Vehicle Survey was conducted to estimate truck trips and trips made by commercial cars in the Triad region (Greensboro, High Point, and Winston-Salem) of North Carolina.[7] A database of employers in the Triad region, including the number of employees and whether or not commercial vehicles are garaged at the employment location, was used as the universe of sampling commercial vehicles in the region. Eligible vehicles were those having a commercial license and being garaged at a non-residential location overnight. The definition of eligible vehicles eliminates company cars that are driven home by employees and effectively eliminates a large share of vehicles that may otherwise have been placed into the personal services commercial vehicle category. Also, missing from the survey are non-commercially licensed vehicles that are used for commercial purposes.

4.2 Vehicle Registration

State Motor Vehicle Departments

State registration databases contain only basic data related to the use of the vehicle (e.g., commercial versus non-commercial, or whether the vehicle is part of a public fleet). Other use information could be inferred by looking at the owner of the vehicle in conjunction with vehicle characteristics, but this level of analysis would require significant effort as well as access to confidential data. As a result, state registration databases were found to have little value for determining the numbers or usage of commercial vehicles by service use, except the California database.

Vehicle registration databases that are maintained by a state, as evidenced by the experience in California, have the potential to yield useful information on the number of commercial vehicles existing within a particular geographic area. Experience has shown, though that it is time-consuming, costly, and difficult to use these vehicle registration databases for reasons other than those for which they originally were developed. Consequently, the only example of a vehicle registration database that has been successfully used to produce information on commercial vehicle travel that was able to be identified was for California.

[7] Barton-Ashman Associates, Inc., *Piedmont Triad Area Commercial Vehicle Survey*, Prepared for the North Carolina Department of Transportation, January 1996.

Nonetheless, it is recommended that other states explore and develop the same kind of multi-year cooperative arrangement that exists in California so that, over time, vehicle registration data can be used to support transportation planning, including, but not limited to, the movement of commercial vehicles.

Processed California Department of Motor Vehicles (DMV) data was obtained from the California Energy Commission and extracted for four urban areas: San Francisco, Los Angeles, San Diego, and Sacramento.[8] To compare the commercial VMT with the total VMT, the total number of personal vehicles was obtained from the DMV. The average number of daily miles traveled for personal vehicles was calculated from the National Highway Travel Survey (NHTS)[9] for MSAs in California. These data were not available for specific cities, and so the calculation was based on MSAs between one and three million population (for Sacramento and San Diego) and MSAs over three million population (for San Francisco and Los Angeles). The total VMT calculation, therefore, was an estimate based not only on local data within each MSA.

Other Registration Sources

We reviewed two other registration databases as follows:

- **Inspection and Maintenance Programs –** Many states collect data for their I/M programs that include the vehicle identification number (VIN) and odometer reading. A VIN decoder is a computer software program that is used to determine the make and model of the vehicle. Other emissions-related data also are collected, such as chassis, engine, emissions control system, fuel control system, etc. Odometer readings from at least two cycles of I/M inspection can be used to get vehicle activity (miles/year). I/M databases often identify whether the vehicle is commercial and include the gross vehicle weight rating (GVWR).
- **R.L. Polk & Co. –** R.L. Polk & Co.,[10] a privately held consumer marketing information company, started motor vehicle statistics operations in 1922. Polk maintains comprehensive vehicle databases on both new and used vehicles in various formats, some of which are potentially useful for this study. Polk develops custom-built reports for customers and data are available by ZIP code, Metropolitan Statistical Area (MSA), county, state, or entire USA. However, these data are not free; they must be purchased from Polk.

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[8] California Energy Commission, processed California Department of Motor Vehicle Database, 2002.

[9] http://nhts.ornl.gov/2001/index.shtml.

[10] R.L. Polk & Co., 26955 Northwestern Hwy, Southfield, MI 48034.

4.3 Vehicle Count Data

We reviewed three sets of vehicle count databases, described below:

- **Highway Performance Monitoring System –** The HPMS data as published in *Highway Statistics* were obtained for all metropolitan areas in the United States and summarized to identify the total VMT for all vehicles. These data were intended to be used as an estimate of overall VMT so that commercial VMT could be assessed as a percent of the total and compared across different cities.
- **Freight Analysis Framework –** The results of the Freight Analysis Framework (FAF) have been made available as a database file on the FHWA's FAF web site. The database file can be mapped to geographic information system (GIS) shape files of highways in the lower 48 states. The shape files allow the specification of highway links within specific urban areas. The database file includes mileage and functional classification information for each link in the FAF network. Because the links in the FAF database do not include all roadways, the FAF VMT does not represent the full universe of VMT although the FAF does include non-freight trucks. The one anomaly in these data is the non-freight trucks on minor arterials, which has a very high percentage of VMT compared to expectations.
- **Vehicle Classification Counts –** Vehicle classification count data, which classifies the vehicles according to FHWA's 13-axle-based classes, are generally available from the state DOTs. Source information was obtained and examined for two states (Georgia and Florida). Summary information was examined on several state DOT web sites (Maine, Ohio, New Jersey, Massachusetts, Virginia, Pennsylvania, Delaware, and Indiana).

4.4 Other Data Sources

There are five databases that provide data directly for a specific vehicle category, such as paratransit vehicles, mail delivery vans, school buses, taxis, and airport shuttle services. These databases are summarized below:

- **The National Transit Database for Paratransit Vehicles –** The Federal Transit Administration (FTA) collects and disseminates data on the state of mass transportation via the National Transit Database (NTD) program. Over 600 of the nation's transportation providers submit data on vehicle miles traveled, passenger miles and passenger trips to the NTD annually. The National Transit Database for paratransit vehicles was available for all 13 urban areas in our study (Los Angeles, San Francisco, Detroit, Atlanta, San Diego, Houston, Denver, Portland, Sacramento, Orlando, Winston-Salem, Greensboro, and High Point). In these cities, paratransit vehicles' total VMT as a percentage of the total VMT in the region varies from 0.003 to 0.035 percent.

