Preliminary Review of Data Sources To Identify Portion of Heavy-Duty Vehicle Activity in Texas Metropolitan Areas from Long-Haul Pass-Through Trucks
PRELIMINARY REVIEW OF DATA SOURCES TO IDENTIFY PORTION OF HEAVY-DUTY VEHICLE ACTIVITY IN TEXAS METROPOLITAN AREAS FROM LONG-HAUL PASS-THROUGH TRUCKS

FINAL

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BACKGROUND

The accuracy of oxides of nitrogen (NOx) and volatile organic compounds (VOC) emissions estimates are critical for State Implementation Plan (SIP) modeling and control strategy development. The Texas Commission on Environmental Quality (TCEQ) is modeling ozone episodes that occurred in the eight-county Houston/Galveston/Brazoria (HGB) nonattainment area during both 2005 and 2006. Additional metropolitan areas throughout Texas may also be relying on these 2005/2006 ozone episodes. The purpose of this work order is to perform a preliminary review of existing data sources that could be used to identify the portion of heavy-duty vehicle activity from “pass-through” trucks within each of the major Texas metropolitan areas. The primary objective of this work order is to develop a list of options with approximate cost estimates that the TCEQ can select for possible further study. Since the potential cost of a comprehensive study could be quite high, this project is intentionally limited in scope:

- no new data are to be collected, and only existing data sources are to be reviewed; and
- no major data analysis is required, but it is expected that the list of options for further study will contain descriptions of the analytical methodologies that could be employed.

This project is part of the ongoing efforts to ensure that accurate and detailed mobile source emissions inventories are produced on a schedule to ensure availability of all inventories required to support SIP development and overall TCEQ planning activities. Heavy-duty trucks (primarily composed of five-axle “18-wheelers”) are a major NOx emissions contributor in metropolitan areas throughout Texas. Current data sets allow for satisfactory estimates of overall heavy-duty truck activity, but are not able to distinguish between local and pass-through trucks. Quantifying this difference would be essential for estimating the magnitude of possible control strategies affecting heavy-duty trucks, because the pass-through trucks do not fall under state regulatory authority.

Introduction

TCEQ works with local planning districts, the Texas Department of Transportation (TxDOT), and the Texas Transportation Institute (TTI) to provide on-road mobile source emissions inventories of air quality pollutants. TxDOT typically funds transportation conformity determinations required under 40 CFR Part 93. TCEQ funds mobile source inventory work in support of Federal Clean Air Act Amendment (CAAA) requirements, such as attainment of the National Ambient Air Quality Standards (NAAQS, 42 USCA 7409), and the study and control of hazardous air pollutants (HAPs), including those from motor vehicles and/or motor vehicle fuels (as mandated under CAAA sections 202 and 211).

TCEQ emissions inventory development activities include inventory development, methodology updates, data gathering, analysis and assessment, and planning for future requirements. In addition to meeting the basic inventory development requirements, Texas has consistently used state-of-the-art methodologies and up-to-date data sets to produce highly detailed on-road mobile SIP inventories. This level of commitment requires a constant update of
emissions inventory and control strategy reduction estimates to include the latest methodologies and data.

TCEQ is continuing its progress toward meeting the requirements of the U.S. Environmental Protection Agency’s (EPA) eight-hour ozone standard. As part of the eight-hour SIP planning and development process, control strategies to reduce NOx emissions are regularly considered. Since heavy-duty trucks are significant NOx contributors, it is necessary to separate those that are operated and registered locally from those that just pass through the area of consideration. This task calls for the review of existing sources of data that may help draw this distinction, along with providing recommendations for further study that may include new data collection. While statewide data is beyond the scope of this study, the methods examined recognize TCEQ’s interest in, and the need for, future application to several areas of particular interest. The areas of particular interest within Texas are:

- the five-county Austin area composed of Bastrop, Caldwell, Hays, Travis, and Williamson counties;
- the three-county Beaumont/Port Arthur area composed of Hardin, Jefferson, and Orange counties;
- the nine-county Dallas/Fort Worth nonattainment area composed of Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant counties;
- El Paso County;
- the eight-county HGB nonattainment area composed of Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller counties;
- the four-county San Antonio area composed of Bexar, Comal, Guadalupe, and Wilson counties;
- the five-county Tyler/Longview area composed of Gregg, Harrison, Rusk, Smith, and Upshur counties;
- an “urban” conglomeration containing all 35 counties referenced above;
- a “rural” conglomeration containing the 219 Texas counties not mentioned above; and
- an aggregate Statewide summary for all 254 Texas counties.

**TASK 2 - PRELIMINARY REVIEW OF DATA SOURCES TO IDENTIFY PORTION OF HEAVY-DUTY VEHICLE ACTIVITY IN TEXAS METROPOLITAN AREAS FROM LONG-HAUL “PASS-THROUGH” TRUCKS**

**Task Description**

This task calls for the identification, review, and assessment of the adequacy of existing data sources that may be used to estimate the portion of pass-through activity from heavy-duty trucks. These data sources include:

- travel surveys that have periodically been conducted in major Texas metropolitan areas (e.g., external station counts);
other surveys of heavy-duty truck movements (e.g., license plate surveys);
• “weigh station” data that are sometimes collected at state/county borders, which may contain origin and destination information for specific truck activity;
• electronic global positioning system (GPS) data collected on a daily basis for fleet management purposes by private trucking and/or telecommunications firms; and
• other sources containing truck activity data within Texas.

These existing data sources were examined and reviewed for data quality, completeness, and possible cost of acquisition. This review and summary is provided in a narrative report containing a list of options for TCEQ to select for possible further study. Every effort has been made to maximize the number of future research options available to TCEQ. For cost effectiveness reasons, specific attention has been given to those options not involving collection of new data. Where acquisition of existing data sets will involve significant cost, approximate estimates are provided. For each future research option, a short summary of the analytical methodologies to be employed to obtain the breakdown between local and pass-through heavy-duty truck activity is provided.

Acknowledgments

Nitin Warrier, of TTI, provided the review and summary of long-haul truck activity methods reported in this document. Gary Lobaugh, of TTI, was responsible for editing, design, and production of this Technical Note. Dennis G. Perkinson, Ph.D., was the principle investigator for this project. TTI performed this work under contract to TCEQ. Chris Kite was the TCEQ project manager.

PURPOSE

Freight movement is one of the critical issues in transportation. The majority of truck movements in a metropolitan area are known through observational data via traffic counts, which are typically insufficient for understanding truck freight movement for transportation modeling and freight planning. There is limited knowledge on trip chaining (pick up/drop off) and the use of distribution centers. While the use of distribution centers has increased dramatically with the advent of supply-chain logistics (third party management of goods movement), almost nothing is known about the extent or frequency of their use, or their role in urban congestion.

