COMMERCIAL VEHICLE STUDY
Should Sample Unit be Commodities or Truck Trips?

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Overview

The predominant mode used for freight transportation is truck. Considering all freight movement, both intercity and local, trucks account for almost 80 percent of the freight revenues in the U.S. "Revenues" refers to fees for transportation spent by shippers. Freight activity can also be measured by weight (tons or ton-miles), by volume, or by value. When measuring domestic freight by ton-miles, rail becomes increasingly important as a mode.

Nationally, about 40 percent of goods movement is between cities, which leaves 60 percent within the local area. There may be factors that drive a local area's share of intercity travel higher, such as agricultural export, a large cargo airport, and geographic peculiarities. A rule of thumb is that rail is economical for goods movement over distances of 750 miles or more, although some opportunity may exist for the 250 to 750 mile range. The rail penetration of the market for goods movement over 750 miles is only about 25 percent, generally because of the poor on-time performance of rail, especially with the growing need to support 'just-in-time' manufacturing operations. Another constraint to the growth of rail shipping is the inability of rail to handle fragile goods.

The majority of truck traffic is within the confines of a single urban area. Many things require transportation of goods to dispersed local destinations. The competition of providers to deliver goods and services to stores, homes, and businesses either saves the consumer money, or offers greater convenience and choice. Given recent trends, it is unlikely that the portion of freight moved by trucks within city limits will fall significantly; on the contrary the bulk of today's intra-urban truck traffic will probably continue to grow.

The ease and efficiency of goods movement in a region in intricately linked to the metropolitan economy. Business and industrial location choices are not only tied to market access, but to dependable transportation facilities for the distribution of products to consumers. Despite its importance, few regions have examined and planned their transportation networks with goods movement in mind. The link between goods movement and economic development has long been acknowledged, but few regions examine the goods movement network as an economic asset or try to integrate transportation development with area wide economic development goals. A study of the commodities moving by truck in and through an area will allow the inclusion of issues related to truck travel in the planning process.

However, measuring commodity flow as a basis to estimate truck trips is limited in developing trip generation models. Commodity flow (especially as tracked by large, secondary commodity-flow databases, such as Census CFS) do not always translate into trip estimates for the following

reasons:

- The amount of trucks moving empty can be between 25 and 35 percent of the trips in a region.
- The geography of goods flow includes:
    - Trips within a study area (Internal only) comprise about 60% of all truck trips when large and small trucks are included. The goods moving fully within an area are not accounted for by most large commodity flow databases.
    - Trips from outside an area to inside an area (External-Internal) depends so much on the area location, size, and characteristics. These would be partially accounted for by large commodity flow databases.
    - Goods moving through an area can often be tracked from goods flow databases
- Regional and seasonal differences in commodity amount and type, destination type and location, etc.
- The growth of intermodal shipments which makes tracking mode (train/truck) difficult using large commodity databases:
    - Growth of container shipments, separation of truck and goods
    - Greater economy/efficiency on rail means more rail-truck distribution within an area.
    - Growth of imports through water ports and truck to rail movements (Drayage)

At this point in the state of the practice of surveying and forecasting truck travel, the recommended design includes measuring truck trips, and obtaining data on commodities for the sampled trips.

Uses of Truck Trip Data

Potential applications for freight truck trip information includes:

Congestion Management and Safety

- Document origins, destinations, and routes used by freight trucks traveling through congested urban areas
- Provide base data to evaluate opportunities to reduce freight truck traffic through urban areas during peak commute periods
- Provide base data to evaluate other policies relating to truck route prohibitions in urban areas

Corridor Planning

- Identify highway corridors most critical to key industries
- Pinpoint major freight truck generators for specific corridors

- Document routes most widely utilized for national and international trade
- Provide base data to project freight truck traffic growth and decline for specific corridors
- Provide base data to estimate the economic value of specific commodities shipped in specific corridors

Intermodal System Planning

- Delineate essential highways linked to rail, air, deep water and river ports
- Evaluate intermodal systems most critical to key industries
- Track geographic proximity of intermodal facilities relative to the origins and destinations of trucks utilizing those facilities
- Provide base data to project changes in highway usage that would results from rail-line abandonment or closing of key river ports
- Document highway segments with the highest average freight cargo volumes and weights
- Provide base data to project future changes in freight cargo volumes and weights on specific highway segments

Collecting Primary Data on Truck Trips

The commercial vehicle survey, formerly referred to as the truck and taxi survey, was an important component of the comprehensive studies of the 1960's and 70's. More recently the lean budget years, coupled with the fact that truck travel is typically 10 to 12 percent of all trips, tended to diminish the conduct of this type of survey. However, current concerns with air quality issues, since trucks can be major emitters of pollutants, and with safety and congestion issues, related to restricting truck access, has refocussed interest in collecting better information about commercial vehicle travel.