- **United States Postal Service Data –** United States Postal Service provided data on fleet size and vehicle miles traveled for specific city districts, based on zip codes. The average daily VMT per vehicle is about 25 miles although it is much lower in urbanized areas (about five to six miles) and higher in suburban areas. In urbanized areas, daily postal delivery vehicles typically stop every block, after which the postal worker walks to deliver the mail. Fleet size and VMT data were obtained from the United States Postal Service (USPS) for seven urban areas (Atlanta, Denver, Detroit, Houston, Greensboro, Orlando, and Portland). In these cities, postal service vehicles' total VMT as a percentage of the total VMT in the region varies from 0.04 to 0.09 percent.
- **School Bus Fleet Survey –** Schoolbusfleet.com[11] is an information service of the magazine *School Bus Fleet,* a trade publication serving school transportation professionals in the United States and Canada. *School Bus Fleet* provides information on the management and maintenance of school bus fleets operated by school districts, private schools, Head Start agencies and childcare centers. These data include the number of buses in operation, the students transported on a daily basis, and the annual route mileage. School bus fleet surveys were available for the largest 100 school districts, including 10 of the urban areas in our study (Los Angeles, Detroit, Atlanta, San Diego, Houston, Denver, Portland, Winston-Salem, and Greensboro). In these cities, school bus total VMT as a percentage of the total VMT in the region varies from 0.01 to 0.55 percent.
- **Taxi Fact Book –** The National Association of Taxicab Operators was established in 1917 in Washington, D.C. In 1991, the Taxicab, Limousine & Paratransit Association (TLPA) was established with five membership divisions, including the Taxicab Division. TLPA publishes the magazine *Transportation Leader* quarterly and the *Taxicab Division Fact Book* annually. These data include nationwide statistics by the size of the fleet on the average annual total miles per taxi, the average distance per paid taxi trip (miles), the average annual paid trips per taxi, the average annual passengers per taxi and the average passengers per paid trip. These data also include annual mileage and number of licenses for each city. The Taxi Fact Book was available for all major cities in the United States, including all 13 urban areas in our study (Los Angeles, San Francisco, Detroit, Atlanta, San Diego, Houston, Denver, Portland, Sacramento, Orlando, Winston-Salem, Greensboro, and High Point).[12] In these cities, taxi total VMT as a percentage of the total VMT in the region varies from 0.15 to 1.19 percent.

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[11] http://www.schoolbusfleet.com.

[12] Taxicab, Limousine and Paratransit Association, *Taxicab Division Fact Book,* 2002.

- **The Airport Ground Access Planning Guide –** The *Airport Ground Access Planning Guide* presents the results of the first phase of a project jointly sponsored by the Federal Highway Administration and the Federal Aviation Administration.[13] It outlines the process for planning ground access to airports within the context of current laws, regulations, and procedures. These data include information on mode split, average trip length and vehicle miles traveled. The Airport Ground Access Planning Guide was available for 27 cities in the United States, including five cities in our study (Los Angeles, San Francisco, Houston, Portland, and Orlando). In these cities, shuttle service VMT as a percentage of the total VMT in the region varies from 0.00 to 0.04 percent.

In addition to the vehicle-specific databases, there are several surveys that contain some relevant data for commercial vehicles; these are described below:

- **Travel Surveys –** The 1995 National Personal Transportation Survey[14] (NPTS) and the new 2000 NHTS[15] are potential sources of information on certain kinds of commercial vehicles. The 1995 NPTS contains the following modes, which may be relevant to this study: Pickup truck; Other truck; Other privately owned vehicle (excluding autos, vans, sport utility vehicles, and recreational vehicles); Taxicab; and School bus.
- **Other Surveys –** There are a number of other types of surveys that we discovered during the literature review that are relevant to different types of commercial vehicles. In Washington,[16] the Department of Transportation conducted a survey of 5,000 tow trucks to determine response times and types of incidents in the region. The original survey data on incident response and additional data on feedback to the survey are available from the WSDOT. In St. Louis, the East-West Gateway Coordinating Council[17] conducted a survey of paratransit operators to collect data on trip purpose, service area, service hours, unused vehicle miles, operating and capital budgets, and other information. In addition, 431 vehicles were surveyed to estimate trips per vehicle.

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[13]*Airport Ground Access Planning Guide* First Phase, Federal Highway Administration Intermodal Division, Washington, D.C. 20590. http://ntl.bts.gov/DOCS/AGAPP.html.

[14]http://www-cta.ornl.gov/npts/1995/Doc/publications.shtml.

[15]http://www.bts.gov/nhts/.

[16]Nee, Jennifer and Hallenbeck, Mark E., Washington State Transportation Center (TRAC), University of Washington, Seattle. *Evaluation of the Service Patrol Program in the Puget Sound Region,* Washington State DOT and US DOT, FHWA Research Project TI803, Task 37, August 2000 to January 2001.

[17]East-West Gateway Coordinating Council, *Social Service Transportation Assets in the St. Louis, Missouri Area*, ftp://ftp.ewgateway.org/library/sst.pdf.

4.5 Individual Contacts

In addition to all of the data sources discussed, individual firms and agencies in both the public and private sectors and in all 12 urban areas were contacted. We did not expect to receive totals for all commercial vehicles operated by the firms contacted and commercial vehicle mileages in each city, but we wanted to capture a snapshot of the typical mileages that are driven by commercial vehicles of different industries in support of the other data sources. Although we contacted all 12 cities in some cases, only a few cities responded to our request for information.

5.0 Magnitude and Distribution

The magnitude and distribution of commercial vehicles in each of 12 commercial vehicle categories were estimated from available data sources. The magnitude was estimated using the total fleet size and fleet size per capita. The distribution was estimated using the vehicle miles traveled, the percentage of total vehicle miles traveled and the average vehicle miles traveled per day.

5.1 Analysis by Commercial Vehicle Category

Table 5.1 presents the summary statistics of the percentage of total VMT for each commercial vehicle category. These data are derived from a variety of data sources. It is important to recognize that the data sources may not be fully compatible, although we tried to achieve compatibility wherever possible.

Table 5.1 Percent of Total VMT

		All Data		
		Minimum	**Maximum**	**Average***
Vehicle Type				
1	School Bus	0.03%	0.55%	0.15%
2	Fixed Shuttle Services	0.00%	0.04%	0.02%
3	Private Transportation	0.09%	0.46%	0.21%
4	Paratransit	0.00%	0.01%	0.01%
5	Rental Cars	0.83%	4.29%	1.98%
6	Package, Product and Mail Delivery	0.00%	0.71%	0.18%
7	Urban Freight Distribution, Warehouse Deliveries	1.01%	4.87%	2.73%
8	Construction Transport	0.02%	1.35%	0.62%
9	Safety Vehicles	0.14%	1.25%	0.44%
10	Utility Vehicles	0.03%	1.03%	0.35%
11	Public Service Vehicles	0.57%	3.48%	1.56%
12	Business and Personal Services	0.66%	6.97%	3.55%
	Movement of People (Cat. 1-5)	1.0%	5.4%	2.4%
	Movement of Goods (Cat. 6-8)	1.0%	6.9%	3.5%
	Services (Cat. 9-12)	1.4%	12.7%	5.9%
	TOTAL	**3.39%**	**25.01%**	**11.79%**

Note: The averages for each group of categories (people, goods and services) are based on weighted averages rather than direct averages and may not be the same as the sum of the categorical averages.