Such knowledge would aid transportation planners as they seek to address problems with traffic flows and choke points of critical commodities on urban highways. Primary freight data collection efforts involve collecting truck travel data directly from the freight community (i.e., shippers, carriers, receivers, and freight forwarders) through surveys, including roadside intercept surveys, mail-out/mail-back questionnaires, combined telephone and mail-out/mail-back questionnaires or telephone interviews. Performed correctly, these survey methods are, in general, the most reliable and accurate methods of obtaining truck travel data for statewide freight planning programs. However, more research is needed to develop and test truck trip data collection methods that can produce data capable of better characterizing freight flows at the metropolitan level for transportation models and freight-planning processes.
There has been considerable research in addressing the needs of passenger transportation as it relates to congestion and capacity, and to a lesser extent on regional or statewide freight truck movements. The number of studies focusing on truck travel demand patterns is limited. The Intermodal Surface Transportation Efficiency Act of 1991 provided renewed interest in freight transportation research and planning, as departments of transportation (DOTs) and individual Metropolitan Planning Organizations (MPOs) were required to incorporate freight planning and analysis into transportation plans. However, no standard methodology was available for implementing truck trip data gathering or modeling, especially as it applies to intra-urban movements, thus resulting in a wide variety of study approaches. This literature review provides a summary of prior studies that have implemented different data collection methodologies to provide a better understanding of the strengths and weaknesses of each methodological approach. The literature review also documents the lessons learned from past studies, especially as they relate to metropolitan or urban truck movements.

In the past decade, there have been multiple studies of different magnitude conducted at the state and metropolitan level to collect truck trip information across the nation. Samuel W. Lau in 1995 provided a synthesis of the studies in his work entitled, *Truck Travel Surveys: A Review of the Literature and State-of-the-Art*. Tables 1-3 present summaries of this survey and other selected truck surveys. Truck survey methods vary in the response rates they generate and in their coverage, accuracy, and cost. The methods of road side intercept/intercept surveys are restricted to controlled facilities, though they have advantages over telephone or mail surveys. A paper presented at the 1995 Transportation Research Board (TRB) meeting by William R. Gillis, Kenneth L. Casavant, and Charles Howard, Jr. provides a comprehensive outline for gathering truck movement data and information on a statewide basis. The paper describes the methodology and procedures employed to interview a total of 30,000 truck drivers at 28 weigh stations located throughout the state of Washington. The interviews were conducted in each of four seasons to account for seasonal differences in truck movements. The data collection effort was highly successful, with a 95 percent response rate providing data and information for an extensive database of statewide freight and goods movement in Washington.

**DATA COLLECTION METHODS**

The Federal Highway Administration (FHWA) has classified the heavy-duty trucks based on the number of axles and trailers. EPA’s classifications for trucks are based on the fuel type and Gross Vehicle Weight Rating (GVWR). The focus of this report is the HDDV8b MOBILE6.2 truck category (heavy duty diesel vehicles weighing more than 60,000 lbs. GVWR), since long-haul trucks are virtually all HDDV8b (but not all HDDV8b trucks are long-haul trucks).

**Surveys**

A critical component of any survey data collection effort is sampling. In determining the optimal survey sample size, consideration must be given not only to the survey design, but also to the logistics of implementing the survey. The various data collection methods are:

- mail survey;
- telephone survey;
- roadside interview/intercept survey;
• video surveillance/license match; and
• GPS receiver.

**Mail Survey:** This is the most commonly used data collection method because the implementation is easy while investment and maintenance costs are low. This type of data collection also does not require manual labor but the response rates are low as seen in the examples in the table. Additionally, the geographical area limits the survey, thereby excluding the external traffic.

**Telephone Survey:** Telephone surveys provide a higher rate of response in comparison to mail surveys but are a potential information bias. This is essentially due to the fact that the trucks are used for a variety of shipment types, routes, and commodities. In addition, this sort of a survey is bound by other factors such as the hours of operation and availability of telephone numbers, thereby restricting the coverage area. The mail-out survey may also be combined with a telephone survey for better response rates.

**Roadside Interview/Intercept Survey:** The roadside or intercept survey has more advantages to the mail or telephone surveys. The major advantages include high statistical reliability, broader geographic coverage, and complete data collection. Implementation of this survey method is difficult in urban areas due to limited parking availability and congestion. Consequently, these surveys are conducted on the outer cordons of the city at interchanges near freeway exit ramps, weigh stations, or truck stops.

**Video Surveillance/License Plate Match:** This method involves the video recording of license plates in and around the study area. It is used to estimate internal-external (local) and external-external (through) trips. However, the data cannot be utilized to estimate origin, destination, route, trip chaining, etc.

**Global Positioning System:** GPS is a satellite-based navigation system comprised of a network of 24 satellites sent into orbit by the U.S. Department of Defense. GPS was originally intended for military applications, but in the government made the system available for civilian use in the 1980s. Figure 1 shows the process of using the technology to track truck fleets as explained in the following section:

- the fleet manager logs on to the Internet or launches a software based tracking system;
- the fleet manager’s computer sends a message to the satellite base station using the Internet requesting a GPS location or passing a message to a driver. The GPS updates can be set automatically to record vehicle history;
- the satellite base station transmits the request to the satellite orbiting the earth;
- the fleet vehicle receives the message and sends an acknowledgement back to the satellite. The acknowledgement includes latest position and confirms that the message was received by the fleet vehicle;
- the satellite transmits the acknowledgement to the base station; and
- the base station communicates with the fleet manager’s computer via the internet.
GPS is an alternative to the license plate match method. It provides accurate information of positioning, routes, and trip details. It is, however, marred by high equipment costs as well as malfunctions. Utilization of a GPS system does provide additional information regarding individual truck travel activity and truck type frequencies on given corridors and may offer future data collection possibilities. However, high equipment costs and frequent equipment malfunctions currently prevent widespread implementation. Additionally, utilizing a GPS system for recording truck travel activity only provides a very limited amount of information. Critical information such as weight, trip purpose, and commodity type hauled is not captured.

The above concerns can be minimized by increasing the density of vehicle numbers with GPS receivers or by narrowing the focus of each individual study (e.g., to a specific corridor or trip generator of interest). However, widespread utilization of GPS receivers for data collection on freight movements is currently cost prohibitive relative to the value of information obtained, especially for large urban areas with a large variety of freight movements.

Survey Procedures

The following describes three survey procedures: truck counts at external stations; truck surveys at external stations; and commercial vehicle origin-destination surveys.