Significant differences in trip characteristics make it inappropriate to factor resident auto trip tables to account for commercial vehicles. Household and truck activity are not directly related, and in some cases mutually exclusive--such as truck limitations in residential areas. The logical solution is to base the activity of these vehicles on employment density and type, rather than household density, as is the case with person trips.

Information on the cargo carried by sampled vehicles is generally obtained in the format of Standard Transportation Cargo Codes (STCC), but the proposed survey is not designed to be a cargo or goods movement survey. The design of the survey will lead to the analysis of commercial vehicle trip characteristics for development of a truck trip model.

The consultant team has been involved in a number of commercial vehicle surveys, for estimating trip generation and trip attraction as well as air quality forecasting, and has discovered

some issues which surface over and over again:

How to Develop a Universe?

Selecting a vehicle randomly from the universe of all vehicles traveling in the study area is not as straightforward as it would appear. Some of the trucks making trips in the region are registered in the region, and some of the trucks making trips in the region are registered in other counties adjacent to the study area, or even in other states. Some of the trucks registered in the region are actually garaged elsewhere. Some trucks are registered in the region but leased to other operators who may or may not be identifiable. Some trucks are making stops in the region, and others are simply traveling through.

The first step in the design of the survey then is to determine the universe from which we are to pull a sample. A listing of trucks garaged in the area must be established before the sample is designated.

Using the DMV files does not provide a robust sample because tractor cabs and trailers can be separated, and licensed separately. For most study areas, multiple state listings should be included, since trucks registered in one area (due to different licensing fees) are often garaged in others. To effectively use the DMV file, if that is the choice, requires that the separate vehicle listings be combined under the same garage address, so recruiting is efficient. This can entail a lot of computer sifting to aggregate the separate vehicles and provide a sample garage location. The telephone number is not listed on most vehicle registration files, therefore once garage locations are developed, the site must be manually looked up in a telephone book. We've hit a number of snags at this point, with business registration names differing from site location names, or sites just not appearing in the phone book (industrial sites especially).

Due to these difficulties the consultant team has developed an alternate, two-stage methodology that uses lists of businesses developed from D&B files, or other business lists. A sample of the businesses in the directory can be telephoned and screened as to whether or not a commercial vehicle is garaged at that location. An inventory of all commercial vehicles garaged at the recruited business location will be compiled, with the license plate number of each vehicle. In this method a sample vehicle is chosen from the inventory of vehicles by matching a random digit to the last number of the license plate.

Generally, between 10 and 25 percent of the contacted sites have a commercial vehicle, but the terminology and definition of such vehicles needs to be clearly stated to ensure that the estimation of the universe is correct. The number/percent of sites with vehicles are tracked by industry type, area type, and other pertinent variables, and some data about the number and type of vehicles at each site is obtained. The final number of truck trips generated by sampled vehicles at the participating sites is first raised to the total number of vehicles at the sampled sites, and then to the total estimated vehicles and sites within the

strata (industry type/area type).

Although this method is sound and applicable to the present situation, it is time-consuming and costly per trip record obtained.

Survey Methodology

Once a specific site with a commercial vehicle has been located, the approach to this type of survey resembles a home interview survey--the truck is equivalent to the household member who keeps track of each trip made during a sample day, and the commercial (garage) location is equivalent to the household location. The trip generation is tied to the garage location (by industry type and area type).

The survey methodology can also be compared to the household travel survey--a vehicle at the sampled site is randomly selected, the owner/operator is recruited to participate in the survey, and the participant driver(s) record all of the trips made in the sampled vehicle during a 24-hour period on a travel diary. The owner/operator is then re-contacted and a trained interviewer collects the survey data. One method we have used in the past is similar to the household travel survey--a telephone recruit, mail-out of the survey packet, and a telephone retrieval of trip data. This method has worked well, with some modifications to the recruiting procedures, and with allowing a mail-back of the survey form when a telephone interview cannot be arranged.