Distribution of commercial vehicles ranged from three to 25 percent of total vehicle miles traveled, across all categories, with an average of 12 percent. This was highest for vehicles providing services (13 percent) based on the percent of total vehicle miles traveled. The maximum percent of total vehicle miles traveled was used to evaluate the individual categories. Urban freight distribution and business and personal services (five and seven percent, respectively) had the highest percent of total vehicle miles traveled, next highest was rental cars (four percent) and public service vehicles (three percent). All other categories had less than two percent of total vehicle miles traveled (maximum).

The magnitude and distribution also was evaluated across time periods and facility types, but these data were not sufficient to stratify the data by urban area or commercial vehicle category. Based on data from the commercial vehicle surveys, the majority of commercial vehicles operate in the off-peak hours (58 percent). The a.m. peak period of three hours (31 percent) has quite a bit more travel than the p.m. peak period of three hours (11 percent). The distribution of commercial vehicles by facility type is based on data in the Freight Analysis Framework. This shows that freight and non-freight trucks have higher allocation of vehicle miles traveled on interstates and lower allocation of vehicle miles traveled on arterials than autos.

5.2 Aggregated Categories

In our original analysis, the commercial vehicle categories were aggregated into three types of vehicles, based on trip purpose. These three types were moving people, moving goods, or providing services. Table 5.2 presents a summary of fleet sizes per 1,000 population for selected urban areas by these aggregated categories. This table includes only urban areas with either a commercial vehicle survey or DMV data. At this aggregated level, the following conclusions can be drawn:

- The inclusion of rental cars in the DMV data and not in the commercial vehicle survey data has a significant impact on the percent of vehicles moving people, with a difference of 14 percent between these two sources.
- The specific definitions of the Business and Personal services and Urban Freight Distribution categories (12 and 7, respectively) for the two data sources have a significant impact on the summary totals for vehicles moving goods and providing services. In the case of the DMV data, Business and Personal Services is the dominant category, and in the case of the commercial vehicle surveys, Urban Freight Distribution is the dominant category. In both cases, the vehicles in these categories were not easily separated to create consistency in the definitions.
- The Package, Product, and Mail Delivery category (#6) is dominated by fleets in the U.S. Postal Service, but these data are not clearly identified in the DMV data. From the results, it appears that U.S. Postal Service vehicles are not included in the DMV data regarding parcel delivery, but are included in the

public service vehicle category. In the commercial vehicle surveys, U.S. Postal Service vehicles were excluded, and the U.S. Postal Service separately provided the necessary data for addition to the commercial vehicle survey data.

- The DMV data yields 73 percent higher average per capita fleet sizes than the commercial vehicle survey because of the more comprehensive nature of these data.

From a data analysis perspective, it may be useful to combine certain categories that were unable to be stratified. This will be considered during the next task to identify methods for evaluation.

Table 5.2 Summary of Fleet Size per 1,000 Population by Aggregated Category and Data Source for Selected Urban Areas

					Percent		
	Moving People	Moving Goods	Providing Services	Total	Moving People	Moving Goods	Providing Services
Los Angeles	7.82	8.59	35.20	51.60	15%	17%	68%
San Francisco	23.70	11.32	50.50	85.50	27%	13%	60%
Detroit	0.59	14.20	5.40	20.20	2%	81%	18%
Atlanta	1.34	27.52	8.69	37.55	4%	73%	23%
San Diego	5.15	5.84	26.30	37.30	14%	16%	70%
Denver	0.81	23.80	8.70	33.20	2%	69%	29%
Sacramento	8.07	13.98	66.60	87.70	9%	16%	75%
Winston-Salem	1.82	16.60	0.90	19.40	3%	93%	4%
Greensboro	2.77	16.60	0.90	19.40	5%	91%	4%
High Point	0.38	16.60	0.90	17.00	1%	95%	4%
DMV Cities	11.03	9.93	44.13	65.09	17%	15%	68%
CV Survey Cities	1.28	37.36	5.06	43.70	3%	85%	12%

6.0 Methods for Estimating and Forecasting Commercial Vehicle Travel

6.1 Overview of Methods

The methods, variables, parameters, and data sources used for estimating commercial vehicle travel must be related to the appropriate level of planning application and the resources that are available to a metropolitan planning organization (MPO). The project team identified numerous sets of commercial vehicle forecasting approaches that could be used to evaluate different categories of vehicle types and meet MPOs' varying needs and levels of travel model complexity. These methods fall into three categories ranging from simple applications requiring limited data inputs to more advanced techniques to produce more spatial and temporal detail for a more specific range of commercial vehicle types:

1. **Aggregate Demand Methods** that apply national default parameters to regional data to produce regional estimates of fleet size, trips, and VMT for each commercial vehicle category.
2. **Network-based Quick Response Methods** that apply national default parameters to zonal and network data to produce zonal and link-based estimates of fleet size, trip origins and destinations, volumes, and VMT for each commercial vehicle category.
3. **Model Estimation Methods** that apply locally derived parameters to zonal and network data to produce zonal and link-based estimates of fleet size, trip origins and destinations, volumes, and VMT for each commercial vehicle category. Although the Model Estimation Methods can include more sophisticated models based on a wider variety of data inputs because they are developed from local data, they also may be modifications of network-based quick response methods, which are based on local data.

MPOs analyze various types of performance measures, including mobility, safety, reliability, and environmental impacts. These analyses are performed at the regional or county level, at the corridor or traffic analysis zone (TAZ) level, and at the intersection or link level, depending on the purpose of the analyses they carry out. To meet MPOs' varying needs, the project team divided the analyses levels into the following three groups:

1. **Macro** analyses that include county, city, or regional-level analysis. MPOs perform travel demand modeling, ozone precursor studies, and conformity

analysis of long-range transportation plans (LRTP) and transportation improvement programs (TIP).

2. **Meso** analyses that include subarea TAZ or corridor-level analysis. MPOs perform operational analysis, intelligent transportation systems (ITS) studies, TDM studies, and TSM studies.

3. **Micro** analyses that include link or intersection-level analysis. MPOs perform site impact analysis, carbon dioxide hotspot analysis, congestion management studies, and intersection analysis.