Truck Counts at External Stations

Truck counts at external stations involve classifying commercial vehicles for calibrating and validating trip distribution forecasts. Cordon or screen line counts are recommended for most situations. Tube counts, electronic sensors, weigh stations, toll or turnpike counts, or video or visual classification counts may be used. Traffic volumes at external stations, as well as the types of trips involved (i.e., external-external, internal-external, and external-internal) vary significantly with location. For example, a 1991 study of nine counties in the San Francisco Bay Area found that 98 percent of all trucks surveyed involved local or intra-regional trips; that is, they either had their origin or destination in one of the nine counties, which means that only 2 percent were pass-through trips. On the other hand, a 1990 study in Yuma, Arizona found that 7 percent of all trips (passenger and freight) were pass-through trips. Still a 1994 origin-destination interview survey conducted on the perimeter of Berks County, PA determined that 27 percent of the trucks entering or leaving the county were not stopping within the county, and were thus pass-through trips. These wide variations indicate that data collection and analysis of actual truck traffic patterns, particularly at external stations, can produce more accurate freight forecasts than those that represent national averages. Research also suggests that there are wide

Figure 1. Typical GPS Tracking Process.
variances in truck counts or classifications based on tube counts due to equipment calibration, vehicle speed, and traffic density.

**Truck Surveys at External Stations**

Truck surveys at external stations are typically accomplished through interviews conducted at external stations to identify internal-external, external-internal, and external-external patterns of travel. These surveys provide the basis for trip generation, trip distribution, and time-of-day analyses, and are usually performed simultaneously with truck counts. The state or regional planning agency may face situations in which pass-through freight traffic, or traffic generated from non-local, widely dispersed sources, contribute significant traffic volumes to the area. In this situation, the agency may decide to conduct vehicle classification surveys and roadside/intercept origin-destination surveys at major external stations to estimate external-external, external-internal, and internal-external trips. Roadside interviews are most easily performed at weigh stations, although toll plazas, border crossing stations, and roadside pull-offs have also been used.

**Commercial Vehicle Origin-Destination Surveys**

Commercial vehicle origin and destination surveys are usually accomplished through telephone and mail surveys with trip logs, and are based on registered vehicles. These surveys tend to focus on internal-internal movements with internal-external and external-internal movements for locally registered vehicles. The results of commercial vehicle origin-destination surveys are used in freight analysis to provide a basis for analyzing trip generation, trip lengths (for distribution), and time-of-day characteristics.

**Travel Surveys Conducted in Texas**

The TxDOT Travel Survey Program is a schedule of travel surveys that are conducted on a recurring basis in all the state’s 25 MPOs. The program consolidates the MPOs into 14 travel survey regions to consolidate efforts and combine areas with similar travel characteristics. The external travel survey, often termed “roadside” survey, is an essential component of TxDOT’s travel survey program. More specifically, the surveys collect data on internal-external “local” trips and external-external pass-through trips by non-commercial and commercial vehicle categories. The external survey “stations” are located at or near the MPO’s study area boundary or cordon line. Figure 2 shows an example of external survey boundaries for the San Angelo area.
In a review and evaluation of over 25 origin-destination type travel surveys from around the country, nine different high-volume survey methods were identical. These fall into four general categories:

- Intercept Interview Surveys;
- Intercept Postcard Mail-Back Surveys;
- License Match Surveys; and
- License Mail-Out Surveys.

Figure 2. San Angelo External Survey Area Example.
A summary of the different types of surveys has been provided in Table 3.

**IH 35/SH 130 through Truck Diversion Analysis**

The 1996 IH 35 external-through truck trips were calculated in the following manner: a vehicle classification count station, which has over 20 years of historical data, located south of FM 1626 (near Buda, TX) was used to calculate the total number of trucks at the southern control point in 1996. The Austin/San Antonio origin-destination survey performed in 1988 (TTI Research Report 1186-2) was then used as a primary source with the one conducted in 1996 serving as an ancillary background reference to calculate the percentage of trucks making external-through trips on IH 35 from Kyle/Buda to north of Georgetown, TX; these percentages were applied to the total trucks to calculate the 1996 IH 35 external-through truck trips. The subsequent projections for the year 2020 were determined through regression analysis.

**El Paso, TX, 1994**

The city of El Paso, TX MPO, in association with TxDOT, developed a six-component travel survey for the El Paso metropolitan area in 1994 (Barton-Aschman Associates, Inc. 1994). One aspect of this travel survey, the Commercial Truck Survey, covered collection of freight data and information for travel demand and air quality modeling. Data was collected via telephone surveys with truck owners of vehicles registered in El Paso County. The list of registered commercial vehicle owners was obtained from Texas Vehicle Information and Computer Services, Inc. Survey participants provided truck travel information, origin and destinations, land use, trip purpose, truck weight and size, odometer readings, fuel type, business types, facility, and route information for each trip segment. Roughly 43 percent of those surveyed responded.

**Houston and Galveston, TX, 1994**

Wilbur Smith Associates conducted a commercial vehicle survey for the Houston-Galveston Area Council in November 1994, to collect truck travel data to be incorporated into the regional travel demand model. The random sample of commercial vehicles from the Department of Motor Vehicle registration list included some passenger for-hire vehicles such as taxis, vans, and limousines. The estimated response rate for participants responding to the commercial vehicle survey was between 35 and 40 percent, which consisted of both telephone contact and mail-out/mail-back surveys. The commercial vehicle survey collected travel attributes such as truck type, origin-destinations, odometer, and commodity and land-use type.

**External Surveys Conducted by TxDOT**

In 2003 and 2005, the Transportation Planning and Programming (TPP) Division of TxDOT funded external travel station surveys to be conducted in various metropolitan areas across the state. Some of the areas of interest where surveys were conducted included: Austin, San Antonio, San Angelo, Midland/Odessa, Tyler, Longview, and Lubbock. There were two methodologies employed for the surveys — the roadside intercept/interview for roadways with low-to-moderate traffic, and the license plate match method for high-volume roadways. The intercept/interview method was also adopted for surveys at weight stations, rest areas, and truck stops.
Travel Surveys Conducted in Other Areas

Automated trip recording technologies, such as GPS and data loggers, can provide great insight into the problem of travel survey misreporting. Recent studies have confirmed the feasibility of applying GPS technology to improve both the accuracy and completeness of travel data by using it as an audit tool for traditional reporting methods. The studies conducted have investigated the use of automated diaries with GPS, including the 1996 FHWA sponsored Lexington study with 100 respondents and a 1999 travel survey conducted in the Netherlands with 150 respondents. This section examines a few studies conducted in the field where GPS has been used to improve trip reporting. Table 1 shows a sample of travel surveys conducted in other areas, the collection procedures used, and the objectives of the surveys.

Researchers at Louisiana State University have been testing a process in which GPS receivers are sent to recruited survey participants and installed in each vehicle of the household. Research conducted at Georgia Tech has focused on GPS data accuracy and equipment functionality necessary to support a variety of data collection needs, including travel surveys and vehicle emissions studies. Table 2 shows a summary of truck travel surveys conducted in urban areas and Table 3 shows advantages and disadvantages of the truck travel surveys conducted in urban areas.

Table 1. Sample of Travel Surveys Conducted in Other Areas.