Most employers do not own or lease commercial vehicles: 74% had no commercial vehicle garaged at the location. Overall, 26% of the employers in the North Carolina study garage commercial vehicles at their business locations. Based on these data, Table __ shows an estimate of the number of vehicles by industry type for the study area (this is Denver--can we get the estimate of the businesses for the SCAG study area?). A table similar to this will be prepared from the screening call data compiled as a part of this task to estimate the number of commercial vehicles garaged in the study area.

Table __ - Estimated Number of Vehicles by Type of Business (Denver Metropolitan Area)

Type of Business (SIC Designation):	Number of Businesses (D&B Summary)	Estimated Number with at Least One Commercial Vehicle	Mean Number of Trucks per Site	Total Estimated Trucks at Commercial Sites
Industrial (1-4999)	18,168	4,542	7.9	35,882
Retail (50-5999)	21,768	5,442	3.2	17,414
Service (70-8999)	35,918	8,980	3.7	33,226
Office and Govt.. (60-6799, 91-9799)	9,323	2,330	6.4	14,912
Total	85,177	21,294	4.8	101,434

Expansion

The expansion of the sample data is a two-stage process. First the sampled trucks are raised to represent the all of the trucks garaged at the sample location, to estimate a trip rate per site by industry type. The trip rate is applied to the proportion of sites of that type which have trucks (as estimated from the universe). This gives a control total for the number of internally generated truck trips linked to employment by type in the study area.

As a second control total, the consultant team has developed an expansion technique using estimates of total truck VMT by facility type. The details are attached as Appendix A.

Using a Manifest in Place of a Trip Diary

In the surveys conducted in the 1960s and 1970s, use was made of a trip manifest rather than a travel diary. Current trip tracking by commercial vehicles includes a range of methods, including electronic tracking and dispatcher. Table ___ shows the percent of sampled garages which used a trip manifest by industry type, and the percent of the vehicles at these garages which made trips.

Table __ North Carolina - Percent of Sampled Garages and Vehicles by Manifest Use and Whether Trips Were Made on Sample Day

Industry Type	Garages		Vehicles	
	Use Manifest	No Manifest	Made Trips	Did Not Make Trips
Industrial	32.6%	67.4%	70.2%	29.8%
Retail	27.6%	72.4%	74.2%	25.8%
Special Retail	23.5%	76.5%	76.5%	23.5%
Service	24.0%	76.0%	62.8%	37.2%
Office	28.1%	71.9%	78.8%	21.2%
Other (unclass.)	0.0%	100.0%	60.0%	40.0%

Vehicle Weight

There is also a lot of confusion about collecting the weight of the vehicle, especially for input into and air quality model (such as Mobile 5). Generally we ask for the empty weight and the loaded weight, but these data may or may not be known with precision by the driver/operator, especially of the smaller vehicles. Larger vehicles usually have better information on tare weight and cargo weight. For input into Mobile5 (or equivalent air quality analysis software) the weights of the vehicle and the fuel-type determine the type of truck or designation category:

Table ___ - Truck Type Categories as Defined by Weight

Designation:	Weight (GVW)	Fuel Type
Light Duty Gas Trucks Type 1	6,000 lbs	Gasoline
Light Duty Gas Trucks Type 2	6,001-8,500 lbs	Gasoline
Heavy Duty Gas Vehicles	8,501 and over lbs	Gasoline
Light Duty Diesel Vehicles	8,500 and less lbs.	Diesel
Heavy Duty Diesel Vehicles	8,501 and over lbs	Diesel

The Gross Vehicle Weight (GVW) is different than the weight listed on the DMV file, for air-quality analysis the GVW is the empty weight of the vehicle plus the weight of the vehicle when fully loaded. However, the weight obtained from the driver/owner on the sample day will be carried in the file. Up to one-half of the vehicles which make trips on the sample day will not be carrying any freight, for these trucks Mobile5 will overestimate the GVW. Defining this variable for collection will be finalized in later discussions.