Both the Aggregate Demand and the Network-based Quick Response Methods have been developed to address the macro analyses, with the difference being that Network-based Quick Response Methods would be more useful for commercial vehicle categories that have larger impacts on congestion or air quality. The Model Estimation Methods are primarily for the meso level of analysis because it is more useful to use local data when considering subarea or corridor-level analyses. This report does not present a method to address the micro level of analyses, leaving this subject instead for future research.

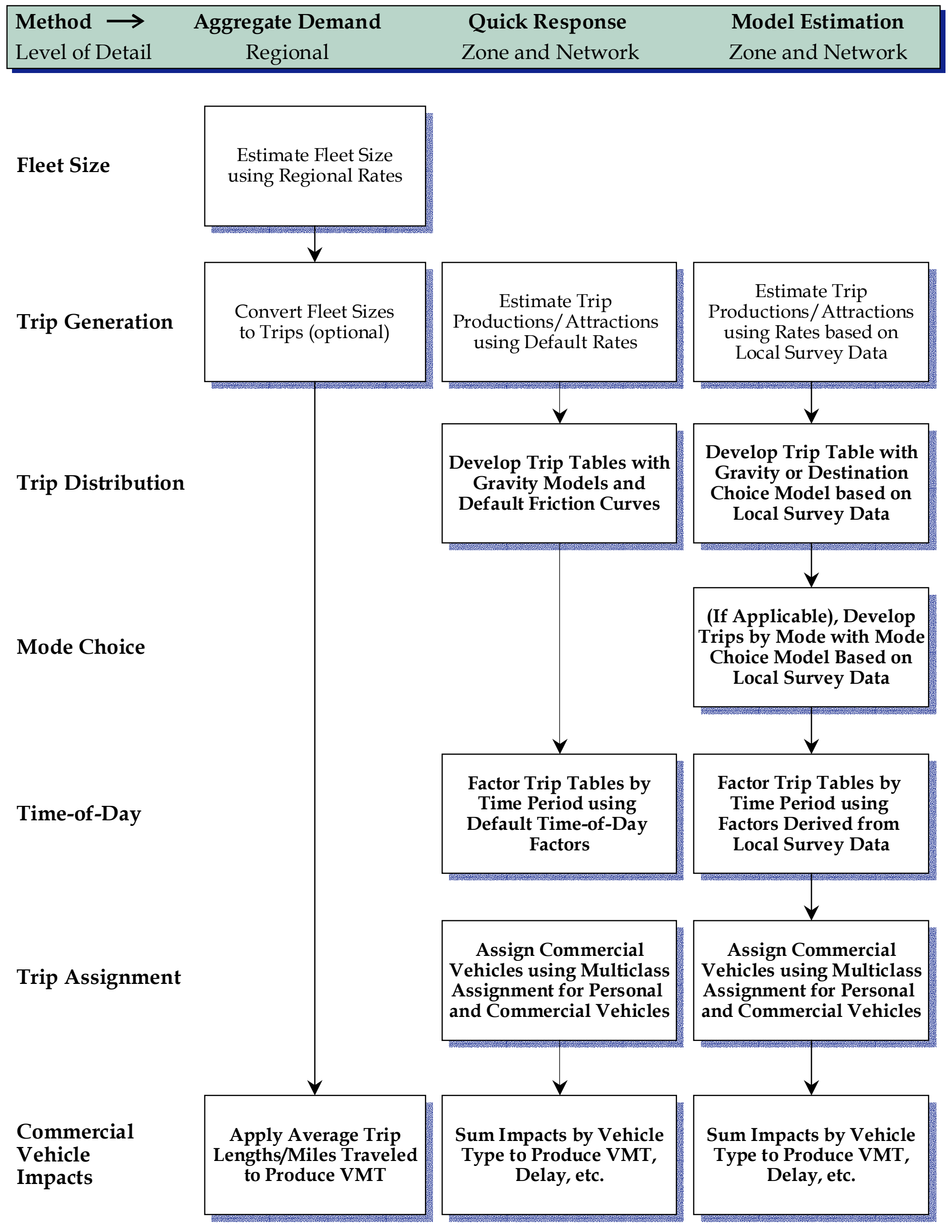
Figure 6.1 presents the modeling process for the aggregate regional VMT, network-based quick response, and Model Estimation Methods. This figure shows, in the form of a flow chart, the steps necessary to estimate impacts for commercial vehicles in urban transportation models. The Aggregate Demand Method provides a means to estimate regional impacts using nationally derived parameters and regional demographic estimates. The network-based quick response and Model Estimation Methods are both based on applying four-step planning modeling techniques to estimate trips, origins and destinations, time periods, and volumes for commercial vehicles traveling in an urban area.

Aggregate Demand Methods

Daily Vehicle Mileage

At the simplest level, MPOs may be served best if the fleet size rate by land use, employment, or any other readily available data can be provided, along with the miles traveled per vehicle per day for each category of commercial vehicle. These rates and miles traveled can be used to estimate VMT. They also can be used for the traditional trip generation and trip distribution steps for estimating commercial vehicle trip tables. The primary advantage of this approach is that it extends the typical commercial vehicle forecasting procedures used by MPOs to a broader range of commercial vehicle and trip types. This technique is primarily applicable at a regional (macro) level of detail.

Figure 6.1 Modeling Process for Three Methods to Estimate Commercial Vehicle Travel in Urban Transportation Models



This is a simple procedure for using national average vehicle rates and miles traveled to project commercial vehicle traffic in the MPO's jurisdiction. It assumes the availability of demographic projections (population, employment, tourists visiting, etc.) for the year under consideration. Using existing data, the number of vehicles for a particular category of commercial vehicle is calculated as follows:

$$FleetSize_c = VehicleRate_c \times SocioeconomicData$$

where:

- $FleetSize_c$ = Number of commercial vehicles of category **c**
- $VehicleRate_c$ = Number of commercial vehicles of category **c** per unit variable(s)
- SocioeconomicData = Data such as population/employment/tourists, set by category **c**

The number of commercial vehicles can be estimated using the above equation. The miles traveled per vehicle per day for commercial vehicle categories are available from a variety of sources, identified in the Task 3 report. Hence, it is possible to estimate the VMT for commercial vehicle categories, as follows:

$$DailyVMT_c = VMTperVehicle_c \times FleetSize_c$$

where:

- $DailyVMT_c$ = Total Daily Vehicle Miles Traveled for commercial vehicles in category **c**
- $FleetSize_c$ = Number of commercial vehicles of category **c**
- $VMTperVehicle_c$ = Average vehicle miles traveled per vehicle for commercial vehicles of category **c**. This may be calculated as the average number of trips per day * the average trip length in miles.