<table>
<thead>
<tr>
<th>Study</th>
<th>Technical Details/Collection Procedure</th>
<th>Main research objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lexington Area Travel Data Collection Test 1996 (Batelle, 1997)</td>
<td>Passive recording plus interactive input by the drivers (PDA); post-usage interviews</td>
<td>Acceptance of using automatic collection devices; test of passive and interactive reporting; analysis of route choice information</td>
</tr>
<tr>
<td>1997-1998 Austin Household Survey (Pearson, 2001)</td>
<td>Passive vehicle-based GPS recording; 200 vehicles; additional paper and pencil diary</td>
<td>Feasibility; underreporting of trips in ordinary paper surveys; identification of trip ends in GPS data</td>
</tr>
<tr>
<td>Transport Research Centre (AVV) experiment 1997, (Draijer et al., 2000); several cities in the Netherlands</td>
<td>Mixed design: Passive GPS recording by mobile equipment plus paper-pencil diary as well as GPS/pencil diary only; total sample size: 150</td>
<td>Acceptance of survey methodology; test of mobile GPS devices (in hand-held computer); test of suitability for all travel modes</td>
</tr>
<tr>
<td>Georgia Tech experiment 2000 (Wolf, 2000; Wolf, Guensler and Bachman, 2001); Atlanta, Georgia</td>
<td>Passive in-vehicle GPS system plus paper trip diary for part of the sample; 30 respondents</td>
<td>Possibility of total substitution of paper travel diaries; post data processing issues</td>
</tr>
<tr>
<td>SMARTRAQ/Drive Atlanta, start: 2002, Atlanta (Wolf, Guensler, Frank and Ogle, 2000; Sanders, 2002)</td>
<td>Passive monitoring of about 1,100 vehicles, up to two years monitoring period plus paper travel diaries</td>
<td>Traffic safety and travel behavior issues; Physical activity of the respondents; Air-quality issues</td>
</tr>
</tbody>
</table>

Source: Stefan Schonfelder and Kay W. Axhausen.
Table 2. Summary of Selected Truck Travel Surveys in Urban Areas.

<table>
<thead>
<tr>
<th>Survey Location</th>
<th>Survey Year</th>
<th>Survey Method</th>
<th>Approx. No. Completed Surveys</th>
<th>Response Rate</th>
<th>Data Applications</th>
<th>Total Survey Cost</th>
<th>$/Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicago</td>
<td>1986</td>
<td>Mail-Out/Mail-Back</td>
<td>3,506</td>
<td>25.3%</td>
<td>Truck travel model development; Corridor/route analysis; Effects of toll on trucks; Truck speed simulation model; Truck activity mapping</td>
<td>$200,000</td>
<td>$57</td>
</tr>
<tr>
<td>Ontario</td>
<td>1988</td>
<td>Roadside Interview</td>
<td>19,225</td>
<td>96.5%</td>
<td>Time series comparison, evaluate and design road geometries, pavement management planning; Truck accident analysis; Dangerous goods regulation and enforcement analysis; Driver education program</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Phoenix</td>
<td>1991</td>
<td>Combined Telephone-Mail-Out/Mail-Back</td>
<td>720</td>
<td>30.0%</td>
<td>Truck travel model development</td>
<td>$90,000¹</td>
<td>$125</td>
</tr>
<tr>
<td>NY and NJ</td>
<td>1991</td>
<td>Roadside Interview</td>
<td>4,500</td>
<td>NA</td>
<td>Evaluate dedicated route/corridor proposal; Traffic management for highway reconstruction; Time-series freight analysis; Freight economic analysis</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Alameda County, CA</td>
<td>1991</td>
<td>Combined Telephone-Mail-Out/Mail-Back and Roadside Interview</td>
<td>8,000</td>
<td>79.0%</td>
<td>I-880 corridor analysis; Creating truck travel sub-model for corridor analysis; Generating 24-hour and PM peak volumes by axle</td>
<td>$285,000²</td>
<td>NA</td>
</tr>
<tr>
<td>NY and NJ</td>
<td>1992-94</td>
<td>Roadside Interview</td>
<td>14,671</td>
<td>37.8%</td>
<td>NA</td>
<td>$312,000³</td>
<td>$21</td>
</tr>
<tr>
<td>El Paso</td>
<td>1994</td>
<td>Telephone Interview</td>
<td>188</td>
<td>42.6%</td>
<td>Truck travel model development part of regional travel study; Truck emissions analysis</td>
<td>$65,000⁵</td>
<td>$345⁶</td>
</tr>
<tr>
<td>Houston-Galveston</td>
<td>1994</td>
<td>Combined Telephone-Mail-Out/Mail-Back</td>
<td>900</td>
<td>35%-40%</td>
<td>Truck travel model development</td>
<td>$150,00</td>
<td>$167</td>
</tr>
</tbody>
</table>


¹ Cost includes data collection, data coding, and model development.

² The cost included sample design, survey design, data collection, coding, data reporting, and model development. Approximately, $5,000 was also included in the total cost for conducting vehicle classification counts at 11 locations along I-80 and I-880.

³ This was a sampling rate. No response rate was given.

⁴ This was a multi-agency effort, with partnership from the New Jersey Department of Transportation (NJDOT), the New York Metropolitan Transportation Council (NYMTC), and the Port Authority of New York and New Jersey. The survey was conducted at 18 locations with three interviewers per toll plaza for 24 hours.

⁵ Cost included sample design, survey design, data collection, coding, reporting, survey analysis, and model development.

⁶ The higher cost was due to a high number of incomplete surveys.
### Table 3. Advantages and Disadvantages of Selected Truck Travel Surveys in Urban Areas.

<table>
<thead>
<tr>
<th>Survey Methods</th>
<th>Place Of Survey</th>
<th>Typical Completed Surveys (% of Total Population)</th>
<th>Typical Response Rate</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telephone Interview</td>
<td>NY (1964) Calgary (1971) El Paso (1994)</td>
<td>4%-15%</td>
<td>40%-50%</td>
<td>High response rate; Easy to follow-up</td>
<td>Can only occur during business hours; “Telephone-tagging” problem; Limited time on telephone if respondent is busy; Requires access to vehicle registration file</td>
</tr>
<tr>
<td>Mail-Out/Mail-Back</td>
<td>Chicago (1986)</td>
<td>1%-5%</td>
<td>10%-45%</td>
<td>Less costly; Good response rate with certified mail; Only follow-up of non-responses is necessary</td>
<td>Low overall and item response rate; Possible bias due to better response from some drivers/owners; Low response from small truck owners; Need to follow-up on non-responses; Difficult to ensure that the driver will fill out the form, instead of the owner or fleet manager who receives the survey forms; Requires access to vehicle registration file</td>
</tr>
<tr>
<td>Combined Telephone and Mail-Out/Mail-Back</td>
<td>Phoenix (1991) Houston (1994) Alameda, CA (1991)</td>
<td>3%-10%</td>
<td>30%-80%</td>
<td>Improved response rate over mail-out/mail-back alone; Early identification of owners who agree to participate and potential non-responses through telephone contact; Telephone contact may help adjust sample size for mail-out/mail-back</td>
<td>Same disadvantages as telephone survey method above; High cost of telephone follow-ups; Need telephone reminders for trip diary; More costly than above methods</td>
</tr>
<tr>
<td>Roadside Intercept/Interview</td>
<td>Calgary (1971) NY (1978, 1983, 1988) and NJ (1974, 1982, 1985, 1991-1994) Alameda, CA (1991)</td>
<td>8%-35%</td>
<td>95%-100%</td>
<td>Complete information; High response rate; Better sampling control; Good representative sample of trucks entering or leaving cordon line; Easy comparison with mainstream traffic through field counts at survey location</td>
<td>Potential disruption to traffic; Quality and conduct of survey affected by weather, lighting; Hazardous to survey crew; Time constraint; No follow-up possible; Enforcement problems; Drivers avoiding the survey station; Only represent trucks traveling on road along survey station, not entire region</td>
</tr>
</tbody>
</table>