Definition of Vehicle Types

Defining and categorizing trucks and other commercial vehicles in the study area is not as straightforward as it would appear. Vehicles are often classified by a combination of fuel type and weight. The FHWA classification scheme is by silhouette for manual classification counts. Automatic classification counters use number of axles, and of course cannot determine fuel type. The current study asks specifically for heavy-duty trucks.

The Texas models incorporate only trucks with three-axles and more, since axles were an easy match to automatic vehicle counters. The North Carolina models include cars used commercially, pickups and vans, and panel trucks as well as big trucks. The trip rates, lengths, routes, land-use at destination, etc. is very different for each vehicle type. For example, Table __ shows the average miles driven on the survey day by vehicle type, and the average trip length in minutes from reported data by vehicle type (this data is from North Carolina where commercial cars, vans, and trucks were included in the sample frame).

Table ___ - North Carolina - Average Miles Driven on the Survey Day by Vehicle Type

Vehicle Type	Miles Driven on Survey Day	Average Travel Time per Trip (mins)
Single Unit Truck	98.44	18.93
Combination Truck	181.06	38.19
Pickup Truck	57.52	17.85
Van	69.21	37.97
Car	76.98	18.46
Overall	84.79	23.93

Table __ presents the estimated proportion of total vehicle miles of travel by eight classifications in the Houston-Galveston Region. These classifications use the fuel type and weight as

illustrated in the discussion on vehicle weight.

Table __ - Proportionate Distribution of VMT by Vehicle Classification

Designation:	Proportion of VMT
Light Duty Gas Vehicles (Cars)	51.3 %
Light Duty Diesel Vehicles (Cars)	0.5 %
Light Duty Gas Trucks Type 1	28.9 %
Light Duty Gas Trucks Type 2	7.9 %
Heavy Duty Gas Vehicles	7.1 %
Light Duty Diesel Vehicles	0.4 %
Heavy Duty Diesel Vehicles	3.7 %
Motorcycles	0.2 %

Using similar proportions from classification counts done in the region, an estimate of the total vehicle miles of travel by vehicles classified as trucks (the non-shaded rows) may be developed. After removing the estimated truck vehicle miles of travel made by trucks passing through the study area (estimated from ? Usually an external survey), the total vehicle miles of travel for each classification of truck would be divided by the vehicle miles of travel for the surveyed trucks to calculate an expansion factor.

Vehicles to Include in the Survey

In addition to the question of how to define vehicle types, there is a question of what specific vehicles to include in the sample frame. Many vehicles besides heavy duty trucks will use diesel fuel and turn up in classification counts by axle. Some of these vehicles may not be included in the sample, information on these types can be collected separately or not at all:

- Transit buses on fixed routes can be analyzed for the VMT from available data
- VMT estimates for school buses can be ascertained from mileage accrual--direct contact with service providers (school districts or independent contractors)
- Post Office vehicle's VMT can be obtained from mileage accruals or analyzed from the Post Office forms 3997 and 4533 for local and regional routes. Postal vehicles are 1 percent of all trucks, but can be 2 percent of all trips within a study area (CATS). The routes will be analyzed for the amount of travel on

neighborhood streets, and the amount on collectors and more major facilities.

- Police Vehicle's VMT can be obtained by directly contacting each precinct for mileage accrual.
- Rental and leased trucks at leasing stations (U-Haul, etc.). Although mileage is obtained on the rental record, these trips may or may not be within the study area--these data should be obtained from a separate visitor survey.
- Fire Station Vehicles and Emergency Medical Service (EMS) Vehicles have widely variant trip characteristics. We recommend that these vehicles not be surveyed.
- Garbage Trucks travel primarily on neighborhood roads and alleys. We recommend that these trucks not be surveyed.

The determination of which vehicles to include will be finalized during later discussions. The resources required to obtain the VMT data from all providers and sources listed above is considerable.

Other Considerations

To assist in air quality modeling we obtain data for whether or not the vehicle was turned off at the destination for each trip end. It is not too surprising that nearly 30 percent of the sampled vehicles did not turn off their engine at the stop. Table ___ shows these data by land-use type.