Annual Vehicle Mileage

Some of the sources of data on mileage for specific commercial vehicle categories report annual vehicle mileage rather than daily vehicle mileage. This method uses these data to estimate daily vehicle miles using the same equation to determine fleet size, but then estimates daily mileage as follows:

$$DailyVMT_c = (AverageAnnualMileage_c \div OperatingDays_c) \times FleetSize_c$$

where:

- $DailyVMT_c$ = Total Daily Vehicle Miles Traveled for commercial vehicles in category **c**
- $FleetSize_c$ = Number of commercial vehicles of category **c**
- $AverageAnnualMileage_c$ = Average annual vehicle miles traveled per vehicle for commercial vehicles of category **c**.
- $OperatingDays_c$ = Average number of operating days of commercial vehicles of category **c**, as presented in Table 6.1.

Table 6.1 Number of Days in a Year by Vehicle Category

Commercial Vehicle Category	Number of Days per Year	Assumption
School Bus	180	Weekdays from September to June
Fixed Shuttle Services	365	Every day
Private Transportation	365	Every day
Paratransit	365	Every day
Rental Cars	365	Every day
Package, Product and Mail Delivery	306	Weekdays and Saturdays, excluding holidays
Urban Freight Distribution, Warehouse Deliveries	306	Weekdays and Saturdays, excluding holidays
Construction Transport	260	Weekdays, excluding holidays
Safety Vehicles	365	Every day
Utility Vehicles	260	Weekdays, excluding holidays
Public Service Vehicles	260	Weekdays, excluding holidays
Business and Personal Services	306	Weekdays and Saturdays, excluding holidays

Network-based Quick Response Methods

The Network-based Quick Response Method applies a simplified four-step planning model where the parameters are derived from national data as default parameters. The method uses national average vehicle rates to develop vehicle trips or tours (depending on the vehicle category) generated by commercial vehicles, distributing these trips using the gravity model method, and assigning these trips to a planning model network to produce VMT. This procedure is applicable for either regional- (macro) or corridor- (meso) level detail, since the data is developed at a TAZ level and applied to a transportation planning network.

For the purposes of this simplified four-step planning model, the project team assumes that commercial vehicle travel does not include trips from outside the region. This assumption is based on the understanding that long-haul movement of commercial vehicles (i.e., tractor-trailers) carrying freight would be estimated using commodity flow forecasting methods separately from this process to estimate commercial vehicles within an urban area. Therefore, the simplified four-step planning model process does not include any external travel. If this process is applied at a corridor level, then trips from the region that pass into, out of, or through the study area must be included as external travel.

The simplified four-step planning model process can be applied by individual vehicle category or by group of commercial vehicles. The parameters, methods, and data sources for these models are described in Section 3.0 by category and by group, respectively. The *Quick Response Freight Manual*[18] provides a similar approach for the development of commercial vehicle trips carrying freight, which is the second group of commercial vehicles.

Model Estimation Methods

The advanced method applies a simplified four-step planning model where the parameters are derived from local survey data. Model Estimation Methods rely on more detailed data sources than network-based quick response techniques. The surveys required are establishment surveys for specific industries, as described below:

- Manufacturing and Industrial (for urban freight vehicles) account for up to five percent of total VMT and 20 percent of all commercial vehicles;
- Retail and Services (for business and personal service vehicles) account for up to seven percent of total VMT and 28 percent of all commercial vehicles;
- Construction (for construction vehicles) account for up to one percent of total VMT and five percent of all commercial vehicles;
- Government (for safety, utility, and public service vehicles) account for up to six percent of total VMT and 23 percent of all commercial vehicles;
- Education (for school buses) account for up to one percent of total VMT and two percent of all commercial vehicles;
- Transportation (for shuttle services, taxi, paratransit, and rental vehicles) account for up to five percent of total VMT and 19 percent of all commercial vehicles; and
- Other Industries (for package, product, and mail delivery vehicles) account for up to one percent of total VMT and three percent of all commercial vehicles.

The four-step planning model components may be similar in structure to the network-based quick response techniques, or they may be developed to be more sophisticated if the data supports this. These models are more resource-intensive than the network-based quick response techniques, but provide greater flexibility in terms of capabilities and accuracy for a specific region. Advanced models developed for macro-level analysis can be used for meso-level (corridor) analysis, but would only be appropriate if the regional models already were are developed.

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[18] Cambridge Systematics, Inc., *Quick Response Freight Manual, Final Report,* prepared for the U.S. Department of Transportation and the U.S. Environmental Protection Agency, DOT-T-97-10, September 1996.

Methods for Future Research

A number of modeling methodologies currently being researched will advance the state-of-the-art for forecasting commercial vehicles. These are described briefly below.

Tour-Based Models

Tour-based models estimate the number of "tours" that an individual commercial vehicle will make from when the vehicle leaves the garage to when it returns to the same garage. A number of individual trips typically comprise each tour. Model estimation requires a tour-based commercial vehicle survey; these are the same type of establishment surveys recommended for use in developing the advanced four-step models. The surveys should include public and private establishments (retail, service, manufacturing, and government). If establishments include movement of people (rental cars, taxis, etc.), then this could cover all commercial vehicles.

Tour-based models are estimated by type of establishment (such as manufacturing and construction, etc.). These establishment models predict the number and types of vehicles (light, medium, heavy), the purpose of each trip on a tour (service, goods, other, return to establishment) and the location of the stops for every trip on a tour. These methods can account for a mixture of vehicles providing service and moving goods as well as empty vehicles returning to the establishment directly. One example of this type of tour-based model was estimated for retail and service delivery vehicles in Calgary.[19]

Supply Chain Models

Supply chain models estimate the supply chain from distributor to warehouses to retailer to buyer. These supply chains can then be converted into the number of commercial vehicles required to support the supply of goods from the distributor to the buyer, including any intermediate storage locations. Supply chain models only represent the movement of goods and possibly services but would not be appropriate to model the movement of people in commercial vehicles. Supply chain models are typically estimated by type of supply chain (just in time, inventory, etc.) and product. One example of this type of supply chain model is the GoodTrip model developed for the City of Groningen, Netherlands.[20]

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[19] Hunt, John Douglas, Stefan, Kevin J., and Abraham, John E., *Modeling Retail and Service Delivery Commercial Movement Choice Behavior in Calgary*, 10th International Conference on Travel Behavior Research, August 2003.