1. The higher response rate was due to better survey participation from large truck fleet operators.
2. The higher response rate was due to an employer survey conducted in California (1991 Caltrans-Alameda County Survey).
3. The higher percentage is from the 1988 Ontario survey which surveyed 57 locations over a 1,855-hour period throughout the Ontario Province.
Lexington Area Travel Data Collection Test

The idea behind this project originated in the Office of Highway Information Management and the field test was further supported by the Office of Technology Application. The resulting travel survey methodology offered a more robust data source for defining personal travel than current methods, which rely on telephone interviews and daily travel diaries. The study was a proof-of-concept and field test. Subsequent analysis of collected data demonstrated that this approach has merit with respect to more clearly defining personal travel behavior.

The sample in this study comprised 100 households. The average household size was 2.94 persons, with an average of 2.17 vehicles. The research program focused on the following objectives: technology, advantages and disadvantages, and future potential. The conclusions as derived from the study and pertaining to urban area traffic studies revolving around trucks indicate that GPS data, by itself, appears sufficient to plot most trips on the roadway network. Additional equipment may be needed to accurately track vehicles in urban canyons and in dense tree cover where absolute GPS technology alone may not be sufficient because the GPS signals are reflected or obscured.

Although the attempt to identify unreported trips remained incomplete, accurate data with regard to travel departure times and speed are easily available. The GPS receiver used in the field test transmits in both NMEA 0183 ASCII format and a Garmin proprietary format. These proprietary formats, and the difference in computer operating systems, make it difficult for software developers to establish programs that work across a variety of GPS hardware. Additionally, newer GPS receivers, such as those using PCMCIA technology may reduce the bulk of the equipment without sacrificing performance. Because the transportation industry is just now realizing the value of GPS in transportation projects, there is little software available for automated post-processing of data. More effort is needed to mesh the needs of transportation data users into the GPS and geographic information systems (GIS) products that are available.

Ontario Commercial Vehicle Survey

The Ontario Commercial Vehicle Survey (CVS) is part of the National Roadside Study (NRS) conducted by Transport Canada about every five years on major highways across Canada and at international border crossings. The NRS is a roadside truck driver intercept survey that captures many aspects of the trip, including the route, commodity, vehicle weights and dimensions, and driver and carrier profile. The Direct Data Entry method was introduced in 1995, followed by GIS-based data processing and reporting techniques in the 1999-2001 survey. The ongoing 2005/2007 survey software includes a GIS-based routing component that will enable the surveyor to confirm the route with the driver and modify it, if required, to obtain an accurate profile of the highways used for the trip. The Ontario Ministry of Transportation is currently in the process of investigating the use of non-intrusive GPS data to supplement, and eventually replace, data collected from roadside surveys. The number of trucks equipped with GPS receivers, which record the location of the vehicle every few seconds, has been increasing steadily over the past few years. In addition to providing detailed origin-destination information, the GPS technology provides many other potential benefits, including:
• coverage of urban freight movement with detailed route origin-destination and performance indicators;
• link-level congestion analysis (travel time and speed);
• near real-time international border transit time monitoring;
• tools and reporting systems to measure economic impacts delays due to incidents;
• fuel consumption and pollution analysis using GPS units that include engine data retrievers; and
• impacts of high-occupancy vehicle (HOV) lanes on general purpose lane (GPL) traffic.

Heavy-Duty Truck Activity Data - California

This research effort was conducted by the Planning and Technical Support Division of the California Air Resources Board (CARB) and jointly supported by the FHWA. The FHWA’s objective was to describe truck travel patterns in urban and rural areas for several vehicle classes and to analyze characteristics of heavy-duty truck travel by producing speed profiles, trip patterns, start patterns, and other data summaries. The project collected activity data from 140 heavy-duty trucks drawn from a volunteer sample from the California trucking industry. The overall objectives of the research program were to:

• collect truck travel activity data to describe truck travel patterns in urban and rural areas to support congestion modeling activities. These data include several truck vehicle classes, trip definition based on engine start and stop, trip time and distance, and highway functional classification; and
• characterize the collected data by producing speed profiles, trip patterns, start patterns, and other data summaries by vehicle class, urban area types, highway functional class, and California counties and air basins.

Cost comparison to traditional survey methods, such as telephone surveys, is inappropriate because the method and results of the data collection are vastly different. However, FHWA’s Lexington study offers a basis of comparison since the methods, equipment, and resultant data are similar. Additionally, both the Lexington study and this study were conducted essentially as a research process rather than a “production” mode of data collection.

Costs associated with the Lexington recruiting effort, which included substantial pre-collection publicity and planning, were approximately 45 percent higher per installation than the CARB study. Field activities, defined as preparing, transporting, installing, and retrieving the data collection devices, were approximately 29 percent higher per installation for the CARB study. The costs associated with preparation and installation of the data collection equipment are essentially equivalent for the two studies after the transportation costs are removed. Data analysis and reporting costs for the CARB study were approximately 35 percent to 40 percent higher per installation than for the Lexington study. Overall, the study cost per installation was approximately 80 percent of the Lexington cost per installation, ignoring equipment purchase and software development costs.
The goal of the CARB study was to develop more accurate data related to truck-travel activity than was currently available from traditional methods such as roadside surveys, telephone interviews, or travel diaries. These self-reported data collection approaches tend to round necessary attributes, such as travel times and start and stop times, omitting useful route information for short trips (Battelle 1999). To provide statewide coverage across different truck weight classes, the state of California was divided into four geographic regions, and five truck weight classes were chosen to provide a sample stratification of 20. The truck weight categories included:

- 8,500-10,000 lbs.;
- 10,000-14,000 lbs.;
- 14,000-33,000 lbs.;
- 33,000-60,000 lbs.; and
- > 60,000 lbs.