Table ___ - North Carolina - Percent of Trips by Whether Vehicle Was Turned Off at Destination

Industry Type	YES		NO	
	Trips	Percent	Trips	Percent
Industrial	841	79.2%	221	20.8%
Retail	444	84.6%	81	15.4%
Special Retail	122	64.9%	66	35.1%
Service	495	76.7%	150	23.3%
Office	131	79.9%	33	20.1%
Other (Unclass.)	13	92.9%	1	7.1%
Total	**2046**	**78.8%**	**552**	**21.2%**

Cargo Type

Cargo is usually tracked by Standard Transportation Cargo Codes (STCC), but in our experience the use of these codes is cumbersome and the resulting data too fine for real analysis. The number of trips by commodity type in each of the categories is so small that the categories are combined to produce meaningful slices of the pie. These proportions are then analyzed as attractions to various land-uses. In addition, many independent carriers are not sure what they're carrying (classified as "Other"), or like UPS they are carrying an assortment (Freight All Kinds). Small carriers (vans and panel trucks) which represent a good proportion of the commercial trips in an area may be carrying non-classified goods (flowers/take-out-meals/catering equipment/lawn equipment/etc.) Another issue alluded to earlier concerns the amount of trucks moving empty. Table ___ shows the percent of trips by cargo type destined to various land-uses.

Table __ - North Carolina - Cargo by Land Use at Destination - Percent of Trips

Cargo Type	Office /Com	Retail	W-house/ Manuf.	Utility	Const- ruction	Other
Empty	32.1	23.2	32.8	7.5	3.1	1.4
Food	5.7	80.4	4.6	9.3	--	--
Tobacco/Textiles/ Apparel	8.6	10.0	75.7	2.9	2.9	--
Conc./Lumb./Pap. or Furn.	60.0	7.3	24.8	2.4	4.2	1.2
Petr./Nat. Gas or Coal	8.6	16.7	58.0	12.3	2.5	1.9
Mach./Equip or Supplies	5.6	6.9	30.6	56.9	--	--
Waste or Scrap/HAZMAT	6.1	39.4	43.9	4.5	1.5	4.5
FAK (Freight All Kinds)	21.7	31.9	33.9	9.4	0.3	2.9
Other	22.6	23.7	36.0	11.2	1.1	4.7

N/A	44.4	20.5	13.0	20.3	0.7	0.7
Total	**26.2**	**26.1**	**32.1**	**11.9**	**1.7**	**2.0**

Some areas, such as Portland, have developed a simplified classification system based on combinations of STCC codes, and some areas, such as the CATS area in Chicago, have simply added categories as needed. The coding and classification of cargo will be finalized in later discussions.

Sample Size

The number of samples is based on the acceptable error and the required confidence in the data, and on the available resources and detail of the data collected. Table ___ shows the estimates from previous studies of trucks by type as a percent of the universe of all trucks, the mean number of vehicle trips, and the coefficient of variation. These data can be used to determine sample sizes within a single dimension or strata (truck type). If more detailed cross-classification strata are used (such as trucks by type by industry type or area type), the estimated sample size will increase.

Table --- Estimate of Coefficient of Variation for Truck Type Categories

Designation:	% of Universe	Mean Number of Trips	C.V.
Light Duty Gas Trucks Type 1	56.2%	5.9	0.966
Light Duty Gas Trucks Type 2	2.1%	5.0	0.848
Heavy Duty Gas Vehicles	4.6%	4.4	1.140
Light Duty Diesel Vehicles	20.4%	7.7	0.872
Heavy Duty Diesel Vehicles	16.7%	6.9	0.874
All	100.0%	6.1	0.967

Addenda

Other urban areas have recently conducted surveys for regional truck travel for input into the truck travel forecasting model. Both Chicago and Phoenix had some common findings[1]:

1) Trip length distribution and the truck size was related: generally the larger the truck the longer the average trip length.

2) Number of daily trips and size of truck were related: generally, the larger the truck the fewer number of average daily trips.

3) Daily peak patterns: truck travel is heaviest in the midday period and declines prior to the P.M. commute period.

4) Trucks primarily serve commercial land uses: a majority of truck trips are destined for retail establishments (25 percent), manufacturers (20 percent), or terminals/warehouses (20 percent). However, a growing segment of truck travel (especially smaller panels and vans) is destined to residential locations.

5) Local area characteristics determine truck travel type, for instance Chicago is a central hub for truck and rail whereas Phoenix is on a through route connecting the east coast and southern California.

[1] Truck Travel in the San Francisco Bay Area, prepared for Caltrans District 4 and Alameda County, prepared by Barton-Aschman Associates, December 1992. p. I