[20] Boerkamps, J. and Binsbergen, A., *GoodTrip – A New Approach for Modeling and Evaluation of Urban Goods Distribution,* Delft University of Technology and the Netherlands Research School for Transport, 2000.

Integrated Models

Integrated models estimate the personal and commercial vehicles from an integrated model of land use and demographics. In this definition, integrated models would include personal travel, commercial travel, and forecasting of households and businesses within a single modeling framework. These models will predict the movement of people, goods, and services by design. These integrated models can predict the demand and supply of each vehicle type – for example, the demand for school buses as a function of the number of children in each household and the supply for school buses as a function of the size and population of the school district. Integrated models also can predict the location and need for new schools as a function of the growth in households and changes in lifestyles (i.e., decisions to have children). One example of this type of integrated model is the Oregon 2nd Generation Land Use Transport Model.[21]

6.2 METHODS BY VEHICLE CATEGORY

All three methods described in Section 5.0 were applied separately for each of the 12 individual categories of commercial vehicles and documented the results in the Methods, Parameters, and Data sources report.[22] Methods and data sources were similar for many categories, but there are differences in application based on available data and expectations for certain causal relationships with demographic variables.

The travel behavior characteristics that are described for the Aggregate Demand Method include the fleet size, the vehicle trips, and the vehicle miles traveled for each commercial vehicle category. For each travel behavior characteristic, we provide a description of appropriate methods and in most cases, an estimate of the parameter for these travel behavior characteristics. These estimates are derived from available data, which is frequently limited in sample size, and not recommended to represent a national default value for the parameter estimates. For detailed information about the application of these methods to individual categories of vehicles, please review the Methods, Parameters, and Data sources report.

The travel behavior characteristics that are described for the network-based quick response method include the trips produced and attracted to a traffic analysis zone, the trips distributed between traffic analysis zones, the vehicle type, the time of day, the vehicle occupancy (for commercial vehicles moving people) and the characteristics of trip assignment. Again, we provided a description of the methods and an estimate of the parameter, but with information on the limited sample size available to estimate these parameters.

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[21] Oregon Department of Transportation, *Oregon Model Improvement Program,* http://www.odot.state.or.us/tddtpau/modeling.html#General%20Papers, 2002.

[22] Cambridge Systematics, Inc., *Accounting for Commercial Vehicles in Urban Transportation Models: Methods, Parameters, and Data Sources,* January 2003.

6.3 METHODS BY VEHICLE GROUPS

Following the evaluation of forecasting commercial vehicle travel by vehicle category (12), the same travel behavior characteristics of the factor analysis and network-based quick response methods were evaluated by groups of commercial vehicles. These groups represent aggregations of the commercial vehicle categories based on the primary purpose of the commercial vehicle: to move people, to move goods or to provide services. The methods and parameters developed for these groups of commercial vehicles are intended for use by metropolitan planning organizations that do not need or want to segregate commercial vehicles into 12 categories. It also is intended to work in coordination with the commercial vehicle categories for agencies that require additional detail for some groups but not others. For example, agencies may decide that it is useful to have more accuracy for commercial vehicles moving goods and providing services, but that this additional accuracy is not required for commercial vehicles moving people.

Commercial Passenger Vehicles

About 2.4 percent of total vehicle miles traveled in urban areas in the United States each year are attributable to vehicles in these five categories. Rental cars, which make up 80 percent of vehicles in the commercial passenger group, account for fully 2.0 percent of total VMT in the United States, while school buses, taxis, and shuttle and paratransit services account for about 0.4 percent of VMT.

The size of the commercial passenger vehicles by category appears to be related to different tradeoffs of service. If the rental car market is higher than average is one city, then the shuttle service and taxi market may be smaller than average, and vice versa. These tradeoffs were apparent in the airport data obtained for the study.[23] Paratransit and school bus categories are more independent categories based on resident populations.

Current urban transportation models do not include the “commercial passenger vehicle” as a separate trip purpose. However, several metropolitan planning organizations have attempted to include specific categories of these commercial vehicle in their models, primarily based on mode choice patterns. For example: the Las Vegas model is the only one that considers taxis as a separate mode in the mode choice model and assigns them to the highway network; the Tucson and Houston-Galveston models predict school bus travel, but do not assign or evaluate these trips; the San Francisco model includes mode choice for rental cars, taxis, and airport shuttles; the Portland model includes shuttle services and taxis in the mode and destination choice models; and the Sacramento model includes airport trips as a separate trip purpose. In addition, a number of models deal separately with the development of trip tables for taxi trips (sometimes combined

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[23] Cambridge Systematics, Inc., *Accounting for Commercial Vehicles in Urban Transportation Models: Magnitude and Distribution*, Appendix D, November 2003.

with 'truck' trips) and their assignment to the network using procedures akin to the network-based quick response methods. Also, all urban models based on local survey data can be presumed to include rental cars used by residents with all trips made using privately owned passenger cars.

Very little research has focused on paratransit vehicles and no models have been developed to estimate the demand for these trips. Similarly, although rental cars contribute a significant percentage of VMT on U.S. roads, the project team could find no models that estimate the demand for rental cars specifically. A few visitor models (San Francisco, Honolulu, and Las Vegas) predict the mode share of auto trips, but the percentage of these trips attributable to rental cars is not considered.

Freight Vehicles

About 3.5 percent of the total vehicle miles traveled each year in urban areas in the United States are attributable to vehicles in these three categories. Urban freight vehicles alone contribute 2.7 percent of total urban area VMT, while package delivery and construction contribute 0.2 and 0.6 percent, respectively. This category does NOT include the related movement of intercity freight to, from, or through urban areas, which is forecast using other techniques.

Urban transportation models typically include "commercial freight vehicles" in a goods movement model. Some of these goods movement models are vehicle-based truck models (Atlanta, Chicago, San Francisco, Buffalo, and Phoenix), some are commodity-based models (Portland) and some are hybrid models (Seattle and Los Angeles). These truck models include trucks from the commercial service vehicles category as well as intercity freight trucks traveling to, from or through an urban area. Most of these models identify trucks by weight class or type (light-, medium-, and heavy-duty) rather than by purpose (package delivery, urban freight, and construction).

Service Vehicles

Public service vehicles are publicly owned. Business and personal service vehicles are privately owned. Safety and utility vehicles may be either publicly or privately owned.