Private trucking fleets operating within each geographical region were then contacted and recruited (on a voluntary basis) to participate in the study by allowing GPS receivers to be placed on their trucks. A total of 167 freight vehicles were recruited and equipped with GPS receivers, although only 140 of these provided usable data (a result of equipment malfunctions). Each GPS receiver contained a memory card that recorded all trip attributes for later data downloading for analysis. Data recorded by the GPS receiver included the following:

- location of travel, by highway and truck weight class;
- travel time;
- trip distance;
- travel by functional highway class;
- speed profiles by weight class and region;
- start, stop, and idle time periods; and
- routes utilized from the collection of GPS points.

Overall, the study produced reasonably accurate information for the data types. However, there was significant difficulty recruiting a large enough sample of participating trucks to equip with GPS receivers. Additionally, significant problems associated with hardware, cabling, and memory card failures limited data accuracy. No information was provided regarding equipment or data collection costs (Battelle 1999). Table 4 shows the advantages and disadvantages of truck survey methods.
Table 4. Comparison of Different Truck Survey Methods.

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MAIL SURVEY</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Implementation</td>
<td>Easy to implement. No disruption of traffic, which is very important in urban settings.</td>
<td>Very difficult to obtain trip detail for all shipment types that the shipper or trip generator may possess.</td>
</tr>
<tr>
<td>Investment and Maintenance</td>
<td>Low investment requirement. Minimal personnel requirement.</td>
<td>Must be replicated periodically to maintain current relevance.</td>
</tr>
<tr>
<td>Statistical Reliability/Sampling Frame</td>
<td>Generally good information for those that respond. Survey design may include targeted truck movement types or specific commodities.</td>
<td>Low response rate may create biased data. Difficulty finding appropriate person to complete survey, also contributing to bias or non-response.</td>
</tr>
<tr>
<td>Data Attributes</td>
<td>Very good data detail for completed responses.</td>
<td>Limited ability to clarify meaning of specific questions.</td>
</tr>
<tr>
<td>Geographic Coverage</td>
<td></td>
<td>Poor coverage of urban truck movements from trucks licensed in other states and areas. Low response also limits coverage.</td>
</tr>
<tr>
<td><strong>TELEPHONE SURVEYS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Implementation</td>
<td>Easy to implement. No disruption of traffic, which is very important in urban settings. Quicker turnaround than mail.</td>
<td>Difficulty finding appropriate and correct telephone numbers. Can only call during business hours. 20-to-30 minutes in length.</td>
</tr>
<tr>
<td>Investment and Maintenance</td>
<td>Low investment requirement.</td>
<td>Must be replicated periodically to maintain current relevance. Higher personnel requirement when compared to mail.</td>
</tr>
<tr>
<td>Statistical Reliability/Sampling Frame</td>
<td>Generally good information for those that respond. Survey design may include targeted truck movement types or specific commodities.</td>
<td>Low response rate may create biased data. Difficulty finding appropriate person to complete survey, also contributing to bias or non-response.</td>
</tr>
<tr>
<td>Data Attributes</td>
<td>Very good data detail for completed responses.</td>
<td>None.</td>
</tr>
<tr>
<td>Geographic Coverage</td>
<td>Generally coverage is limited to those vehicles licensed within the area.</td>
<td>Poor coverage of urban truck movements from trucks licensed in other states and areas.</td>
</tr>
<tr>
<td><strong>ROADSIDE INTERVIEW/LICENSE PLATE MATCH</strong></td>
<td>Relatively easy to implement. 2 to 6 minute interview.</td>
<td>Relatively high labor requirement, especially for large geographic areas. Potential disruption of traffic. Significant risk to survey personnel.</td>
</tr>
<tr>
<td>Investment and Maintenance</td>
<td>If managed properly, investment costs are relatively low.</td>
<td>Must be replicated periodically to maintain current relevance. Higher personnel requirement than telephone and mail.</td>
</tr>
<tr>
<td>Statistical Reliability/Sampling Frame</td>
<td>Best statistical control since sample is from known traffic population, over a known time period. Highest response rate.</td>
<td>Limited locations where survey may be implemented may bias sampling.</td>
</tr>
<tr>
<td>Data Attributes</td>
<td>Excellent ability to obtain all desired data and information, given one-on-one contact with driver. Complete information on O-D, route, trip purpose, commodity, etc.</td>
<td>None.</td>
</tr>
<tr>
<td>Geographic Coverage</td>
<td>Does provide coverage of truck activity other than at survey locations but truck must first pass through survey site. Includes vehicles passing through from outside geographical area.</td>
<td>Only captures truck traffic that passes through interview sites.</td>
</tr>
</tbody>
</table>
Table 4. Comparison of Different Truck Survey Methods (Continued).

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIDEO SURVEILLANCE</td>
<td>Implementation No disruption of traffic.</td>
<td>Potential for equipment failure or technical difficulties.</td>
</tr>
<tr>
<td></td>
<td>Investment and Maintenance High equipment cost and requirements. Relatively high maintenance and replacement cost for video equipment.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Statistical Reliability/Sampling Frame Captures all trucks passing a video site, during all (visible) time periods.</td>
<td>Provides limited information.</td>
</tr>
<tr>
<td></td>
<td>Data Attributes Provides general descriptive information on traffic flows.</td>
<td>No information regarding O-D, trip purpose, freight/goods type carried, route, etc.</td>
</tr>
<tr>
<td></td>
<td>Geographic Coverage Limited to locations with video capability within and around urban area.</td>
<td></td>
</tr>
<tr>
<td>GLOBAL POSITIONING SYSTEM (RECIEVER)</td>
<td>Implementation No disruption of traffic.</td>
<td>Requires private shipper participation.</td>
</tr>
<tr>
<td></td>
<td>Investment and Maintenance Very high equipment investment cost. Equipment malfunction and technical difficulties common.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Statistical Reliability/Sampling Frame Limited to sample of vehicles participating in study. Very limited sample of all freight movements in urban setting.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Data Attributes Relatively accurate route and trip activity data.</td>
<td>Very limited information regarding trip purpose, commodity hauled and trip chaining.</td>
</tr>
<tr>
<td></td>
<td>Geographic Coverage Limited to sample size.</td>
<td></td>
</tr>
</tbody>
</table>

Source: Truck Trip Data Collection Methods, FHWA and Oregon Department of Transportation.

Summary

Over the past 15 years, the ability to collect detailed travel information has been expanded by developments in GPS technology. With GPS, it is now possible through integration with GIS to determine origins, destinations, travel times, distances, routes, and vehicle speeds at highly disaggregate levels of spatial and temporal resolution without relying on participant recall (Wolf et al., 2003). Beginning in 2005, around 250,000 trucks per year have been monitored with GPS to assess speed and travel time reliability on five major Interstate freight routes (FHWA, 2006). The scarce usage of truck GPS data cannot be attributed to the fact that these data cannot be readily collected. It is increasingly common for commercial vehicles to be fitted with GPS as part of the monitoring of operations and driver behavior, such as speeding or exceeding legislated driving hours.
PILOT STUDY

According to a Truck Inventory and Use Study report by the FHWA (2000), about 36 percent of the vehicle miles traveled by trucks occur on trips of less than 50 miles, and an additional 30 percent fall into the category of 50-200 miles. Moreover, 95 percent of all trips are less than 200 miles in length, with 81 percent less than 50 miles. Thus, the majority of all truck trips are local, and most vehicle miles can be considered local. From the various survey approaches discussed earlier, the use of GPS is the most effective approach as it requires a minimal amount of labor and can be conducted in a reasonable amount of time. For this experimental analysis, it is necessary to analyze and verify the identified method to realize the objective. The data for the Pilot Study analysis was obtained from American Transportation Research Institute (ATRI). This section of the report will analyze and check the reliability of the data for differentiating pass through trucks from the entire sample.