About 5.9 percent of the total vehicle miles traveled in the urban areas in the United States each year is attributable to vehicles in these three categories. Business and personal service vehicles alone contribute 3.6 percent of the total VMT in urban areas across the nation, while public service vehicles contribute 1.6 percent of the total VMT and safety and utility vehicles contribute 0.4 percent each.

Urban transportation models currently do not include any commercial service vehicles specifically, although some models have identified a commercial vehicle trip purpose that is based on a fixed factor of personal non-home-based travel.

Some truck models also include delivery and service vehicles that are four-tire commercial vehicles, based on the inclusion of these vehicles in the *Quick Response Freight Manual*.[24]

Summary

The average weighted impact of commercial vehicles on VMT is 11.8 percent of total VMT. The impact of individual categories on VMT does not necessarily sum to this average weighted impact of all commercial vehicles on VMT because of the different weights from each category. The range of the impact of VMT by category also is helpful to understand the potential impact, since this identifies the potential range of the impact of commercial vehicles on the transportation system. These data are summarized by vehicle group below:

- Commercial passenger vehicles average 2.4 percent of total VMT, with a range of 1.0 to 5.4 percent.
- Commercial goods movement vehicles average 3.5 percent of total VMT, with a range of 1.0 to 6.9 percent.
- Commercial service vehicles average 5.9 percent of total VMT, with a range of 1.4 to 12.7 percent.
- All commercial vehicles average 11.8 percent of total VMT (weighted), with a range of 3.4 to 25 percent.

[24] Cambridge Systematics, Inc., *Quick Response Freight Manual, Final Report,* prepared for the U.S. Department of Transportation and the U.S. Environmental Protection Agency, DOT-T-97-10, September 1996.

7.0 Calibration and Validation Data

The term "model calibration" is the process of adjusting parameter values until predicted travel matches observed travel demand levels in the given region. The term "model validation" is the process of comparing the model predictions with information other than that used in estimating the model. Model calibration and validation data should be obtained from different sources than the data used in estimating model parameters. As a result, one needs to identify unique sources of data that can support model calibration and validation. For the purpose of this study, calibration and validation data are those data that can be used to compare with model predictions to determine the reasonableness of the model parameters. Model calibration and validation data also are used as a means to adjust the model parameter values so that model predicted travel match observed travel in the region. This is especially important when applying nationally derived model parameters to a specific region.

7.1 Registration Records

State vehicle registration databases often indicate whether registered vehicles are used for commercial purposes. These databases typically show vehicle weight classes, but not service use. Service use can be inferred based on vehicle make/ model, weight class, owner, and possibly other data. However, this requires considerable data processing. Many states' databases also do not include odometer readings.

Vehicle registration databases that are maintained by a state can yield useful information on the number of commercial vehicles existing within a particular geographic area. For example, the California Energy Commission has been working with the California DMV and other agencies since the late 1990s in an effort to clean, organize, and analyze the State's vehicle data. The California DMV employed all key words from the 120-character owner field of each record in the database that reveal any potential business use information. The Energy Commission divided the DMV data into two main groups: 1) light vehicles and 2) medium and heavy vehicles. It further divided the light vehicle category by use, and the medium and heavy vehicle category by body type.

The project team recommends that other states explore and develop the same kind of multi-year cooperative arrangement that exists in California so that, over time, vehicle registration data can be used to support transportation planning – including, but not limited to, the movement of commercial vehicles.

Vehicle registration and new vehicle data also may be purchased from R.L. Polk & Co., a privately owned consumer marketing information company. Polk develops custom reports for customers, providing data by ZIP code, Metropolitan Statistical Area, county, state, or for the entire United States.

Vehicle registration data for New York State are available at their web site (New York State Department of Motor Vehicles 2001). These data are not as detailed as processed California DMV.

7.2 VEHICLE MILES OF TRAVEL

An independent regionwide estimate of vehicle miles traveled (VMT), based on traffic counts and roadway miles, can be used to validate the base year assignment of commercial vehicles produced by a travel demand model. These traffic counts are collected in most urban areas as part of the ongoing transportation planning process and are used to validate the passenger portion of urban travel demand models. In addition to any counts that might be undertaken for planning purposes, state departments of transportation are required to include Annualized Average Daily Traffic Counts and mileage for all roadways, based on a statistical sample, for each urban area as part of their annual Highway Performance Monitoring System (HPMS) submittal. The HPMS VMT can be summarized by functional classification of highways and by area type and compared to the urban area model volumes by functional classification and area type. When using HPMS estimates of VMT, it is important to understand that VMT is for all roadways, including local roads. Travel demand models, in contrast, generally do not include these local roads so this comparison should consider an adjustment for them to allow the comparison of the total observed and estimated VMT.

Generally, traffic counts are collected and VMT is calculated either for all vehicles or for vehicles classified by axle configuration. Traffic count information is predominately collected by Automatic Traffic Recorders (ATR) and thus will rarely include any other classification of commercial vehicles. That information will typically be based on a visual identification of commercial markings on the vehicle or a visual observation of the commercial registration plate.

HPMS estimates of percentages of single unit and combination trucks, based on ATRs, can be used to develop VMT for these types of trucks. Not all commercial vehicles are included in these classes, and intercity freight trucks that are excluded from the definition of urban commercial vehicles are responsible for a considerable portion of the truck travel on higher functional classes. Nevertheless, HPMS estimates of truck VMT can be used to validate commercial vehicle models. It should be noted, however, that the HPMS values for trucks are based on statistical samples. Thus, the "observed" truck VMT is in reality an estimate.

Based on accepted standards for model validation, modeled regional VMT should generally be within five percent of observed VMT.[25] When the regional models are used to track VMT for air quality purposes, the Environmental Protection Agency requires that estimates be within three percent. However, these estimates are for the total of all vehicles irrespective of vehicle type. If commercial vehicles generally represent 13 percent of total VMT, and if a travel demand model's estimate of commercial VMT is within five percent of that value, it would be consistent with the overall validation standards.

In addition to validating modeled VMT to observed VMT by functional class, it is customary to use measures and VMT per person or per household to assess the reasonableness of urban models. Reasonable ranges of total VMT per household are 40 to 60 miles per day for large urban areas and 30 to 40 miles per day for small urban areas. If one applies the 13 percent of total VMT that is estimated for commercial VMT in this report to these household ranges, then the VMT per household for commercial vehicle demand would represent five to eight miles per day for large urban areas and four to five miles per day for small urban areas.

7.3 Vehicle Classification Counts

Travel demand models are validated by comparing observed versus estimated traffic volume on the highway network and by comparing summations of volumes at both cordons and screenlines. As described in the Task 3 Report, vehicle classification count data, which classifies vehicles according to the 13-axle-based classes of the Federal Highway Administration (FHWA), is generally available from state departments of transportation for sampled sets of streets and highways. For the 13 classes, the information includes counts by location, by hour of the day, and by date. In summary format, this information generally presents truck volumes (defined as FHWA Classes 5 through 13, six tires and above) and occasionally includes buses (FHWA Class 4). Four-tire pickup trucks, vans, and sport utility vehicles (FHWA Class 3), are usually included with passenger cars.

The project team expects that the network-based quick response techniques for developing commercial vehicle models will include methods to convert commercial vehicle trip tables into assignments of commercial vehicles by type (auto and truck at a minimum). These vehicle classification counts can be used to compare the observed auto and truck counts (and shares by vehicle type) with the estimated auto and truck volumes (and shares) produced by the urban area model. These vehicle assignments will include both personal and commercial vehicles, derived from both personal and commercial models, so calibration adjustments deemed necessary from these comparisons might be required for either the personal or

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[25] Barton-Aschman Associates, Inc., and Cambridge Systematics, Inc., *Model Validation and Reasonableness Checking Manual: Travel Model Improvement Program*, Arlington, Texas, 1997.

commercial models or both. The project team does not recommend that vehicle classification counts be used to evaluate individual count locations, but that they be summarized by functional class, area type, or screenline.

Traffic counts may include truck "counts" for locations that are in reality estimated from the actual percentages of truck or total vehicles observed at nearby vehicle classification count stations for the same class of roadway. Care should be taken in understanding the source of truck "counts" used in validating commercial vehicle models. In many cases values for truck "counts" given at the stations comprising cutline, screenlines, and cordon lines will be derived, not observed. Since estimates of commercial vehicles derived from these estimated vehicle counts would effectively be estimates based on estimates, they should not be used for statistical analysis but rather for (cautious) qualitative comparisons.

8.0 Conclusions

The purpose of the first phase of the project was to estimate the magnitude and distribution of commercial vehicles in urban areas and to identify methods, data and parameters that would be appropriate to forecast these commercial vehicles in urban transportation planning models. The conclusions of the first phase of the project area described in the following sections.

8.1 Impact on Urban Transportation Models

Many of the commercial vehicle categories defined for this project have a negligible impact on VMT; school buses, fixed shuttle services, private transportation, and paratransit vehicles all comprise less than one percent of VMT. It may therefore be reasonable to estimate these commercial vehicles using the Aggregate Demand Method or to estimate these commercial vehicles as a group (all vehicles moving people) using the network-based quick response method. If a particular study focuses on areas such as central business districts or airports that are more greatly impacted by these types of vehicles, then more robust techniques may be considered.

The commercial vehicles with the largest impact on VMT are urban freight distribution vehicles, business and personal service vehicles, rental cars, and public service vehicles. To more accurately capture the impacts of these commercial vehicles on congestion and air quality in the transportation planning models, network-based quick response or Model Estimation Methods should be used.

The commercial vehicles with some (but still not significant) impact on VMT are the package, product, and mail delivery vehicles, the construction transport vehicles, and the safety and utility vehicles. Their impact may be estimated using Aggregate Demand Methods or network-based quick response techniques, depending on the characteristics of the urban area under consideration. Network-based techniques are desirable, but not necessary, for these categories, given their low overall impact on congestion.

The overall impact of commercial vehicles ranges from six to 18 percent of the total VMT for the urban areas in the project team's evaluation. This percent indicates that commercial vehicles should be considered directly in urban transportation planning models, at a minimum with the Aggregate Demand Methods, but preferably with network-based quick response or Model Estimation Methods.

8.2 Methods to Forecast Commercial Vehicles

Three types of methods to forecast commercial vehicles in urban transportation planning models were considered in this phase of the work. The network-based quick response method is recommended for both macro and meso scale applications because the level of effort to implement this method is reasonable within current four-step planning practices and new data collection is not required. Model Estimation Methods are considered and strongly emphasized as a means to improve the forecasting of commercial vehicles in urban transportation planning models, but new data collection will be required to pursue further evaluation of these methods.

8.3 Recommendations for Future Data Development

The project team identified a number of areas of future data development, based primarily on gaps in the data required to support the development of advanced commercial vehicle models. These data collection recommendations are designed to support the development of traditional four-step transportation planning models and state-of-the-art tour-based transportation planning models. In this way, the recommendations will support both current practice and future planning models.

The areas of future data development are summarized in three categories: vehicles by type, establishment surveys and forecasting. It is very difficult to definitively classify personal and commercial vehicles based on their use, rather than their registration. Personal vehicles that are used for commercial purposes and commercial vehicles that are used for personal reasons are estimated based on data from the Vehicle Inventory and Use Survey, but it would be useful to collect specific data on these classifications. In addition, not all commercial vehicles are trucks and should therefore be classified by vehicle type (autos, trucks and buses) for use in urban transportation planning models. Current registration data contains this information, but is not processed for this purpose in most states.

The most significant improvement in data collection for commercial vehicles would be collection of establishment surveys to support the following types of vehicles: manufacturing and industrial (for urban freight vehicles); retail and services (for business and personal service vehicles); construction (for construction vehicles); government (for safety, utility, and public service vehicles); education (for school buses); transportation (for shuttle services, taxi, paratransit, and rental vehicles); and other Industries (for package, product, and mail delivery vehicles).

The establishment surveys could be standardized or adapted for unique types of establishments, although the project team recommends standardizing these surveys as much as possible to improve the usefulness for model development. All of the surveys should include a complete day's travel diary information for a sample of vehicles in the establishment.

The current proposed methods for forecasting commercial vehicle travel are necessarily limited by the expected forecast data that would be available to a metropolitan planning organization. These methods could be expanded to provide more accurate assessment of future commercial vehicle travel as these future data sources become available.

Data needs were further identified specifically for each vehicle category and prioritized based on their overall impact on VMT. All of the recommended methods for estimating commercial vehicles in urban transportation planning models (factor analysis, network-based quick response, and Model Estimation Methods) use existing model forms and are not expected to require any future research to support these efforts. Other methods, such as activity-based or tour-based models, would advance the methods proposed in this project, but are beyond the scope of this initial effort, which was primarily aimed at developing network-based quick response techniques that could be adapted or transferred by metropolitan planning agencies. Tour-based models should be considered during the development of any locally specific models using the Model Estimation Methods described here and could be developed using the same data recommended here to support the Model Estimation Methods.