Study Area and Data Characteristics

The American Transportation Research Institute (ATRI) provided Bexar County data for this effort. Figure 3 shows the geographical area and the survey locations. Three survey locations — East, Central, and West — were identified for the process and data recorded was provided in the following format for each truck. The survey was conducted in October 2007 along the major interstate in the area – I-10. A total of 25,835 GPS-equipped trucks were identified and tracked. Table 5 shows sample GPS data and map to the right in Figure 3 shows the study area.

The essential components of the data provided for analysis are:

- journey beginning time;
- beginning coordinates (longitudes and latitudes);
- beginning location demarcated by East, Central, or West;
- ending coordinates;
- ending location demarcated by East, Central, or West; and
- journey time in minutes.
Table 5. Sample GPS Data.

<table>
<thead>
<tr>
<th>Site No.</th>
<th>Truck ID</th>
<th>Start Time-GMT</th>
<th>Longitude</th>
<th>Latitude</th>
<th>Location 1</th>
<th>Longitude</th>
<th>Latitude</th>
<th>Location 2</th>
<th>Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3042</td>
<td>19:33:44</td>
<td>-96.1753</td>
<td>29.7597</td>
<td>East</td>
<td>-98.3808</td>
<td>29.4381</td>
<td>Central</td>
<td>159.42</td>
</tr>
<tr>
<td>3</td>
<td>5128</td>
<td>23:28:45</td>
<td>-96.1758</td>
<td>29.7603</td>
<td>East</td>
<td>-98.2686</td>
<td>29.4728</td>
<td>Central</td>
<td>120.68</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>25,834</td>
<td>3230</td>
<td>22:03:49</td>
<td>-100.324</td>
<td>30.48</td>
<td>West</td>
<td>-98.3803</td>
<td>29.4372</td>
<td>Central</td>
<td>151.58</td>
</tr>
<tr>
<td>25,835</td>
<td>6174</td>
<td>14:33:48</td>
<td>-100.326</td>
<td>30.48</td>
<td>West</td>
<td>-98.5936</td>
<td>29.5681</td>
<td>Central</td>
<td>120.52</td>
</tr>
</tbody>
</table>

A through trip is defined as the movement from East-to-West or West-to-East without a stop in C. From the data set, the following movements of Trucks could be observed: East-to-West, East-to-C, C-to-West, C-to-East and West-to-East.

Analysis Approach

To analyze the data set, average speeds for each of the trucks were computed. For computational requirements, the following formula was used to obtain the distance in miles when given the geographical coordinates:

\[
\text{Distance (D)} = 3963.0 \times \arccos [\sin (\text{Lat1}/57.2958) \times \sin (\text{Lat2}/57.2958) + \cos (\text{Lat1}/57.2958) \\
\times \cos (\text{Lat2}/57.2958) \times \cos (\text{Lon2}/57.2958 - \text{Lon1}/57.2958)].
\]

The derived distances were then used to calculate the speeds of the trucks using: \( S = \frac{D}{T} \), where \( t \) is the time taken to travel from Location 1 to Location 2. Alternatively, a GIS program could be used to plot the origin-destination coordinates on the Bexar County map having a detailed roadway system.
Observations

Table 6 shows that the number of explicit pass-through trips, i.e., from East-to-West and West-to-East account for only 2,094, which is 8 percent of the total sample. Anomalies were observed in the speeds for certain trucks as operating speeds were above 100 mph, which could be a result of improper reporting times. The anomalies have been discussed in the latter part of this section. It is also necessary to identify possibilities of stoppages in a trip performed by trucks traveling from East-to-West or West-to-East. To determine the possible stoppages in the truck trips, the following assumptions were made:

- a majority of the trucks making pass-through trips would have a consistent average speed and would take the same amount of time to reach a particular destination; and

- major variations in the time taken to perform a trip is a direct result indicating intermediary stoppages for breaks, at weigh stations, or due to factors such as peak hour congestion or accidents.

Table 6. Total Pass-Through Trips by Direction.

<table>
<thead>
<tr>
<th>Count of Truck Id</th>
<th>Location2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Central</td>
</tr>
<tr>
<td>Location 1</td>
<td></td>
</tr>
<tr>
<td>Central</td>
<td>-</td>
</tr>
<tr>
<td>East</td>
<td>6,751</td>
</tr>
<tr>
<td>West</td>
<td>4,828</td>
</tr>
<tr>
<td>Total</td>
<td>11,579</td>
</tr>
</tbody>
</table>

The maximum speed on I-10 was assumed to be 70 miles per hour, speeds were assumed to vary up to 75 miles per hour. Table 7 shows the average speeds for the total sample of trucks performing trips in all directions.
Table 7. Average Speeds of Sample Trucks.

<table>
<thead>
<tr>
<th>Average Speed (Intervals)</th>
<th>Frequency of Trucks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 5</td>
<td>502</td>
</tr>
<tr>
<td>5 – 10</td>
<td>944</td>
</tr>
<tr>
<td>10 – 15</td>
<td>891</td>
</tr>
<tr>
<td>15 – 20</td>
<td>908</td>
</tr>
<tr>
<td>20 - 25</td>
<td>954</td>
</tr>
<tr>
<td>25 – 30</td>
<td>1,101</td>
</tr>
<tr>
<td>30 – 35</td>
<td>1,228</td>
</tr>
<tr>
<td>35 – 40</td>
<td>1,606</td>
</tr>
<tr>
<td>40 – 45</td>
<td>2,063</td>
</tr>
<tr>
<td>45 – 50</td>
<td>2,572</td>
</tr>
<tr>
<td>50 – 55</td>
<td>2,611</td>
</tr>
<tr>
<td>55 – 60</td>
<td>3,409</td>
</tr>
<tr>
<td>60 – 65</td>
<td>4,484</td>
</tr>
<tr>
<td>65 – 70</td>
<td>2,071</td>
</tr>
<tr>
<td>70 - 75</td>
<td>245</td>
</tr>
</tbody>
</table>

A majority of the trucks were operating at average speeds varying from 55mph to 65 mph. A total of 246 trucks were reportedly operating at speeds above 75 mph. Figure 3 shows that a considerable number of trucks were observed operating well above 120 mph, which is a clear indication of discrepancies in the data.
Figure 4. Average Operating Speeds of the Trucks (All Directions).

For further analysis, the average speeds were computed for the trucks making pass-through trips (i.e., East-to-West and West-to-East) (Figure 5).

Figure 5. Average Operating Speeds of the Trucks (East-to-West and West-to-East).
Figures 6 and 7 separate the speeds for the pass-through trips by direction. Table 8 summarizes the graphs. It is not possible however, to ascertain whether the trucks operating a lower speeds or higher speeds have stopped for breaks. This is primarily due to the limitation of the data characteristics, which do not provide alternative reporting times, other than the origin-destination.

A. Direction East-to-West

![Operating Speeds for E to W Direction](image)

Figure 6. Average Operating Speeds for the East-to-West Direction.

B. Direction West-to-East

![Operating Speeds for W to E Direction](image)

Figure 7. Average Operating Speeds for the West-to-East Direction.
Table 8. Speed Data Summary.

<table>
<thead>
<tr>
<th>Speed Intervals</th>
<th>Frequency</th>
<th>Speed Intervals</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 5</td>
<td>2</td>
<td>0 – 5</td>
<td>1</td>
</tr>
<tr>
<td>5 – 10</td>
<td>16</td>
<td>5 – 10</td>
<td>11</td>
</tr>
<tr>
<td>10 – 15</td>
<td>25</td>
<td>10 – 15</td>
<td>25</td>
</tr>
<tr>
<td>15 – 20</td>
<td>27</td>
<td>15 – 20</td>
<td>32</td>
</tr>
<tr>
<td>20 – 25</td>
<td>42</td>
<td>20 – 25</td>
<td>45</td>
</tr>
<tr>
<td>25 – 30</td>
<td>49</td>
<td>25 – 30</td>
<td>43</td>
</tr>
<tr>
<td>30 – 35</td>
<td>72</td>
<td>30 – 35</td>
<td>64</td>
</tr>
<tr>
<td>35 – 40</td>
<td>109</td>
<td>35 – 40</td>
<td>111</td>
</tr>
<tr>
<td><strong>40 – 45</strong></td>
<td><strong>193</strong></td>
<td><strong>40 – 45</strong></td>
<td><strong>207</strong></td>
</tr>
<tr>
<td><strong>45 – 50</strong></td>
<td><strong>251</strong></td>
<td><strong>45 – 50</strong></td>
<td><strong>297</strong></td>
</tr>
<tr>
<td>50 – 55</td>
<td>123</td>
<td>50 – 55</td>
<td>153</td>
</tr>
<tr>
<td>55 – 60</td>
<td>40</td>
<td>55 – 60</td>
<td>33</td>
</tr>
<tr>
<td>60 – 65</td>
<td>10</td>
<td>60 – 65</td>
<td>11</td>
</tr>
<tr>
<td>65 – 70</td>
<td>14</td>
<td>65 – 70</td>
<td>5</td>
</tr>
<tr>
<td>70 – 75</td>
<td>15</td>
<td>70 – 75</td>
<td>4</td>
</tr>
</tbody>
</table>

A majority of the trucks in either direction operated at an average speed of 45-to-50 mph as compared to the overall sample, which operated at speeds of 55-to-65 mph.

Anomalies

A primary level analysis of the data results in a number of anomalies with respect to the parameters under consideration — distance, speed, and time taken to travel from trip origin to the trip destination. Table 9 summarizes the observed maximum and minimum distance traveled and the travel time for the sample of trucks operating at all speeds. Table 10 summarizes the observed maximum and minimum’s considering the average operating speed as 40-to-50 miles per hour. The graphs in Figure 8 show that there is a significant variation in the origin-destination travel time while the trucks were operating at the same average speed.
Table 9. Summary of Observed Minimums and Maximums (All Speeds).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>East-to-West</th>
<th>West-to-East</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Distance Covered (mi)</td>
<td>35.6</td>
<td>35.3</td>
</tr>
<tr>
<td>Maximum Distance Covered (mi)</td>
<td>234.8</td>
<td>237.5</td>
</tr>
<tr>
<td>Minimum Travel Time (min)</td>
<td>36.0</td>
<td>20.3</td>
</tr>
<tr>
<td>Maximum Travel Time (min)</td>
<td>598.4</td>
<td>576.5</td>
</tr>
<tr>
<td>Minimum Average Speed (mph)</td>
<td>4.7</td>
<td>4.6</td>
</tr>
<tr>
<td>Maximum Average Speed (mph)</td>
<td>140.4</td>
<td>314.4</td>
</tr>
</tbody>
</table>

Table 10. Summary of Observed Minimums and Maximums (Average Speeds).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>East-to-West</th>
<th>West-to-East</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Distance Covered (mi)</td>
<td>38.2</td>
<td>40.4</td>
</tr>
<tr>
<td>Maximum Distance Covered (mi)</td>
<td>179.6</td>
<td>216.4</td>
</tr>
<tr>
<td>Minimum Travel Time (min)</td>
<td>53.9</td>
<td>52.6</td>
</tr>
<tr>
<td>Maximum Travel Time (min)</td>
<td>226.4</td>
<td>292.7</td>
</tr>
</tbody>
</table>

Note: Average operating speed considered was 40-to-50 mph.

Figure 8. Time and Speed Relation for East-to-West and West-to-East Direction.

Summary of Findings

This analysis demonstrates the basic feasibility of identifying pass-through trips using commercially available GPS data, in spite of the measurement error, and other anomalies inevitably encountered in this type of data. Unfortunately, at this time, comparable comprehensive GPS data are not available.
CONCLUSIONS AND RECOMMENDATIONS

The feasibility of automatic data collection for studying travel behavior in general is well established. The advantages of data collection by GPS include:

- the reduction (or even elimination) of respondents’ burden;
- the availability of path choice information;
- the high level of spatial accuracy; and
- the fact that data are generated in a digital format, which allows direct analysis.

In addition to specific limitations as discussed earlier, the following GPS data has drawbacks:

- the possibility of sporadic or even systematic technical problems of transmission, eventually leading to total loss of information (e.g., certain warm-up times before receiving signals);
- costly post-processing of the GPS data, i.e., trip end, trip purpose, and street address detection; and
- still relatively high equipment costs.

Truck traffic and flows with respect to an urban area can be categorized as external-to-external, internal-to-external, and internal-to-internal. The major classification in the context of this study is comparing those which have a destination within an urban area and those that pass through an urban area. In most studies conducted across the nation, truck intercept studies have proved to be the most appropriate and effective method of obtaining travel and trip characteristics. Use of GPS systems to record truck travel activity does not capture information such as weight, trip purpose, and commodity type hauled, but the data can be enhanced by limiting the focus of the study area to a specific corridor or trip generator. The choice of the type of survey is based on the requirements in terms of data for the subsequent analysis.

This study has demonstrated the basic feasibility of identifying pass-through trips using commercially available GPS data as well as determining the relative unavailability of those data at this time.
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